Does change of residence affect pollinosis? A study of Japanese university students

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Abstract (141/150 words)

The effects of change of residence on pollinosis symptoms remain unclear. We investigated effects of geographical change of residence on pollinosis symptoms among university freshmen. All freshmen (n=2,142) entering Shinshu University in 2011 completed self-administered questionnaires. Associations between history of pollinosis and environmental factors were assessed. Subjects were classified into three groups according to pollen count at previous residences (stationary, low pollen and high pollen). Pollinosis both before and after relocation were compared among and within the groups. Of the 1,558 subjects, 540 (34.7%) developed pollinosis before, and 483 (31.0%) after entering university. The rates of pre- and post-university entrance pollinosis were 40.0% and 32.5% in the high pollen group ($P<0.001$) but were similar in the other two groups. Pollinosis symptoms decreased among students that moved from high to low pollen areas, indicating that pollinosis was affected by geographic environmental factors.

Keywords

Pollinosis; hay fever; moving; university students

Introduction

Prevalences of several allergic diseases have increased worldwide since the middle of the twentieth century (The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee 1998; Eder et al. 2006; Greiner et al. 2011). These allergic diseases include allergic rhinitis, which has a high prevalence (Strachan et al. 1997), affecting patient quality of life (Meltzer 2001; Scadding et al. 2008) and having significant socio-economic impact (Hellgren et al. 2010; Greiner et al. 2011). Pollinosis, caused by seasonal pollen and usually called hay fever, is especially prevalent among patients with allergic rhinitis (Okubo et al. 2011). The prevalence of pollinosis differs by patient age (Baba et al. 2008; Okamoto et al. 2009; Okubo et al. 2011) and is influenced by several environmental factors, including sibling number (Strachan 1989), farming (Braun-Fahrlander et al. 1999; von Mutius and Vercelli 2010), occupational exposure (Gautrin et al. 1994), exposure to automobile exhaust gas (Hazenkamp-von Arx et al. 2011), air pollution (Seaton et al. 1994), and western life-style (von Mutius et al. 1998; Kramer et al. 2010). Furthermore, the prevalence of pollinosis is affected by geographic environment (Smith 1971; Strachan et al. 1997; Austin et al. 1999).

These findings have suggested that the prevalence of pollinosis in a population may be altered if the population moves to another geographic location with a different environment. For example, immigrants who have moved were found to subsequently develop pollinosis due to exposure and sensitization to new types of pollen (Shilkret and Lazarowitz 1953; Hughes 1958; Fine and Abram 1960; Dervaderics et al. 2002). However, as far as the authors are aware, there are no reports relating decrease of pollinosis symptoms to change in level of pollen exposure by relocation.

In Japan, university freshmen customarily relocate from their home towns to the locality of their university, often resulting in a marked change in their environment. We hypothesized that pollinosis symptoms would not change in freshmen who moved from a low to another low pollen area or remained within the same low pollen area, but would decrease in freshmen who moved from a high to a low pollen area. We therefore investigated the effects of geographic and environmental factors on pollinosis in pre- and post-university entrance students.

Materials and Methods

Study population

Subjects comprised all freshmen (n=2,142) who entered Shinshu University, Nagano Prefecture, Japan, on 4 April 2011. The university has approximately 12,000 full-time students among eight faculties (Agriculture, Arts, Economics, Education, Engineering, School of Medicine, Science and Textile Science and Technology). All freshmen were enrolled at one campus to receive general education for one year. Approximately one third of these freshmen previously resided in Nagano Prefecture, and the others in other prefectures throughout Japan.

Questionnaire

The freshmen, divided into 20 classes of almost equal numbers were required to attend “Health Science” lectures as part of their initial health education. This lecture was held sequentially through 20 classes from May 2011 to February 2012. At the lecture of each class, a self-administered questionnaire was distributed to every student at the beginning of the lecture and collected immediately afterwards. The questionnaire items, shown in Table 1, include two sections as below. To ensure reliability of the questionnaire, question items were adopted from previous studies (Strachan 1989; The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee 1998; von Mutius et al. 1998; Kilpelainen et al. 2000; Svanes et al. 2003; Shaaban et al. 2008) in which the reliability of the items had been confirmed.

