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# Environmental factors associated with allergic rhinitis symptoms in Japanese university students: A cross-sectional study

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ABSTRACT

*Objective:* Numerous studies have reported that various environmental factors during early life are key determinants for developing allergic disease. Herein, we aimed to investigate the impact of environmental factors on allergic rhinitis.

*Methods:* This cross-sectional study was conducted in a single university in Japan (from April to June, in 2015 and 2016). Students voluntarily answered online questionnaires regarding their allergic rhinitis symptoms and their exposure to various environmental factors during preschool-age.

*Results:* Overall, 3075 students participated the questionnaire. After excluding those with incomplete datasets, 3016 students were eligible. Of these, 49% had allergic rhinitis symptoms. Female sex was associated with a lower risk of allergic rhinitis symptoms (odds ratio [OR], 0.82; 95% confidence interval [CI], 0.68–0.99). Comorbidity of asthma or atopic dermatitis and a family history of allergy (asthma, atopic dermatitis, or allergic rhinitis) were associated with higher risks of allergic rhinitis symptoms. Regarding the number of household members, compared with subjects with <3 people, those with 5 (OR, 0.74; 95% CI, 0.57–0.97) and ≥6 people (OR, 0.66; 95% CI, 0.49–0.88) in their household showed lower incidences of allergic rhinitis symptoms. No other environmental factors, including birth order, number of siblings, living environment, passive smoking, furry pet ownership, housing, bedding, breastfeeding, dairy product intake, preschool setting, and starting age of preschool, was associated with the incidence of allergic rhinitis symptoms.

*Conclusion:* Sex, current asthma and atopic dermatitis symptoms, family history of allergies, and the number of people in the household at preschool-age were associated with the incidence of allergic rhinitis symptoms.

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## 1. Introduction

Allergic rhinitis is one of the most common diseases in industrialized countries [1–3], affecting 10–40% of the population in these countries, and its prevalence has markedly increased in recent decades [4,5]. Allergic rhinitis symptoms such as rhinorrhea, sneezing, nasal obstruction, and nasal itching usually lower the quality of life [6]. In fact, millions of people have been reported to experience physical impairments and reductions in quality of life, as well as economic burdens, derived from rhinitis and its associated comorbidities [1].

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The development of allergic rhinitis is affected by hereditary and environmental factors [7,8]. In particular, early-life exposure can interact with the child's genotype and affect the response to environmental factors [9,10]. Therefore, environmental factors during one's early life can be key determinants of the development of allergic disease.

Numerous previous studies have reported that environmental factors are associated with the incidence of allergic rhinitis [7]. However, the impact of individual environmental factors on disease onset is still a matter of debate. For example, some studies have reported that male sex [11], passive smoking [12,13], and lack of breastfeeding [14] are risk factors for the occurrence of allergic rhinitis, whereas other studies displayed insignificant results for these factors [11,15,16].

In the present study, we investigated the association between environmental factors in early childhood and allergic rhinitis symptoms among Japanese university students.

## 2. Methods

### 2.1. Study participants and procedures

This cross-sectional study was conducted at The University of Tokyo, Japan, from April to June in 2015 and 2016. Students were encouraged to participate in the study when they received their annual medical checkup at the beginning of each fiscal year (April).

Students who voluntarily agreed to participate in the survey accessed a website of questionnaires, formatted using the Google Form web service. The participants answered consecutive questions about (i) symptoms of allergic rhinitis, asthma, and atopic dermatitis; (ii) background characteristics; and (iii) environmental factors in early childhood, especially during preschool-age.

### 2.2. Definition of symptoms of allergic rhinitis, asthma, and atopic dermatitis

Allergic rhinitis symptoms were defined using the Japanese version of the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire [17]. We classified participants as having "current allergic rhinitis symptoms" when they answered "Yes" to both of the following questions: "In the past 12 months, have you had a problem with sneezing or a runny or blocked nose when you DID NOT have a cold or the flu?" and "In the past 12 months, has this nose problem been accompanied by itchy-watery eyes?" In addition, we asked about the months when the symptoms of allergic rhinitis were present. We also classified the participants as having "current asthma" when they answered "Yes" to the question "Have you had wheezing or whistling in the chest in the last 12 months?" and as having "current atopic dermatitis" when they answered "Yes" to both of the following questions: "Have you had an itchy rash at any time in the last 12 months?" and "Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears, or eyes?"

