

Article

Study of the Interrelations of the Concentrations of Six Tree Pollen Types and Six Atmospheric Pollutants with Rhinitis and Allergic Conjunctivitis in the Community of Madrid

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Abstract: Allergic pathologies of aerobiological origin, specifically those caused by exposure to pollen allergens, have shown a growing trend in recent decades worldwide. This trend is most evident in urban areas experiencing an incessant expansion of their territory. Several studies have shown an interaction between atmospheric pollutants and pollen grains, which implies a potentiation of the allergenicity of the latter. This study aims to analyze the possible influence, in the Community of Madrid (CAM), of the concentrations of six atmospheric pollutants (O₃, particles PM₁₀ and PM_{2.5}, NO₂, CO, and SO₂), and of the pollen concentrations of six types of tree pollen (*Cupressaceae*, *Olea*, *Platanus*, *Pinus*, *Ulmus*, and *Populus*) on the episodes of attention of two pathologies, rhinitis and allergic conjunctivitis. The data collected came from the Air Quality Networks of the CAM and the Madrid City Council, the Palynological Network of the CAM, and the General Subdirectorate of Epidemiology of the Health Department of the CAM. Descriptive multiple linear regression models were used to analyze the interrelationships of the three variables. In most of the calculations performed, the adjusted R² value is higher than 30%, and, in all cases, the *p*-values of the models obtained are less than 0.0001. All the models performed in the study period for allergic rhinitis indicate a reasonable correlation, and this is also true for almost all of the models calculated for allergic conjunctivitis. Moreover, it is allergic rhinitis for which the highest values of adjusted R² were obtained. *Pinus* is the pollen type most frequently interrelated with conjunctivitis and allergic rhinitis (followed in both cases by *Olea* and *Populus*) throughout the study years. In this same period, O₃ is the air pollutant most frequently present in the models calculated for allergic conjunctivitis (followed by NO₂ and PM₁₀), while particle PM₁₀ is the most frequently included in the calculations made for allergic rhinitis, followed by O₃ and SO₂.

Keywords: urban trees; pollen; air pollutants; rhinitis and allergic conjunctivitis



Citation: Chico-Fernández, J.; Ayuga-Téllez, E. Study of the Interrelations of the Concentrations of Six Tree Pollen Types and Six Atmospheric Pollutants with Rhinitis and Allergic Conjunctivitis in the Community of Madrid. *Appl. Sci.* **2024**, *14*, 2965. <https://doi.org/10.3390/app14072965>

Academic Editor: Jiangjun Wei

Received: 2 March 2024

Revised: 28 March 2024

Accepted: 29 March 2024

Published: 31 March 2024



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1. Introduction

Both asthma and allergic rhinoconjunctivitis, as well as other diseases of the exact etiology in general, are pathologies that, in recent decades, have been reaching increasing levels of prevalence worldwide. Pollen is considered as the primary aeroallergen inducing allergic hypersensitivity reactions. In addition, among people living in urban areas, there is a higher prevalence rate of these pathologies, which induce inadequate responses of the immune system to substances that, under normal conditions, are harmless [1].

In addition, the existence of atmospheric pollutants determines an interaction with aeroallergens capable of increasing their allergenic capacity. This interaction can occur according to different mechanisms. Thus, these pollutants can enhance the release of allergens present in pollen grains by weakening their cell walls, modifying their allergenic potential, acting as adjuvants for the stimulation of immunoglobulin E (IgE)-mediated responses, as

well as acting as stressors, causing the exacerbation of the manifestation of some allergens present in pollen grains, and thus inducing immune responses in humans [1–4].

The effects of atmospheric pollutants on pollen grains will differ depending on the pollen type involved. Thus, for example, in *Cupressaceae*, they can cause an increase in the fragility of the exine and, consequently, an increase in the allergenicity of the affected pollen grain, as well as an increase in the expression of the Cup a 3 allergen; or, in *Platanus*, they can cause an increase in the total protein content of the pollen grain, with a consequent increase in the levels of the major allergen of this pollen type, Pla a 1, after exposure of the pollen grain to gaseous pollutants [1,5].

On the other hand, as shown in other studies, meteorological parameters also act synergistically on pollen grains (as well as on all types of aerobiological particles and pollutants) in the atmosphere. These parameters strongly influence—in a wide variety of ways and on different time scales—their presence and concentration in the atmosphere. This occurs both in the stages prior to flowering and during flowering itself, in the stages of emission, transport, dispersion, and/or deposition [6]. Thus, wind generally acts as a promoter of pollen grain transport if its intensity is within certain limits [6–8]. Solar radiation, with its accumulation over time, acts, like insolation, as a stimulator of biological activity and as an agent enhancing the increase in pollen concentrations in the atmosphere. However, ultraviolet radiation can lead to a stress modification of plant physiology and, together with an excessive increase in temperature and a variation in humidity in time and space, can cause excessive production of pollen grains and lead to a consequent increase in their allergenicity, with negative consequences for the health of citizens [9–12].

If atmospheric pollutants bind to these pollen particles, an allergen with increased allergenic potential may be formed, leading to exacerbations in the manifestations of asthmatic disease or any other pollen allergic pathology. Likewise, pollen grains can release biologically active lipids, which can provoke the activation of immune cells. Thus, the morphological changes induced by atmospheric pollutants in pollen grains could be behind the increase in allergic diseases referred to above, which implies that in urban areas, the allergenicity of pollen may increase in comparison to rural areas. There is increasing evidence from studies indicating an association between urbanization and an increase in the severity and prevalence of allergic symptoms. Accordingly, it is necessary to manage air pollution and urban planning in terms of the selection of plants for green areas in cities, limiting as far as possible those with anemophilous pollination whose pollens have a higher allergenic potential [1,13]. Apart from their positive effects on health, various studies recognize that trees emit a high percentage of pollen (73.5%) of the total generated by the total anemophilous flora in the CAM [14].

Although pollen grains have resistant exines, they are subjected to aggressive environmental conditions that can impair their viability, such as dehydration and radiation, although atmospheric pollutants are the most threatening agents for pollen survival. For this reason, the concentration of pollen grains can become an indicator of the health of plant masses [14].

Under favorable conditions, the viability of pollen grains in the atmosphere varies from a few hours to more than a year, as in the case of *Pinus* pollen. In addition, some meteorological phenomena, such as thermal inversions, convection, and turbulence, can condition the greater or lesser accumulation of pollen grains and their transport. This fact could help us understand atmospheric dynamics better and design predictive models [14,15].

Knowledge of the concentration and composition of pollen in the atmosphere, with its capacity to affect the population affected by pollinosis and asthma in each geographical area and on each day of the year [14], makes it possible to obtain crucial data related to the diagnosis and treatment of these conditions, as well as to establish preventive measures. Two other objectives of the Palinocam Network are to disseminate daily information to the affected population, as well as to the health professionals who care for these patients, and to carry out a study on the association over time between the levels of pollen in the atmosphere and their effects on health [14,16–18].