Pollinosis

Japanese cedar pollinosis, defined as pollinosis in this study, is the most common form of pollinosis in Japan (Baba et al. 2008; Okamoto et al. 2009; Okubo et al. 2011). Because the pollen is airborne from January through May (Baba et al. 2008), all freshmen had experienced part of this pollen season at the time of entrance into Shinshu University. The questionnaire, based on previous reports (The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee 1998; von Mutius et al. 1998; Kilpelainen et al. 2000), contained questions on pollinosis before moving to university: “Before enrolment, were you ever diagnosed with pollinosis by a doctor, and if so, at what age?” The questionnaire also contained questions on pollinosis after university entrance: “Have you had pollinosis symptoms since university entrance in April or May?” We classified all subjects twice in accordance with pre- and post-university entrance: first, subjects who were diagnosed with pollinosis prior to entering university were defined as “past pollinosis”: second, all subjects were reclassified and subjects who reported symptoms of pollinosis after university entrance were defined as “after entrance pollinosis.”

Geographic and environmental factors

A descriptive epidemiological method was employed to assess geographic effects on pollinosis. The most important geographic factor associated with prevalence of pollinosis was shown to be pollen count at place of residence (Okamoto et al. 2009). A previous report shows that the association between pollen count and pollinosis prevalence showed a dose-response relationship (Ozasa et al. 2008). In addition, the prevalence of pollinosis in Japan, stratified into 12 districts (Okuda 2003), was found to correspond with the pollen counts of each district (Okamoto et al. 2009). Thus, pollen count of each district was approximated with pollinosis prevalence rate in this study. The 47 prefectures were divided into 12 districts and each district further dichotomized into a “high pollen area” and a “low pollen area” (Figure 1) based on average pollinosis prevalence rate (Okuda 2003). Nagano prefecture is classified as a “low pollen area.”

The university freshmen were divided into three groups based on their hometown before university entrance: subjects from Nagano prefecture were categorized as "stationary group", those from other low pollen areas were placed in the "low pollen group" and subjects from high pollen areas were classified as "high pollen group."

The questionnaire also asked about other past environmental factors, including history of other allergic diseases (e.g., asthma or atopy) (Shaaban et al. 2008), number of siblings in the household (Strachan 1989) and experience with animal pets (Svanes et al. 2003).

Statistical analysis

Univariate and multivariate logistic regression models were used to estimate the association between pollinosis and environmental factors; these associations were expressed as odds ratios (ORs) and 95% confidence intervals (95% CIs). The Chi square test was used to compare the pollinosis among groups and the McNemar's test was used to assess the pollinosis within each group before and after university entrance. Differences with $P<0.05$ were deemed statistically significant. PASW 18.0 software (SPSS Inc., Chicago, IL, USA) was used for all analyses.

Ethics

Because the questionnaires were filled out voluntarily and could be answered anonymously, with none of the responses leading to any disadvantages for the student, written informed consent was not required. The study design and procedure were reviewed and approved by the Committee for Medical Ethics of Shinshu University (approval number 1709).

Results

Of all 2,142 freshmen, 1,839 (85.9%) returned completed questionnaires. Because subjects in this study were matched by birth years, all subjects ≥20 years old were excluded. Thus, responses were analysed in the 1,558 subjects (72.7%) aged 18 and 19 years.

Table 1 shows the questions and answers of subjects. Of the 1,558 enrolled subjects, 983 (63.1%) were male and 573 (36.8%) were female. We found that 540 (34.7%) had been previously diagnosed with pollinosis, the highest percentage (n=248, 45.9%) at ages 10-14 years, whereas 483 (31.0%) experienced pollinosis after university entry. We also found that 608 subjects (39.0%) had been diagnosed with other allergic diseases and 828 (53.5%) had one sibling. Geographically, 560 subjects (35.9%) were classified as being from Nagano prefecture (stationary group), whereas 296 (19.0%) were from low pollen areas (low pollen group) and 680 (43.6%) from high pollen areas (high pollen group).

