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ORIGINAL RESEARCH

Main Airborne Pollen Species and Characteristics of Allergic Rhinitis Patients with Pollen-Related Allergies in 13 Northern Chinese Cities

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Background: Pollen allergies have a high prevalence in northern China, whereas, the types of pollen allergens and population characteristics among different regions remain unclear.

Objective: To study the species and temporal distribution of the main allergenic pollen, as well as the characteristics of patients with pollen-related allergic rhinitis (AR) in different cities in northern China.

Methods: Pollen data were obtained from pollen-monitoring stations in 13 cities of northern China between 2020 and 2021. Questionnaire surveys and allergen testing were conducted in 494 patients with pollen-related allergies from Beijing in Central, Shenyang in Northeast, and Xi'an in Northwest China.

Results: In 13 cities of northern China, the main sources of pollen were cypress, poplar, elm, pine, birch and ash in spring, and mugwort, goosefoot, hop and ragweed in autumn. In Northwest China, the spring and autumn pollen periods started earlier and lasted longer than that in Central and Northeast China, and the pollen counts in autumn in was significantly higher than that in Central and Northeast China. Furthermore, the nasal, ocular and respiratory symptom and quality of life scores of AR patients in Northwest China were significantly higher than that in Central and Northeast China. 69.32–73.28% of patients had annual cost of anti-allergic medication between 500–5000 yuan. However, 40.93–48.86% of patients reported minor control of symptoms.

Conclusion: Our results can be used as a basis for developing effective prevention and management measures for patients with pollen-related allergy in these regions, including timely pollen monitoring, patient guidance on protective measures, early intervention, and specific immunotherapy, to improve pollen-related allergy management.

Keywords: allergic rhinitis, pollen monitoring, Northern China, questionnaire survey, symptom scores

Introduction

Worldwide prevalence of allergic rhinitis (AR) has increased over the last fifty years, affecting between 10–30% of the world population.[1,2] Air-borne pollen is a major outdoor allergen that causes AR. Pollen is inhaled into the respiratory tract of allergic patients, activating IgE-mediated hypersensitivity reactions and triggering clinical symptoms, also known as pollinoses.[3] In addition to causing symptoms of allergic rhinitis such as paroxysmal sneezing, rhinorrhea, itchy nose, and nasal obstruction, pollen also causes symptoms of allergic conjunctivitis such as ocular itching and tearing, as well as asthma symptoms such as cough, chest tightness, dyspnea and wheezing, seriously affecting the life of patients.[4] Compared with other allergen-induced AR, pollinoses is characterized by a higher prevalence, more severe clinical symptoms, and a higher incidence of co-asthma, as well as poor symptom control with conventional standardized drug therapy.[5,6]

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Air-borne pollen has significant seasonal and regional characteristics and is influenced by environmental and climatic factors.[7,8] In northern China, the air is dry and windy, pollen particles are easy to peel and disperse from the pollen sac. Therefore, the pollen concentration in northern China is significantly higher than that in southern China, and the incidence of pollen allergy is also higher than that in southern China.[9]

A study involving 6043 subjects from the grasslands of Northern China has demonstrated that 18.5% of these subjects had pollen-induced AR based on allergen tests, indicating a large population of pollinoses patients.[10] Other studies showed that in the northern, mugwort pollen-related allergy accounts for 52.3–58.2% of the population with allergies.[11,12] A study conducted in China revealed that over 45% of outpatient visits for allergic diseases occur in August and September each year, predominantly due to exposure to autumn pollen allergens.[13]

There is no research report on the difference of main allergenic pollen and characteristics of AR patients in different areas of northern China. In this study, we aimed to identify the allergenic pollen species and analyze the characteristics of patients with pollen allergies in different areas of northern China to establish a foundation for the defense and treatment of these allergies.

Materials and Methods

Airborne Pollen

Daily airborne pollen concentrations (grains/1000 mm^2) and species were obtained from 13 pollen-monitoring sites established by the Beijing Tongren Hospital in various regions of northern China. The northwestern region included Baotou, Ordos, and Hohhot in the Inner Mongolia Autonomous Region; Lanzhou in Gansu Province; Xining in Qinghai Province; Urumqi in the Xinjiang Uygur Autonomous Region; and Xi'an in Shaanxi Province. The northeastern region included Harbin in Heilongjiang Province, Changchun in Jilin Province, and Shenyang in Liaoning Province. The central region includes Beijing and Chengde in Hebei Province, and Liaocheng in Shandong Province (Figure 1). Pollen samples were collected using Durham pollen samplers (gravimetric method) from March 1 to October 15 each year during the sampling period of 2020–2021.[14] The sampling slides were replaced every 24 h, stained with alkaline fuchsin, counted and sorted manually under a microscope (Olympus BX-51, 200X). The daily pollen concentration is the average for the same dates in 2020 and 2021. The start and end dates of the spring and autumn pollen seasons were determined according to the literature method:[15] when the total pollen count on a certain day and all preceding days reached or exceeded 2.5% of the total annual count, that day was considered the start of the pollen season; when the total pollen count reached or exceeded 97.5% of the total annual count, that day was considered the end of the pollen season.

