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Title	The relationship between atopic dermatitis and indoor environmental factors : a cross-sectional study among Japanese elementary school children
Author(s)	Ukawa, Shigekazu; Araki, Atsuko; Kanazawa, Ayako et al.
Citation	International Archives of Occupational and Environmental Health, 86(7), 777-787 https://doi.org/10.1007/s00420-012-0814-0
Issue Date	2013-10-01
Doc URL	https://hdl.handle.net/2115/87328
Rights	The final publication is available at link.springer.com
Type	journal article
File Information	56_Int Arch Occup Environ Health, 2013.pdf



Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

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The relationship between atopic dermatitis and indoor environmental factors: a cross-sectional study among Japanese elementary school children

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Introduction

Atopic dermatitis, classified as an allergic disease (The ISAAC Steering Committee 1998), is a common chronic inflammatory skin condition, that appears in early infancy and childhood (Leung et al. 2008). It is reported to have a negative effect on the quality of life of children and their parents (Al Shobaili 2010; McKenna et al. 2005). The overall prevalence of atopic dermatitis in school-age children is estimated to be between 15 and 20% (Baumer 2008) and is increasing in the industrialised world (Torres-Borrego et al. 2008) . In Japan it is about 16.9% (Williams et al. 1999). While the prevalence is similar among boys and girls (Saeki et al. 2005), while prevalence is similar among boys and girls (Saeki et al. 2005), sensitization to allergens such as mite and pollen has been shown to be significantly higher in boys (Govaere et al. 2007). A family history of atopic dermatitis as determined by genetic factors (Osawa et al. 2011) and immunological factors (Wu et al. 2011) is reported to be a strong risk factor for atopic dermatitis. Mutations in the gene encoding filaggrin (FLG), which plays a role in epidermal barrier formation and hydration, have been identified in 30% of Japanese atopic dermatitis patients (Nomura et al. 2007). However, these factors do not sufficiently explain the aetiology of atopic dermatitis. Thus, environmental factors are thought to be important aspects of its pathophysiology (Leung et al. 2004).

Health risks from indoor air pollution have become a major issue (Fisk et al. 2010). Although the indoor environment of dwellings is important, few epidemiological studies showing an association between home environment factors and atopic dermatitis have been reported. Some epidemiological studies have demonstrated that dampness in buildings and mould have adverse health effects on

respiratory, nose, and skin systems in infancy (Bornehag et al. 2004; Bornehag et al. 2005; Fisk et al. 2010). However, these factors were not associated with atopic dermatitis in elementary school children in a Taiwanese study in subtropical areas (Yang et al. 2000). In two German studies, NO_2 emission (Eberlein-Konig et al. 1998) and keeping pets indoors (Schafer et al. 1999) were reported to be risk factors for atopic dermatitis. However, similar results were not found in other studies (Yang et al. 2000); (Ibargoyen-Roteta et al. 2007). Despite these important studies, environmental risk factors for atopic dermatitis in elementary school children are still not well known.

The aim of this study was to ascertain (1) which home environmental factors were associated with atopic dermatitis in Japanese elementary school children aged 6 through 12 years and (2) whether susceptibility to the home environment differed by gender.

Material and methods

Study population

This cross-sectional study was conducted in Sapporo city on Hokkaido, the north island of Japan. Due to financial restrictions, 35 of Sapporo's 202 public elementary schools were invited to participate in the present study. To include schools from all ten wards of Sapporo city, we approached schools with the assistance of Sapporo Board of Education and Sapporo City Head Teachers' Association. A total of 12 schools in eight wards agreed to participate in the study. Questionnaires were distributed to

all 6,393 children attending these schools via the classroom teachers. Parents were asked to fill in the questionnaires. Each classroom teacher collected the questionnaires from his or her students. This study was conducted after obtaining informed consent from all participants, and the study protocol was approved by the ethics board for epidemiological studies at Hokkaido University Graduate School of Medicine and conformed to the principles outlined in the Declaration of Helsinki of 1975, as revised in 1983.

Definition of atopic dermatitis

To define atopic dermatitis, we used the International Study Asthma and Allergies in Childhood (ISAAC) core questionnaire (The ISAAC Steering Committee 1998). Atopic dermatitis was defined as: a) "Having an itchy rash that comes and goes for at least 6 months?"; b) "Having the aforementioned itchy rash at any time during the last 12 months?"; and c) "Having the aforementioned itchy rash affect one or several of the following areas: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears, or eyes?"