### 2.3. Assessment of environmental status in early childhood

We assessed the participants' background characteristics and environmental factors in early childhood by asking consecutive questions about their family history of allergic disease and main status of environmental factors, especially during preschool age. This questionnaire for environmental factors included the following: birth order, number of siblings, number of people living in their household, living environment (rural, suburb, or urban), exposure to passive smoking, furry pets in the home, housing (single family house or housing complex), bedding (bed on wooden floor or futon on a tatami mat [Japanese style bedding]), feeding during infancy (breastfeeding, mixed, or artificial), dairy product intake (everyday, sometimes, or rarely), preschool setting (nursery school or kindergarten), age when starting preschool (in years), history of tonsillectomy, and vaccination status (varicella, measles, rubella, mumps, and bacillus Calmette-Guérin).

### 2.4. Statistical analyses

Categorical variables are presented as the number of students (percentage). The chi-squared test was used to analyze associations of allergic rhinitis symptoms with participant characteristics and environmental factors. Multivariate logistic regression analysis was performed to evaluate the effect of the environmental factors on allergic rhinitis symptoms after adjustment for potential confounders.

All analyses were performed using Statflex version 6.0 (Artech Co., Ltd., Osaka, Japan). Statistical significance was set as a P value of less than 0.05.

### 2.5. Ethical considerations

This study was approved by the ethical committee of The University of *****, Graduate School of Medicine (approval no. 14-168). Informed consent was waived owing to the voluntary participation in the survey.

## 3. Results

In total, 3075 students (12% of the students attending the university) answered the questionnaires. After excluding those with incomplete datasets, data from 3016 students were evaluated. Overall, 1475 (49%), 236 (8%), and 745 (25%) students reported to have current allergic rhinitis, asthma, and atopic dermatitis symptoms, respectively.

Table 1 shows the participants' characteristics and environmental factors in early childhood among participants with and without allergic rhinitis symptoms. Current allergic rhinitis symptoms were more frequent in male participants (50.2% vs. 45%, $p = 0.012$) and in participants with a parental history of allergies (61.6% vs. 41%, $p < 0.001$) or a history of allergies in their siblings (57.6% vs. 45.3%, $p < 0.001$). Factors significantly associated with allergic rhinitis symptoms included current asthma and/or atopic dermatitis status, number of siblings, birth order, number of people in their household, living environment, school settings, and starting age of preschool.

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**Table 1**
Association between allergic rhinitis symptoms and participant characteristics/environmental factors.