Thus, the Palinocam Network was conceived in such a way that, with its different sampling points, located in different environments and with complementary to each other, it would provide information on the levels of average pollen concentrations in the atmosphere in which the lives of the citizens of the CAM take place [19]. Thanks to the existence of the Network, it was possible to complete a study between 1994 and 1999 (which was analyzed in another study [20]), in which 18 types of pollen were included, selected—among the approximately 60 total identified—for their levels of presence in the atmosphere, as well as for their potential allergenic power. Among these 18 selected types are the 6 included in the present study. The amounts of time that these 18 pollen types were present in the atmosphere were similar in all the Network stations. Some remained suspended in the air for a long time (as in the case of *Cupressaceae*, *Gramineae*, or *Urticaceae*). In contrast, others persisted only briefly (as in the case of *Platanus*, *Moraceae*, or *Betula*). The main differences detected were the different concentrations of the different types of pollen in the various points of the Network due to the different floristic compositions surrounding each of the measurement stations [14].

The highest pollen concentrations during the year in the CAM have been recorded from March to June. The highest levels of pollen present in the atmosphere in the 1994–1999 period were recorded for *Platanus* (21.6% of total pollen), followed by *Cupressaceae* (16.1%) and *Quercus* (12.4%). This fact is explained by the use of shade plane trees and cypresses as ornamental trees in the green areas of the CAM and, in the case of *Quercus*, by the existence of holm oaks and honey oaks in the more rural areas of the study territory. Pollen from tree species accounts for 73.5% of the total pollen, while herbaceous species account for 17.2%. Grasses are the most frequent contributors among herbaceous species, with 8.7%, which, among other locations, are also spontaneous and are part of the lawns of many urban green areas [14].

According to another investigation carried out in the period 1979–1996 by J. Subiza et al. in the city of Madrid [18], the most frequent pollen types in this city were *Platanus* (with 17% of the total pollen), grass pollen (13%), *Cupressaceae* (12%), *Olea* (8%) and *Plantago* (3%). These counts were correlated with the results of prick tests performed on 411 patients with pollinosis living in Madrid. The prevalence of positive prick tests among these patients was 94% for grass pollen, 61% for *Olea*, 53% for *Plantago*, 52% for *Platanus*, and 20% for *Cupressaceae*. Polysensitization was the rule in this study. Of the patients, 95% with positive skin tests against *Poaceae* pollen showed positive sensitivity to other types of pollen. Thus, it can be observed that three of the tree types included in this study are among the producers of pollens with the highest allergenic power, as already mentioned in another analysis [20]. It can be affirmed, because of this study, that although grass pollen seems to be, by far, the leading cause of pollinosis in the city of Madrid, pollen from tree species, specifically *Olea*, *Platanus*, and *Cupressaceae*, also has an essential allergenic power [14,18,21]. Particular attention should be paid to the types of pollen that can generate what is known as epidemic pollinosis and, of course, those that can generate epidemic asthma [14].

Pollen is a growing health problem, affecting a continuously increasing number of people. Thus, the prevalence of asthma and allergic rhinitis has been increasing severely in recent years in Japan, Europe, and North America. Pollen allergy can cause more or less chronic symptoms depending on the severity of the cases. It can manifest itself, among other ways, in rhinitis, conjunctivitis, asthma, atopic dermatitis, and anaphylactic shock, depending on which part of the body is affected [14]. In addition, more and more studies confirm that air pollution plays an essential role in the increase of pollinosis [22]. Given this reality, it is worth adopting the measure of adequate planning of green areas aimed at reducing the presence of species with particularly allergenic anemophilous pollination [14].

This study aims to determine the influence of certain atmospheric pollutants and pollen types on the cases of rhinitis and allergic conjunctivitis detected in the CAM.

2. Materials

The years of this study are 2014, 2015, 2016, and 2017. To be able to carry it out, data on pollen concentrations in the atmosphere, concentrations of atmospheric pollutants, and episodes of attention of 2 types of allergic diseases have been collected.

Pollen data have been supplied by the Palinocam Network of the Regional Ministry of Health of the CAM [20]. In 1992, the Regional Commission for the Prevention and Control of Asthma was created from the Regional Program of the same name to improve the quality of life of patients with asthma in the CAM and, to this end, it began to develop its activity in the form of 4 areas of work. One of them consists of epidemiological surveillance, which initially aimed to know the prevalence and incidence of asthma and its evolution in the territory of the Autonomous Community. Another area of work is environmental surveillance, whose aim is to detect the evolution of atmospheric pollutants, to know the types of pollen and their distributions in time and space, and to disseminate these pollen data to allergists, pulmonologists, pediatricians, emergency services, primary care teams, and allergic patients [14]. The air pollutant data have been provided by the Air Quality Network of the Regional Ministry of Environment, Spatial Planning and Sustainability of the CAM, and by the Air Quality Network of the Madrid City Council [20].

These two data types are collected daily and obtained from measurements made by sampling stations. They have been described in detail in the abovementioned study, in which the correlation between both factors was also analyzed. Thus, in that study, the six types of tree pollen and the six atmospheric pollutants are analyzed, including their mean values, standard deviation, and coefficient of variation of both independent variables. In addition, in the case of the pollen types, their percentage of representation concerning the total pollen collected in the 11 stations of the Palinocam Network is specified. The geographical location and nomenclature of the measurement stations of the two types of variables, the description of the arboreal biodiversity, and the analysis of the benefits of its presence in the CAM are also noted [20].

As for the data on episodes of care, also collected daily, they have been collected by primary care consultations from the Health Centers located in the 11 areas of the Palinocam Network (Table 1) and supplied by the General Subdirectorate of Epidemiology of the Health Department of the Regional Ministry of Health of the CAM.

Table 1. Names of the CAM Health Centers from which the data on episodes of care for the allergic pathologies analyzed in this study were obtained. These centers were selected within the areas of influence of the 11 stations of the Palinocam Network. The approximate distances of each Health Center from the corresponding Palinocam Network station, measured with the Google Earth geographic information system, are shown in parentheses. The areas corresponding to the capital of Madrid have been shaded in light blue.

Palinocam Network Stations	Nearest Health Centers
Alcalá de Henares	Carmen Calzado (505 m), Reyes Magos (1020 m), María de Guzmán (1090 m), Manuel Merino (1100 m), Puerta de Madrid (1130 m), Luis Vives (1180 m), Nuestra Señora del Pilar (1550 m), Juan de Austria (1630 m), La Garena (2140 m), Miguel de Cervantes (2800 m).
Alcobendas	Marqués de Valdavia (630 m), Valdelasfuentes (880 m), La Chopera (1130 m), Miraflores (1420 m), Arroyo de la Vega (1890 m).
Aranjuez	Aranjuez (0 m), Las Olivas (1400 m).
Coslada	Doctor Tamames (290 m), El Puerto (816 m), Valleaguado (1930 m), Jaime Vera Coslada (2115 m), Ciudad San Pablo (2137 m).

Table 1. Cont.

