

Original article

Involvement of urban living environments in atopy and enhanced eosinophil activity: potential risk factors of airway allergic symptoms

Background: Airway allergic diseases, such as bronchial asthma and allergic rhinitis, have increased, especially in urban areas. These diseases are characterized by airway inflammation with enhanced eosinophil activity, and the risk of disease development has been shown to increase with the prevalence of atopy.

Methods: Questionnaires were administered to 426 healthy adult women aged 30–74 years, living in an urban area of Osaka, Japan, to survey individual living environments and airway allergic symptoms such as cough, sputum, and wheezing. Moreover, serum house-dust-mite (*Dermatophagoides pteronyssinus*, [Der p]-specific immunoglobulin E (IgE) and serum eosinophil cationic protein (ECP) were examined by radioimmunoassay, and the atopic status (atopic sensitization) and enhanced eosinophil activity were assessed as Der p-specific IgE RAST scores of 2–6 and ECP levels of more than 10 ng/ml, respectively.

Results: Intensive use of electric air conditioners in hot weather (odds ratio: 2.07 [95% CI: 1.11–3.87]) and mold proliferation in the kitchen (2.77 [1.34–5.73]) significantly increased the risk of atopic sensitization. Poor home ventilation and family smoking appeared to be positively but not significantly associated with atopic sensitization. Personal smoking and intensive use of the air conditioner appeared to be positively related to enhanced eosinophil activity. Atopic status showed significant involvement in the development of wheezing, and the development of cough was significantly associated with enhanced eosinophil activity.

Conclusions: The results suggest that some urban styles of living are involved in atopic sensitization and enhanced eosinophil activity in the Japanese urban population, probably due to living conditions, such as indoor dampness and poor home ventilation, caused by tight insulation, which increase exposure to indoor air pollutants, such as respirable mite allergens and tobacco smoke.

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The prevalence of airway allergic diseases, such as bronchial asthma and allergic rhinitis, has increased in most industrialized countries, particularly in urban areas (1, 2). Previous studies revealed that the prevalence of atopy, which is a major risk factor in the development of allergic diseases (3, 4), has also increased in recent decades (5–7) and is significantly higher in urban areas (2, 8, 9). Indoor air quality is a very important health issue, because many people spend much of their life indoors (10). House-dust mites are considered to be the most common cause of atopic sensitization and airway hyperresponsiveness, and their proliferation has increased markedly with the urbanization of life in many countries including Japan (11, 12). Moreover, recent studies have demonstrated that chronic airway inflammation associated with eosinophils commonly underlies the basic mechanism of

airway allergic diseases (13, 14); eosinophils accumulate in lung tissue and release some cytotoxic molecules, such as eosinophil cationic protein (ECP), which injure the bronchial epithelia. Therefore, modern styles of living in urban areas have been considered potentially responsible for the development of airway allergic diseases due to proliferating house-dust mites and increasing concentrations of indoor air pollutants, such as respirable mite allergens or tobacco smoke, which lead to the elevation of serum immunoglobulin E (IgE) levels or the enhancement of eosinophil activity.

To identify the potential risk factors aggravating airway allergic symptoms in an urban population, we administered a questionnaire on individual living environments and recent histories of airway allergic symptoms, such as cough, sputum, and wheezing, to healthy adult women living in an urban district of

Japan. Moreover, atopic sensitization to house-dust mites and enhanced eosinophil activity were assessed by measuring serum levels of *Dermatophagoides pteronyssinus* (Der p)-specific IgE and ECP, respectively. The influence of urban living environments on atopic sensitization and eosinophil activity was investigated, and the association between atopic status and enhanced eosinophil activity and the development of airway allergic symptoms was examined.

Material and methods

Population and area studied

A cross-sectional study was carried out between February and March in 1995–7. The original study population consisted of 486 healthy adult women, who underwent yearly preventive medical examination for adults in Yao City, an urban district of Osaka Prefecture, Japan, with a population of approximately 270 000. Questionnaires on individual styles of living, airway allergic symptoms, and history of allergic diseases were administered, and serum Der p-specific IgE and ECP levels were measured. The information was obtained from 426 women aged 30–74 years (mean 52.5); the response rate was 87.7%. The number of subjects varied between 387 and 426 for the various analyses, because cases with missing data were excluded as necessary.