| Variable | n (%) | Allergic rhinitis symptoms | | P-value |
|---|---|---|---|---|
| | | Yes | No | |
| | | *n*(%) | *n*(%) | |
| Number of participants | | 1475 (48.9) | 1541 (51.1) | |
| Sex | | | | |
| Male | 2296 (76.5) | 1153 (50.2) | 1143 (49.8) | 0.012* |
| Female | 707 (23.5) | 317 (45) | 390 (55) | |
| Current allergic symptoms | | | | |
| Neither asthma or eczema | 2131 (71) | 948 (44.5) | 1183 (55.5) | <0.001* |
| Asthma only | 140 (4.7) | 86 (61.4) | 54 (38.6) | |
| Atopic dermatitis only | 651 (21.7) | 380 (58.4) | 271 (41.6) | |
| Both asthma and eczema | 94 (3.1) | 61 (64.9) | 33 (35.1) | |
| Parental history of allergies | | | | |
| Neither parent | 1869 (62.0) | 767 (41) | 1102 (59) | <0.001* |
| Both parents | 315 (10.4) | 202 (64) | 113 (36) | |
| Father only | 377 (12.5) | 216 (57) | 161 (43) | |
| Mother only | 455 (15.1) | 290 (63.7) | 165 (36.3) | |
| Sibling's history of allergies | | | | |
| Yes | 881 (29.2) | 508 (57.6) | 373 (42.3) | <0.001* |
| No | 2135 (70.8) | 967 (45.3) | 1168 (54.7) | |
| Number of siblings | | | | |
| 1 | 696 (23.1) | 332 (47.7) | 364 (52.3) | 0.0206* |
| 2 | 1687 (55.9) | 860 (51) | 827 (49) | |
| ≥3 | 633 (21) | 283 (44.7) | 350 (55.3) | |
| Birth order | | | | |
| 1st | 2031 (67.3) | 1031 (50.8) | 1000 (49.2) | 0.0073* |
| 2nd | 799 (26.5) | 367 (45.9) | 432 (54.1) | |
| ≥3rd | 186 (6.2) | 77 (41.4) | 109 (58.6) | |
| Number of people in household | | | | |
| ≤3 | 668 (22.2) | 351 (52.5) | 317 (47.5) | 0.0362* |
| 4 | 1461 (48.4) | 715 (48.9) | 746 (52.1) | |
| 5 | 536 (17.8) | 258 (48.1) | 278 (51.9) | |
| ≥6 | 351 (11.7) | 151 (43.1) | 200 (56.6) | |
| Living environment | | | | |
| Urban | 1185 (39.3) | 581 (49.1) | 604 (50.9) | 0.0123* |
| Rural | 324 (10.8) | 134 (41.4) | 190 (58.6) | |
| Suburb | 1507 (50) | 760 (50.4) | 747 (49.6) | |
| Housing | | | | |
| Single family house | 1353 (45.1) | 666 (49.2) | 687 (50.8) | 0.7642* |
| Housing complex | 1648 (54.9) | 808 (48.7) | 852 (51.3) | |
| Type of bedroom | | | | |
| Wooden floor + bed | 846 (28.1) | 412 (48.7) | 434 (51.3) | |
| Tatami + futon | 1633 (54.1) | 786 (48.1) | 847 (51.9) | |
| Feeding during infancy | | | | |
| Breastfeeding | 1395 (46.3) | 675 (48.4) | 720 (51.6) | 0.8315 |
| Mixed | 842 (27.9) | 411 (48.8) | 431 (51.2) | |
| Artificial | 253 (8.4) | 118 (46.6) | 135 (53.4) | |
| Passive smoking | | | | |
| Yes | 970 (32.2) | 472 (48.7) | 498 (51.3) | 0.8524 |
| No | 2046 (67.8) | 1003 (49) | 1043 (51) | |
| Furry pet ownership | | | | |
| Yes | 1016 (33.7) | 489 (48.1) | 527 (51.9) | 0.5435 |
| No | 2000 (66.3) | 986 (49.3) | 1014 (50.7) | |
| Dairy product intake | | | | |
| Everyday | 1806 (59.9) | 897 (49.7) | 909 (50.3) | 0.2473 |
| Sometimes | 935 (31) | 437 (46.7) | 498 (53.3) | |
| Rarely | 275 (9.1) | 141 (51.3) | 134 (48.7) | |

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**Table 1** (*Continued*)