Questionnaire for home environment and lifestyle

The questionnaire on home environment investigated the following: housing type (solitary or other), housing architecture (wooden or other), age of the house, home renovation within 5 years (yes or no), living near a crowded street (yes or no), mechanical ventilation in the living room and/or bedroom

(yes or no), wall-to-wall carpeting in the home (yes or no), heating system (electronic, other (gas, kerosene, or wood stove) with a ventilation duct to the outside, or other (gas, kerosene, or wood stove) without a ventilation duct to the outside), furry animals and/or birds in the home (yes or no), indoor smoker at home (yes or no), visible mould (yes or no), perception of mouldy odour (yes or no), condensation on windowpanes (yes or no) and episodes of water leakage within the past 5 years (yes or no). Demographic information such as gender, school grade, number of siblings, being the firstborn child, number of family members, and parental history of allergies was also collected. Parental history of allergies was assessed by the question: Have you ever been diagnosed by a doctor as having allergic diseases such as asthma, allergic rhinitis, pollen allergy, or atopic dermatitis? Answers were classified as: neither parent, mother only, father only, or both parents. Queries about lifestyle included hours of sleep, getting enough sleep (never, sometimes, almost every day, or every day), refreshing sleep (never, sometimes, almost every day, or every day), and deep sleep (never, sometimes, almost every day, or every day).

Statistical analysis

Continuous variables are presented as medians (25 percentile-75 percentile); categorical variables are presented as numbers (percentages). Characteristics and home environment of the study participants with or without atopic dermatitis were compared using the Mann-Whitney U test and χ^2 test. Odds ratios (ORs) and 95% confidence intervals (95% CI) for atopic dermatitis were calculated using

logistic regression. To obtain multivariate-adjusted ORs for atopic dermatitis in relation to home environment, we controlled for possible confounders, including gender, school grade, parental history of allergies (neither, mother only, father only, or both parents), number of siblings, and being a firstborn child (yes or no). Study participants were then divided into two groups according to gender, and a stratified analysis was performed to obtain adjusted ORs for atopic dermatitis in relation to home environment factors. An alpha level of 0.05 was considered to be statistically significant. All statistical analyses were performed using JMP version 9.0.2 for Windows (SAS Institute Inc., Cary, NC, USA).

Results

Of the subjects we approached, 4,445 (69.5%) responded to the questionnaire. After eliminating subjects with missing data for the outcome variable and gender, 4,254 participants (2,089 boys and 2,165 girls) were evaluated in the final analysis. The prevalence of atopic dermatitis was 16.7% (boys, 16.8%; girls 16.6%).

Table 1 shows associations between atopic dermatitis and characteristics of study participants. Variables such as school grade, being a firstborn child, and parental history of allergies were significantly associated with atopic dermatitis. There prevalence of atopic dermatitis was higher in children in lower school grades who were not the firstborn, and who had both parents with a history of allergies.

Table 2 shows the associations between atopic dermatitis and home environment factors. There were significantly more reports of visible mould, mouldy odour, and condensation on windowpanes in the

houses of the atopic dermatitis group at 40.2%, 7.5%, and 58.1%, respectively.

Table 3 shows the multivariate analysis of atopic dermatitis and home environment factors. Having visible mould (OR 1.25, 95% CI: 1.01-2.11), mouldy odour (OR 1.54, 95% CI: 1.10-2.14), and condensation on windowpanes in the house (OR 1.25, 95% CI: 1.05-1.48) were found to be risk factors for atopic dermatitis after adjusting for gender, school grade, parental history of allergies, number of siblings, and being a firstborn child (yes or no). Compared with use of an electric heating system, using a non-electric heating system without a ventilation duct to the outside, was shown to have no significant influence in the crude analysis. After adjusting for gender and school grade, a significant difference appeared (OR 1.47 95% CI: 1.01-2.11).