Questionnaire

The self-administered questionnaire on individual living environments comprised 10 questions relating to the following risk factors: living in a heavy traffic area, type of housing (concrete or wooden), heating system (use of unvented combustion appliances), cleaning habits, use of electric air conditioners in hot weather, visible mold proliferation on surfaces inside the house, home ventilation, type of floor cover, personal smoking habit, and family smoking habits. There were also questions on recent history of airway allergic symptoms, including cough, sputum, and wheezing. In addition, information was requested on the history of allergic diseases, including asthma, allergic rhinitis, atopic dermatitis, and urticaria. A translation of the questions is presented in Table 1.

Measurements of serum IgE and ECP

Venous blood samples of 5 ml each were obtained from each subject and kept at room temperature for 60 min. The sera were separated by centrifugation and immediately frozen with dry ice. They were stored at -80°C until the analysis. Serum Der p-specific IgE and ECP levels were measured by radioimmunoassay (RIA) using CAP-RAST kit (Pharmacia Upjohn Diagnostics, Uppsala, Sweden).

Atopic status (atopic sensitization) was assessed by whether serum Der p-specific IgE was present/absent (positive/negative). The IgE values were classified into seven levels: classes 0–6, with classes 2–6 defined as positive and classes 0 and 1 as negative. Eosinophil activity was regarded as enhanced if the concentration of serum ECP was above 10 ng/ml.

Informed consent was obtained from all subjects.

Statistical analysis

The living environment data were converted to two values, 0 or 1, based on the absence or presence of corresponding risk factors, respectively. The cleaning habit data were converted to values of 0, 1, and 2 according to the choice of answer, 0–2, 3–5, and 6 or more times a week, respectively. For use of electric air conditioners (hours per day), the answers were converted to 0 or 1 for use less than the

approximate average value of 6 h or not, respectively. Home ventilation was considered to be poor if the windows were kept open for less than 1 h on a sunny day, and adequate if not. For the type of floor cover, the value of 1 was assigned if the answer was Japanese straw mats (tatami) and 0 for others. For personal smoking habit, the data were converted to 0, 1, and 2 according to the number of cigarettes smoked, 0, 1–10, and more than 10 a day, respectively.

Airway allergic symptoms were considered to be present if the answer was “frequently, regardless of having a cold” or “always when having a cold” for the presence of cough and sputum, and “twice and more in the last 2 years” or “once in the last 2 years” for wheezing.

The data were analyzed with a NEC PC9821Xn personal computer (Tokyo, Japan) using the statistical software, Statistical Package for Social Science (SPSS) for Windows (SPSS, Inc., Chicago, IL, USA). For each factor, the crude odds ratio (OR) with 95% confidence interval (95% CI) was calculated by logistic regression analysis. In addition, in order to adjust for confounders, multiple logistic regression analysis was done by entering all the factors additionally, including age and history of allergic diseases, to obtain adjusted ORs. Data from 387 subjects were examined to determine the influence of urban living environments on atopic sensitization and enhanced eosinophil activity, and data from 422–426 subjects were used to examine the association between atopic status and enhanced eosinophil activity and the development of airway allergic symptoms, after excluding cases with missing data on even a single item. Statistical significance was defined by a *P* value of less than 0.05 determined by Wald chi-square test. *P* < 0.10 was considered to be indicative of a trend.

Results

Characteristics of the study population

Table 2 shows the descriptive information for the population studied. Almost one-fourth (23.5%) of the population lived in a heavy traffic area. The vast majority (87.9%) lived in wooden houses. Electric air conditioners were used by 42.1% for at least 6 h a day in hot weather. Although the rate of personal smoking was as low as 5.2%, 61.0% had household smoker(s). The prevalence of atopy and the mean $\pm$ SD of ECP were 13.7% (*n* = 387) and 8.10 ± 5.85 ng/ml (*n* = 387), which approximately coincide with the values found by some epidemiologic studies with healthy Japanese adults, i.e., 15.8% (*n* = 198) (15) and 7.5 ± 4.5 ng/ml (*n* = 80) (16), respectively. The prevalence of airway allergic symptoms was much higher for cough (32.4%) and sputum (21.3%) than wheezing (4.5%).