| Variable | n (%) | Allergic rhinitis symptoms | | P-value |
|---|---|---|---|---|
| | | Yes *n*(%) | No *n*(%) | |
| School setting | | | | |
| Nursery school | 1017 (33.7) | 455 (44.7) | 562 (55.3) | 0.0032* |
| Kindergarten | 1986 (65.9) | 1015 (51.1) | 971 (48.9) | |
| Starting age of preschool (years) | | | | |
| <1 | 238 (7.9) | 133 (55.9) | 105 (44.1) | 0.0098* |
| 1–3 | 518 (17.2) | 292 (56.4) | 226 (43.6) | |
| ≥4 | 2247 (74.5) | 1108 (49.3) | 1139 (50.7) | |
| History of tonsillectomy | | | | |
| Yes | 41 (1.4) | 20 (48.8) | 21 (51.2) | 0.9871 |
| No | 2975 (98.6) | 1455 (48.9) | 1520 (51.1) | |
| Vaccination | | | | |
| Varicella | | | | |
| Yes | 1579 (52.4) | 778 (49.3) | 801 (50.7) | 0.5637 |
| No | 467 (15.5) | 223 (47.8) | 244 (52.2) | |
| Measles | | | | |
| Yes | 2345 (77.8) | 1114 (48.1) | 1201 (51.9) | 0.2685 |
| No | 69 (2.9) | 29 (42) | 40 (58) | |
| Rubella | | | | |
| Yes | 2275 (75.4) | 1115 (49) | 1160 (51) | 0.9784 |
| No | 88 (2.9) | 43 (48.9) | 45 (51.3) | |
| Mumps | | | | |
| Yes | 1702 (56.4) | 818 (48.1) | 884 (51.9) | 0.6135 |
| No | 476 (15.8) | 235 (49.4) | 241 (50.6) | |
| BCG | | | | |
| Yes | 2235 (74.1) | 1097 (49.1) | 1138 (50.9) | 0.778 |
| No | 264 (8.8) | 132 (50) | 132 (50) | |

Values are expressed as number (percentage).
BCG, Bacillus Calmette-Guérin.
* $p < 0.05$.

Fig. 1 demonstrates the distributions of the months when allergic rhinitis symptoms were present. A total of 660 students (21.5%) had perennial symptoms. The peak month of seasonal allergic rhinitis symptoms was March.

Table 2 shows the results of the multivariate logistic regression analysis for the associations between allergic rhinitis symptoms and background characteristics and environmental factors after adjustment for potential confounders. Female participants were less likely to have allergic rhinitis (odds ratio [OR] = 0.82; 95% confident interval [CI], 0.68–0.99; p = 0.048), whereas comorbidity of asthma or atopic dermatitis was associated with higher risks of allergic rhinitis symptoms. With "neither parent having allergies" as the reference, both a parental history of allergies (OR = 2.45; 95% CI, 1.85–3.25; p < 0.001), maternal history of allergy (OR = 2.24; 95% CI, 1.76–2.86; p < 0.001), and paternal history of allergy (OR = 1.78; 95% CI, 1.38–2.29; p < 0.001) were significantly associated with allergic rhinitis symptoms. With "no sibling history of allergies" as reference, sibling history of allergies was significantly associated with allergic rhinitis symptoms (OR = 1.34; 95% CI, 1.10–1.64; p = 0.003). With "less than three people in the household" as the reference, having five (OR = 0.74; 95% CI, 0.57–0.97; p = 0.027) or six or more people in the household (OR = 0.66; 95% CI, 0.49–0.88; p = 0.005) was inversely associated with the risk of allergic rhinitis symptoms. None of the other environmental factors, including birth order, number of siblings, living environment, passive smoking exposure, furry pet ownership, housing, bedding, feeding, dairy product intake, preschool setting, or starting age of preschool, was significantly associated with the symptoms of allergic rhinitis.

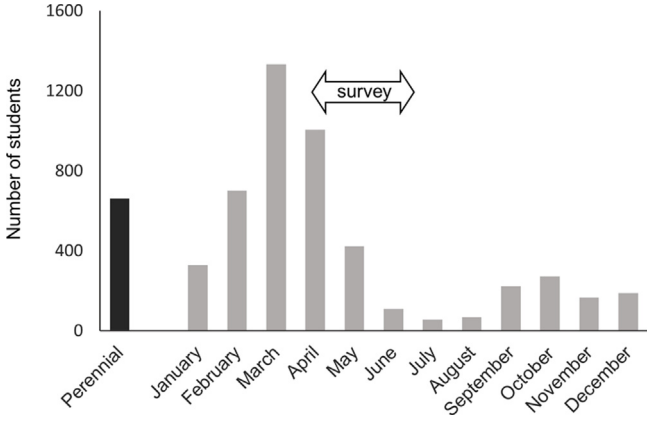



**Fig. 1.** Monthly distribution regarding the presence of allergic rhinitis symptoms.
This survey was performed between April and June. Overall, 660 students (21.5%) displayed perennial symptoms.