Table 4 and table 5 show the multivariate analysis of atopic dermatitis and home environment factors for boys and girls, respectively. Having visible mould (OR 1.28, 95% CI: 1.00-1.64), and mouldy odour in the house (OR 1.64, 95% CI: 1.00-1.64) were found to be risk factors for atopic dermatitis for boys (table 4). All ORs remained statistically significant after adjusting for gender, school grade, parental history of allergies, number of siblings, and being firstborn. Having condensation on windowpanes in the house was found to be a risk factor in the crude analysis, but statistical significance disappeared after adjusting for school grade and parental history of allergies.

For girls, living near a crowded street, visible mould, and condensation on windowpanes in the house were shown to be risk factors in the crude analysis. However, statistical significance disappeared after adjusting for school grade and parental history of allergies.

Discussion

In this study, we found a significant relationship between atopic dermatitis and using a heating system other than an electronic one without a ventilation duct to the outside. In a Taiwanese study, no association was reported between atopic dermatitis and indoor use of gas heating (Yang et al. 2000), whereas using gas heating with a wall mounted exhaust pipe was positively associated with atopic dermatitis in a German study with a skewed sample distribution (Schafer et al. 1999). Exposure to even low concentrations of NO_2 emission (Eberlein-Konig et al. 1998) or particulate matter (PM) (Song et al. 2011) from gas heating is considered to influence skin physiology parameters, and indoor pollutants from gas combustion are thought to increase the likelihood of initial sensitisation to house dust mite (Ponsonby et al. 2001). When a gas, kerosene, or wood stove is used, adequate ventilation should be provided to keep the skin from drying out. Indoor air quality in winter in Sapporo city may have more of an effect on people's health than in summer because the average outside temperatures are 20.3°C in summer, compared to -2.5°C in winter (World Meteorological Organization; Japan Meteorological Agency). In our study, housing materials, housing type, age of the house, and home renovation within 5 years were not risk factors for atopic dermatitis.

We found significant relationships between atopic dermatitis and visible mould, perception of mouldy odour, and episodes of condensation on windowpanes in the house. We also found a significant association between episodes of condensation on windowpanes and atopic dermatitis. One previous study

demonstrated that moisture provides suitable environmental conditions necessary for mould growth (Eggleston 2003). Most fungal spores are known to contain allergens (Green et al. 2003). Immunoglobulin E (IgE)-mediated sensitisation to fungi such as *Alternaria*, *Aspergillus*, *Cladosporium*, and *Penicillium* species, the main indoor fungi in Sapporo city (Takeda et al. 2009), is a strong risk factor for asthma (Chapman 2006) and exposure to mould significantly elevates the levels of IgE antibodies (Savilahti et al. 2001). Mould seems to cause and maintain skin inflammation, but the precise immunological pathway has not yet been elucidated (Roll et al. 2004). To clarify this point, further experimental studies are needed.

In the stratified analysis by gender, visible mould and mouldy odour were significantly related to atopic dermatitis among boys, and this relationship remained after adjusting for variables such as school grade, parental history of allergies, number of siblings, and being a firstborn child. No significant association was observed between home environment and atopic dermatitis among girls after adjusting for school grade and parental history of allergies. Sex hormones such as estradiol (Yamatomo et al. 2001; Narita et al. 2007), progesterone (Mitchell and Gershwin 2007), testosterone (Schroeder et al. 1997), and dehydroepiandresterone (Sudo et al. 2001; Tabata et al. 1997) have been shown to positively or negatively influenced allergic sensitisation, although such influences are now controversial (Chen et al. 2008). However, since the average age of menarche in Japan is 12.4 years old (Fukuda et al. 2011), the influence of sex hormones should not affect our results. To find whether boys are more susceptible to moulds than girls in elementary school children, further experimental and epidemiological studies are

needed.

When one German study was conducted in spring (Schafer et al. 1996), there was a significant association between atopic dermatitis and a short distance of home from busy roads, however, this association was not found in the present study which was conducted in winter. As housing in Sapporo city, especially in cold winter, seems to have greater airtightness than other regions in Japan (Kanazawa et al. 2010), indoor air quality could be affecting atopic dermatitis more than outside air quality. No associations between atopic dermatitis and wall-to-wall carpeting, furry animals or birds, and indoor smoker at home were found. These results are consistent with several reports that showed no association between atopic dermatitis and carpets (Austin and Russell 1997; Yang et al. 2000), presence of cats or dogs, and passive smoking (Ibargoyen-Roteta et al. 2007; Yang et al. 2000; Schafer et al. 1999). Several studies have reported that atopic dermatitis causes sleep problems (Schmitt J et al. 2009; Bender BG et al. 2003, 2008). In this study, atopic dermatitis was associated with less refreshing sleep and less deep sleep. Intermittent skin itching may cause lower quality sleep. Although atopic dermatitis was associated with school grade, parental history of allergies, and being a firstborn child (yes or no), these variables were independent of home environments in this population because little change was found in estimated ORs after adjusting for these variables.

