

Very high birch pollen concentration in the air in selected Polish cities in 2022 – clinical implications

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A – Study Design
B – Data Collection
C – Statistical Analysis
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E – Manuscript Preparation
F – Literature Search
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ABSTRACT:

Introduction: In the Polish population, the most common cause of allergic rhinitis (AR) in the spring is birch pollen.

Aim: The aim of this study was to assess the basic characteristics of the birch pollen season in selected cities in central and northern Poland including Warsaw, Piotrkow Trybunalski, and Bydgoszcz in 2022, considering their clinical implications.

Material and method: Pollen monitoring was conducted using the volumetric method with the Hirst-type continuous volumetric sampler. Measurements were taken in 7-day cycles, and the microscopic analysis was performed for each 24-hour period.

Results During the studied period, birch pollen posed a threat in the 2nd and 3rd decades of April and the 1st and 2nd decades of May. The birch pollination intensity was reflected by the very high values of maximum average daily pollen concentration – 4102 pollen/m³ in Warsaw, 4389 pollen/m³ in Piotrkow Trybunalski, 3832 pollen/m³ in Bydgoszcz and the sum of the average daily pollen concentrations (i.e. Annual Pollen Integral, API) from 32439 in Bydgoszcz to 37638 in Warsaw, and long periods of exposure to high concentrations (29–30 days).

Conclusions: The pollen season 2022 is part of an alternating 2-year cycle of the birch pollen season intensity. The variability of parameters describing the dynamics of pollen seasons over years makes it necessary to monitor information on the pollen concentration in the air during the pollen season, both by the patients with inhalant allergy and their physicians.

KEYWORDS:

Allergic rhinitis, birch pollen season

ABBREVIATIONS

API – Annual Pollen Integral

AR – allergic rhinitis

EAACI – European Academy of Allergy and Clinical Immunology

EAN – European Aeroallergen Network

ECAP – Epidemiology of the Allergic Diseases in Poland

MPS – Main Pollen Season

OR – odds ratio

INTRODUCTION

In the last decades, there has been a significant increase in the incidence of AR, making this disease one of the major public health issues [1]. In the most extensive Polish epidemiological study (ECAP), nearly one-quarter of the respondents reported symptoms of AR [2]. Thus, it is one of the main reasons for visiting both the laryngologist and the allergologist, especially during periods when symptoms may exacerbate. For individuals allergic to pollen allergens, the symptoms occur during the pollen season of the sensitizing plant. The pollen that

is present in the air is the source of aeroallergens, which act on the respiratory tract of the allergic individual, eliciting symptoms of inhalant allergy, i.e. AR and/or asthma. Implementation of appropriate therapy allows for disease control, and one of the reasons of failure to control symptoms is an increased exposure to the allergen.

In the Polish population, the most common cause of symptoms of AR in the spring is birch pollen [3]. In the ECAP study, the incidence of positive skin prick tests for birch pollen allergens in the representative studied population was 14.9% [3]. Trees of many birch species are widely spread in Poland, and their flowers produce huge amounts of pollen [4]. Birch pollen seasons are characterized by high spatial and temporal variability [5–10], which affects symptoms in allergic individuals.

AIM

The aim of this study was to assess the basic characteristics of the birch pollen season in selected cities in central and northern Poland including Warsaw, Piotrkow Trybunalski, and Bydgoszcz in 2022, considering their clinical implications.

MATERIAL AND METHOD

Pollen monitoring in the pollen season 2022 was conducted in Bydgoszcz, Warsaw and Piotrków Trybunalski. Birch pollen concentrations in the air were recorded according to the EAN (European Aeroallergen Network) recommendations, using the volumetric method with the Hirst-type continuous volumetric sampler (Burkard, Lanzoni) [11, 12]. The measurements were taken in 7-day cycles, and the microscopic analysis was performed for each 24-hour period. The birch pollen season was characterized by the following parameters [13]:

- The average daily pollen concentration expressed as the number of pollen grains per unit volume of air (pollen/m³), including the highest value and the date its of registration,
- Annual Pollen Integral (APIn), which is the sum of the average daily pollen concentrations throughout the year,
- The Main Pollen Season (MPS) is the period of significant birch pollen concentrations in the air defined as:
 1. according to the EAN (European Aeroallergen Network) guidelines: beginning on the date when 1% of APIn is reached and ending on the day when APIn reaches 95%, [14, 15],
 2. according to the EAACI (European Academy of Allergy and Clinical Immunology) guidelines: beginning on the 1st out of five days over seven consecutive days, when each is characterized by the pollen concentration of at least 10 pollen/m³, and the sum of pollen concentrations for those five days is at least 100 pollen/m³. The end of the birch pollen season is the last day meeting the same conditions [15–18].
- The number of days with average daily pollen concentration beyond the threshold for eliciting allergic symptoms based on the literature [19].