Influence of urban living environments on atopic sensitization

Table 3 shows the crude and adjusted associations between urban living environments and the atopic status (atopic sensitization) determined by the increase of specific IgE against house-dust mite. Mold growth in the kitchen (adjusted OR: 2.77 [95% CI: 1.34–5.73], *P* = 0.006) and intensive use of air conditioners in hot weather (for 6 h or more per day in the living room) (adjusted OR: 2.07 [1.11–3.87], *P* = 0.023) were significantly associated with atopic sensitization. Such significant associations were also apparent in the crude ORs. Poor home ventilation (adjusted OR: 2.17

Table 1. Questions concerning living environments, airway allergic symptoms, and history of allergic diseases

Questions about living environments	
1. Residential area:	"Do you live in a heavy traffic area (within 25 m of main road traversed by many large trucks)?"
2. Type of housing:	"What type of housing do you live in: concrete or wooden?"
3. Heating system:	"Do you usually use unvented combustion appliances (oil, gas, coke, coal, etc.) for heating the room in which you spend most time in winter?"
4. Cleaning habits:	"How often do you clean the room in which you spend most time with a vacuum cleaner per week: 0–2, 3–5, 6 or more times?"
5. Use of air conditioner:	"How often do you use an electric air conditioner in the room in which you spend most time in hot weather (hours per day)?"
6. Mold proliferation:	"Have you ever had mold growth on surfaces in the kitchen?"
7. Home ventilation:	"How long do you keep windows open on a sunny day (hours per day)?"
8. Floor cover:	"What type of floor cover do you use in the room in which you spend most time: tatami (Japanese straw mat), wooden, plastic, carpet, others?"
9. Personal smoking habit:	"How much do you smoke (number of cigarettes smoked daily)?"
10. Family smoking habit:	"How many household smokers do you have other than yourself?"
Questions about airway allergic symptoms	
1. Cough:	"How often do you cough? a) frequently, regardless of having a cold; b) always when having a cold; c) sometimes when having a cold; d) seldom even when having a cold."
2. Sputum:	"How often do you emit sputum? a) frequently regardless of having a cold; b) always when having a cold; c) sometimes when having a cold; d) seldom even when having a cold."
3. Wheezing:	"Have you ever had wheezing or whistling in your chest? a) twice or more in the last 2 years; b) once in the last 2 years; c) not in the last 2 years although have experienced it; d) never experienced it."
Questions about history of allergic diseases	
"Has a doctor ever said that you had the following allergic disease(s): asthma, allergic rhinitis, atopic dermatitis, or urticaria?"	

Table 2. Characteristics of study population

Characteristic	Frequency (%)
Environmental factors (<i>n</i> =387 ^a)	
1. Living in heavy traffic area	23.5
2. Type of housing: concrete	12.1
3. Use of unvented combustion appliances	56.1
4. Frequent cleaning habits: 6 or more times a week	48.8
3–5 times a week	34.4
5. Intensive use of air conditioner: at least 6 h a day	42.1
6. Mold proliferation in kitchen	14.2
7. Poor home ventilation: less than 1 h air-exchange a day	11.1
8. Floor cover, Japanese straw mat (tatami)	38.2
9. Personal smoking habit	5.2
10. Family smoking habit	61.0
Age (<i>n</i> =387 ^a)	
30–40 (years)	7.5
40–50	33.1
50–60	43.9
60–70	14.5
70–	1.0
Atopic status (<i>n</i> =387 ^a)	13.7
Enhanced eosinophil activity (<i>n</i> =387 ^a)	23.3
History of allergic diseases (<i>n</i> =387 ^a)	40.1
Airway allergic symptoms	
Cough (<i>n</i> =423 ^a)	32.4
Sputum (<i>n</i> =422 ^a)	21.3
Wheezing (<i>n</i> =426 ^a)	4.5

^a Numbers of subjects varied with analyses, as described in "Statistical analysis".

[0.88–5.32], *P*=0.093) and family smoking habits (adjusted OR: 1.84 [0.91–3.68], *P*=0.088) appeared to be positively associated with atopic sensitization, but, as for poor home ventilation, no correlation was found in the crude OR. There was a significant association in the crude OR between concrete housing and atopic status (crude OR: 2.17 [1.03–4.58], *P*=0.043), although no significant correlation was found in the adjusted OR. Use of tatami for floor covering appeared to be inversely but not significantly associated with atopic sensitization (crude OR: 0.54 [0.28–1.03], *P*=0.059). As for the other environmental factors, no correlation was found for both the adjusted ORs and the crude ones.

Atopic status appeared to be inversely but weakly associated with aging, and significantly with a history of allergic diseases by the crude ORs, but not the adjusted ORs.