Patients with Pollen-Related Allergies

The data of patients with pollen-related allergies were obtained from three hospitals representing the northwest, central, and northeast regions: the Second Affiliated Hospital of Xi'an Jiaotong University, Beijing Tongren Hospital, and the First Affiliated Hospital of China Medical University. These patients were diagnosed with pollen-related allergies in the outpatient departments. The diagnostic criteria followed the guidelines:[16] a clinical history of AR for at least two years, and at least one of the pollen allergens confirmed by the presence of specific immunoglobulin E (sIgE; ≥0.7 kUA/L) using ImmunoCAP system (Pharmacia, Uppsala, Sweden). Pollen allergens tested included tree pollen in spring: Ulmus (elm, tx5), Cupressaceae (cypress, t6), Populus (poplar, tx5), Betula (birch, t3), Corylus (hazel, tx5), weed pollen in autumn: Artemisia (mugwort, w6), Chenopodium (goosefoot, w10), Humulus (hop, w22) and Ambrosia (ragweed, w1)(Thermo Fisher Scientific, Sweden). All patients also completed questionnaires. The present study was conducted in accordance with the Declaration of Helsinki and approved by the Medical Ethics Committee of Beijing TongRen Hospital (TRECKY2020-076), and all participants provided informed consent.

Questionnaire

The questionnaires mainly involved symptoms, Quality of Life (QoL), medication usage,[17–19] symptoms control and cost.[20] The subjective assessment of AR symptoms was based on the symptom scores for four nasal symptoms (sneezing, rhinorrhea, nasal itching and nasal obstruction), three ocular symptoms (ocular itching and tearing) and four respiratory symptom (chest tightness, dyspnea, coughing and wheezing); scored range of 0 (not at all) to 10 (severe). Total nasal symptom score was assessed as the sum of the scores for the four nasal symptoms.[17,18] Mini QoL contains 6 questions

Figure 1 Geographic distributions of pollen monitoring in 13 cities in Northern China.

scored between 0 and 6 for daily and leisure activities, sleep, irritability, thirst and fatigue.[19] Medication score was calculated according to the use of drugs on a four-level scale; with I = no medication; II = nasal steroids; III = oral antihistamines; IV = oral antihistamines and nasal steroids were used. Symptom control was calculated as follows: I = No control; II = Minor control; III = Substantial control; IV = Total control. The annual cost of AR treatment was evaluated as follows: I = 100–500 yuan; II = 500–1000 yuan; III = 1000–5000 yuan; IV = > 5000 yuan.

Statistical Analysis

We analyzed questionnaires of AR patients with pollen-related allergies in central, northeast and northwest China, including symptoms, QoL, medication usage, symptoms control and cost. Data analysis was performed using SPSS 19.0 software (IBM Inc., Armonk, NY, USA). Continuous variables are expressed as mean ± standard deviation, and between-group comparisons were conducted using *t*-tests. Categorical variables are expressed as frequencies, and between-group comparisons were performed using the chi-square test. $p< 0.05$ was considered to be statistically significant.

Results

Main Airborne Pollen Species and Period in Northern China

The annual pollen concentration in Northwest, central and Northeast China showed two peak times. The first peak occurred in March–May for spring tree pollen, the second occurred in August–September for autumn weed pollen, whereas grass pollen concentrations were low in June–July, with no peak (Figure 2a–c). The total spring tree pollen concentration in Central and Northeast China was significantly higher than that of autumn weed pollen (Figure 2a and b). However, in Northwest China there was no difference in pollen concentration between spring and autumn, and high concentration of weed pollen was found in autumn (Figure 2c).