Statistical significance may have occurred by chance because we ran a number of analyses. However, as mentioned previously, environmental factors in this study are consistent with previous reports (Yang et al. 2000; Eberlein-Konig et al. 1998; Schafer et al. 1999; Ibargoyen-Roteta et al. 2007).

We conducted multiple regression analysis using all variables from table 2 as well as, gender, school grade, parental history of allergies, number of siblings, and being a firstborn child. Significant associations were not found with variables such as heating system (Using a non-electric heating system with a ventilation duct to the outside vs. an electronic system, OR(95%CI): 1.24(0.88-1.79), p=0.23; using non electric heating system without a ventilation duct to the outside vs. an electronic system, OR(95%CI): 1.35(0.91-2.02), p=0.13); visible mould present (OR(95%CI): 1.13(0.91-1.41), p=0.28); mouldy odour (OR(95%CI): 1.41(0.96-2.02), p=0.08); condensation on window panes (OR(95%CI): 1.23(0.91-1.40), p=0.28). Thus, each environmental variable was not independently associated with atopic dermatitis, but these environmental factors are mutually related to each other. These variables should be associated with atopic dermatitis because changes in the odds ratio were within 10% compared to variables in Table 3. Furthermore, problems with multicollinearity may include the results of a multiple regression model. This could lead to important factors being overlooked. Consequently, each environmental variable was introduced into the model separately and adjusted for subjective characteristics such as gender, school grade, parental history of allergies, number of siblings, and being a firstborn child.

This study was conducted in public elementary schools located in eight out of ten wards in Sapporo. We distributed questionnaires to all the children attending these schools, and approximately 70% replied. Demographic characteristics in this population are similar to those for Sapporo city. Furthermore, the prevalence of atopic dermatitis in this study is consistent with previous studies (Baumer

2008; Williams et al. 1999). Therefore, our results could be generalised to elementary school children living in Sapporo city.

The present study had several limitations. First, socio-economic status (Werner et al. 2002), parental educational level (Shaw et al. 2011), and food allergens such as milk, eggs, and soybeans (Akdis et al. 2006; Breuer et al. 2004) have been reported to be risk factors for atopic dermatitis. However, these factors were not examined in the present study. Second, we did not measure allergen levels; determination of home environment in this study relied on self-reporting and was therefore subjective. The association between exposure to mould and asthma has been highlighted over the world (Ahluwalia and Matsui 2011; Smit et al. 2011). Thus, if subjects with atopic dermatitis thought that mould, condensation on windowpanes, and their heating system were also risk factors for atopic dermatitis, this could have led to reporting bias (Larsson et al. 2011). Third, genetic factors were also not measured. Gene mutations for Filaggrin, a key protein that facilitates the terminal differentiation of the epidermis and formation of the skin barrier, has been reported as a risk factor for atopic dermatitis (Osawa et al. 2011; Nemoto-Hasebe et al. 2009; Osawa et al. 2010). However, genetic factors should have been partly controlled as we calculated odds ratio adjusting for parental history of allergies. Fourth, because we used the well-validated ISAAC questionnaire (The ISAAC Steering Committee 1998), the definition of atopic dermatitis should be valid. However, measuring immunological factors such as cytokine and allergen specific immune globulin (Wu et al. 2011; Namkung et al. 2011; Yanagi et al. 2010; Flohr et al. 2004) would make our results more robust. Fifth, we distributed questionnaires to all of the children in the

schools, and thus the same parent would fill out two or more questionnaires for brothers and/or sisters. Therefore, our population was not entirely independent. Sixth, this study could not show causal relationship since it was a cross sectional study. To resolve this point, a prospective birth cohort study is needed.