The dynamics of the pollen season is shown on the graphs [Fig. 1.–3.]. The assessment of seasonal parameters was based on descriptive statistics.

RESULTS

In 2022, the main birch pollen season at the three monitoring sites (in Bydgoszcz, Warsaw, Piotrków Trybunalski) started in the 1st decade of April (between April 5th and 9th) and lasted until the 2nd decade of May (Tab. I., Fig. 1.–3.). The main pollen season (calculated according to the EAN guidelines) in Bydgoszcz and Warsaw lasted for 38 days, and in Piotrków Trybunalski – for 40 days, while based on the EAACI guidelines the calculated values were 42 days both in Bydgoszcz and in Warsaw, and 43 days in Piotrków Trybunalski, respectively (Tab. I., Fig. 1.–3.).

In Warsaw and Piotrków Trybunalski, the highest average daily birch pollen concentration in the air was recorded during the 1st week of the main pollen season and it was 4102 pollen/m³ and 4389 pollen/m³, respectively (Tab. 1., Fig. 1.,2.). The highest average daily birch pollen concentration in Bydgoszcz was recorded at 3832 pollen/m³ (Tab. 1., Fig. 3.).

The number of days with pollen concentration exceeding the threshold for allergic symptoms was 35–37 days (at least 20 pollen /m³) and 34–35 days (at least 30 pollen/m³), respectively. Exposure to high birch pollen level (at least 75 pollen /m³), resulting in exacerbated clinical symptoms, was noted for 29 days in Piotrków Trybunalski and for 30 days in both Warsaw and Bydgoszcz (Tab. I.).

In addition to the very high values of the highest average daily birch pollen concentrations and long exposure to high concentrations, the pollination intensity in 2022 was reflected by the high annual sum of the APIn, which was 32439 in Piotrków Trybunalski, 35093 in Bydgoszcz, and 37638 in Warsaw, respectively (Tab. I.).

The dynamics of the pollen season with rapidly increasing birch pollen concentration and characteristic peak values related to the highest average daily concentration are shown in graphs (Fig. 1.–3.). The course of the birch pollen season in the 3 studied monitoring centers in 2022 was similar (Tab. I., Fig. 1.–3.).

DISCUSSION

The characteristics of pollen seasons for each year vary in terms of time, course, and intensity.

The beginning of the main birch pollen season 2022 in the three monitoring sites, which was observed between April 5th and 9th, coincided with the beginning of the 2020 season, which started on April 7th (20). However, the beginning of the birch pollen season in 2021 in Warsaw and Bydgoszcz was recorded later, i.e. in the 2nd decade of April [21]. The average beginning of the birch pollen season in Warsaw over the years 2003–2017 was on April 10th [10]. This year's birch pollen season lasted until the 2nd decade of May, similar to the previous year, while in 2020 the birch pollen season in Warsaw, Bydgoszcz, and Piotrków Trybunalski ended at the end of April [20, 21]. The average end of the birch pollen season in the years 2003–2017 was April 29th, and the latest end of the birch pollen season in Warsaw during that period was on May 8th 2006 [10]. The results of the study conducted between 2001 and 2016 in Poland indicate that the end of the birch pollen season is more variable than the beginning of the season [5].

Due to their different functionality, 2 methods are used to define main pollen season: one method uses the percentage of the APIn (EAN definition), while the 2nd uses the pollen concentration threshold in the air (EAACI definition) [14–18]. While the definition by EAN has been developed to use in aerobiology, the definition by EAACI is applicable for clinical purposes, including, but not limited to, clinical trials and symptom control in patients with inhalant allergy. This year's birch main pollen season, calculated in accordance with the EAN guidelines, both in Bydgoszcz and Warsaw, was longer than in the two previous years, and lasted 38 days vs 32 days in Warsaw, 24 days in Bydgoszcz in 2021 vs 23–24 days in 2020, respectively [20, 21]. The use of the EAACI guidelines to determine the main birch pollen season in 2022, as clinically needed, increased its duration by a few days at all studied monitoring sites.

Tab. 1. Characteristics of Betula pollen season in 2022.