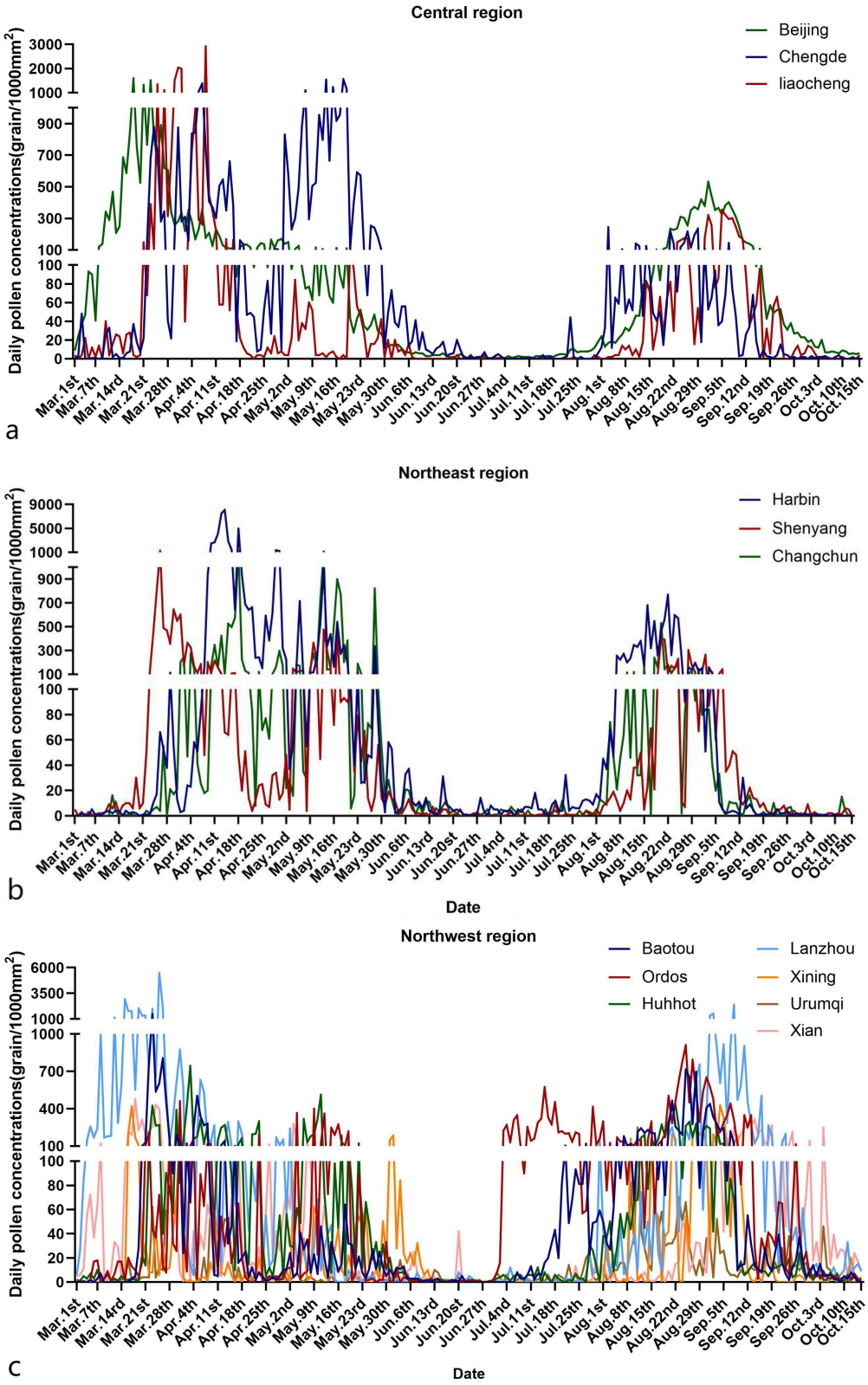

Figure 2 Daily average pollen counts in Central, Northeast, and Northwest China. (**a**) daily average pollen counts in Central China; (**b**) daily average pollen counts in Northeast China; (**c**) daily average pollen counts in Northwest China.

Table 1 Start and End Dates (Year-Date Sequence) of Spring and Autumn Pollen, Major Pollen Sources, the Percentage of Total Annual Pollen, and Pollen Count (Grains/1000 Mm²) of Spring and Autumn

Region	Spring				Autumn			
	Start	End	Dominant Plants (%)	Pollen Concentrations	Start	End	Dominant Plants (%)	Pollen Concentrations
Beijing	63	150	Cypress (25.50)	25,701	203	277	Mugwort (10.52)	10,301
Chengde	81	161	Pine (39.12)	40,190	182	266	Mugwort (6.70)	4166
Liaocheng	80	141	Ash (43.89)	19,344	213	275	Hop (13.25)	5104
Ordos	65	177	Pine (11.18)	6007	184	272	Mugwort (72.31)	21,483
Hohhot	79	151	Poplar (17.09)	10,489	192	276	Mugwort (30.71)	7137
Baotou	79	153	Elm (18.83)	8841	197	271	Mugwort (46.39)	10,680
Lanzhou	63	134	Poplar (37.65)	37,644	212	271	Mugwort (26.13)	18,423
Xi'an	62	172	Poplar (22.91)	8351	211	288	Mugwort (21.47)	5867
Xining	75	181	Moraceae (17.21)	6058	189	262	Mugwort (28.86)	6180
Urumqi	82	122	Fabaceae (13.29)	2618	185	279	Goosefoot (25.43)	2108
Harbin	98	150	Poplar (44.80)	54,869	205	249	Mugwort (9.78)	11,275
Shenyang	81	164	Poplar (32.17)	21,840	213	269	Ragweed (11.02)	7067
Changchun	86	159	Poplar (31.16)	17,097	215	259	Mugwort (13.38)	4262