In conclusion, although we know the limitations of cross-sectional studies, the results of this study showed that using a heating system other than electric without a ventilation duct to the outside, visible mould, perception of mouldy odour, and episodes of condensation on windowpanes in the house are associated with self-reported prevalence of atopic dermatitis. Especially among boys, visible mould, and perception of mouldy odour are associated with atopic dermatitis. Further study is needed to corroborate these findings.

Conflict of Interest

The authors declare that we have no conflict of interest.

Acknowledgments

We thank all participants and the public elementary schools in Sapporo city for their assistance. This study was conducted with support from the Ministry of Health, Labour and Welfare, Health and Labour Sciences Research Grant, Japan (H20-Research on Community Health Crisis Management-Ippan-009) and the Environment Research and Technology Development Fund (C-1151) from the Japan Ministry of

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Table 1. Association between atopic dermatitis and subject characteristics (n=4254)

Variable	Code	Atopic dermatitis (n=710)	Without atopic dermatitis (n=3644)	P-value
Gender				
	Boys	350(49.3)	1739(49.1)	0.91
	Girls	360(50.7)	1805(50.9)	
School grade				
	1st	128(18.1)	571(16.1)	0.03*
	2nd	145(20.5)	576(16.3)	
	3rd	118(16.7)	605(17.1)	
	4th	118(16.7)	628(17.8)	
	5th	101(14.3)	568(16.1)	
	6th	98(13.8)	589(16.7)	
Number of siblings	Person	2(2-3)	2(2-3)	0.43
Firstborn child				
	Yes	343(48.7)	1945(55.5)	0.001*
	No	361(51.3)	1559(44.5)	
Number of family members	Person	4(4-5)	4(4-5)	0.72
Parental history of allergies	Neither parent	125(18.0)	1361(39.5)	<0.001*
	Mather only	199(28.8)	830(24.1)	
	Father only	92(13.3)	479(13.9)	
	Both parents	275(39.8)	777(22.5)	
Sleeping hours	Hours	9(9-9.8)	9(9-9.8)	0.67
Sleep enough				
	Never	93(13.1)	380(10.8)	0.07
	Sometimes	126(17.7)	561(15.9)	
	Almost every day	347(48.9)	1746(49.6)	
	Everyday	144(20.3)	835(23.7)	
Refreshing sleep				
	Never	133(18.7)	463(13.1)	0.004*
	Sometimes	146(20.6)	702(19.9)	
	Almost every day	322(45.3)	1705(48.3)	
	Everyday	109(15.4)	662(18.7)	
Deep sleep				
	Never	39(5.5)	87(2.5)	<0.001*
	Sometimes	70(9.9)	234(6.6)	
	Almost every day	334(47.1)	1453(41.1)	
	Everyday	266(37.5)	1758(49.8)	

Values are expressed as median (25^{th}-75^{th}) or number of children (percentage).
P values were calculated between atopic dermatitis and without atopic dermatitis by Mann-Whitney U test or χ^2 test.
$P<0.05$.

Table 2. Association between atopic dermatitis and home environment (n=4254)

Variables	Code	Atopic dermatitis (n=710)	Without atopic dermatitis (n=3644)	P-value
Housing type				
	Solitary	303(42.7)	1542(43.7)	0.64
	Other	406(57.3)	1989(56.3)	
Architecture				
	Wooden	356(50.5)	1816(51.7)	0.56
	Other	349(49.5)	1698(48.3)	
Age of house	Year	13(6-20)	13(6-20)	0.37
Home renovation within 5 years				
	No	591(85.9)	2957(86.7)	0.56
	YES	97(14.1)	453(13.3)	
Living near a crowded street				
	No	150(22.2)	838(23.9)	0.12
	YES	557(78.8)	2666(76.1)	
Mechanical ventilation in the living room or bed room				
	No	243(34.7)	1210(34.6)	0.98
	YES	458(65.3)	2285(65.4)	
Wall-to-wall carpeting in the home				
	No	303(42.9)	1507(42.8)	0.93
	Yes	403(57.1)	2018(57.2)	
Heating system				
	Electronic	49(7.1)	303(8.8)	0.14
	Using a without electric heating system with a ventilation duct to the outside	493(71.0)	2456(71.7)	
	Using a without electric heating system without a ventilation duct to the outside	152(21.9)	669(19.5)	
Furry animals or bird in the home				
	No	539(75.9)	2642(74.7)	0.50
	YES	171(24.1)	894(25.3)	
Indoor smoker at home				
	No	378(55.4)	1835(51.9)	0.47
	YES	330(46.6)	1699(48.1)	
Visible mould				
	No	423(59.8)	2330(66.0)	0.001*
	YES	285(40.2)	1201(34.0)	
Mouldy odour				
	No	654(92.5)	3360(95.1)	0.004*
	YES	53(7.5)	172(4.9)	
Water leakage				
	No	611(86.8)	3148(89.2)	0.06
	YES	93(13.2)	383(10.8)	
Condensation on windowpanes				
	No	297(41.9)	1729(49.0)	<0.001*
	YES	412(58.1)	1801(51.0)	