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**Table 2**
Univariate and multivariate analyses of the associations between allergic rhinitis symptoms and participant characteristics/environmental factors.

| Variable | n (%) | Crude OR (95% CI) | Adjusted OR (95% CI)[a] | P-value |
|---|---|---|---|---|
| Sex | | | | |
| Male | 2296 (76.5) | 1.00 | 1.00 | |
| Female | 707 (23.5) | 0.81 (0.68–0.95)* | 0.82 (0.68–0.99) | 0.048* |
| Current allergic symptoms | | | | |
| Neither asthma or atopic dermatitis | 2131 (71) | 1.00 | 1.00 | |
| Asthma only | 140 (4.7) | 1.99 (1.40–2.82)* | 1.93 (1.29–2.90) | 0.002* |
| Atopic dermatitis only | 651 (21.7) | 1.75 (1.45–2.10)* | 1.57 (1.28–1.93) | <0.001* |
| Both asthma and dermatitis | 94 (3.1) | 2.31 (1.50–3.55)* | 2.56 (1.48–4.41) | <0.001* |
| Parental history of allergies | | | | |
| Neither parent | 1869 (62.0) | 1.00 | 1.00 | |
| Both parents | 315 (10.4) | 2.57 (2.00–3.29)* | 2.48 (1.87–3.29) | <0.001 |
| Father only | 377 (12.5) | 1.93 (1.54–2.44)* | 1.80 (1.40–2.33) | <0.001* |
| Mother only | 455 (15.1) | 2.53 (2.04–3.12)* | 2.26 (1.77–2.88) | <0.001* |
| Sibling's history of allergies | | | | |
| Yes | 881 (29.2) | 1.65 (1.40–1.93)* | 1.34 (1.10–1.64) | 0.003* |
| No | 2135 (70.8) | 1.00 | 1.00 | |
| Number of siblings | | | | |
| 1 | 696 (23.1) | 1.00 | 1.00 | |
| 2 | 1687 (55.9) | 1.14 (0.96–1.36) | 1.15 (0.92–1.45) | 0.213 |
| ≥3 | 633 (21) | 0.89 (0.71–1.10) | 1.00 (0.75–1.34) | 0.997 |
| Birth order | | | | |
| 1st | 2031 (67.3) | 1.00 | 1.00 | |
| 2nd | 799 (26.5) | 1.01 (0.67–1.52) | 0.84 (0.69–1.03) | 0.087 |
| ≥3rd | 186 (6.2) | 0.82 (0.70–0.97)* | 0.75 (0.50–1.13) | 0.164 |
| Number of people in household | | | | |
| ≤3 | 668 (22.2) | 1.00 | 1.00 | |
| 4 | 1461 (48.4) | 0.86 (0.72–1.04) | 0.82 (0.66–1.01) | 0.065 |
| 5 | 536 (17.8) | 0.84 (0.67–1.05) | 0.74 (0.57–0.97) | 0.027* |
| ≥6 | 351 (11.7) | 0.68 (0.53–0.88)* | 0.65 (0.48–0.88) | 0.005* |
| Living environment | | | | |
| Urban | 1185 (39.3) | 1.00 | 1.00 | |
| Rural | 324 (10.8) | 0.73 (0.57–0.94)* | 0.75 (0.55–1.01) | 0.057 |
| Suburb | 1507 (50) | 1.05 (0.90–1.23) | 1.05 (0.88–1.25) | 0.614 |
| Housing | | | | |
| Single family house | 1353 (45.1) | 1.00 | 1.00 | |
| Housing complex | 1648 (54.9) | 0.98 (0.85–1.13) | 0.94 (0.79–1.13) | 0.46 |
| Type of bedroom | | | | |
| Wooden floor + bed | 846 (28.1) | 1.00 | 1.00 | |
| Tatami + futon | 1633 (54.1) | 0.93 (0.81–1.08) | 0.88 (0.74–1.04) | 0.144 |
| Feeding during infancy | | | | |
| Breastfeeding | 1395 (46.3) | 1.00 | 1.00 | |
| Mixed | 842 (27.9) | 1.02 (0.85–1.21) | 0.97 (0.81–1.17) | 0.772 |
| Artificial | 253 (8.4) | 0.93 (0.71–1.22) | 0.90 (0.68–1.20) | 0.475 |
| Passive smoking | | | | |
| Yes | 970 (32.2) | 0.98 (0.84–1.15) | 1.08 (0.90–1.29) | 0.386 |
| No | 2046 (67.8) | 1.00 | 1.00 | |
| Furry pet ownership | | | | |
| Yes | 1016 (33.7) | 0.95 (0.82–1.11) | 0.94 (0.79–1.13) | 0.517 |
| No | 2000 (66.3) | 1.00 | 1.00 | |
| Dairy product intake | | | | |
| Everyday | 1806 (59.9) | 1.00 | 1.00 | |
| Sometimes | 935 (31) | 0.89 (0.75–1.04) | 0.89 (0.74–1.06) | 0.195 |
| Rarely | 275 (9.1) | 1.06 (0.82–1.37) | 1.09 (0.81–1.48) | 0.556 |
| Preschool settings | | | | |
| Nursery school | 1017 (33.7) | 0.78 (0.67–0.90)* | 0.88 (0.69–1.11) | 0.281 |
| Kindergarten | 1986 (65.9) | 1.00 | 1.00 | |