Influence of urban living environments on eosinophil activity

Crude and adjusted ORs for urban living environments concerning enhanced eosinophil activity defined by the increase of serum ECP concentration are also shown in Table 3. Although there was no significant association between living environments and enhanced eosinophil activity, personal smoking habit (adjusted OR: 1.64 [0.92–2.91], *P*=0.093) and intensive use of air conditioners (crude OR: 1.52 [0.94–2.44], *P*=0.085) showed tendencies of positive correlation to the elevation of serum ECP.

Enhancement of eosinophil activity appeared to be

Table 3. Involvement^a of urban living environments in atopic sensitization and enhanced eosinophil activity

Characteristic	Atopy		Enhanced eosinophil activity	
	Crude OR <i>n</i> =387	Adjusted OR <i>n</i> =387	Crude OR <i>n</i> =387	Adjusted OR <i>n</i> =387
Environmental factors				
1. Living in heavy traffic area	1.66 (0.88–3.12)	1.68 (0.84–3.36)	0.70 (0.39–1.27)	0.72 (0.39–1.35)
2. Type of housing (concrete vs wooden)	2.17* (1.03–4.58)	1.65 (0.72–3.79)	1.01 (0.49–2.08)	0.89 (0.41–1.92)
3. Use of unvented combustion appliances	0.79 (0.44–1.41)	0.80 (0.43–1.51)	1.16 (0.72–1.87)	1.11 (0.67–1.83)
4. Frequent cleaning habits ^b	0.89 (0.61–1.31)	0.83 (0.54–1.27)	1.12 (0.81–1.54)	0.96 (0.68–1.35)
5. Intensive use of electric air conditioner	2.16* (1.20–3.89)	2.07* (1.11–3.87)	1.52 ⁺ (0.94–2.44)	1.34 (0.82–2.20)
6. Mold proliferation	2.90** (1.47–5.74)	2.77** (1.34–5.73)	1.03 (0.52–2.01)	0.90 (0.45–1.81)
7. Poor home ventilation	1.80 (0.81–4.02)	2.17 ⁺ (0.88–5.32)	0.40 ⁺ (0.15–1.05)	0.45 (0.17–1.22)
8. Floor cover (tatami vs others)	0.54 ⁺ (0.28–1.03)	0.62 (0.31–1.25)	0.67 (0.40–1.10)	0.81 (0.47–1.38)
9. Personal smoking habit ^c	1.41 (0.73–2.69)	1.31 (0.65–2.62)	1.63 ⁺ (0.94–2.83)	1.64 ⁺ (0.92–2.91)
10. Family smoking habit	1.74 ⁺ (0.92–3.29)	1.84 ⁺ (0.91–3.68)	1.21 (0.74–1.98)	0.99 (0.59–1.66)
Intrinsic factors				
11. Age ^d	0.97 ⁺ (0.93–1.00)	0.98 (0.95–1.03)	0.96** (0.93–0.99)	0.97 ⁺ (0.94–1.00)
12. History of allergic diseases	1.83* (1.02–3.27)	1.58 (0.84–2.98)	1.70* (1.06–2.74)	1.69* (1.02–2.78)

^a Data expressed as odds ratios (ORs) with 95% confidence intervals in parentheses.^{b,c} Data expressed as ORs for 1-value elevation among three values: 0, 1, and 2.^d Data expressed as ORs for 1-year aging.⁺ $P < 0.10$, * $P < 0.05$, and ** $P < 0.01$ by Wald chi-square test.

significantly but inversely associated with aging in the crude OR (0.96 [0.93–0.99], $P = 0.006$), and significantly with a history of allergic diseases in both the adjusted OR (1.69 [1.02–2.78], $P = 0.040$) and crude OR (1.70 [1.06–2.74], $P = 0.029$).

Association between atopic status and enhanced eosinophil activity and the development of airway allergic symptoms

As shown in Table 4, enhanced eosinophil activity was significantly associated with the development of cough (adjusted OR: 2.01 [1.24–3.27], $P = 0.005$). Atopic status showed involvement in wheezing with a significant crude OR (3.08 [1.12–8.46], $P = 0.028$), but not with the adjusted OR. The history of allergic diseases appeared to be significantly involved both in cough (adjusted OR: 1.76 [1.15–2.70], $P = 0.010$) and wheezing (adjusted OR: 3.17 [1.15–8.71], $P = 0.025$). No significant correlations were found in other combinations of parameters.

