

# The ambient pollen distribution in Beijing urban area and its relationship with consumption of outpatient anti-allergic prescriptions

X.-Y. WANG<sup>1</sup>, Z.-M. TIAN<sup>2</sup>, H.-Y. NING<sup>1</sup>, X.-Y. WANG<sup>1</sup>

<sup>1</sup>Department of Allergy, Beijing Shijitan Hospital, Capital Medical University, Beijing, China

<sup>2</sup>Information Center, Beijing Shijitan Hospital, Capital Medical University, Beijing, China

**Abstract. – OBJECTIVE:** The impact of pollen exposure on allergy medication is poorly characterized. We aim to study the main kind of ambient pollen in Beijing urban area and the correlation with outpatient anti-allergic prescriptions throughout one year in a tertiary hospital.

**MATERIALS AND METHODS:** With a modified volumetric trap, ambient pollens were sampled from January to December 2015. Meanwhile, information on 15 anti-allergic medication prescriptions in outpatient pharmacy was obtained and analyzed by generalized linear model.

**RESULTS:** The total quantity of pollens amounted to 76164 grains in 2015. Two peaks of pollen concentration were observed, which happened from March to April 2015, and from August to September 2015. Consumption of antihistamines, LATRA, nasal sprays, and SABA showed two peaks trend in accordance with pollen distribution ( $p < 0.01$ ). ICS+LABA showed no seasonal peak without a significant correlation with pollen counts ( $p > 0.05$ ). Medication peak was higher in autumn than spring ( $p < 0.01$ ).

**CONCLUSIONS:** The ambient pollen distribution was in accordance with the anti-allergic prescription amount with the two-peak season. The autumn medication peak was higher than spring peak, which clarified that outpatients were more sensitive to autumn pollen compared with spring pollen.

Key Words:

Ambient pollen, Antihistamine prescriptions, Peak season, Pollinosis.

## Introduction

Allergic diseases are a group of multi-factorial diseases with genetic and environmental factors influencing, which gradually have drawn more and more attention in recent decade. It could cau-

se major illness and disability, affecting over 10% to 40% of the population worldwide<sup>1</sup>. Ambient pollen is a key culprit allergen and usually causes hay fever including allergic rhinitis (AR), allergic conjunctivitis and allergic asthma (AS). The disease often results in sneezing, nasal congestion, itching nose and eyes, serious cases may induce asthma attack, seriously affecting the quality of life<sup>2,3</sup>. In a large survey of patients with allergy, 54% reported the use of an allergy medication during the past 4 weeks<sup>4</sup>. Thus, estimating the impact of pollen on these outcomes is relevant to public health policy. The ambient pollen differed from different regions and countries<sup>4-6</sup>. Its dissemination pattern could affect the allergic diseases especially AR and AS. Several recent reports showed a connection between pollen distribution and the incidence of allergic diseases. Sun et al<sup>7</sup> analyzed the short-term associations between ambient concentration of various pollen types (tree, grass, and weed) and emergency department visits for asthma and found a 3 days lag. Canova et al<sup>8</sup> also drew similar conclusions. Kim et al<sup>9</sup> in Korea reported several allergic diseases including AR, AS and were affected by pollen. All those findings demonstrated that symptoms of allergic diseases (mainly AR and AS) were affected by pollen distribution, but seldom such study was conducted in China. The increase of AR or AS subsequently caused an increase in anti-allergic drug consumption. Whether the drug consumption was linear related with pollen, it has not been confirmed yet<sup>9-11</sup>. To our knowledge, only few studies have focused on the effect of ambient allergens on drug consumption<sup>12-14</sup>. Sheffield et al<sup>15</sup> reported the peak dates of three tree pollens were associated with daily OTC allergy medication sales during years

2003-2008. This study was conducted to examine the relationship between pollen distribution and visit of allergic diseases outpatient.