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**Table 2** (*Continued*)

| Variable | n (%) | Crude OR (95% CI) | Adjusted OR (95% CI)[a] | P-value |
|---|---|---|---|---|
| Starting age of preschool (years) | | | | |
| <1 | 238 (7.9) | 0.77 (0.59–1.01) | 0.92 (0.64–1.30) | 0.634 |
| 1–3 | 518 (17.2) | 0.76 (0.63–0.92)* | 0.83 (0.63–1.09) | 0.175 |
| ≥4 | 2247 (74.5) | 1.00 | 1.00 | |
| History of tonsillectomy | | | | |
| Yes | 41 (1.4) | 0.99 (0.53–1.84) | | |
| No | 2975 (98.6) | 1.00 | | |
| Vaccination | | | | |
| Varicella | | | | |
| Yes | 1579 (52.4) | 1.00 | | |
| No | 467 (15.5) | 1.06 (0.86–1.31) | | |
| Measles | | | | |
| Yes | 2345 (77.8) | 1.00 | | |
| No | 69 (2.9) | 1.31 (0.81–2.13) | | |
| Rubella | | | | |
| Yes | 2275 (75.4) | 1.00 | | |
| No | 88 (2.9) | 1.01 (0.66–1.54) | | |
| Mumps | | | | |
| Yes | 1702 (56.4) | 1.00 | | |
| No | 476 (15.8) | 0.95 (0.77–1.16) | | |
| BCG | | | | |
| Yes | 2235 (74.1) | 1.00 | | |
| No | 264 (8.8) | 0.96 (0.74–1.24) | | |

Values are expressed as number (percentage).
OR, odds ratio; CI, confidence interval; BCG, Bacillus Calmette-Guérin.
* $p < 0.05$.
[a] Based on multiple logistic regression adjusted for sex, parental history of allergies, sibling's history of allergies, number of older siblings, birth order, number of people in household, current allergic symptoms, type of housing, type of bedding, history of passive smoking, history of having a furry pet, dairy product intake, preschool setting, and starting age of preschool.

## 4. Discussion

In the present cross-sectional study of Japanese university students, we clarified that male sex, current asthma and atopic dermatitis, and family history of allergies was significantly associated with the development of allergic rhinitis symptoms. Further, participants with more than five people in their household were significantly less likely to develop symptoms of allergic rhinitis. The symptoms peaked in March, corresponding to the cedar pollen season in Japan [2].

A strength of our study is the large number of participants, consisting of students with relatively high socioeconomic status, mostly around 20 years of age. The inclusion of such a homogeneous population allowed us to explore the risk factors for developing allergic rhinitis, which is common in early adulthood.