The beginning of the pollen period varied by region. The spring pollen period started earlier in Central and Northwest China than that in Northeast China. In Central Beijing, the spring pollen period started on the 63rd day of the year. Lanzhou, Xi'an, and Ordos in Northwest China started on the 63rd, 62nd, and 65th days respectively. In Northeast China Harbin started the latest, on the 98th day of the year. The average spring pollen period in 13 cities was 78.5 days, while the spring pollen period in Northwest China lasted for a long time, the average spring pollen period in Ordos, Xi 'an and Lanzhou exceeded 100 days. Autumn pollen period began earlier in Northwest China than that in central and northeast China. The average autumn pollen period in the 13 cities was 70.2 days, while the autumn pollen period in Northwest China lasted for a long time, the autumn pollen period in Ordos, Hohhot and Urumqi exceeded 80 days. The autumn pollen period in Northeast China lasted for a short period, such as the pollen period in Harbin and Changchun lasted only 44 days, which was lower than the average (Table 1). In general, the spring and autumn pollen periods in Northwest China start earlier and last longer than those in Central and Northeast China.

We also analyzed the main airborne pollen species in northern China (Table 1). In the Central region, the main spring pollen sources are cypress, pine, and ash. For instance, cypress was the predominant spring pollen source in Beijing, accounting for 25.50% of the annual pollen count, pine in Chengde, Hebei Province (39.12%), and ash in Liaocheng, Shandong Province (43.89%). In Northwest China, spring pollen mainly originated from poplar, elm, pine, Moraceae, and Fabaceae. Elm was the most significant spring allergenic pollen in Baotou, Inner Mongolia (18.83%). Poplar was dominant in Hohhot, Inner Mongolia, Lanzhou, Gansu Province, and Xi'an, Shaanxi Province (17.09%, 37.65%, and 22.91%, respectively). Pine was the major source in Ordos, Inner Mongolia (11.18%), Moraceae the main source in Xining, Qinghai Province (17.21%); and Fabaceae the predominant source in Urumqi, Xinjiang (13.29%). In Northeast China, spring pollen mainly originated from poplar. Poplar was the dominant spring allergenic pollen in Shenyang, Liaoning Province; Harbin, Heilongjiang Province; and Changchun, Jilin Province (32.17%, 44.80%, and 31.16%, respectively) (Table 1, Figure 3). Autumn pollen primarily derived from mugwort in most cities in northern China, particularly Ordos in the northwest, where mugwort pollen accounted for 72.31% of the annual pollen. The main pollen in autumn was not mugwort in some cities: for instance, goosefoot was the main pollen source in Urumqi, hop was the key source in Liaocheng, and ragweed was the major contributor in Shenyang.

Characteristics of Pollen-Related Allergy Patients in Three Regions

A questionnaire survey was conducted among 494 patients with pollen-related allergies in Beijing (281 patients), Shenyang (126 patients), and Xi'an (87 patients), representing Central, Northeast, and Northwest China, respectively. No significant