### **Materials and Methods**

#### **Pollen Collection and Pollen Count**

Aeroallergen pollen concentrations were monitored with modified Durham pollen sampler. Pollen collector was placed in the top floor of a tertiary hospital outpatient building since 1<sup>st</sup> of January to 31<sup>th</sup> of December 2015. The height was about 30 meters, no tall buildings and trees blocking, with the long-term power supply, sampler was fixed in a horizontal position. Pollen monitoring site was located nearby urban main road, which represents the typical area of the city. The location was 116°18'51" E longitude and 39°53'54" N latitude. These pollen traps recorded pollen particles with diameter ranged from 10 to 100  $\mu\text{m}$  daily. A 75 mm  $\times$  25 mm glass slide coated with a thin layer of vaseline was placed over the sampler and replaced daily. Basic fuchsin in glycerol was added to the slide and dissolved overheating. Then a 22 mm  $\times$  22 mm cover slide was applied and the periphery of the cover slide was sealed with resin glue after cooling. The category and count of pollens on the cover slide were analyzed under the 100x and 400x microscope. Pollen concentrations were recorded as grains/1000  $\text{mm}^2$ . The study was approved by the Ethics Committee of Beijing Shijitan Hospital. Signed written informed consents were obtained from all participants before the study.

#### **Climate Data Collection**

Climate data of Beijing in 2015 included 5 indexes: precipitation (mm), average temperature ( $^{\circ}\text{C}$ ), sunshine duration (h), average wind speed (m/s) and average atmospheric pressure (hPa). These data were obtained from Beijing statistical yearbook 2015 online. The website was as follows: <http://www.bjstats.gov.cn/nj/main/2015-tjnj>. Climate factors were calculated and adjusted in the analysis model.

#### **Data Collection of Anti-Allergic Medications Consumption**

Hospital Special Package 2007 (Version: 1.0.83) was applied to obtain the basic data from three departments that are mostly related with allergic diseases: Allergy, ENT and Respiratory Department. Data regarding reimbursements for anti-allergic drugs were provided by information

center of our hospital through Hospital Special Package 2007 (Version: 1.0.83). This study included the anti-allergic medications mainly used in daily treatment for seasonal or pollen related AR or AS. According to our system, 6 main kinds and 15 chemical name medications were enrolled in this study. The investigated medications were showed in Table I.

#### **Statistical Analysis**

Categorical data was described as numbers and percentages. Continuous data were shown as mean $\pm$ SD. Between-group differences in subject characteristics were tested using *t*-test/Wilcoxon rank-sum test for continuous variables and  $\chi^2$ /Fisher exact test for categorical variables. Kruskal-Wallis test was applied for comparison of pollen counts. Generalized linear model (GLM) analysis was performed to explore the relation between pollen distribution and anti-allergic medications consumption. The climate factors were adjusted. All tests were two-sided with significance level of 0.05. All of the analyses were performed using SAS software version 9.4 (SAS Institute Inc. Cary, NC, USA).

## **Results**

### **Pollen Distribution in Beijing Urban Area in 2015**

A total of 76164 pollen grains were examined in 2015. Pollen peak season started from 8<sup>th</sup> March to 26<sup>th</sup> of September, accounting for 55.6% of the annual pollen grains. Typical double-peaks were observed. Pollen distribution throughout the year presented two peaks: March and April in spring, August and September in autumn, respectively. As shown in Figure 1, the highest daily pollen grain was 3510, which was presented on 20<sup>th</sup> of March. The absence of pollen counts was seen in 70 days through the whole year, distributed mainly in January, February, November and December. Kruskal-Wallis test showed a higher pollen count in spring than autumn ( $p < 0.001$ ). The predominant pollens were diverse in different seasons as shown in Figure 2. The highest pollen in March as monitored was *Cupressaceae* accounting for 12918 grains (57.1% of the whole month pollen count). *Platanaceae* was the dominant pollen in April (8640 grains, 32.6%). *Artemisia* was the predominant pollen both in August and September (2780, 36.7% vs. 4052, 50.5%).