Feature of pollen season	Bydgoszcz	Warsaw	Piotrków Trybunalski	mean	stand.dev.	coeff. of variation C.V.
Main Pollen Season (EAACI definition)	8.04–19.05 (42 days)	6.04–17.05 (42 days)	8.04–21.05 (43 days)	42,33	0,58	1,36%
Main Pollen Season (EAN definition)	9.04–16.05 (38 days)	7.04–14.05 (38 days)	5.04–15.05 (40 days)	38,67	1,15	2,99%
Annual Pollen Integral (API _n)	35 093	37 638	32 439	35056,7	2599,69	7,42%
Peak value and peak date	3 832 (29.04)	4 102 (15.04)	4 389 (15.04)	4107,67	23090,78	562,14%
Days ≥ 20 pollen/m ³	36	35	37	36	1	2,78%
Days ≥ 30 pollen/m ³	34	34	35	34,33	0,58	1,68%
Days ≥ 75 pollen/m ³	30	30	29	29,67	0,58	1,95%

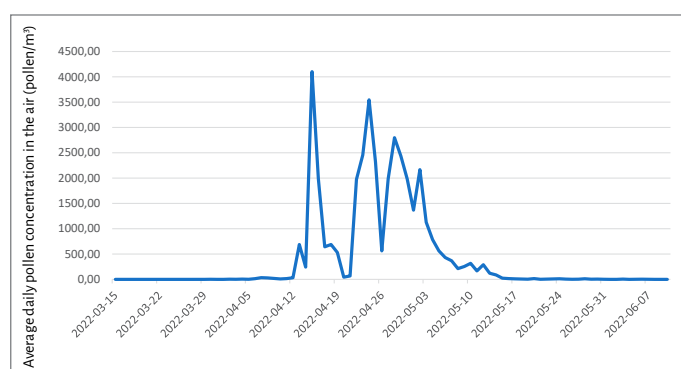


Fig. 1. Birch pollen concentration in Warsaw in 2022.

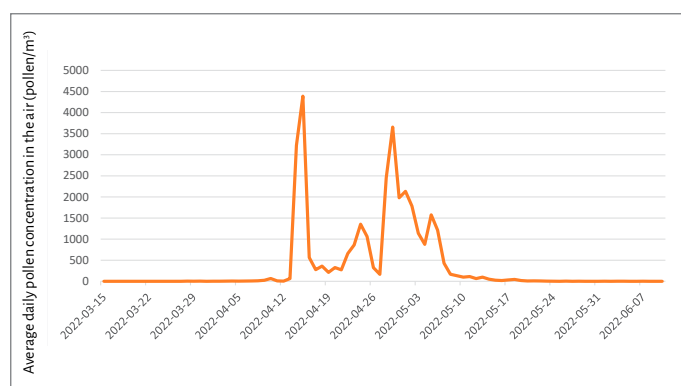


Fig. 2. Birch pollen concentration in Piotrków Trybunalski in 2022.

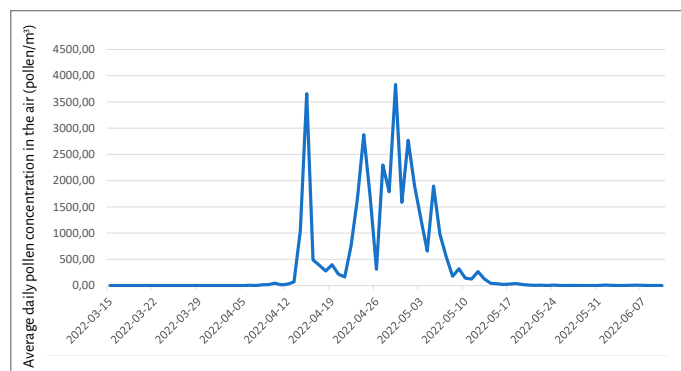


Fig. 3. Birch pollen concentration in Bydgoszcz in 2022.

The published studies show that the duration of the main pollen season is highly dependent on meteorological conditions, including temperature [22]. It is worth noting that birch pollen grains may be present in the air for a certain period of time after the end of the pollen season due to long-distance transportation of pollen or redeposition, which has been confirmed in studies [23]. The long-distance transportation can also affect the daily concentrations, which has been shown for the birch pollen season 2016 [24].

In the monitoring centers in central Poland, the highest average daily birch pollen concentration in the air was reached already in the 1st week of the main pollen season, which is consistent with the observations by other researchers on dynamically growing concentrations at the beginning of the birch pollen season [6]. This results in a sudden onset of symptoms in people allergic to birch pollen allergens, without gradual development of symptoms seen for other pollens.