Palinocam Network Stations	Nearest Health Centers
Madrid: Barrio de Salamanca	Príncipe de Vergara (515 m), Lagasca (585 m), Montesa (815 m), Castelló (939 m), Prosperidad (1070 m), Londres (1118 m), Santa Hortensia (1150 m), Ciudad Jardín (1332 m), Baviera (1392 m), Espronceda (1685 m), Goya (1734 m), Segre (1761 m), Daroca (1770 m), Ibiza (2003 m), Eloy Gonzalo (2044 m), Justicia (2110 m), Canal de Panamá (2170 m), Potosí (2290 m).
Madrid: Ayuntamiento de Madrid	Delicias (219 m), Embajadores (345 m), Cáceres (429 m), Martín de Vargas (558 m), Párroco Julio Morate (656 m), Lavapiés (927 m), Alameda (1070 m), Legazpi (1456 m), Las Cortes (1593 m), Paseo Imperial (1610 m), Las Calesas (1637 m), Comillas (1660 m), Pacífico (1687 m), Segovia (1748 m), Adelfas (1791 m), Quince de Mayo (1992 m).
Madrid: Ciudad Universitaria	Andrés Mellado (1346 m), Reina Victoria (1616 m), María Auxiliadora (1725 m), Cea Bermúdez (1818 m), Guzmán el Bueno (1948 m), Casa de campo (2038 m), Arguëlles (2150 m), Villaamil (2189 m), Isla de Oza (2478 m).
Getafe	Las Margaritas (784 m), Juan de la Cierva (816 m), Sánchez Morate (940 m), El Greco (1332 m), Las Ciudades (1693 m), El Bercial (1783 m), Getafe Norte (1969 m), Sector III (2050 m), Perales del Río (6584 m).
Leganés	Santa Isabel (153 m), Doctor Mendiguchia Cariche (765 m), María Jesús Hereza (920 m), Huerta de los Frailes (1195 m), María Ángeles López Gómez (1460 m), Jaime Vera Leganés (1705 m), María Montessori (2070 m), Leganés Norte (2375 m), Marie Curie (3690 m).
Las Rozas	Monterrozas (2710 m), Consultorio La Marazuela (pertenece al C.S. Las Rozas—El Abajón) (3700 m), Las Rozas-El Abajón (3908 m).
Collado Villalba	Collado Villalba Pueblo (1315 m), Collado Villalba Estación (3115 m), Sierra de Guadarrama (3180 m).

The episodes of care for rhinitis and allergic conjunctivitis refer to the number of persons consulted daily about these pathologies. These data are recorded in the electronic medical record of primary care with the respective codes R97 and F71, according to the International Classification of Primary Care (CIAP-2). These episodes do not include their etiology or other circumstances, such as confirmation by allergy testing. Nor do they imply the presence of symptoms derived from such diseases. Because of these circumstances, the clinical prevalence of the two pathologies under study cannot be calculated directly from the data on episodes of care. However, this calculation can be approximated, considering the limitations of the information recorded.

The episodes of care are not counted on weekends or holidays since, on those occasions, there are no consultations. On the other hand, for the processing of these daily data, given that each of the Health Centers that make up each of the 11 study areas has been attending, in the different study years, a specific total assigned population (collected in the Observatorio de Resultados del Servicio Madrileño de Salud, in the 5th and 6th Primary Care Reports) [23], a weighted average of the episodes of care has been made, so that different weights have been assigned to each of the different Health Centers. These weights were calculated by dividing the total assigned population—of all age groups—of each Health Center by the sum of the populations of all the Health Centers in each of the 11 zones of the Palinocam Network.

2.1. Data on Allergic Pathologies

The following describes each of the two allergic pathologies analyzed in this study. Prevalence data are provided for each of them to obtain an approach to the influence of pollinosis on the Spanish population and, more specifically, on the population of the CAM.

2.1.1. Data on Allergic Conjunctivitis

Allergic conjunctivitis is a pathology that affects the eye's mucous membranes and is caused by allergy to substances present in the environment, such as pollen, mites, molds, and animal epithelia. It may also occur because of food allergy. Conjunctivitis often occurs together with rhinitis (inflammation of the mucous membrane of the nose). When this occurs, it is called rhinoconjunctivitis. The symptoms of conjunctivitis are similar to those that occur in the mucous membranes of the nose in rhinitis: the patient's contact with the allergen causes inflammation of the layers of the eye, inflammation that leads to an excessive reaction (ocular hyperreactivity) to the triggers, which ultimately results in the appearance of the typical symptoms. Thus, there may be congestion resulting in redness due to dilation of the veins, sometimes followed by swelling of the eyelids; photophobia, i.e., a reaction of intense, even unbearable discomfort to light; tearing; itching, which leads to blinking, more frequent than usual, and even to winking of the eyes, which may be mistaken for a nervous tic; and the appearance of eyelashes, usually in small quantities. These symptoms may occur together or in isolation. Depending on the case, they can be severe or almost imperceptible. They may also vary in duration, with some occurring for only a few minutes, or they may last for several months [24].

2.1.2. Data on Allergic Rhinitis

Allergic rhinitis is the most prevalent allergic pathology. It is frequently associated with other allergic pathologies, both respiratory and other, such as allergic conjunctivitis and asthma. It presents with inflammation of the nasal mucosa, mediated by IgE antibodies, and is caused by exposure to an allergen in previously sensitized patients. These allergens, as occurs in pollinosis, are very diverse: pollen, dust mites, animal epithelia, fungal spores, and chemical substances, among others. It can present with itching and a runny nose, leading to throat pain, paroxysmal sneezing, and nasal congestion [25].

When the allergen that causes this disease is inhaled, the mucosal cells of the nasal passages produce histamine, which induces the nasal itching characteristic of this pathology and inflammation and mucus production. To determine whether this disease (and pollinosis in general) is specific to pollen exposure, skin tests (prick tests) are performed, as well as the determination of specific IgE in the blood. Seasonal allergic rhinitis, or "hay fever" (in contrast to perennial rhinitis, which occurs throughout the year and is caused by allergens continuously present in the environment that the patient breathes in, such as animal epithelium, fungal spores, or dust mites), occurs when the allergen, usually pollen, is present in the atmosphere in sufficient concentrations to provoke a hyperreactivity response in the patient [25].

A total of 79.5% of the patients had already undergone treatment the year before consultation, mainly antihistamines and, to a lesser extent, topical nasal corticosteroids. Of the patients with rhinoconjunctivitis, 68% also suffered from other allergic diseases; the coexistence of rhinoconjunctivitis and asthma (in 33.7% of the cases) stands out. Of the cases of rhinoconjunctivitis diagnosed, 79.3% had an allergic cause, which indicates an appropriate referral to the Allergology Department. As for the allergens involved in the cases studied, the most frequent were pollens (70.8%), followed by mites (43.2%) and animal epithelia (21.3%). The remaining allergens are much less frequent. Specifically, in the study area, the CAM, the percentage of patients with rhinoconjunctivitis sensitized to some pollen is 93.8%, the second highest value of all the regions of Spain, after Castilla-La Mancha [25].

3. Methods

The information provided for the independent variables, "concentration of pollen grains" and "concentration of atmospheric pollutants", as well as for the dependent variables, "episodes of attention for rhinitis and allergic conjunctivitis", corresponds to daily data.

To determine the degree of relationship between each of the two dependent variables and each of the independent variables, the Statgraphics Centurion 19 data analysis tool was used for all statistical calculations. For this purpose, descriptive calculations of multiple linear regression were performed because the number of independent variables included in each adjusted model is between 9 and 12, depending on the availability of data from the Air Quality Networks, the Madrid City Council, and the CAM, and since the total information on the pollen types was available from the 11 stations of the Palinocam Network. The methodological sequence used to obtain the multiple regression models is shown in Figure 1.