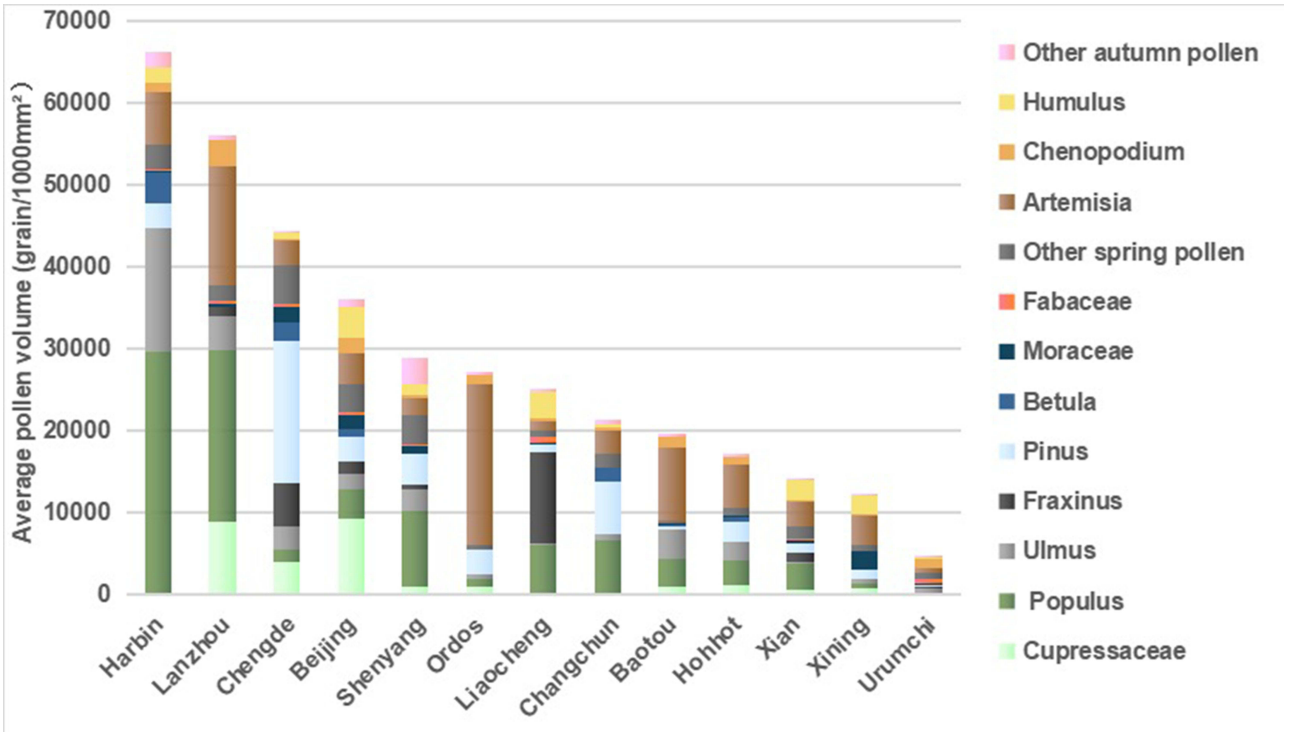

Figure 3 Main pollen species and daily average pollen count in 13 cities in Northern China.

gender differences were observed among the patients in the three regions. The demographic characteristics of these patients are shown in Table 2. Family history was reported in 51.6% of Central, 31.74% of Northwest, and 31.03% of Northeast patients with pollen allergy. AR patients with allergic conjunctivitis were more prevalent in Northwest (33/87, 37.93%) and Central China (99/281, 35.23%), AR patients with asthma was 11.74% (33/281) in Central China, 14.28 (18/126) in Northeast China, and 19.54% (17/87) in Northwest China. There was no difference in AR patients with asthma and allergic dermatitis in the three regions. 21.42% of pollen-related allergy patients in Northeast China reported a history of food allergies, higher than those in the Northwest and Central China. The patients with single pollen allergy accounted for

Table 2 Characteristics of Patients with Pollen-Related Allergy in Central, Northeast, and Northwest China

	Central China	Northeast China	Northwest China
Gender Ratio (M:F)	152:129	76:50	51:36
Age (years)	25.93 ± 14.80	25.76 ± 16.40	31.40 ± 12.78
Family History (%)	145 (51.60)	40 (31.74)	27 (31.03)
Complications			
Asthma (%)	33 (11.74)	18 (14.28)	17 (19.54)
Atopic Dermatitis (%)	40 (14.23)	22 (17.46)	15 (17.24)
Allergic Conjunctivitis (%)	99 (35.23)*	21 (16.67)	33 (37.93)*
Allergy history			
Food Allergy History (%)	21 (7.47)	27 (21.42)	9 (10.34)
Drug Allergy History (%)	8 (2.84)	10 (7.94)	11 (12.64)
Detected pollen allergens			
Mono-pollen allergy (%)	84 (29.89)	72 (57.14)*	42 (48.28)*
Pauci-pollen allergies (%)	102 (36.30)	35 (27.78)	25 (28.73)
Poly pollen allergies (%)	95 (33.81)	19 (15.08)	20 (22.99)

57.14% and 48.28% in Northeast and Northwest China, respectively, while 70.11% of AR patients in Central China were allergic to two or more pollen allergens (Table 2).

Symptom Scores of Pollen-Related Allergy Patients in Three Regions

We assessed nasal, ocular, and airway symptoms in patients with pollen allergy in three northern regions. The results showed that nasal, ocular, and respiratory symptom scores were significantly higher in Northwest than in Central and Northeast China, except for wheezing ($p< 0.01$ for total nasal score, nasal congestion, nasal itching, sneezing, watery rhinorrhea, ocular itching, tearing, and coughing, as compared with Central and Northeast China; $p < 0.01$ for chest tightness, dyspnea, and wheezing, as compared with Northeast China; chest tightness, and dyspnea as compared with the central region; $p < 0.05$). Furthermore, the symptom scores for dyspnea, wheezing, and tearing in Central China were higher than those in Northeast China ($p < 0.01$ and $p<0.05$, respectively) (Figure 4).