Association between past pollinosis and past environmental factors

Table 2 shows the association between past pollinosis and past environmental factors. Univariate logistic regression analysis showed that past pollinosis was associated with female gender (OR 0.802, 95%CI 0.644-0.998, P=0.048), history of other allergic diseases (OR 2.115, 95%CI 1.707-2.619, P<0.001), 2 (OR 0.627, 95%CI 0.444-0.886, P=0.008), and ≥3 (OR 0.516, 95%CI 0.293-0.908, P=0.022) siblings in the household, and classification into the high pollen group (OR 1.431, 95%CI 1.131-1.810, P=0.003). Multivariate logistic regression analysis showed that past pollinosis was associated with female gender (OR 0.791, 95%CI 0.629-0.994, P=0.045), history of other allergic diseases (OR 2.121, 95%CI 1.704-2.640, P<0.001), 2 (OR 0.624, 95%CI 0.436-0.893, P=0.010) and ≥3 (OR 0.528, 95%CI 0.296-0.941, P=0.030) siblings and classification into the high pollen group (OR 1.430, 95%CI 1.121-1.824, P=0.004).

Association between post-entrance pollinosis and past environmental factors

Table 3 shows the association between pollinosis experienced after entrance to university and past environmental factors. Univariate and multivariate logistic regression analysis were employed. As a result of multivariate analysis, history of other allergic diseases also showed a significant association (OR 1.690, 95%CI 1.353-2.112, P<0.001). In addition, ≥3 siblings in the household (OR 0.519, 95%CI 0.279-0.968, P=0.039) showed a significant association although the effect was weakened. In contrast, the significant association of pollinosis with gender and geographic factor disappeared after entrance.

Change in pollinosis following university entry

According to the change of affecting factors for pollinosis in Table 2 and Table 3, geographic factor was focused on and the change of pollinosis proportion among geographic groups was analysed. Prior to university entrance, the prevalence of pollinosis differed significantly among the stationary (31.9%), low pollen (27.6%) and high pollen (40.0%) groups (Chi square test P<0.001). This difference, however, was no longer observed following university entrance, with pollinosis symptoms of 31.9%, 26.9% and 32.5%, respectively, in these three groups (P=0.197). When we assessed the differences within each group (Table 4), we found no differences of pollinosis in the pre- and post-university entry in the stationary (31.9% vs. 31.9%, P=1.000 by McNemar's test) and low pollen (27.6% vs. 26.9%, P=0.892) groups, but a significant reduction in the high pollen group (40.0% vs. 32.5%, P<0.001). The OR of the effect of moving in the latter group was 0.724 (95%CI 0.579-0.904, P=0.004). Assessments of changes in status among individual subjects showed loss and acquisition of pollinosis in 61 and 61 subjects, respectively, in the stationary group; in 28 and 26, respectively, in the low pollen group; and in 107 and 57, respectively in the high pollen group.

Since both the stationary and low pollen groups were from low pollen areas, we compared the sum of these groups with the high pollen group. The prevalence of pollinosis was significantly lower in the summed than in the high pollen group before university entrance (30.5% vs. 40.0% Chi square test P<0.001), but was equivalent after university entrance (30.4% vs. 32.5%, P=0.359). Moreover, past and after entrance pollinosis were similar in the summed group (30.5% vs. 30.4%, P=0.999 by McNemar's test).

Discussion

We have investigated the prevalence of past pollinosis among university freshmen, as well as the association between pollinosis and geographic environmental factors and changes in pollinosis symptoms after university entrance. In this study, we employed question items that had been used to assess factors associated with pollinosis in several previous studies (Strachan 1989; The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee 1998; von Mutius et al. 1998; Kilpelainen et al. 2000; Svanes et al. 2003; Shaaban et al. 2008) and further added the geographic factor. Moreover, the questionnaire was also conducted according to the established study design. As a result, we found that past pollinosis was associated with several environmental factors and that its symptoms changed after moving.