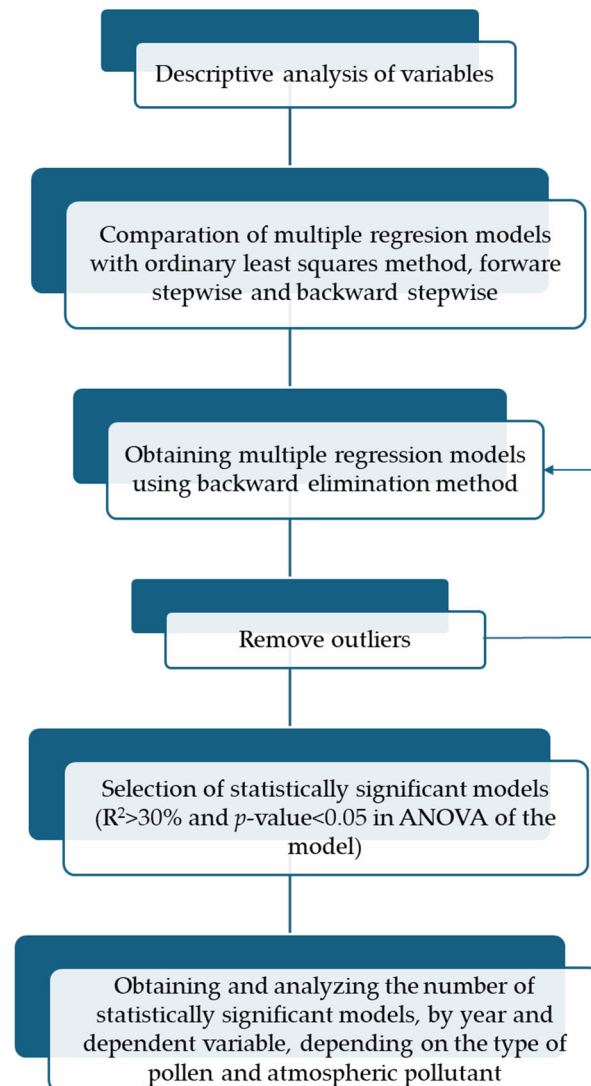


Figure 1. Flowchart of research methodology.

As a result of these calculations, the values of the R^2 statistic adjusted to the degrees of freedom were obtained since this is the most appropriate method for comparing models with different numbers of independent variables.

As already mentioned, there needs to be more information available on the daily measurement values of several of the atmospheric pollutants collected in all the sampling stations of the 2 Air Quality Networks mentioned above and in all the years of study [20]. O_3 and NO_2 values were measured at all stations in all 4 study years. Particulate matter PM_{10} was recorded in 10 of the 11 study areas except for Collado Villalba, where it was only measured in 2014 and stopped being counted in 2015, 2016, and 2017. CO was only measured in all four years in the three stations of the city of Madrid (Escuelas Aguirre,

Farolillo, and Casa de Campo, which are located, respectively, in the same areas as the pollen measurement stations of Madrid Barrio de Salamanca, Madrid Ayuntamiento, and Madrid Facultad de Farmacia), as well as in Alcalá de Henares; in addition, it was only recorded in 2014 in the areas of Alcobendas and Collado Villalba. PM_{2.5} particles were only recorded at the Escuelas Aguirre, Casa de Campo, and Collado Villalba stations in the study period. Moreover, SO₂ was quantified throughout the study period in the stations of Alcalá de Henares, Collado Villalba, and the three stations in the city of Madrid. At the same time, it was only recorded in 2014 in Alcobendas and Coslada.

On the other hand, calculations of the multiple linear regression models were made, with all the statistically significant explanatory variables, both by the ordinary least squares method and the forward stepwise and backward stepwise procedures. Thanks to the first method mentioned, it has already been possible to observe to what extent the adjusted model expresses the variability of the dependent variable, using the value of R², as well as the *p*-value, level of significance obtained for said model, and the *p*-values of each of the independent variables. However, this procedure performs the multiple linear regression adjustment by calculating the equation that includes all the variables, regardless of whether or not these *p*-values are statistically significant (i.e., if they are less than 0.05, with a confidence level of 95%), and without discarding those variables that do not adequately explain the variability of the dependent variable.

For this reason, calculations of the regression models were performed additionally with the forward and backward stepwise procedures. It has been found that, in general, the fits are at least equal (in terms of the *p*-value of the model and of the independent variables, as well as in terms of the adjusted R² value) for both, and in some cases, better with the backward stepwise method. Therefore, this is the one that was selected in all cases. This procedure starts with a model involving all the variables. It eliminates the least significant variable from the model at each step until only those that are statistically significant remain, i.e., those whose *p*-value is less than 0.05, with a confidence level of 95%.

The *p*-values of both the model (using Fisher's *F*-ratio), reflected in the results of the analysis of variance for the model, and the *p*-values of each of the independent variables included in each of the calculations were checked to see if they are statistically significant. In this case, the test was performed using Student's *t*-statistic.

In each of the calculations, for each of the 2 study response variables, the total of the potential explanatory variables (the six pollen concentration variables and the six air pollutant concentration variables) available in each of the 11 study stations of the Palinocam Network as well as the Air Quality Network of the CAM and the Madrid City Council were included, which, as mentioned above, do not reach 12 variables in total except in the Escuelas Aguirre and Casa de Campo stations. In the rest of the stations, at least one of the types of atmospheric pollutants has yet to be measured.

When the models gave rise to study residuals more significant than three standard deviations, the data corresponding to these residuals was eliminated, and the model was recalculated as many times as possible; new outliers that could distort the resulting model arose. In the few cases in which, when eliminating these values, information on an air pollutant concentration variable could have been lost, the elimination was stopped, and the resulting model thus calculated was considered acceptable. In other words, priority was given in these cases to obtaining a better explanation of the model over obtaining a better fit. In the rest of the cases, priority was given to obtaining the best possible adjustments, if there was at least one explanatory variable for the concentration of atmospheric pollutants included in each calculated model.

For all statistical analyses, including obtaining regression models, Statgraphics Centurion 19 software was used.

4. Results

The values for each study year were obtained from the calculations performed on the multiple linear regression models. They are reflected in Appendix A, in Tables A1–A4, and

the equations of the calculated models are shown in Appendix B, in Tables A5–A7, for the respective study years 2014, 2015, 2016, and 2017. In almost all the calculations performed, even after eliminating outlier residuals, the model included several pollen concentration variables. They are the ones that, in general, have best explained the resulting model relative to the other types of independent variables.