Values are expressed as median (25^{th}-75^{th}) or number of children (percentage).
P values were calculated between atopic dermatitis and without atopic dermatitis by Mann-Whitney U test or χ^2 test.
*P<0.05.

Table 3. Multivariate analysis of atopic dermatitis and home environment

Variables	Code	COR (95%CI)	AOR[a] (95%CI)	AOR[b] (95%CI)	AOR[c] (95%CI)
Housing type					
	Solitary	1.00	1.00	1.00	1.00
	Other	1.03(0.88-1.22)	1.03(0.87-1.21)	0.99(0.83-1.17)	0.97(0.81-1.15)
Architecture					
	Wooden	1.00	1.00	1.00	1.00
	Other	1.04(0.89-1.23)	1.04(0.89-1.23)	1.01(0.85-1.20)	1.01(0.85-1.19)
Age of house	Every 5 years	1.01(0.65-2.13)	1.01(0.97-1.05)	1.01(0.97-1.06)	1.01(0.97-1.05)
Home renovation within 5 years					
	No	1.00	1.00	1.00	1.00
	YES	1.07(0.84-1.35)	1.09(0.86-1.38)	1.09(0.85-1.39)	1.08(0.84-1.38)
Living near a crowded street					
	No	1.00	1.00	1.00	1.00
	YES	1.16(0.96-1.42)	1.16(0.96-1.42)	1.10(0.90-1.36)	1.10(0.90-1.36)
Mechanical ventilation in the living room or bed room					
	No	1.00	1.00	1.00	1.00
	YES	0.99(0.84-1.18)	0.99(0.83-1.17)	1.01(0.85-1.21)	1.04(0.87-1.25)
Wall-to-wall carpeting in the home					
	No	1.00	1.00	1.00	1.00
	YES	0.99(0.84-1.16)	1.00(0.85-1.18)	1.00(0.84-1.18)	0.99(0.84-1.18)
Heating system					
	Electronic	1.00	1.00	1.00	1.00
	Using a without electric heating system with a ventilation duct to the outside	1.24(0.91-1.72)	1.29(0.95-1.80)	1.33(0.96-1.83)	1.28(0.93-1.80)
	Using a without electric heating system without a ventilation duct to the outside	1.40(0.99-2.00)	1.47(1.03-2.11)*	1.50(1.05-2.18)*	1.45(1.01-2.11)*
Furry animals or bird in the home					
	No	1.00	1.00	1.00	1.00
	YES	0.93(0.77-1.12)	0.96(0.79-1.16)	0.98(0.80-1.19)	0.94(0.77-1.15)
Indoor smoker at home					
	No	1.00	1.00	1.00	1.00
	YES	0.94(0.80-1.10)	0.94(0.79-1.10)	0.99(0.84-1.17)	1.01(0.85-1.20)
Visible mould					
	No	1.00	1.00	1.00	1.00
	YES	1.30(1.10-1.54)*	1.33(1.12-1.57)*	1.28(1.08-1.52)*	1.25(1.05-1.49)*
Mouldy odour					
	No	1.00	1.00	1.00	1.00
	YES	1.58(1.14-2.16)*	1.57(1.13-2.15)*	1.55(1.10-2.14)*	1.54(1.10-2.14)*
Water leakage					
	No	1.00	1.00	1.00	1.00
	YES	1.25(0.97-1.58)	1.27(0.99-1.62)	1.17(0.91-1.51)	1.15(0.89-1.48)
Condensation on windowpanes					
	No	1.00	1.00	1.00	1.00
	YES	1.33(1.13-1.56)*	1.34(1.14-1.58)*	1.25(1.06-1.48)*	1.25(1.05-1.48)*

Each environmental variable was introduced into the model separately. COR, crude odds ratio; AOR, adjusted odds ratio; CI, confidence interval.*P<0.05

[a] Adjusted for gender and school grade. [b] Adjusted for gender, school grade, and parental history of allergies.