Study population

We found that the after entrance pollinosis among university freshmen aged 18-19 years was 31.0%, similar to the prevalence previously reported (31.4%) among the general population of 10-19 year olds in Japan (Baba et al. 2008). Although the prevalence of pollinosis in Japan is highest in those aged 30-40 years, it increases markedly during the teen-age years (Baba et al. 2008; Okamoto et al. 2009; Okubo et al. 2011). We found that almost 50% of those with past pollinosis had been diagnosed at ages 10-14 years, followed by those at ages 15-19 years, resulting in an increased rate of pollinosis among teenagers. Moreover, about 80% of individuals diagnosed with allergic rhinitis develop symptoms before age 20 years (Greiner et al. 2011), making the pollinosis survey among teenagers important.

Previous investigations of pollinosis prevalence among university students (Maternowski and Mathews 1962; Kilpelainen et al. 2000) included subjects over a broader age range, including both teenagers and those aged ≥20 years. To assess a more uniform population, we included only freshmen aged 18-19 years, excluding those aged ≥20 years. This exclusion also excluded the effects of confounding variables such as smoking (Hellgren et al. 2002) and drinking (Bendtsen et al. 2008), which affect allergic rhinitis, making our findings on the association between pollinosis and other environmental factors more reliable.

Similar to previous findings, we observed that the prevalence of pollinosis was lower among female students (Kilpelainen et al. 2000). In addition, the prevalence of allergic rhinitis is lower among females than among males (Greiner et al. 2011), which may affect the prevalence of pollinosis.

Association between past pollinosis and past environmental factors

The prevalence of past pollinosis differed among the stationary, low pollen, and high pollen groups. Both univariate and multivariate logistic regression analyses showed that the OR of past pollinosis was consistently higher in the high pollen than in the stationary group (OR 1.430 P=0.004), indicating that the geography of high pollen areas significantly affected the prevalence of past pollinosis. In addition, previous prevalence was slightly higher in the stationary (31.8%) than in the low pollen (28.0%) group (OR 0.771 P=0.111), although the difference was not significant. The low pollen group may have included subjects living in areas with lower pollen density than that in Nagano prefecture.

Allergic disease prevalence rates were found to be lower in individuals with many older siblings (Strachan 1989; von Mutius et al. 1994; Bodner et al. 1998; Ball et al. 2000). Although we assessed only number of siblings, not their relative ages, we found that the prevalence of pollinosis was lower in individuals with many siblings. In addition, approximately 50% of our subjects with pollinosis were first diagnosed at ages 10-14 years. Early infectious illness was found to have little effect on pollinosis (Strachan et al. 1996) and pollinosis may be affected by environmental factors after infancy (von Mutius et al. 1998), pollinosis may be affected by number of siblings simply. Since individuals with other allergic diseases had a high prevalence of pollinosis, these allergic diseases may occur simultaneously (Shaaban et al. 2008). This phenomenon was also observed in this study. Although pet animals in the home have been associated with the onset of allergic disease, we did not observe this association among our subjects. The effects of pet animals on allergic diseases were found to differ among animal type (Sears et al. 1989) and by length of time the pet is kept (Svanes et al. 2003). However, because our questionnaire only asked about whether there were animals in the home, not about type of animal or duration kept, these associations may have been masked. Further research, including factors of animal type and duration kept, are needed to determine the association between pollinosis and pet animals.

Association between post-entry pollinosis and past environmental factors

We further analysed the association between pollinosis experienced after entering university and past environmental factors. History of other allergic diseases also affected after entrance pollinosis. Because past history of allergic diseases might reduce an individual's tolerance of allergens, the association was consistent regardless of change in environment. According to a previous cohort study (Shaaban et al. 2008) which indicated that some respiratory allergic diseases occurred simultaneously over a long period, other allergic diseases concomitant with pollinosis may continue. In addition, number of siblings remained a significant factor for pollinosis after entrance although its significance was decreased. This result showed that the sibling number effect might continue consistently (Strachan 1989) but may be attenuated when individuals are separated from their siblings due to university entrance. Therefore, in this study, after entrance pollinosis was revealed to be affected by both sibling number and living together or not. In contrast, although geographic factor affected past pollinosis significantly, the association disappeared after entrance. This result indicated that the rate of pollinosis symptoms became almost equivalent among geographic groups because the difference in pollen count disappeared after change of residence. There are few reports referring to the association between geographic factor and alteration in pollinosis. The results of this study add to the evidence that geographic factor affects pollinosis. In addition, the effect of gender difference in which pollinosis had been higher in pre-university entrance male students disappeared after entrance. We suppose that this might be due to changes in activity patterns among the genders rather than any biological difference because gender does not change before or after entrance. In other words, close contact among male students that became more intimate because of the large number of male students in this university might have enabled, male students to acquire some protection against allergens resulting in decreased pollinosis symptoms among the males. As shown above, sibling number effect was probably attenuated because of change of residence, and close contact among male individuals may have affected the pollinosis symptoms after entrance. However, this gender effect is not explained by this study alone, further study is needed to clarify the association between gender and pollinosis.