Accordingly, some observations can be made:

1. In the models calculated, p -values of less than 0.05 were obtained, with a confidence level of 95%. In fact, in all of them, the p -values were <0.0001 , which implies that all the models are explanatory, i.e., that there is a statistically significant relationship between the independent variables and the dependent variable in every one of the calculations performed.
2. The adjusted R^2 value is, in most of the calculations performed for allergic conjunctivitis, higher than 30%, and is so in all those performed for allergic rhinitis. Only 5 of the 22 models calculated for 2014 (Table A1) present values of adjusted R^2 lower than 30%. Moreover, these occur in the stations of Alcobendas, Aranjuez, Coslada, Las Rozas, and Collado Villalba. As for 2015 (Table A2), six models have poor fits (in Aranjuez, Coslada, Madrid Barrio de Salamanca, Leganés, Las Rozas, and Collado Villalba). Only statistically non-significant models were obtained for 2017 (Table A4) for the Las Rozas and Collado Villalba stations, as well as for 2016 (Table A3) in those same stations, in addition to Coslada. Of the 88 models, 72 were calculated to have adjusted R^2 values higher than 30%.
3. In summary, in 16 of the 44 total regression calculations performed for allergic conjunctivitis, the fits achieved are of low intensity (adjusted $R^2 < 30\%$). In contrast, all the models performed with allergic rhinitis fit well for the four years of study. Therefore, allergic conjunctivitis can be considered worse when related to the independent variables than allergic rhinitis; it also provides worse adjusted R^2 values.
4. The models calculated for allergic rhinitis obtained the highest adjusted R^2 values. For the year 2014, the highest value of adjusted R^2 was 93.5469%, and it was given for the Madrid Ayuntamiento station. In the same year, the lowest value of this coefficient was 68.8893%, and it was given for the Collado Villalba station (Table A1). As for the year 2015 (Table A2), the value of 95.6993%, the highest for adjusted R^2 , corresponded to the Madrid Ayuntamiento station again (in fact, it is the highest for allergic rhinitis in the whole period and the highest obtained from this study for the two dependent variables). The lowest value for 2015 was 50.4156%, again for Collado Villalba. For 2016, the highest value of the multiple regression coefficient was 81.5532%, this time for Madrid Barrio de Salamanca station, and the lowest value was 38.4723%, for the Coslada area (Table A3). Finally, for 2017, the most significant adjusted R^2 value was 93.0111% for the Leganés station, and the lowest, 35.2626%, was for the Madrid Facultad de Farmacia area. This is the lowest adjusted value for allergic rhinitis in this study.
5. Regarding allergic conjunctivitis, the highest adjusted R^2 values in the different years are 42.0507% for the year 2014, corresponding to the Alcalá de Henares station (Table A1); 42.2195% for the year 2015 (Table A2) and for the Getafe station; 62.6635% (the highest value for allergic conjunctivitis in this study) for the year 2016 and the Madrid Barrio de Salamanca area (Table A3); and 45.2764% for the year 2017, corresponding to the Madrid Facultad de Farmacia station (Table A4). The lowest values of the regression coefficient adjusted R^2 (within the statistically significant, i.e., with adjusted $R^2 > 30\%$) are given in Madrid Barrio de Salamanca station, 32.7335%, in 2014 (Table A1); in Madrid Facultad de Farmacia, with value of 30.5163% (the lowest adjusted R^2 value in this study for allergic conjunctivitis), for the year 2015 (Table A2); in the Alcobendas area, with an adjusted R^2 value of 32.0685%, in the year 2016 (Table A3); and in Alcalá de Henares, with a value of 33.3049% in the year 2017 (Table A4).
6. In most of the models calculated, there is an interrelation of the dependent variables with at least one of the pollen types under study and at least one of the atmospheric pollutants. Only in 10 of the 88 total regression calculations performed was one of the

two types of independent variables not represented. In none of the cases were both types of explanatory variables missing simultaneously, thus invalidating the model. In 9 of the 10 cases cited, the atmospheric pollutants do not appear in the resulting equation, so only some of the pollen types maintain a relationship with the dependent variable. In 9 of the 10 cases in which there is only one type of independent variable in the equation, the dependent variable is allergic conjunctivitis. In the other case, it is allergic rhinitis. Among them, seven are models with adjusted R^2 value $> 30\%$, all with the absence of air pollution variables, specifically for allergic conjunctivitis: in Leganés in 2014 (Table A1); in the stations of Alcobendas, Madrid Ayuntamiento, and Getafe in 2015 (Table A2); in the areas of Alcobendas and Coslada in 2017 (Table A4). For allergic rhinitis, there was an absence of air pollution variables only in the Las Rozas station in 2015 (Table A2). There were no cases in 2016.

7. In most models with adjusted $R^2 > 30\%$ (specifically in 63 of the 72), the presence of pollen types is greater than that of atmospheric pollutants. In only six of them are there more air pollutant concentration variables than pollen types. Moreover, only in three cases are both variables equal in number (Tables A1–A4). What has already been pointed out regarding the lack of meters for different pollutants in the sampling stations should be considered. For this reason, it is not surprising that, in general, there is a more significant presence of pollen-type variables in the calculated models and that, thus, there is a greater probability of interrelation of these variables with those of episodes of attention of the allergic pathologies under study. However, there is the circumstance of the existence of three exceptions, all of them with allergic conjunctivitis. Thus, for the Farolillo Air Quality station (corresponding to the Ayuntamiento de Madrid pollen station) in 2014, the model obtained contains four atmospheric pollutants and three types of pollen, despite the lack of $PM_{2.5}$ in the station above (Table A1). For the Alcalá de Henares station, in 2016, the model obtained contained five atmospheric pollutants and three pollen types (a circumstance that also occurred in 2017, this time in the ratio of four versus two), despite the lack of $PM_{2.5}$ measurement (Tables A3 and A4, respectively).

The presence of the different independent variables for the models obtained with adjusted $R^2 > 30\%$ is quantified in Tables 2 and 3.

Table 2. Quantification of the presence of the 6 studied pollen-type variables in the calculated models, statistically significant (with adjusted $R^2 > 30\%$) for the allergic diseases allergic conjunctivitis (C) and allergic rhinitis (R), for each of the four years of study. The total number of times (T) that each type of pollen appears in all the equations found for the two pathologies is also counted for each year. The right-hand side of the table shows the sum for each dependent variable and the study period. The right column, shaded in blue, shows the total sum for each pollen type and the two dependent variables. Finally, the lower row (Total C/R) shows the number of occurrences of the pollen types for each of the pathologies under study, both for each year and for the whole period.

Types of Pollen	Year 2014			Year 2015			Year 2016			Year 2017			Period 2014–2017		
	C	R	T	C	R	T	C	R	T	C	R	T	C	R	T
<i>Cupressaceae</i>	1	2	3	2	5	7	6	3	9	3	3	6	12	13	25
<i>Olea</i>	6	9	15	5	10	15	8	10	18	5	8	13	24	37	61
<i>Pinus</i>	6	11	17	5	11	16	7	10	17	8	11	19	26	43	69
<i>Platanus</i>	1	8	9	-	8	8	1	10	11	6	6	12	8	32	40
<i>Populus</i>	5	10	15	3	10	13	3	5	8	6	11	17	17	36	53
<i>Ulmus</i>	1	2	3	1	9	10	4	9	13	6	9	15	12	29	41
Total C/R	20	42		16	53		29	47		34	48		99	190	

Table 3. Quantification of the presence of the six air pollutant variables in the calculated models, statistically significant (with adjusted $R^2 > 30\%$) for the allergic diseases allergic conjunctivitis (C) and allergic rhinitis (R), for each of the four years of study. The total number of times (T) that each type of pollen appears in all the equations found for the two pathologies is also counted for each year. The right-hand side of the table shows the summed quantities for each dependent variable and the study period. The right column, shaded in blue, shows the total sum for each air pollutant and the two dependent variables. Finally, the bottom row shows the amounts of air pollutants that occur for each of the pathologies under study, both for the years and the whole period (Total C/R).