[c] Adjusted for gender, school grade, parental history of allergies, number of siblings, and firstborn child (yes or no).

Table 4. Multivariate analysis of atopic dermatitis and home environment (boys only)

Variables	Code	n	COR (95%CI)	AOR[a] (95%CI)	AOR[b] (95%CI)	AOR[c] (95%CI)
Housing type						
	Solitary	908	1.00	1.00	1.00	1.00
	Other	1171	1.09(0.87-1.38)	1.09(0.86-1.38)	1.10(0.87-1.14)	1.10(0.86-1.40)
Architecture						
	Wooden	1062	1.00	1.00	1.00	1.00
	Other	1008	1.13(0.89-1.42)	1.12(0.89-1.41)	1.08(0.85-1.37)	1.06(0.83-1.35)
Age of house	Every 5 years	2014	1.01(0.95-0.99)	1.01(0.96-1.07)	1.02(0.96-1.08)	1.01(0.96-1.07)
Home renovation within 5 years						
	No	1762	1.00	1.00	1.00	1.00
	YES	254	1.05(0.74-1.48)	1.10(0.76-1.54)	1.04(0.72-1.47)	1.05(0.72-1.49)
Living near a crowded street						
	No	473	1.00	1.00	1.00	1.00
	YES	1600	0.99(0.76-1.31)	0.99(0.76-1.31)	0.95(0.72-1.26)	0.93(0.70-1.25)
Mechanical ventilation in the living room or bed room						
	No	700	1.00	1.00	1.00	1.00
	YES	1356	0.89(0.70-1.14)	0.89(0.70-1.14)	0.91(0.71-1.17)	0.94(0.73-1.21)
Heating system						
	Electronic	170	1.00	1.00	1.00	1.00
	Using a without electric heating system with a ventilation duct to the outside	1442	1.05(0.69-1.65)	1.11(0.72-1.76)	1.14(0.74-1.83)	1.12(0.72-1.79)
	Using a without electric heating system without a ventilation duct to the outside	424	1.25(0.78-2.05)	1.31(0.82-2.17)	1.35(0.83-2.25)	1.34(0.83-2.24)
Wall-to-wall carpeting in the home						
	No	875	1.00	1.00	1.00	1.00
	YES	1202	0.91(0.72-1.15)	0.91(0.72-1.16)	0.89(0.70-1.13)	0.88(0.69-1.13)
Furry animals or bird in the home						
	No	1624	1.00	1.00	1.00	1.00
	YES	460	0.86(0.64-1.14)	0.88(0.66-1.17)	0.91(0.66-1.20)	0.88(0.65-1.18)
Indoor smoker at home						
	No	1096	1.00	1.00	1.00	1.00
	YES	987	0.90(0.71-1.13)	0.89(0.70-1.12)	0.95(0.74-1.20)	0.95(0.75-1.21)
Visible mould						
	No	1355	1.00	1.00	1.00	1.00
	YES	727	1.14(1.06-1.70)*	1.37(1.08-1.73) *	1.31(1.03-1.68) *	1.28(1.00-1.64) *
Mouldy odour						
	No	1965	1.00	1.00	1.00	1.00
	YES	114	1.67(1.06-2.57) *	1.68(1.06-1.98) *	1.61(1.00-2.51) *	1.64(1.00-1.64) *
Water leakage						
	No	1841	1.00	1.00	1.00	1.00
	YES	239	1.41(1.00-1.95) *	1.42(1.01-1.98) *	1.30(0.91-1.83)	1.30(0.91-1.82)
Condensation on windowpanes						
	No	988	1.00	1.00	1.00	1.00
	YES	1092	1.31(1.04-1.66) *	1.33(1.05-1.68) *	1.24(0.98-1.58)	1.23(0.96-1.57)

Each environmental variable was introduced into the model separately. COR, crude odds ratio; AOR, adjusted odds ratio; CI, confidence interval. *P<0.05.