Effects of moving on pollinosis

Following the above findings, we focused on the change of geographic factor and analysed the association between this factor and pollinosis. The prevalence rate of pollinosis in the high pollen group was significantly decreased after the subjects relocated, whereas it was unchanged in the other two groups. After moving, the rates of pollinosis symptoms in the three groups were almost equivalent. Moreover, only previously diagnosed individuals in the high pollen group showed a significant decrease in pollinosis symptoms after moving, a change that may have been caused by a decrease in exposure to pollen after moving. Although this result was expected, few previous studies assessed the relationship between pollinosis and moving. For example, studies of immigrants did not show decreased pollinosis prevalence after moving (Shilkret and Lazarowitz 1953; Hughes 1958; Fine and Abram 1960; Dervaderics et al. 2002), although the development of pollinosis required several years of exposure to new pollens (Hughes 1958; Fine and Abram 1960). In contrast, we found that the appearance and disappearance of pollinosis in some subjects was quite rapid, suggesting that this change was not due to exposure to novel pollen but to increased and decreased exposure to the same types of pollen (Fine and Abram 1960). We found that the pollinosis symptoms were decreased within a short period if subjects moved from a high to a low pollen area, a finding that may be clinically useful in treating subjects with pollinosis. For example, relocation may facilitate patient comfort and care and may decrease the symptoms of pollinosis in cases that do not respond to pharmaceutical intervention.

Limitations

This study had several limitations. First, we could not assess changes over time in pollinosis prevalence and environmental factors because we used a cross-sectional study design. For example, we did not evaluate individuals who had moved frequently before university entrance; rather we only determined residence information just before entrance. Moreover, pollen count might vary from year to year or new onset pollinosis may have occurred subsequent to this investigation, thus altering the prevalence of pollinosis. Prospective studies are needed to address these problems. Second, the pollinosis we assessed is seasonally dependent, since the survey was conducted from May 2011 to February 2012, there may have been some recall bias due to time between pollen exposure and administration of the questionnaire (Okuda 2003). In addition, students may have been exposed to several types of pollen in April and May, resulting in an overestimation of the prevalence of pollinosis. However, as almost all cases of pollinosis in Japan involve Japanese cedar pollen, which peaks from January through May, we regarded the effects of other kinds of pollen minimal. Third, because pollinosis was not evaluated immunologically but only by a self-administrated questionnaire, we may have included some subjects with symptoms similar to those of pollinosis but without this condition. Moreover, past pollinosis was based on a previous diagnosis, whereas after entrance pollinosis was assessed symptomatically, such that, pollinosis outcomes may not have corresponded. However, because questionnaires are nationally accepted in investigating allergic diseases (The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee 1998; von Mutius et al. 1998; Kilpelainen et al. 2000), we regarded this method as appropriate. Moreover, since pollinosis is difficult to cure (Okubo et al. 2011), we regarded diagnosis over time as approximating its prevalence before moving. Fourth, areas classified as high pollen areas in this study tended to include developed urban areas and allergic diseases are known to be affected by factors such as automobile exhaust gas (Hazenkamp-von Arx et al. 2011), air pollution (Seaton et al. 1994) or western lifestyle (von Mutius et al. 1998; Kramer et al. 2010), these factors were not analysed in this study and their associations remain unclear. Additional studies are needed to further assess these relationships and possible confounding variables.