Air Pollutant	Year 2014			Year 2015			Year 2016			Year 2017			Period 2014–2017		
	C	R	T	C	R	T	C	R	T	C	R	T	C	R	T
O ₃	2	6	8	1	3	4	7	6	13	3	7	10	13	22	35
NO ₂	1	3	4	1	5	6	4	4	8	6	3	9	12	15	27
PM ₁₀	3	8	11	2	7	9	3	6	9	3	3	6	11	24	35
PM _{2.5}	1	-	1	1	3	4	1	1	2	-	1	1	3	5	8
CO	3	3	6	-	1	1	3	2	5	3	2	5	9	8	17
SO ₂	2	5	7	-	3	3	3	4	7	4	4	8	9	16	25
Total C/R	12	25		5	22		21	23		19	20		57	90	

As shown in Table 2, the types of pollen most present in the equations obtained for the allergic pathologies under study are, in 2014, *Pinus* on 17 occasions and *Olea* and *Populus* on 15. In 2015, again, it was *Pinus* that was the most present, with 16 appearances, followed by *Olea* with 15 and *Populus* with 13. In 2016, *Olea* was the most frequent, with 18, followed by *Pinus*, with 17, and *Ulmus*, with 13. In 2017, *Pinus* appeared on 19 occasions, followed by *Populus*, with 17, and *Ulmus*, with 15. Likewise, in the 2014–2017 period as a whole, with allergic conjunctivitis and with allergic rhinitis, the same order is repeated, led by *Pinus* (with 26 and 43 occasions, respectively), followed by *Olea* (with 24 and 37, respectively) and by *Populus* (with 17 and 36, respectively). As for the total number of relationship occasions with the two dependent variables (column shaded in blue), *Pinus* is the most frequent, with 69 times, followed by *Olea*, with 61, and *Populus*, with 53. In this order, they are followed by *Ulmus*, with 41, *Platanus*, with 40, and *Cupressaceae*, with 25.

In the 11 stations of the Palinocam Network, the concentrations of the six types of pollen are measured. Therefore, they all have the same probability of participating as explanatory variables in the multiple linear regression models.

On the other hand, as can be seen in the last row of Table 2 (Total C/R), the overall relationship of the six studied pollen types with allergic rhinitis is undoubtedly the most frequent of the two studied pathologies, as already argued (with values of 42, 53, 47, and 48 total occasions, in the years 2014, 2015, 2016, and 2017, respectively), compared to 20, 16, 29, and 34 interventions for allergic conjunctivitis, respectively. In the study period, the total number of occasions of the relationship of pollen types with allergic rhinitis was 190, compared to 99 for allergic conjunctivitis. For this reason, it can be affirmed that, on an overall level, it is with allergic rhinitis that there is a more significant interrelation between the types of pollen and the two allergic diseases, considering the variations in the different years of study that have been pointed out. On only three occasions does allergic conjunctivitis not lag in its representation in the calculated models, namely: in 2016, for *Cupressaceae*, this pathology exceeds allergic rhinitis in the proportion of six versus three; and in 2017, the interventions of both dependent variables are equal in number (three), also for *Cupressaceae*, and they are equal in number (six) for *Platanus* (Table 2).

As for the atmospheric pollutants, considering that only some are measured at all stations, they have a different probability of appearing in the models. The pollutants most frequently measured at the Air Quality stations are O₃, NO₂, and the particle PM₁₀; it

would not be surprising if they were the most frequently related to the dependent variables. However, this is only the case in some years of study (Table 3).

It can be observed that SO₂, with 7 appearances, is the third most present in 2014, after PM₁₀ (with 11) and O₃ (which appears on 8 occasions in the equations calculated); CO is the fourth most frequent, present in 6 equations and ahead of NO₂, with 4. In 2015, it is the particle PM₁₀ that is most frequently related to the dependent variables with the bold number 9, followed by NO₂ (6), O₃ (4), and PM_{2.5} (4). SO₂ is the third most frequent in 2016 (11), after O₃ (21) and PM₁₀ (15). In 2017, SO₂ was the third most frequent air pollutant (8 equations) for the two study pathologies, after O₃ (10) and NO₂ (9).

In the whole period, 2014–2017, the air pollutant most frequently appearing in the models calculated for allergic conjunctivitis is O₃ (13), followed by NO₂ (12), and PM₁₀ (11). Particle PM₁₀ is the most frequently involved in the case of allergic rhinitis (24), followed by O₃ (22) and SO₂ (16), ahead of NO₂ (15).

Regarding the sum of values of the two dependent variables, in the period 2014–2017 (right column, shaded in blue), O₃ and PM₁₀ are the most present in the models, both with 35 appearances, followed by NO₂ (27) and SO₂, with 25 (which is configured as the most present air pollutant among the three that were least recorded in the Air Quality stations). Moreover, CO is among the three most represented in the models, even ahead of NO₂ or PM₁₀, in the years 2014 and 2017. After them, CO intervened on 17 occasions and PM_{2.5} on 8; keep in mind that this variable is only measured in 4 of the 11 total Air Quality stations from which data were collected in this study. The variable PM_{2.5} is present in 25% of the models where it could appear.

Looking at the last row of Table 3 (Total C/R), it can be seen that, for the set of the six air pollutants, allergic rhinitis exceeds allergic conjunctivitis in terms of the number of pollutants present in the calculated models, in the 4 years of study. For 2014, the ratio is 25 versus 12; for 2015 it is 22 versus only 5; while for 2016 (23 versus 21) and 2017 (20 versus 19), they are more similar.

For the study period, air pollutants are present in 90 of the models with a good fit calculated for allergic rhinitis, compared to 57 for allergic conjunctivitis. Therefore, it can be affirmed that, at a global level, as occurs with the types of pollen, it is also with allergic rhinitis that there is a more significant interrelation with air pollutants.

5. Discussion

Nationwide, 79.3% of patients diagnosed with conjunctivitis and rhinitis (rhinoconjunctivitis) have an allergic cause well above the frequency of other causes. Conjunctivitis is considered intermittent when symptoms occur four days or fewer per week or for four consecutive weeks or fewer. Persistent forms occur more than four days per week and for more than four consecutive weeks. According to these criteria, 50.6% of patients suffer from intermittent conjunctivitis and 48.8% from persistent conjunctivitis (in the case of rhinitis, it is 34% and 66%, respectively, for intermittent and persistent rhinitis). In addition, 50% suffer from mild allergic conjunctivitis, 47% moderate, and 1.6% severe (annoying signs and symptoms, impact on vision, interference with academic or work tasks, and impairment in daily activities, reading, and/or sports are considered to assess the severity of the disease) [25].

In recent decades, there have been significant increases in allergic rhinitis, especially in Western countries. In international epidemiological studies, such as that carried out in 1994 in children in 54 countries by the ISAAC (International Study of Asthma and Allergies in Childhood), very variable prevalence figures were recorded (1.4–39.7% in children aged 13 to 14 years, and 0.8–14.9% in children aged 6 to 7 years), while in Spain there were intermediate values: between 11.7% and 21.8%. In adults, it is around 25% in Western Europe in the general population and 21.5% in Spain [25–28].