**Table I.** The 6 main kinds of anti-allergic medications enrolled in this study.

N	Medication category	No.	Chemical name	Dosage unit
1	H1 antihistamine	1	Loratadine/desloratadine	Pill
		2	Cetirizine/levocetirizine	Pill
		3	Ebastine	Pill
		4	Cyproheptadine	Pill
		5	Mizolastine	Pill
		6	Chlorpheniramine	Pill
		7	Ketotifen	Pill
2	LATRA	8	Montelukast	Pill
3	Nasal corticosteroids spray	9	Budesonide	Bottle
		10	Mometasone furoate	Bottle
		11	Fluticasone propionate	Bottle
4	Nasal anti-histamine spray	12	Azelastine	
5	Inhalant (ICS+LABA)	13	Salmeterol/fluticasone propionate	Set
		14	Symbicort turbuhaler	Set
6	Inhalant (SABA)	15	Salbutamol	Set

Footnote: Loratadine syrup and cetirizine drops were switched into the equivalent dosage as pills. LATRA has 3 different dosage types: 4 mg, 5 mg, 10 mg for different age group. ICS+LABA (salmeterol/fluticasone propionate) had three different dosage types: 25 g/50 g, 25 g/125 g and 25 g/250 g.

**Anti-allergic Medication Distribution Throughout 12 Months**

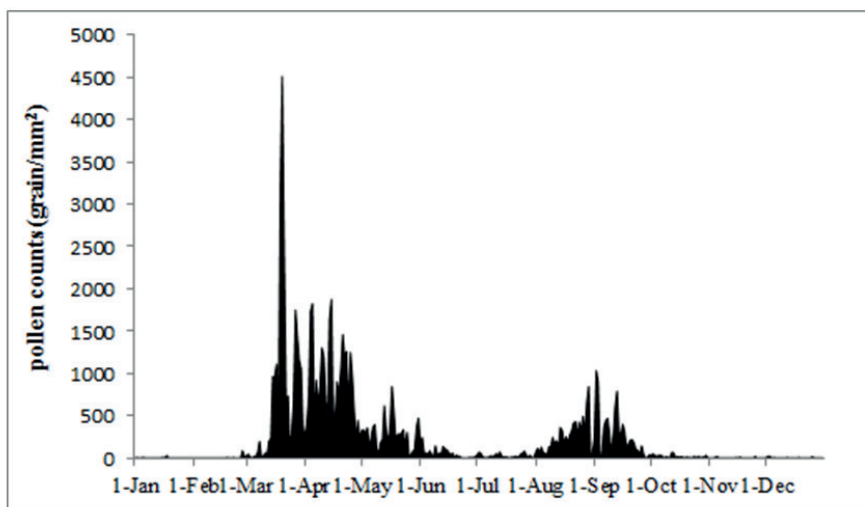
*Antihistamines Usage Distribution*

A total of 2015 prescription antihistamines were recorded as 187402 pieces. Among them, the Allergy Department accounted for 56.7%, ENT Department for 6.6%, and Respiratory Department for 36.6%, accordingly. Throughout the year, two prescription peaks were observed as shown in Figure 3A. Allergy Department and overall usage of antihistamine

showed a typical two-peak season while Respiratory and ENT Departments showed no significant fluctuation. The consumption of antihistamine was higher in autumn peak than spring peak ( $\chi^2=13.4$ ,  $p<0.05$ ,  $n^2=21.7$ ,  $p<0.01$ , respectively).

*LATRA Usage Distribution*

A total of 2015 prescription antihistamines were recorded as 315747 pieces. Among them, Allergy Department accounted for 27.1%, ENT Department for 11.2%, and Respiratory Department



**Figure 1.** Pollen distribution in Beijing urban area in 2015. The highest concentration of pollen was presented on 20<sup>th</sup> of March. Two peak seasons were Mar-Apr and Aug-Sep, respectively. The average pollen concentration was 24586.5 grains in spring peak and 15584 grains in autumn peak ( $p<0.001$ ).

**Table II.** GLM – Gamma distribution fitting analysis results of association between medication consumption and pollen concentration.