Conclusions

We investigated the prevalence rate and symptoms of pollinosis and association with environmental factors in university freshmen. We found that pollinosis symptoms decreased among students who had moved from a high pollen area to the low pollen area around the university. This result indicates that pollinosis was affected by geographic environmental factors of that time. Additional studies are needed to clarify the association between environmental factors and pollinosis.

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References

Austin JB, Kaur B, Anderson HR, Burr M, Harkins LS, Strachan DP, Warner JO. Hay fever, eczema, and wheeze: a nationwide UK study (ISAAC, international study of asthma and allergies in childhood). *Arch Dis Child* **1999**;81:225-230.

Baba K, Konno A, Takenaka H (2008) Practical guideline for the management of allergic rhinitis in Japan, **2009** edition. Life Science,

Ball TM, Castro-Rodriguez JA, Griffith KA, Holberg CJ, Martinez FD, Wright AL. Siblings, day-care attendance, and the risk of asthma and wheezing during childhood. *N Engl J Med* **2000**;343:538-543.

Bendtsen P, Gronbaek M, Kjaer SK, Munk C, Linneberg A, Tolstrup JS. Alcohol consumption and the risk of self-reported perennial and seasonal allergic rhinitis in young adult women in a population-based cohort study. *Clin Exp Allergy* **2008**;38:1179-1185.

Bodner C, Godden D, Seaton A. Family size, childhood infections and atopic diseases. The Aberdeen WHEASE Group. Thorax **1998**;53:28-32.

Braun-Fahrlander C, Gassner M, Grize L, Neu U, Sennhauser FH, Varonier HS, Vuille JC, Wuthrich B. Prevalence of hay fever and allergic sensitization in farmer's children and their peers living in the same rural community. SCARPOL team. Swiss Study on Childhood Allergy and Respiratory Symptoms with Respect to Air Pollution. *Clin Exp Allergy* **1999**;29:28-34.

Dervaderics M, Fust G, Otos M, Barok J, Pataky G. Differences in the sensitisation to ragweed pollen and occurrence of late summer allergic symptoms between native and immigrant workers of the nuclear power plant of Hungary. *Immunol Invest* **2002**;31:29-40.

Eder W, Ege MJ, von Mutius E. The asthma epidemic. *N Engl J Med* **2006**;355:2226-2235.

Fine AJ, Abram LE. The period of sensitization in immigrant hay fever patients. *J Allergy* **1960**;31:375-380.

Gautrin D, Vandenplas O, DeWitte JD, L'Archeveque J, Leblanc C, Trudeau C, Paulin C, Arnoud D, Morand S, Comtois P, et al. Allergenic exposure, IgE-mediated sensitization, and related symptoms in lawn cutters. *J Allergy Clin Immunol* **1994**;93:437-445.

Greiner AN, Hellings PW, Rotiroti G, Scadding GK. Allergic rhinitis. Lancet 2011;378:2112-2122.

Hazenkamp-von Arx ME, Schindler C, Ragettli MS, Kunzli N, Braun-Fahrlander C, Liu LJ. Impacts of highway traffic exhaust in alpine valleys on the respiratory health in adults: a cross-sectional study. *Environ Health* **2011**;10:13.

Hellgren J, Cervin A, Nordling S, Bergman A, Cardell LO. Allergic rhinitis and the common cold--high cost to society. Allergy 2010;65:776-783.

Hellgren J, Lillienberg L, Jarlstedt J, Karlsson G, Toren K. Population-based study of non-infectious rhinitis in relation to occupational exposure, age, sex, and smoking. *Am J Ind Med* **2002**;42:23-28.

Hughes RF. Incidence of hay fever in recent immigrants to Canada. *Can Med Assoc J* **1958**;80:651-653.

Kilpelainen M, Terho EO, Helenius H, Koskenvuo M. Farm environment in childhood prevents the development of allergies. *Clin Exp Allergy* **2000**;30:201-208.

Kramer U, Oppermann H, Ranft U, Schafer T, Ring J, Behrendt H. Differences in allergy trends between East and West Germany and possible explanations. *Clin Exp Allergy* **2010**;40:289-298.

Maternowski CJ, Mathews KP. The prevalence of ragweed pollinosis in foreign and native students at a midwestern university and its implications concerning methods for determining the inheritance of atopy. *J Allergy* **1962**;33:130-140.