Quality of Life Scores of Patients in the Three Regions

The quality of life (QoL) score showed that, compared with Central and Northeast China, patients in Northwest China experienced more significant effects of their pollen-related allergies on their daily activities, leisure activities, and sleep (all $p < 0.01$). They also had manifestations such as fatigue ($p < 0.01$), irritability ($p < 0.01$), and thirst ($p < 0.05$) (Figure 5). The QOL did not differ significantly among patients in Northeast and Central China ($p > 0.05$), except for irritability ($p <0.01$).

Medication Usage, Symptom Control and Medical Cost in Three Regions

We assessed medication Usage, symptom control, and cost of pollen-related allergy patients in three regions. The results showed that the proportion of pollen allergy patients choosing to used oral antihistamines alone was the highest in three regions (40.93% in Central China, 32.95% in Northwest China, 34.35% in Northeast China), and 28.83% of pollen allergy patients in central China, 29.55% of Northwest China and 23.66% of pollen allergy patients in Northeast China used oral antihistamines combined with nasal steroids. Regarding symptom control, a significant percentage of patients

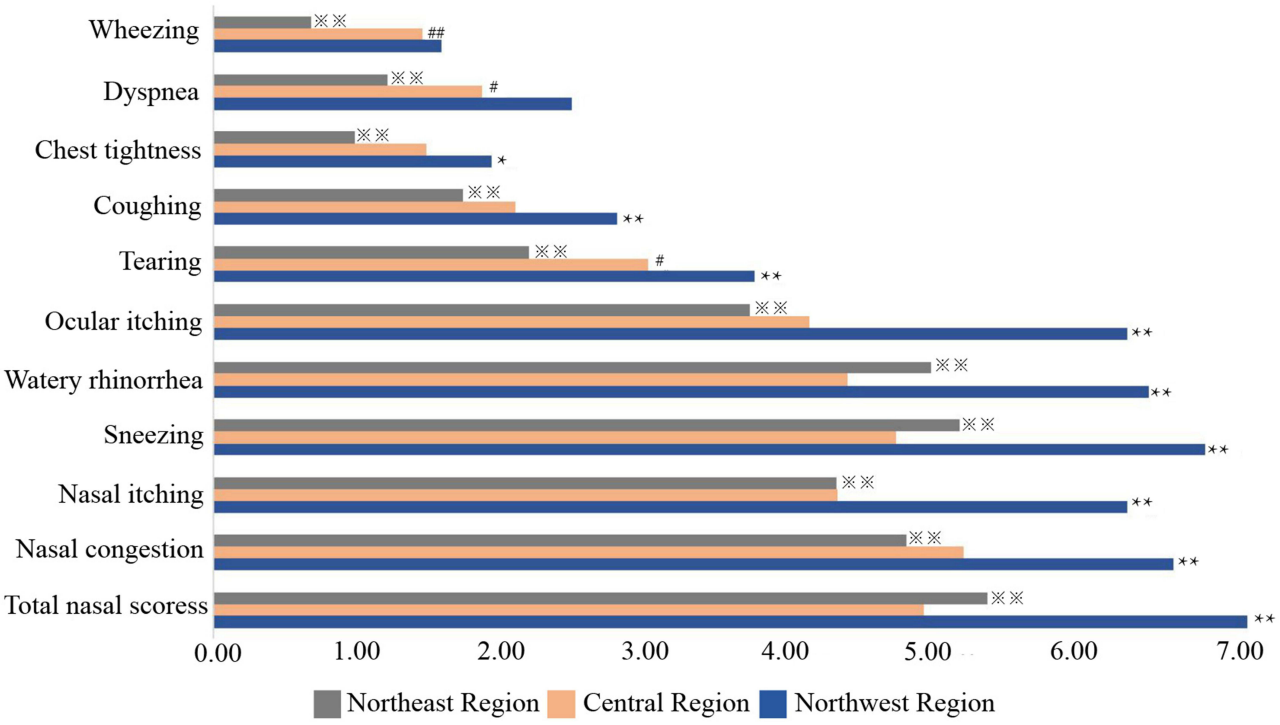

Figure 4 Symptom scores of pollen-related allergy patients in the Northwest, Northeast, and Central China. *Northwest vs Central; ※Northeast region vs Northwest region; #Central region vs Northeast region. Double markers indicate $p < 0.01$, single markers indicate $p < 0.05$.