Discussion

According to previous reports, the increasing prevalence rates of atopy and respiratory allergic diseases in

urbanized areas have been attributed to various potential risk factors, i.e., personal or maternal smoking habits (17, 18), total level of indoor bacteria (19), type of dwellings (11), ownership of furry animals (20), family income and education level (8), Western dietary habits (21), and diesel exhaust particulates (22). However, there are conflicting issues among the results of these epidemiologic studies. On the other hand, there seems to be a clear consensus on the increase of indoor air pollutants, such as respirable mite allergens and tobacco smoke, that play critical roles in the prevalence of atopy and airway allergic symptoms. We selected 10 risk factors, as shown in Table 1, which may play a part in creating these situations in urbanized living environments.

House-dust mites are thought to be the most common allergen and an important determinant in the development of allergic diseases. The majority of people with atopy (nearly 90%) react to Der p (4), which is the predominant house-dust mite in Asia, Europe, and other parts of the world. According to these findings, we defined atopic status in this study as the positivity of IgE to Der p. This species has a system for extracting water from unsaturated air to replenish its body water, and the most suitable relative humidity for growth and the critical equilibrium humidities, at which the transport

Table 4. Association^a between atopic status and enhanced eosinophil activity and development of airway allergic symptoms

Characteristic	Cough		Sputum		Wheezing	
	Crude OR n=423	Adjusted OR n=423	Crude OR n=422	Adjusted OR n=422	Crude OR n=426	Adjusted OR n=426
1. Atopic status	1.22 (0.68–2.17)	1.02 (0.56–1.87)	1.02 (0.53–1.99)	0.93 (0.47–1.83)	3.08* (1.12–8.46)	2.39 (0.84–6.79)
2. Enhanced eosinophil activity	2.04** (1.27–3.27)	2.01** (1.24–3.27)	1.28 (0.75–2.21)	1.25 (0.71–2.18)	1.67 (0.62–4.53)	1.23 (0.43–3.53)
3. Age ^b	1.00 (0.98–1.03)	1.01 (0.99–1.04)	1.00 (0.97–1.03)	1.00 (0.98–1.03)	0.97 (0.91–1.02)	0.98 (0.97–1.03)
4. History of allergic diseases	1.79** (1.18–2.71)	1.76** (1.15–2.70)	1.44 (0.90–2.31)	1.43 (0.88–2.32)	3.71** (1.38–9.96)	3.17* (1.15–8.71)

^a Data expressed as odds ratios (ORs) with 95% confidence intervals in parentheses.

^b Data expressed as ORs for 1-year aging.

* $P < 0.05$, and ** $P < 0.01$ by Wald chi-square test.

and countertransport of water between mite body and ambient air are balanced, have been determined to be 60–80% and 65–73% at 25°C, respectively (23). Hence, home dampness is considered to have the potential to increase the proliferation of such house-dust mites (24–26) and aggravate respiratory symptoms (17, 18, 24, 27). Their indoor populations have been rapidly increasing, especially in urbanized home environments (11, 12). In the present study, visible mold growth on the surfaces inside homes was used as an indicator of elevated relative humidity. Mold proliferation in the kitchen was significantly correlated with the elevated serum Der p-specific IgE, and using tatami flooring, which has a hygroscopic property, was inversely correlated with it. In addition, atopic status showed involvement in increasing the risk of wheezing with a significant and higher crude OR (3.08). These results suggest that home dampness sufficient to cause mold growth may be responsible for increasing the prevalence of atopy by facilitating the proliferation of house-dust mites, leading to the development of respiratory allergic symptoms, especially wheezing.

The effects of indoor air conditioning in hot weather on atopic sensitization and airway allergic symptoms have been poorly investigated. In Japanese urban areas, most homes use electric air conditioners intensively during hot weather because of the high temperature and humidity. In the areas studied, the average temperature and relative humidity in August are 28.2°C and 68%, respectively. A study in the USA suggested that mite allergens detected in dust samples are reduced by the use of air conditioners in summer because of their water-drainage effects (28). Another investigator reported that air conditioning can reduce mite density if it decreases relative humidity to below 50% (29). On the other hand, a recent Japanese study (30) found that specific mite populations, including Der p, were significantly higher in homes with air conditioning. Japanese urban areas are very humid compared with the USA in summer. Thus, the intensive use of air conditioners is likely to reduce the indoor absolute humidity to the 13 g/m³ level as opposed

to the outdoor level of 21 g/m³. However, the relative humidity in a room with air conditioning rapidly increases locally near the wall and floor when the air conditioning stops and outdoor air enters (30), because the relative humidity becomes higher as the temperature decreases due to reduced saturated vapor pressure, thus leading to a favorable local climate for mite proliferation. This study has demonstrated a significantly positive relationship between the intensive use of air conditioning in hot weather and atopic sensitization. To the best of our knowledge, this is the first report showing such a relationship. Our finding suggests that intensive use of air conditioning cannot reduce relative humidity below the level of mite survival, but, instead, creates a mite-friendly local environment in the hot and humid climate of the area studied. In order to evaluate the validity of this hypothesis, further studies are necessary, including direct measurements of local relative humidity and proliferation of house-dust mites in electrically air-cooled rooms.