Some 52.5% of patients who visit allergology clinics in Spain for the first time (with the main reason being nasal symptoms -89.4%- , followed by eye discomfort -56.5%- , and, less frequently, cough -26.9%- , dyspnea -26.9%- , and chest noises -10.9%-) are diagnosed with rhinoconjunctivitis, compared to 21% in the case of asthma, which is the second cause

of visits to the allergy specialist. In addition, 17.5% of patients consult for both diseases at the same time. People with rhinoconjunctivitis mostly come from urban environments (65.1% of the cases)—some 24.3% live in semi-urban areas and 10.3% in rural areas. Of the patients, 62.7% have a family history of atopy, specifically rhinitis in 46.7% of cases, asthma in 28.1%, and conjunctivitis in 17.8%. This is followed by drug allergy (6.3%), atopic eczema (5.4%), food allergy (4.9%), Hymenoptera allergy (0.7%), and others (3.15%) [25].

In the CAM, 12.4% of these patients are sensitized to mites, 27.5% to animal epithelia, and 7.9% to fungal spores. More specifically, the types of pollen to which patients with rhinoconjunctivitis show a sensitization reaction are *Gramineae*, 87.1%; followed by *Olea*, with 58.9%; *Cupressaceae*, with 40.5%; and *Platanus*, with 23.9%, among the most prominent. Sixty-six percent of patients seen for the first time in allergology clinics in Spain for allergic rhinitis are of the persistent type (symptoms occurring more than four days per week and for more than four consecutive weeks), compared to 34% of the intermittent type. In addition, 29.9% suffer from mild allergic rhinitis, 59.7% from moderate, and 8.7% from severe allergic rhinitis [25].

Although some epidemiological studies have questioned that the trend of increasing prevalence of allergic pathologies in the last three decades may be due to an increase in the concentration of pollutants in the atmosphere, several botanical studies affirm that there is an increase in the expression of allergenic proteins in several types of pollen grains, as a consequence of the joint effect of atmospheric pollutants and changes in weather patterns [12]. This fact could indicate, as suggested by different researchers, the need to study the concentrations of pollen allergens and these pollutants to perform an epidemiological evaluation of the environmental determinants of respiratory allergies. In addition, establishing a system for measuring pollen's allergenic potential that can assess the increased allergenicity of pollen affected by pollution, could be considered a new indicator of health risks for citizens in urban areas [12]. This is consistent with the results obtained in this study, which show that both types of variables influence the pathologies considered.

In addition, the interaction between pollutants and pollen grains [20] can increase the allergenicity of the latter. It could be stated that the solution to this problem lies in three measures: the adequate planning and management of green areas in cities, using a careful selection, particularly of anemophilous pollination flora species; the increasing control of air pollution; and the management of adequate epidemiological surveillance.

Work [29], carried out in Korea, includes the same pollutants as the present study, except PM_{2.5}, as well as pollen data from trees and herbaceous plants in the two periods of the year, spring and autumn, when pollen concentrations are highest, and also comments on the relevance of climate change in terms of being the cause of the increase in the number of pollutants present in the atmosphere, as well as the expansion of allergens. With the increase in the mean annual temperature, the flowering stage of plants is anticipated to expand, which may lead to an increase in the concentration of pollen in the atmosphere and an increase in the number of people exposed to it, and, consequently, an increase in the prevalence rates of allergic diseases, allergic rhinitis, asthma, atopic dermatitis, and allergic conjunctivitis [29,30]. However, in some of the models obtained in this work, it can be observed that the effects of the variables do not always increase the effects on the pathologies, as is the case of O₃ and PM₁₀ in some models for allergic rhinitis or, to a lesser extent, PM₁₀ in those for conjunctivitis (Appendix B).

On the other hand, atmospheric pollutants wherein climate alterations have originated can cause a deformation of the epidermis, which affects the immune response, and which, with their binding to pollen grains, can increase the chances of inducing allergic diseases [29].

In the same study [29], there is a generally significant relationship between air pollutants, pollen levels, and the number of patients seen in outpatient clinics in Korea for allergic diseases in both spring and autumn. Particularly significant is the relationship between NO₂ and the three pathologies analyzed (allergic rhinitis, asthma, and atopic dermatitis) in spring and SO₂ (with a high positive association) with the three pathologies

in autumn. In addition, a highly significant relationship was obtained between allergic rhinitis and PM₁₀, NO₂, SO₂, O₃, and CO, as well as with the so-called tree and herbaceous pollen risk index, both in spring and autumn. Likewise, there is a significant association between the emergence of patients with allergic rhinitis and the concentration levels of pollen and pollutants PM₁₀, NO, SO₂, and CO [29]. These results agree with those obtained in the present study for allergic rhinitis, where PM₁₀ particles and O₃ are the pollutants most often involved in the calculated models, with NO₂, SO₂, and CO in fifth place.

Japan stands out worldwide, together with Africa and Latin America, as one of the geographical areas with the highest prevalence rates for rhinoconjunctivitis, according to research conducted by the ISAAC (International Study of Asthma and Allergies in Childhood) between 1993 and 2003 [31]. There has, indeed, been an increase in the prevalence of this pathology worldwide in recent decades. Moreover, there are variations within the same country and its different regions, which can be caused by different factors: ethnicity, related to the types of allergens, and in terms of environmental risk factors, among which is atmospheric pollution. This agrees with the results of this work, where different models are shown for different locations and years. Today, air pollution and other essential factors such as concomitant diseases, socioeconomic factors, and other environmental factors such as climate contribute to geographical differences in the prevalence of allergic conjunctivitis. Air pollution contributes to the exacerbation of the symptoms of this pathology but also to the increased incidence of its severe manifestations [31].

In the study conducted in Japan [31], both PM₁₀ and NO₂ showed a statistically significant association with the prevalence of vernal keratoconjunctivitis, one of the most severe forms of ocular allergy, and which presents with bilateral inflammation of the conjunctiva, and occurs more frequently in children and in the spring and autumn months [31,32]. Furthermore, in that study, atopic keratoconjunctivitis, another severe ocular allergy that, like the previous one, threatens vision and presents with similar clinical manifestations, showed a significant relationship with NO₂ levels. Seasonal allergic conjunctivitis was associated with PM₁₀ and oxidants (NO₂ and O₃, both recognized as essential pollutants associated with allergies), albeit with a low relative contribution, considering the high prevalence of seasonal allergic conjunctivitis. Therefore, it can be stated from that study that air pollution may particularly affect severe forms of ocular allergic diseases [31]. Comparatively, in the present study, as could be seen, O₃ is the most frequently included in the equations found for allergic conjunctivitis, followed by NO₂ and particle PM₁₀, which confirms the importance of these three air pollutants to allergic conjunctivitis, as in [31].

According to some authors [33], it would be convenient to analyze this interrelation in the pollination seasons (within the main pollination period) of the species under study to avoid the possible masking of the interrelation between the independent variables by the most stable variables in their concentrations throughout the year, such as atmospheric pollutants.

An analysis of meteorological parameters should also be carried out, together with the variables included in this work, since they have an essential influence on pollination and act synergistically on pollen grains and all types of aerobiological particles and pollutants in the atmosphere [9,34]. The annual variation in the models fitted for each season in this study indicates the possible influence of time-varying meteorological parameters.