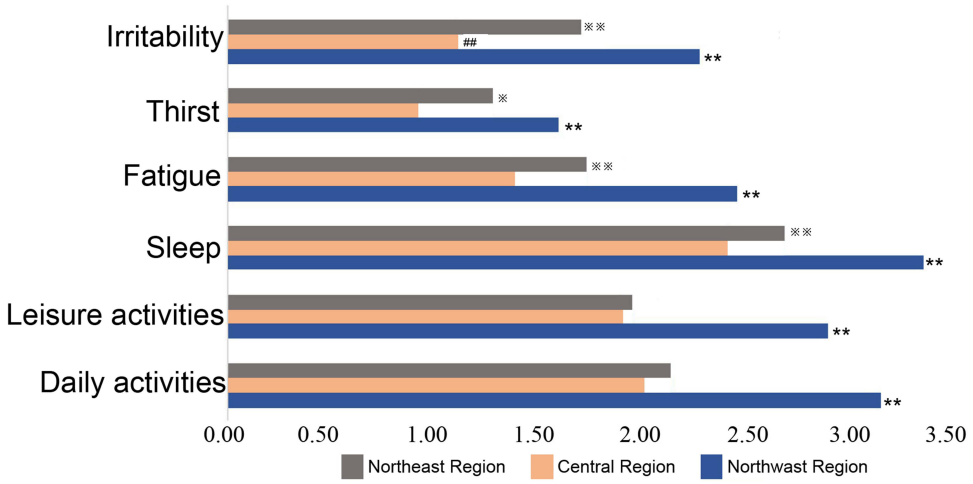

Figure 5 Quality of life scores of pollen-related allergy patients in the Northwest, Northeast, and Central China. *Northwest vs Central; ※Northeast region vs Northwest region; #Central region vs Northeast region. Double markers indicate $P < 0.01$, single markers indicate $p < 0.05$.

reported minor control (40.93% in Central China, 48.86% in Northwest China, and 44.27% in Northeast China), and only 1.14–6.90% reported complete control of symptoms. The annual cost of medication was estimated to be between 500 and 5000 yuan for 69.32–73.28% of the patients in various regions (Table 3).

Discussion

This study investigated the major airborne pollen sources and their temporal dispersion in 13 cities in northern China. Central and Northeast China had higher pollen counts in spring than in autumn, whereas in the Northwest China, spring and autumn pollen counts were similar, pollen periods start earlier and last longer than those in Central and Northeast China, and the autumn pollen counts in was significantly higher than in Central and Northeast China. Northern China has a temperate monsoon climate with little rainfall, with winds throughout the year. This climate is suitable for poplar, elm, pine and cypress, which have a high pollen yield and cause pollen-related allergy in spring.[21] Mugwort grow vigorously in the north China in autumn, particularly in Northwest China, where it is extensively planted for desert control, causing a significant increase in allergies in this region. A study of 6340 patients in different regions of China who underwent SPT to assess sensitization to related allergens found that the most common airborne allergen in northwest China was mugwort pollen,[11] with high levels of mugwort pollen exposure being the main cause. In addition to mugwort pollen, some northern cities show other weed pollen as the main autumn pollen, such as goosefoot in Urumqi, hop in Liaocheng, and ragweed in Shenyang. Unlike studies in some countries,[22] the summer gramineous pollen count in northern China is low, less than 1% of the annual pollen count, so the study did not include it in the main pollen.

We also analyzed the characteristics of patients with pollen-related allergy in these regions using questionnaires and serum-specific IgE (sIgE) tests. We found that AR patients with allergic conjunctivitis were more prevalent in Northwest (37.93%) and Central China (35.23%). Seasonal allergic conjunctivitis (AC) is the most common form of ocular allergy and accounts for 90% of AC cases.[23] Yamana et al found that pollen allergens sensitize the conjunctiva more strongly than other allergens.[24] High pollen concentrations in the Northwest can lead to more AR patients with AC symptoms.

Our results also showed 21.42% of patients in Northeast China reported a history of food allergies, higher than those in the Northwest and Central China. Pollen-food allergy syndrome (PFAS) has received attention in recent years because of the cross-reactivity between allergenic molecules in pollen and homologous epitopes containing plant-derived food proteins.[25] PFAS is a typical comorbidity of pollinosis. Clinically, PFAS is commonly characterized by isolated oral and pharyngeal symptoms with immediate onset upon food intake (oral allergy syndrome).[26] Adult and pediatric studies have shown that over 70% of patients with birch allergy had PFAS symptoms, while over 20% of patients with grass and ragweed allergy had PFAS symptom.[27,28] The underlying reason for food allergies in people with pollen-related allergies in Northeast China requires further study. Additionally, the results of allergens found that 57.14% and 48.28% of patients

Table 3 Medication Usage, Symptom Control, and Cost of Pollen-Related Allergy Patients in Central, Northeast, and Northwest China