Variation	OR	95%	CI	p
H1 antihistamine				
Allergy dept.	1.000	1.000	1.000	<0.001
ENT dept.	1.002	1.002	1.002	<0.001
Respiratory dept.	1.001	1.001	1.001	<0.001
Total	1.000	1.000	1.000	<0.001
LATRA				
Allergy dept.	1.001	1.001	1.001	<0.001
ENT dept.	1.002	1.002	1.002	<0.001
Respiratory dept.	1.001	1.001	1.001	<0.001
Total	1.000	1.000	1.000	<0.001
Nasal corticosteroids spray				
Allergy dept.	1.023	1.015	1.031	<0.001
ENT dept.	1.008	1.006	1.010	<0.001
Respiratory dept.	1.085	0.878	1.341	0.447
Total	1.006	1.004	1.008	<0.001
Nasal antihistamine spray				
Allergy dept.	1.015	1.009	1.021	<0.001
ENT dept.	1.017	1.011	1.023	<0.001
Respiratory dept.	1.142	1.016	1.285	0.027
Total	1.008	1.006	1.010	<0.001
ICS+LABA				
Allergy dept.	1.013	0.953	1.077	0.681
ENT dept.	0.329	0.086	1.253	0.103
Respiratory dept.	1.014	1.002	1.026	0.017
Total	1.012	1.002	1.022	0.024
SABA				
Allergy dept.	1.095	0.978	1.227	0.115
Respiratory dept.	1.094	1.067	1.122	<0.001
Total	1.062	1.039	1.085	<0.001

Note: The GLM model adjusted climate factors, including precipitation, average temperature, sunshine duration, average wind speed and average atmospheric pressure.

ment for 61.8%, respectively. Throughout the year, two prescription peaks were observed as shown in Figure 3B. Allergy Department and overall usage of LATRA showed a typical two-peak season while Respiratory and ENT Departments showed no significant fluctuation. The consumption of LATRA was higher in autumn peak than spring peak ( $\chi^2=19.4, p<0.01, t^2=33.7, p<0.01$ , respectively).

#### Nasal Spray Usage Distribution

Nasal spray was categorized into corticosteroids and antihistamine type as shown in Figure 3C-D. A total of 10287 nasal corticosteroids spray was used in 2015. The percentage of consumption was 9.9%, 87.1%, and 3.0% for Allergy, ENT and Respiratory Departments. A total of 4400 nasal antihistamine spray was used in 2015. The percentage of consumption was 39.7%, 56.7%, and 3.6% for Allergy, ENT and Respiratory Departments. Both two-peak seasons were seen in

Figure 3C-D in Allergy, ENT Departments, and overall group, but without Respiratory Department. No significant difference was found in nasal corticosteroids spray group compared spring peak to autumn peak ( $p>0.05$  in all three groups). The consumption of nasal antihistamine spray was higher in autumn compared with spring peak in both three groups ( $\chi^2=10.4, 9.83, 16.9$  respectively,  $p<0.01$ ).

#### Inhalant Usage Distribution

Inhalant devices were categorized as ICS+LABA and SABA group. The total amount of ICS+LABA was 5520 sets while SABA was 863 sets. The percentage of consumption was 11.6% and 18.8% for Allergy Department while 88.4% and 81.2% for Respiratory Department. No obvious peak season or fluctuation was seen in Figure 4A. A two-peak season was found in Figure 4B in Allergy Department and total group. A slight increase of SABA usage was found in autumn