Meltzer EO. Quality of life in adults and children with allergic rhinitis. *J Allergy Clin Immunol* **2001**;108:S45-53.

Okamoto Y, Horiguchi S, Yamamoto H, Yonekura S, Hanazawa T. Present situation of cedar pollinosis in Japan and its immune responses. *Allergol Int* **2009**;58:155-162.

Okubo K, Kurono Y, Fujieda S, Ogino S, Uchio E, Odajima H, Takenaka H, Baba K. Japanese guideline for allergic rhinitis. *Allergol Int* **2011**;60:171-189.

Okuda M. Epidemiology of Japanese cedar pollinosis throughout Japan. *Ann Allergy Asthma Immunol* **2003**;91:288-296.

Ozasa K, Hama T, Dejima K, Watanabe Y, Hyo S, Terada T, Araki N, Takenaka H. A 13-year study of Japanese cedar pollinosis in Japanese schoolchildren. *Allergol Int* **2008**;57:175-180.

Scadding GK, Durham SR, Mirakian R, Jones NS, Leech SC, Farooque S, Ryan D, Walker SM, Clark AT, Dixon TA, Jolles SR, Siddique N, Cullinan P, Howarth PH, Nasser SM. BSACI guidelines for the management of allergic and non-allergic rhinitis. *Clin Exp Allergy* **2008**;38:19-42.

Sears MR, Herbison GP, Holdaway MD, Hewitt CJ, Flannery EM, Silva PA. The relative risks of sensitivity to grass pollen, house dust mite and cat dander in the development of childhood asthma. *Clin Exp Allergy* **1989**;19:419-424.

Seaton A, Godden DJ, Brown K. Increase in asthma: a more toxic environment or a more susceptible population? *Thorax* **1994**;49:171-174.

Shaaban R, Zureik M, Soussan D, Neukirch C, Heinrich J, Sunyer J, Wjst M, Cerveri I, Pin I, Bousquet J, Jarvis D, Burney PG, Neukirch F, Leynaert B. Rhinitis and onset of asthma: a longitudinal population-based study. *Lancet* **2008**;372:1049-1057.

Shilkret HH, Lazarowitz LC. Hay fever in immigrants. *Ann Allergy* **1953**;11:194-198.

Smith JM. The long-term effect of moving on patients with asthma and hay fever. *J Allergy Clin Immunol* **1971**;48:191-199.

Strachan D, Sibbald B, Weiland S, Ait-Khaled N, Anabwani G, Anderson HR, Asher MI, Beasley R, Bjorksten B, Burr M, Clayton T, Crane J, Ellwood P, Keil U, Lai C, Mallol J, Martinez F, Mitchell E, Montefort S, Pearce N, Robertson C, Shah J, Stewart A, von Mutius E, Williams H. Worldwide variations in prevalence of symptoms of allergic rhinoconjunctivitis in children: the International Study of Asthma and Allergies in Childhood (ISAAC). *Pediatr Allergy Immunol* **1997**;8:161-176.

Strachan DP. Hay fever, hygiene, and household size. BMJ 1989;299:1259-1260.

Strachan DP, Taylor EM, Carpenter RG. Family structure, neonatal infection, and hay fever in adolescence. *Arch Dis Child* **1996**;74:422-426.

Svanes C, Heinrich J, Jarvis D, Chinn S, Omenaas E, Gulsvik A, Kunzli N, Burney P. Pet-keeping in childhood and adult asthma and hay fever: European community respiratory health survey. *J Allergy Clin Immunol* **2003**;112:289-300.

The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: *ISAAC Lancet* **1998**;351:1225-1232.

von Mutius E, Martinez FD, Fritzsch C, Nicolai T, Reitmeir P, Thiemann HH. Skin test reactivity and number of siblings. *BMJ* **1994**;308:692-695.

von Mutius E, Vercelli D. Farm living: effects on childhood asthma and allergy. *Nat Rev Immunol* **2010**;10:861-868.

von Mutius E, Weiland SK, Fritzsch C, Duhme H, Keil U. Increasing prevalence of hay fever and atopy among children in Leipzig, East Germany. *Lancet* **1998**;351:862-866.