	Medication Usage				Symptom Control				Cost			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Central China	34 (12.10%)	50 (17.79%)	115 (40.93%)	81 (28.83%)	29 (10.32%)	115 (40.93%)	125 (44.48%)	12 (4.27%)	49 (17.44%)	102 (36.30%)	99 (35.23%)	31 (11.03%)
Northeast China	22 (16.79%)	33 (25.19%)	45 (34.35%)	31 (23.66%)	20 (15.27%)	58 (44.27%)	44 (33.59%)	9 (6.90%)	24 (18.32%)	43 (32.82%)	53 (40.46%)	11 (8.40%)
Northwest China	10 (11.36%)	23 (26.14%)	29 (32.95%)	26 (29.55%)	21 (23.86%)	43 (48.86%)	23 (26.14%)	1 (1.14%)	22 (25.00%)	27 (30.68%)	34 (38.64%)	5 (5.68%)

Notes: Medication Usage: I, no medication was used; II, nasal steroids was used; III, oral antihistamines was used; IV, oral antihistamines and nasal steroids were used. Symptom control: I. No control; II. Minor control; III. Substantial control; IV. Total control. Cost (years): I, 100–500 yuan; II. 500–1000 yuan; III. 1000–5000 yuan; IV. > 5000 yuan.

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in Northeast and northwest regions were allergic to single-pollen, while 70.11% of patients in central regions were allergic to two or more pollen allergens, possibly because of the greater variety of vegetation in Central China.

We also found that the nasal, ocular, and other respiratory symptom scores were significantly higher in Northwest than in Central and Northeast China. Moreover, QoL scores were significantly higher in patients in Northwest China than in those in Central and Northeast China. These results are consistent with those of previous studies,[29] which demonstrated that the nasal symptom scores in patients with pollen allergies in Baotou City in Northwest China were significantly higher than those in Beijing. These results correspond to the long duration and large amount of pollen dispersal in Northwest China with its dry and windy climate, causing the plant's pollen sac to break easily, releasing a large amount of pollen. Additionally, Northwest China is vast, with a high yield of weed pollen, particularly mugwort pollen in autumn, as this plant has a long pollen period and the pollen exhibits more severe allergic symptoms.[30] Moreover, the spring pollen period in Northwest China occurred earlier, the autumn pollen period was longer, and the annual average pollen concentration was higher. Therefore, the extent and duration of exposure to pollen allergens are higher in Northwest China than in the other two regions, resulting in more severe allergic symptoms.

We also assessed medication Usage, symptom control, and cost of pollen-related allergy patients in three regions. The results showed that 40.93% of pollen allergy patients in Central China, 32.95% in Northwest China, and 34.35% in Northeast China used oral antihistamines alone, and 28.83% of pollen allergy patients in central China, 29.55% of Northwest China and 23.66% of pollen allergy patients in Northeast China used oral antihistamines combined with nasal steroids. 69.32–73.28% of patients had annual cost of anti-allergic medication between 500–5000 yuan. However, a significant percentage of patients reported minor control (40.93% in Central China, 48.86% in Northwest China, and 44.27% in Northeast China), and only 1.14–6.9% of patients reported total control of symptoms. These results indicated that although the annual medication cost was high for pollen allergy patients, their symptoms were not effectively controlled. A study investigating AR patients in UK general practice has reported that only 27% of the patients used standard medication involving both oral antihistamines and nasal steroids regularly, and 62% of these subjects described their symptom control as partial or poor.[31] More recent evidence also suggests that adherence to treatment is fairly low in AR,[32,33] suggesting that novel treatments or treatment strategies may be needed to improve adherence and management of patients whose symptoms are inadequately controlled with standard medication care.

Atmospheric pollen concentrations and pollen-related allergies are affected by air pollution and climate change.[7] Oak pollen exposed to elevated levels of SO2 or NO2 could significantly increase the fragility and disruption of the pollen, subsequently leading to increased release of pollen cytoplasmic granules. This increased bioavailability of airborne pollen allergens has been shown to cause an increased incidence of allergic disease.[34] A warming climate leads to earlier start of the pollen season and probably a longer SAR season.[35] Air pollutants also induce or aggravate allergic inflammation through various mechanisms such as disrupting the homeostasis of the epithelial barrier.[36]

Our study was limited in that it lacked a detailed analysis of patients' economic burden, which comprises direct (eg, medication and medical visits) and indirect costs (eg, absenteeism and presenteeism).[37]

In summary, this study analyzed the pollen dispersion in 13 cities of Northern China, and symptom characteristics, quality of life, medication, and medical costs of patients with pollen allergies. These results can be used as a basis for developing effective prevention and management measures for patients with pollen-related allergy in these regions, including timely pollen monitoring, patient guidance on protective measures, early intervention, and specific immunotherapy for different pollen allergens, to improve pollen-related allergy management.

Abbreviations

AR, Allergic rhinitis; sIgE, specific IgE; PFAS, Pollen-food allergy syndrome.

IRB Statement

Ethics approval and informed consent: Medical Ethics Committee of Beijing TongRen Hospital (version number: TRECLY 2020-076).

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Disclosure

The authors declare that they have no competing interests in this work.

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