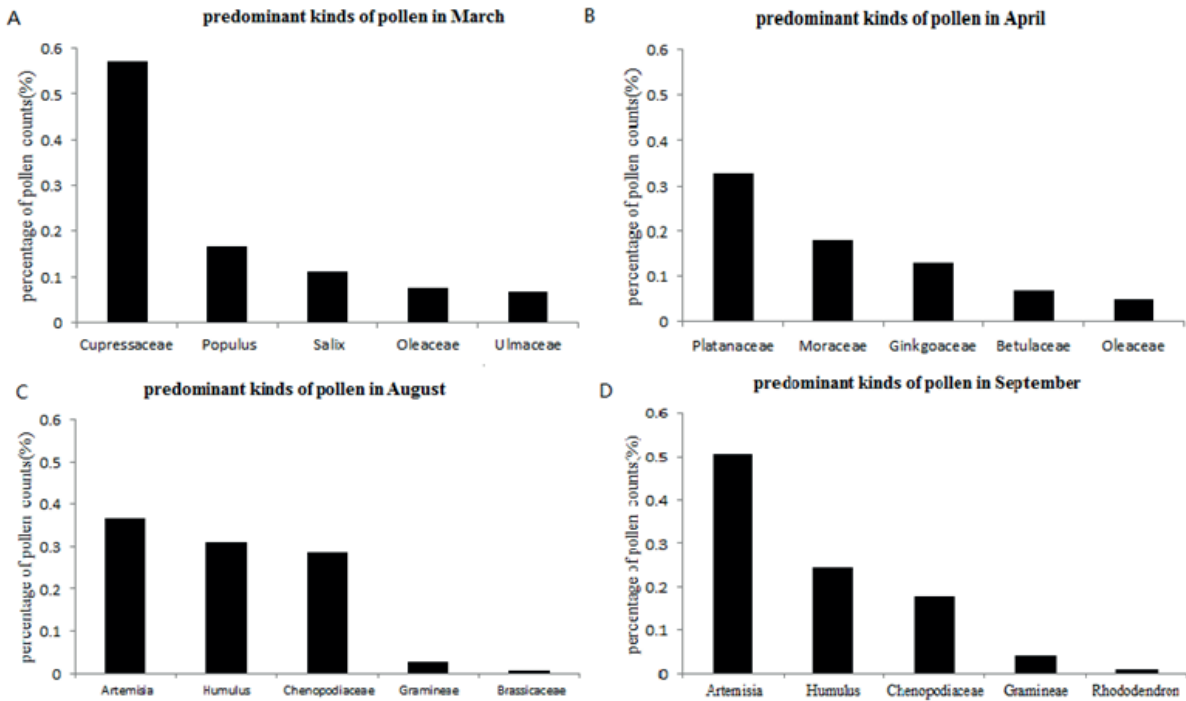


Figure 2. Predominant kind of ambient pollen in Beijing urban area in pollen peak season of spring and autumn.