As mentioned above, our study revealed that male sex was a risk factor for the occurrence of allergic rhinitis. According to a recent meta-analysis, the male-to-female ratio in allergic rhinitis patients showed a strong male predominance in childhood but changed towards a slight female predominance around puberty, which persisted into adulthood, and female sex was found to be a risk factor for allergic rhinitis [18]. These conflicting results may partly result from the difference in the male-to-female ratio between the current study and the previous meta-analysis.

Coexisting asthma and atopic dermatitis was associated with an increased incidence of allergic rhinitis symptoms in the present study. These findings are in agreement with those of previous studies, which found that allergic rhinitis often coexists with rhinitis, atopic dermatitis, and asthma [19], especially in children [20,21]. For example, approximately 60% of asthmatics reported having allergic rhinitis, whereas subjects with allergic rhinitis presented an eight-fold higher risk of having asthma compared to subjects without allergic rhinitis [19].

Our study revealed that having a family history of allergy was also a risk factor for allergic rhinitis. Many studies have demonstrated that a family history of allergic disorders is associated with an increased incidence of allergic rhinitis [7,15,22], suggesting that genetic factors may play an important role in the development of allergic rhinitis. One previous study revealed that, among people with a parental history, the risk of allergic rhinitis was higher compared with that for asthma or atopic dermatitis [22]. Another study reported that a positive allergic history in both parents was associated with a quadrupled incidence of allergic rhinitis [15]. In addition, in one study, a positive maternal allergic history was more evidently associated with an increased prevalence of allergic rhinitis than a positive paternal allergic history [15].

Moreover, our findings indicated that having a large number of people in the household during preschool age was associated with a decreased risk of allergic rhinitis. The present findings were concordant with those in previous studies, in that allergic rhinitis (hay fever) was inversely related to the number of children in the household [23], known as the original hygiene

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hypothesis. However, other environmental factors, such as the number of siblings, birth order, living environment, housing, type of bedroom, feeding, passive smoking, furry pet ownership, dairy product intake, preschool settings, stating age of preschool, history of tonsillectomy, and vaccination status showed no significant associations with allergic rhinitis. We categorized the type of bedroom into (i) futon (Japanese mattress) on a tatami (straw) mat (traditional Japanese style) and (ii) a bed on the floor (typical Western style). The use of a futon and tatami was reportedly a risk factor for allergic disease in previous studies [24,25]; however, there was no significant association between the type of bedroom and allergic rhinitis symptoms in our study.

Of note, the incidence of allergic rhinitis symptom (49%) in the present study was similar to that of a previous survey at our institution, conducted nearly a decade ago [11]. This previous survey was conducted in March in 2003–2005 during the freshman medical checkup, and almost 100% of students completed the questionnaire. The cumulative prevalence rates of allergic rhinitis, asthma, and atopic dermatitis in that study were 47.2%, 9.3%, and 17.4%, respectively, as compared to 49%, 8%, and 25% in the present study.

This study has several limitations. First, owing to the cross-sectional nature of the study, causal relationships could not be ascertained, and recall bias, especially on environmental factors, may exist. Second, because information on medical diagnoses of allergic rhinitis or any diagnostic findings was not available, we used the ISAAC questionnaire to identify allergic rhinitis patients. Although, in general, identifying patients by a questionnaire alone may result in overestimation [26], the ISAAC questionnaire has good sensitivity and specificity [17,27]. Further, it can be performed easily at a low-cost and is widely used. Therefore, we believe that the results of the current study are robust. Third, focusing on university students as participants might partly cause selection bias due to their high educational status, which can be an increased risk factor for allergic rhinitis [28]. However, our participants appear to represent the adolescent population of Japan, at least to some extent.

In conclusion, male sex, current asthma and atopic dermatitis, and family history of allergies was strongly associated with an increased incidence of allergic rhinitis symptoms. With regard to environmental factors, having a large number of people in the household during preschool age was associated with a decreased incidence of symptoms of allergic rhinitis.

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