[a] Adjusted for school grade. [b] Adjusted for school grade and parental history of allergies

[c] Adjusted for school grade, parental history of allergies, number of siblings, and firstborn child (yes or no).

Table 5. Multivariate analysis of atopic dermatitis and home environment (girls only)

Variables	Code	n	COR (95%CI)	AOR[a] (95%CI)	AOR[b] (95%CI)	AOR[c] (95%CI)
Housing type						
	Solitary	937	1.00	1.00	1.00	1.00
	Other	1224	0.99(0.79-1.24)	0.98(0.78-1.23)	0.93(0.73-1.17)	0.97(0.77-1.24)
Architecture						
	Wooden	1110	1.00	1.00	1.00	1.00
	Other	1039	0.97(0.78-1.23)	0.98(0.78-1.24)	0.96(0.76-1.21)	0.97(0.76-1.23)
Age of house	Every 5 years	2078	1.02(0.96-1.07)	1.02(0.96-1.08)	1.01(0.96-1.08)	1.01(0.95-1.07)
Home renovation within 5 years						
	No	1786	1.00	1.00	1.00	1.00
	YES	296	1.08(0.78-1.49)	1.11(0.80-1.52)	1.15(0.81-1.60)	1.11(0.78-1.55)
Living near a crowded street						
	No	515	1.00	1.00	1.00	1.00
	YES	1623	1.37(1.04-1.83) *	1.37(1.04-1.83) *	1.29(0.97-1.74)	1.32(0.99-1.79)
Mechanical ventilation in the living room or bed room						
	No	1387	1.00	1.00	1.00	1.00
	YES	753	1.11(0.88-1.42)	1.10(0.87-1.41)	1.16(0.90-1.49)	1.17(0.91-1.52)
Heating system						
	Electronic	182	1.00	1.00	1.00	1.00
	Using a without electric heating system with a ventilation duct to the outside	1507	1.47(0.94-2.41)	1.51(0.96-2.47)	1.55(0.98-2.58)	1.46(0.91-2.43)
	Using a without electric heating system without a ventilation duct to the outside	397	1.58(0.96-2.70)	1.63(0.99-2.78)	1.67(0.99-2.91)	1.56(0.92-2.72)
Wall-to-wall carpeting in the home						
	No	935	1.00	1.00	1.00	1.00
	YES	1219	1.08(0.86-1.36)	1.11(0.88-1.40)	1.13(0.89-1.43)	1.13(0.89-1.44)
Furry animals or bird in the home						
	No	1557	1.00	1.00	1.00	1.00
	YES	605	1.00(0.78-1.29)	1.04(0.80-1.34)	1.04(0.79-1.34)	0.99(0.76-1.30)
Indoor smoker at home						
	No	1117	1.00	1.00	1.00	1.00
	YES	1042	0.99(0.79-1.24)	1.00(0.80-1.25)	1.05(0.83-1.33)	1.08(0.85-1.38)
Visible mould						
	No	1398	1.00	1.00	1.00	1.00
	YES	759	1.28(1.01-1.61) *	1.31(1.03-1.65) *	1.26(0.99-1.60)	1.23(0.96-1.57)
Mouldy odour						
	No	2049	1.00	1.00	1.00	1.00
	YES	111	1.49(0.92-2.32)	1.48(0.92-2.32)	1.50(0.92-2.38)	1.46(0.88-2.33)
Water leakage						
	No	1918	1.00	1.00	1.00	1.00
	YES	237	1.10(0.76-1.83)	1.12(0.78-1.59)	1.04(0.71-1.49)	1.01(0.69-1.46)
Condensation on windowpanes						
	No	1038	1.00	1.00	1.00	1.00
	YES	1121	1.35(1.07-1.69) *	1.36(1.08-1.71) *	1.27(0.99-1.60)	1.27(0.99-1.61)

Each environmental variable was introduced into the model separately. COR, crude odds ratio; AOR, adjusted odds ratio; CI, confidence interval.*P<0.05

[a] Adjusted for school grade. [b] Adjusted for school grade and parental history of allergies.

[c] Adjusted for school grade, parental history of allergies, number of siblings, and firstborn child (yes or no).