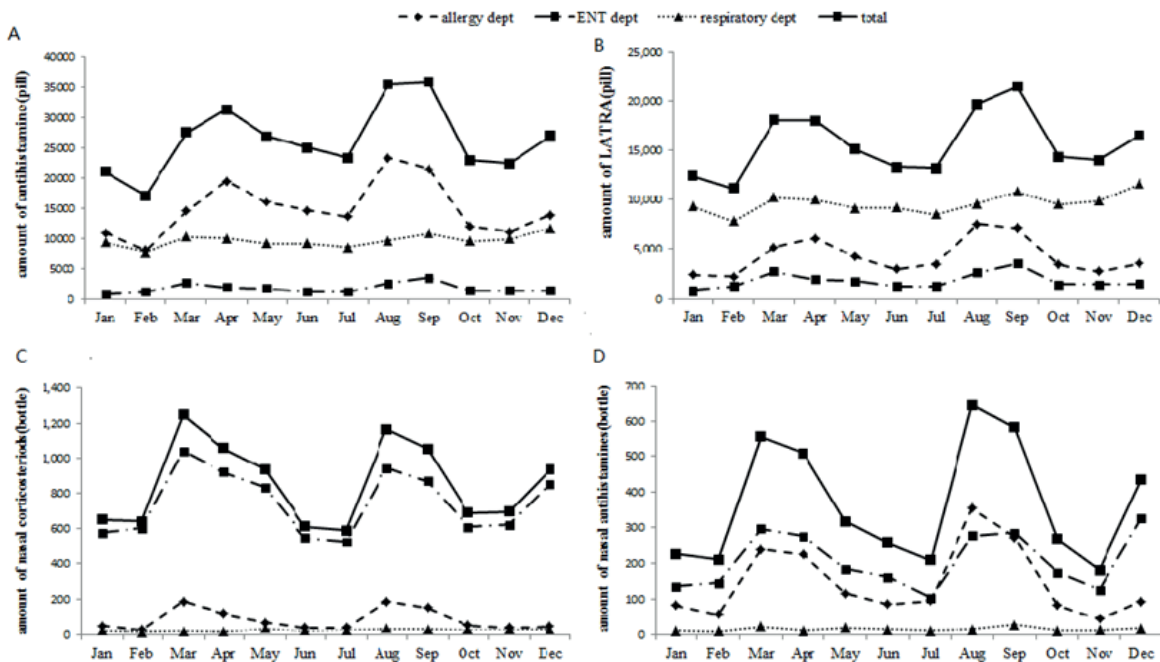
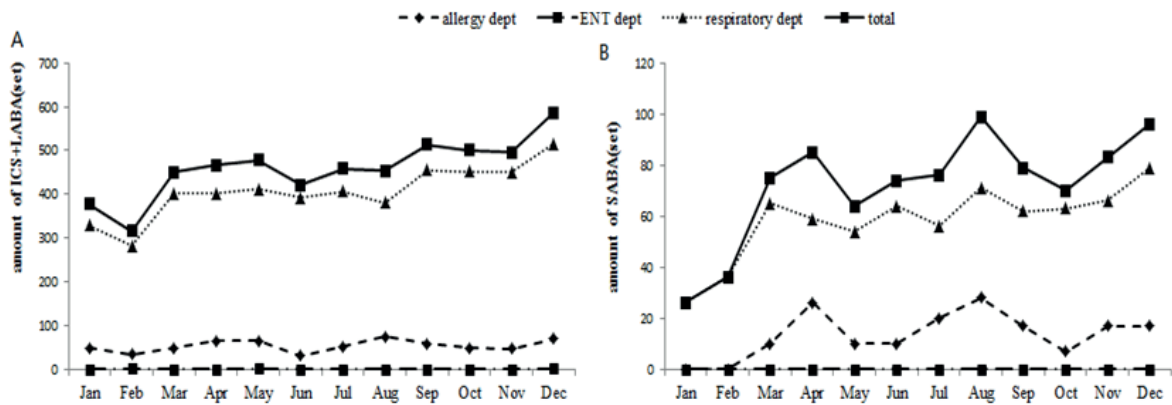


Figure 3. Anti-allergic medications consumption in different department through 12 months. **A**, showed the variation of antihistamines during 12 months; **B**, showed the variation of LATRA; **C-D**, showed the prescription situation of nasal corticosteroids and antihistamines spray, respectively. Two peak seasons were seen in all four categories of anti-allergic medications with a higher level in autumn than spring.



**Figure 4.** Anti-allergic medications consumption in different department through 12 months. *A*, showed the variation of ICS+LABA during 12 months; *B*, showed the prescription situation of SABA. No obvious peak season was seen in Figure 4A. Two peak seasons were seen in Figure 4B with a higher level in autumn than spring.

than spring peak with no significant difference ( $p>0.05$ ).

**Pollen Distribution and Dosage of Anti-allergic Medications Correlation Analysis**

GLM-Gamma distribution fitting analysis was applied and the results were showed in Table II. Our results demonstrated that antihistamine consumptions in Allergy, ENT, Respiratory Departments and total group, were significantly correlated with pollen concentration ( $p<0.001$ ). The LATRA group and nasal antihistamine spray group were significantly associated with pollen concentration in all four Departments ( $p<0.05$ ). Nasal corticosteroids spray consumption was significantly related with pollen in Allergy, ENT Departments and total group ( $p<0.001$ ). ICS+LABA and SABA were first line therapies for asthma whether acute or chronic ones. In our study, both ICS+LABA and SABA consumptions were related with pollen only in Respiratory Department and total group ( $p<0.05$ ). The OR value in SABA group was higher than in ICS+LABA group.