The highest daily average birch pollen concentrations recorded in 2022 were following: 4102 pollen/m³ in Warsaw, 3832 pollen/m³ in Bydgoszcz, and 4389 pollen/m³ in Piotrków Trybunalski, respectively, which was 15.5 times higher than the highest average daily pollen concentration recorded in Warsaw in 2021 and more than 4 times in Bydgoszcz [21]. The birch pollen season 2020, which was more intense than season 2021, was characterized by the highest average daily pollen concentrations lower than in this year's season, it was 2.3 times lower in Warsaw, 3.9 times lower in Bydgoszcz, and 1.8 times lower in Piotrków Trybunalski, respectively [20–21].

The comparative analysis of multi-center data from various Polish cities between 2001 and 2015 showed that the highest birch pollen concentrations were recorded in the central part of the country in Warsaw and in Lublin, with the maximum value of the achieved concentrations being among the most varied feature [5]. The analysis of pollen monitoring data in Warsaw between 2003 and 2017 showed that the highest average daily birch pollen concentration reaching 6321 pollen/m³, recorded in 2012, exceeded the lowest maximum average daily pollen concentration by almost 20 times in season 2015 [10].

The parameter reflecting the pollination intensity is the API_n, which, according to the published studies, is among the most diverse characteristics of birch pollen seasons [5, 6]. The value achieved in 2022 for Warsaw was 12.7 times higher than the value recorded in 2021, and 3.6 times higher than the value recorded in 2020 [20, 21]. The value of this variable in 2022 in Bydgoszcz was 6.4 times higher than the value achieved in 2021 and 5 times higher than the value recorded in 2020 [20, 21].

The variability in birch pollination intensity observed in the recent years is consistent with the two-year birch pollen intensity pattern described in many publications, where subsequent seasons are characterized by alternating high and low API_n and highest average daily pollen [5–10]. In the published multi-center studies between 2001 and 2016, due to the wide variety of birch pollen seasons over those years, high pollen-emitting seasons were distinguished [5]. Based on the recordings during the birch pollen season 2022, this year's season can be put in this group as well. The alternating pollen emission cycle is strongly influenced by weather conditions, including temperature and relative humidity [6, 7, 22, 25]. Differences in the intensity of birch pollen seasons may also be linked to cyclical rhythms of high and low pollen production [6].

The Hirst-type volumetric trap is a low-volume sampler, and the air intake can be compared to the air intake in humans [14]. Therefore, data on pollen concentration in the air can be related to data on symptoms in patients suffering from allergic rhinitis and allergic asthma. Symptoms of allergy to pollen allergens will appear when the airways of the sensitized person are exposed to pollen concentrations exceeding the threshold level, which may vary in terms of individual reactivity, type of pollen, and environmental factors [26, 27].

The parameter analyzed in our study was the number of days with the average daily birch pollen concentration above the threshold level for the development of allergic symptoms. Compared to the literature data [19], the birch pollen season 2022 was abundant in days with pollen concentration that could elicit allergic symptoms. The number of days when the symptoms might occur (at least 20 pollen/m³) was approximately 1.5 times higher than in the previous year, both in Warsaw and Bydgoszcz, and the number of days with the concentrations of at least 75 pollen/m³ resulting in more pronounced clinical symptoms, was 2.3 times higher in Warsaw (30 days in 2022 vs 13 days in 2021) and 1.7 higher in Bydgoszcz (30 days in 2022 vs 18 days in 2021), respectively [20, 21]. This number 1.7 times exceeds the average number of days with high pollen concentrations in Warsaw between 2003 and 2017 (30 vs 18) [10].

The study published by Jantunen et al. indicated a correlation between the allergy symptoms and pollen concentration in the air, and led to the conclusion that the risk of symptoms at low, moderate, and high pollen concentration is affected by progression of the pollen season [28]. It is accompanied by the so-called 'priming' effect, which is related to different levels of allergen-triggering symptoms at the beginning and at the end of the pollen season. Due to the priming effect, early exposure reduces the sensitivity threshold for triggering symptoms at the later stage of the pollen

season [17, 18, 29]. In the case of birch pollen allergy, the priming effect can also be attributed to the prior exposure to the allergens of hazel and alder, the pollen of which is present in the air during the period preceding the birch pollen season [7].