In modern well-insulated dwellings such as concrete housing built for energy conservation, inadequate home ventilation appears to be a risk factor for increasing indoor air pollution with respirable allergens such as house-dust mites and fungi or tobacco smoke. An inverse correlation between concentration of house-dust mites and the indoor air-exchange rate has been reported (25, 26). Tobacco smoke contains hazardous oxidants such as nitrogen dioxide and formaldehyde, which, on exposure, cause airway mucosal inflammation via injury of the epithelial cells, and may allow easier and greater access of respirable allergens to subepithelial lymphoid tissue (31, 32). In this study, poor home ventilation and concrete housing showed an influence on atopic sensitization. Moreover, there was a weak association between atopic status and family smoking habits.

We also examined the association between enhanced eosinophil activity and airway allergic symptoms and studied the involvement of urbanized living environments in enhanced eosinophil activity.

Enhanced eosinophil activity is an important feature of IgE-dependent airway allergy. Hence, any environmental factor involved in atopic sensitization can be considered to be involved in this enhancement. However, only about 10% of sensitized Japanese children develop asthma (33), while the other 90% display no remarkable symptoms of airway allergy. Unsensitized children, even if an extremely small number, can develop asthma, suggesting some possible risk factor enhancing eosinophil activity independent of atopic sensitization. Stimulated eosinophils produce a potent cytotoxic molecule, ECP, which causes destruction of the mucociliary apparatus of the bronchial epithelium. ECP also induces the release of chemical mediators, such as histamine and leukotrienes, from mast cells and basophils (13). Such pathologic features are likely to occur in IgE-sensitized people when they are exposed to respirable allergens, and also in the unsensitized on inhaling hazardous air pollutants such as tobacco smoke. In relation to this, a previous study found significantly higher amounts of molds in the air and surfaces of homes using air conditioning throughout the year (34). Moreover, contamination of home, office, and car air conditioners with fungi has been reported to cause hypersensitivity pneumonitis (35, 36). Several epidemiologic studies have also demonstrated an association between smoking and the development of atopy (37, 38) or respiratory symptoms (18).

In agreement with these previous findings, we found a weak association between the intensive use of air conditioning in hot weather and personal smoking habit and enhanced eosinophil activity in the present study. Furthermore, the elevated serum ECP level was significantly associated with the development of cough. These findings suggest that the intensive use of air conditioning, which may cause contamination of the air by fungi on filters, and personal smoking can lead to enhancement of eosinophil activity related to airway inflammation. However, no clear evidence of these factors' influence through atopic sensitization could be obtained.

Our study population was restricted to adult women, the majority of whom were middle-aged housewives,

because the subjects seem to have lived in the present residence for a long time and have spent much time in their homes, and thus were likely to have been influenced by their individual living environments. Our findings should be applicable to men, because a number of general population-based studies have revealed no sex difference in the prevalence of atopy for the overall age range (6, 39). On the other hand, there has been general agreement that the peak prevalence of atopy occurs among older teenagers and young adults, and declines rapidly after the age of 55 years. This was also found in the present study from the crude OR for aging in Table 3. According to these findings on the age-related difference of reactivity to common allergens, the influence of living environments may be greater in younger age groups.

In conclusion, intensive use of electric air conditioning in summer and mold proliferation were significantly associated with the development of atopy in adult women in a Japanese urban district. Poor home ventilation and family smoking habits appeared also to be weakly involved in atopic status. Intensive use of electric air conditioning and personal smoking habit showed weak associations with enhanced eosinophil activity. In addition, among airway allergic symptoms such as cough, sputum, and wheezing, atopic status appeared to be significantly related to wheezing, and enhanced eosinophil activity to coughing. According to these findings, the increase of atopy and airway allergic symptoms in Japanese urban areas is likely to be associated with the living conditions such as indoor dampness and poor home ventilation caused by tight insulation, which lead to increased exposure to common indoor air pollutants, including respirable allergens of house-dust mites or tobacco smoke.

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