Table 1. Questions and answers of subjects.

Question	Answer	n=1558	(%)
Please describe your gender	Male	983	63.1
	Female	573	36.8
Before enrolment, were you ever diagnosed with pollinosis by a doctor? and if so, at what age	Yes	540	34.7
	No	1018	65.3
Diagnosed age [a]	0 ~ 4	23	(4.3)
	5 ~ 9	92	(17.0)
	10 ~ 14	248	(45.9)
	15 ~ 19	109	(20.2)
	unknown	68	(12.6)
Have you had pollinosis symptoms since university entrance in April or May?	Yes	483	31.0
	No	1060	68.0
Before enrolment, did you have any allergic diseases other than pollinosis?	Yes	608	39.0
	No	950	61.0
Before enrolment, have you ever kept any pets?	Yes	691	44.4
	No	858	55.1
Before enrolment, how many siblings did you have?	0	214	13.8
	1	828	53.5
	2	423	27.3
	≥3	84	5.4
Before enrolment, in which prefecture did you live?	Stationary	560	35.9
	Low pollen	296	19.0
	High pollen	680	43.6

Incomplete answers were excluded.

[a] The percent of subjects diagnosed in each age group is indicated relative to individuals diagnosed.

Table 2. Association between past pollinosis and past environmental factors.

Variable		Univariate logistic regression model				Multivariate logistic regression model [a]			
		OR	95%CI		P	OR	95%CI		P
Gender	Male	1				1			
	Female	0.802	0.644	0.998	0.048	0.791	0.629	0.994	0.045
Other allergic diseases	No	1				1			
	Yes	2.115	1.707	2.619	<0.001	2.121	1.704	2.640	<0.001
Experience keeping pets	No	1				1			
	Yes	0.95	0.769	1.173	0.632	0.985	0.792	1.226	0.893
Number of siblings	0	1				1			
	1	0.926	0.680	1.261	0.626	0.891	0.647	1.227	0.480
	2	0.627	0.444	0.886	0.008	0.624	0.436	0.893	0.010
	≥3	0.516	0.293	0.908	0.022	0.528	0.296	0.941	0.030
Geographic group	Stationary	1				1			
	Low pollen	0.836	0.613	1.140	0.258	0.771	0.561	1.061	0.111
	High pollen	1.431	1.131	1.810	0.003	1.430	1.121	1.824	0.004

[a] Variables are adjusted for each other in the model

Table 3. Association between post-entry pollinosis and past environmental factors.

Variable		Univariate logistic regression model				Multivariate logistic regression model [a]			
		OR	95%CI		P	OR	95%CI		P
Gender	Male	1				1			
	Female	1.046	0.836	1.308	0.693	1.039	0.825	1.308	0.744
Other allergic diseases	No	1				1			
	Yes	1.693	1.360	2.109	<0.001	1.690	1.353	2.112	<0.001
Experience keeping pets	No	1				1			
	Yes	1.123	0.904	1.396	0.294	1.140	0.914	1.423	0.245
Number of siblings	0	1				1			
	1	1.067	0.773	1.471	0.694	1.080	0.778	1.500	0.644
	2	0.796	0.557	1.139	0.212	0.816	0.566	1.177	0.277
	≥3	0.498	0.269	0.923	0.027	0.519	0.279	0.968	0.039
Geographic group	Stationary	1				1			
	Low pollen	0.785	0.573	1.074	0.130	0.754	0.547	1.038	0.083
	High pollen	1.030	0.810	1.310	0.809	1.045	0.817	1.338	0.724

[a] Variables are adjusted for each other in the model

Table 4. Pollinosis before and after moving within each group.

Pollinosis	Stationary group				Low pollen group				High pollen group			
	Answer		Rate		Answer		Rate		Answer		Rate	
	No	Yes	(%)	P	No	Yes	(%)	P	No	Yes	(%)	P
Past pollinosis	378	177	31.9	1.000	213	81	27.6	0.892	404	269	40.0	<0.001
After entrance pollinosis	378	177	31.9		215	79	26.9		454	219	32.5	

McNemar's test