When considering the relationship between the exposure to pollen grains present in the air and the occurrence of allergy symptoms, it should also be taken into account that pollen grains are not the only respiratory particles that can carry pollen allergens. Aeroallergens reach the airways with breathing air also in the form of cytoplasmic starch granules and pollen-derived small particles (in the range of 0.6 to 2.5 micrometers in diameter), as well as sub-micron particles (orbicules) (0.02–1 micrometers in diameter). Thus, the severity of symptoms during the pollen season may also be associated with the high level of allergens in the air as the fine particle fraction a few days after the peak of pollination, or as allergens released from pollen grains due to atmospheric conditions [29]. In the study by Bastl et al., the concentration of the main antigenic components of the birch *Bet v 1* in the air proved to have a strong effect on symptom development in people with birch allergy, regardless of the number of birch pollen grains in the air [30].

The concept of Pollen Allergy Risk is defined as the ability of pollen grains, either alone or with other factors such as air pollution, meteorological variables, to cause health effects [13]. The published data indicate that air pollutants should be treated as 'adjuvants' modifying the expression of allergenic proteins in pollen grains. The increase in pollen allergenicity in the presence of air pollutants can be considered as a new environmental factor affecting the increase in inhalant allergy, particularly in urban areas [31–33]. Climate change can also have an impact on this, similar to the anthropogenic atmospheric increase in carbon dioxide (CO₂) [34]. The experimental increase in CO₂ concentration showed changes in the amount of pollen and its allergenicity [35]. Analysis of the effect of pollen concentration in the air on the severity of symptoms should also include the above-listed variables.

The study carried out by French researchers Caillaud et al. on a group of 61 patients with birch pollen allergy indicates that the reaction to natural exposure to birch pollen changes during the pollen season; with a threshold concentration eliciting symptoms at the beginning of the season and linear relationship during the season, until the saturation point is reached, followed by a plateau effect. For symptoms of allergic rhinitis, the saturation point in that group of patients was reached at 110 pollen/m³ [27].

Allergic rhinitis affects 60–95% of asthma patients, while 19–38% of individuals with allergic rhinitis have co-existing asthma [36]. Ross et al. investigated the relationship between the average daily pollen concentration in the air and the likelihood of asthma exacerbation due to tree pollen exposure in the pediatric population living in Philadelphia. They assessed the effect of exposure on the same days as well as 5 days after exposure. The odds ratio (OR) for moderate symptoms indicated an increased risk at tree pollen concentrations above 10 pollen/m³, and the risk of moderate to severe symptoms increased after exposure to more than 30 pollen/m³ (OR 1.31) then 60 pollen/m³ (OR 1.45), respectively. The odds ratio of severe asthma exacerbation after exposure to tree pollen

concentration of more than 1000 pollen/m³ was 1.64 [27]. In the monitoring sites in the birch pollen season of 2022, the number of days with the average daily pollen concentrations exceeding 1000 pollen/m³ was between 12 and 13. Guillbert et al. investigated the relationship between the level of aeroallergens in the air, including birch pollen, and the rate of hospitalization resulting from asthma exacerbation in the Brussels region, Belgium [38]. The asthma-related hospitalization rate was statistically significantly influenced by the birch pollen concentrations in the air. They observed a relationship between hospitalization and an increase in birch pollen concentration by 40 pollen/m³. A significant increase in hospitalization rate due to asthma correlating with increasing pollen concentration was observed for the birch (3.2%, 95% CI: 1.1, 5.3).

The intensity of the pollen season has a significant effect on symptoms in individuals with inhalant allergy [39]. The results from pollen monitoring provide information on the course of the pollen seasons for each year as well as on-going information on the current and predicted exposure to aeroallergens. It allows patients to self-check for allergic symptoms, which is essential for

comprehensive diagnosis of allergic rhinitis and for the application of preventive measures, since avoiding contact with the allergen is an important part of the disease control strategy. The physician uses this information to make a diagnosis, prescribe symptomatic treatment, assess its effectiveness and the risk of hospitalization due to asthma exacerbation [40].

CONCLUSIONS

In 2022, birch pollen was a threat in the 2nd and 3rd decades of April and the 1st and 2nd decades of May in the studied central and northern cities of Poland. The birch pollination intensity in the studied season was reflected by the very high values of the highest average daily birch pollen concentration as well as the sum of the APIn and the long exposure period to high concentrations. The pollen season 2022 is part of an alternating 2-year cycle of the birch pollen season. The variability of parameters describing the dynamics of pollen seasons over years makes it necessary to monitor the pollen concentration in the air during the pollen season, both by the patients with inhalant allergy and their physicians.

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