**Discussion**

Pollen has generally been linked to an increased risk for allergic diseases especially AR and AS. We explored the association between pollen distribution and allergic medications consumption and found a positive connection among antihistamine, LATRA, nasal corticosteroids spray, nasal

antihistamine spray and SABA usage compared with pollen variation along one year. Our findings confirmed the positive association between ambient pollen and increases in the form of anti-allergic medication usage. These findings were similar to previous studies<sup>15,16</sup>. In our study, we noticed that pollen distribution had a typical seasonal change as shown in Figure 1, implying that pollen induced AR, AS and other related diseases could be varied in the same pattern. Accordingly, anti-allergic medications treating pollen induced diseases appeared similar. Globally, due to the difference of geographic position and vegetation, kinds and concentrations of ambient pollen differ. The main sensitizing pollen was ragweed in northern America, *gramineae* in Europe, and tree plants in Austria, New Zealand and Japan<sup>17</sup>. In our monitoring, the main sensitizing pollen was tree plant in spring including *cupressaceae* and *platanaceae*, while *artemisia* was the predominant pollen in autumn. The typical two peaks of pollen distribution were in accordance with previous study<sup>18</sup>. It's worth nothing that in our study tree pollen peak (spring) was higher than weed pollen (autumn), which could be the consequence of our observation site selection or the afforestation of cities in recently years. After a GLM analysis, our study found a significant linearity between antihistamine consumption and pollen concentration, which was similar to the study of Ito et al<sup>19,20</sup>. LATRA, nasal sprays also showed a seasonal change along with pollen concentration. As talking to asthma treated agents, the short-term drugs as SABA was also affected by pollen. These findin-

gs stated that antihistamine, LATRA, and nasal sprays were regular pollen treating agents and were affected by pollen. Nevertheless, we found a negative correlation of regulatory asthma medication (ICS+LABA) with pollen variation. This could be explained as follows: ICS+LABA had a broad application besides AS. Pollen induced AS could be paroxysmal and increases the demand for short-term drugs (SABA) but not the long-term drugs (ICS+LABA). In our data collection, we discussed three related Departments of pollen diseases. According to our findings, medication consumption of Allergy and ENT Departments were highly associated with pollen concentration, except Respiratory Department. This could be caused by the difference of illness types among three Departments. Thus, Allergy and ENT Departments should be more aware of peak season than Respiratory Department. There were both two peaks in medication usage and pollen distribution. Paradoxically, we found a significantly higher level in autumn than spring, in contrast to the pollen quantity distribution. This phenomenon suggested more allergenic pollen in weed pollen compared with tree pollen. Thus, autumn peak could lead to more visits and more demand. To our knowledge, this is the first study to discuss the difference of anti-allergic medication usage between two peak seasons in China. Caillaud et al<sup>13</sup> found that pollen counts concentration was less than 1%, which suggested a strong potential allergenic role of local tree pollen. In our study, grass or weed pollen showed a stronger allergenic ability than tree pollen. Taking into account pollen distribution and climate factors, autumn weed/grass pollen (*artemisia*, chenopods, *gramineae*) sensitization was shown to be the major cause of pollen allergy in Beijing urban area. In recent years, the rapid development of social economy, accelerating the speed of urban greening, is changing cultivated plant species. Therefore, analyzing pollen and allergy related drugs have important implications for optimizing targeted allergic disease prevention and management. Also, it could help better understanding the etiology of ambient exposure-induced allergic diseases. Our results should be interpreted in light of several limitations. The anti-allergic medication was calculated by the hospital pharmacy and could not include the out-of-counter consumption of allergic drugs. Thus, it could cause a bias. Additionally, we counted pollen and drugs by month not by date, so we couldn't perform a time-series study. Time-series studies based on drug consumption

are useful to highlight and to supervise pollen-related diseases requiring ambulatory care. A further detailed study is needed.

## Conclusions

We observed the strong connection between ambient pollen distribution and anti-allergic medications consumption. Two typical peak seasons were observed in spring and autumn, and weed pollen in autumn showed a stronger sensitization compared with tree pollen. The mechanism needs further study.

## Statement

None of sources of support were directly involved in the design of the study, or in the collection and analysis of the data in this report.

## Conflict of interest

The authors declare no conflicts of interest.

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