The interaction between pollen and pollutants also manifests itself in the form of other pathologies such as asthma, as shown in the cohort study conducted by Feo Brito, F. et al. [33], which analyses the evolution of asthmatic patients allergic to grass and olive tree pollens (with positive sensitization in the skin test), with a mild to moderate clinical evolution, during the *Poaceae* and *Olea* pollination season, in two Spanish cities, one highly industrialized, Puertollano, and the other with a lower concentration of atmospheric pollutants, Ciudad Real. In this study, it is concluded that patients living in Puertollano have a worse clinical evolution of asthma, significantly related to environmental pollution, due to the presence of PM₁₀, NO₂, SO₂, and O₃ in the atmosphere, and evidenced by an increase in the severity of symptoms and in the consumption of medication. This study

is of special interest, as the clinical course of asthmatic patients with increased severity of their disease is usually analyzed [33].

Also, in relation to asthma, the study by Lambert, A.L. et al., using a Brown Norway (BN) rat model of a house dust mite (HDM) allergy, indicates that an exacerbation of the symptoms associated with asthma may occur because of pre-exposure of asthmatic patients to the metallic components of residual oil fly ash particles (ROFA). And these metal components may enhance sensitization to HDMs, and lung inflammation may be an important factor in this adjuvant effect [35].

The study by Nielsen, G.D. et al. explores the role of exposure to tobacco smoke as a coadjuvant agent that can lead, in some cases, to sensitization through stimulation of a specific IgE, and even to the development of allergic respiratory diseases such as asthma and allergic rhinitis. The study found that more people are sensitized than develop allergic diseases due to exposure to tobacco smoke. However, it highlights the importance of developing animal models to support cause–effect relationships, while considering hereditary factors, types of allergens, and levels of exposure to allergens and adjuvants [36].

6. Conclusions

The location and timing of measurements influence our understanding of the relationships between the number of primary care episodes for conjunctivitis and allergic rhinitis and the concentrations of air pollutants and tree pollen grains.

Both pathologies present statistically significant relationships with the two types of variables in all locations and all years, so the influence of these variables in both pathologies can be established.

The combination of both types of particles influences both pathologies, explaining more than 30% of the variability in the episodes of attention due to rhinitis, with this being less in the case of conjunctivitis. In most of the models calculated, there is an interrelation of both pathologies with at least one of the pollen types under study and at least one of the atmospheric pollutants.

The six atmospheric pollutants analyzed are influential in the estimated models, with the highest presence of O₃ and PM₁₀, so the presence of these particles influences the cases of rhinitis and conjunctivitis. *Pinus*, *Olea*, and *Populus* pollen concentrations are the most present in the relationships with both pathologies.

It is exciting to consider that the meteorological variables will be further studied in future works, and a focus on the pollination seasons of the species will be beneficial to adjust better models that better explain the episodes of rhinitis and conjunctivitis care.

Given that the interaction between pollutants and pollen grains can increase the allergenicity of the latter, it could be argued that the solution to this problem involves three measures: proper planning and management of green areas in cities, through careful selection, particularly of species of anemophilous pollinating flora; increased control of air pollution; and the management of adequate epidemiological surveillance.

Author Contributions: Conceptualization, J.C.-F. and E.A.-T.; Formal analysis, J.C.-F. and E.A.-T.; Methodology, E.A.-T.; Resources, J.C.-F.; Supervision, E.A.-T.; Writing—original draft, J.C.-F. All authors have read and agreed to the published version of the manuscript.

Funding: This research did not receive external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data belongs to public organizations that provide them on demand and the name of the organizations appears mentioned in the Section 2 and in the acknowledgments.

Acknowledgments: Our thanks to the Palynological Network of the CAM, to the Air Quality Networks of the CAM and the Madrid City Council, as well as to the General Subdirectorate of Epidemiology of the Health Department of the CAM, for the transfer of the data essential for carrying out this study.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Tables of Results of the Calculations of the Multiple Linear Regression Fits Performed for Each of the Two Allergic Pathologies in This Study

Table A1. Results of the calculations of the multiple linear regression fits performed for each of the 2 allergic pathologies of this study (named with the CIAP-2 codes), in each of the 11 zones of the Palinocam Network, which constitute the geographical reference of this study, for the year 2014. The explanatory variables (air pollutants and pollen types) are also shown in the different models. Shaded in light blue are the equations with good correlation ($R^2 > 30\%$).

Year 2014	Allergic Conjunctivitis (F71)			Allergic Rhinitis (R97)		
Alcalá de Henares	42.0507 232 0.0000	O ₃ CO SO ₂	Olea Pinus Platanus Populus	71.6556 222/232 0.0000	SO ₂	Olea Pinus Populus
Alcobendas	19.3007 211/212 0.0000	NO ₂	Olea Pinus Populus Ulmus	81.5023 188/212 0.0000	PM ₁₀ SO ₂	Olea Pinus Platanus Populus
Aranjuez	23.6189 232/235 0.0000	PM ₁₀	Olea Pinus Platanus Populus	75.1692 226/234 0.0000	PM ₁₀	Olea Pinus Platanus Populus
Coslada	24.3872 239/241 0.0000	PM ₁₀ SO ₂	Olea Platanus	71.7605 218/242 0.0000	O ₃ NO ₂ SO ₂	Olea Pinus Platanus Populus
Madrid: Barrio de Salamanca	32.7335 244/248 0.0000	PM ₁₀ SO ₂	Olea Pinus Populus	81.7273 220/247 0.0000	O ₃ PM ₁₀ CO	Cupressac. Pinus Platanus Populus
Madrid: Ayuntamiento	39.8401 227/231 0.0000	O ₃ NO ₂ PM ₁₀ CO	Cupressac. Olea Pinus	93.5469 192/231 0.0000	PM ₁₀ CO SO ₂	Olea Pinus Platanus Populus Ulmus
Madrid: Facultad de Farmacia	35.9480 239/246 0.0000	PM _{2.5} CO	Olea Pinus Populus	77.1382 231/246 0.0000	O ₃ NO ₂ PM ₁₀ CO	Olea Pinus Platanus Populus
Getafe	34.6728 237 0.0000	PM ₁₀	Olea Pinus Populus	85.5392 209/237 0.0000	O ₃ NO ₂	Olea Pinus Populus
Leganés	40.9629 236 0.0000	-	Olea Pinus Populus Ulmus	90.8438 202/236 0.0000	O ₃ PM ₁₀	Olea Pinus Platanus Populus
Las Rozas	10.7613 231/239 0.0000	PM ₁₀	Olea Populus	78.9482 220/240 0.0000	O ₃ PM ₁₀	Olea Pinus Platanus Populus Ulmus
Collado Villalba	16.4693 192 0.0000	NO ₂ SO ₂	Cupressac. Populus	68.8893 189/196 0.0000	PM ₁₀ SO ₂	Cupressac. Pinus

R^2 adjusted for degrees of freedom. No. observations without outliers/no. total observations; p -value of the model.

Table A2. Results of the calculations of the multiple linear regression fits performed for each of the 2 allergic pathologies of this study (named with the CIAP-2 codes), in each of the 11 zones of the Palinocam Network, which constitute the geographical reference of this study, for the year 2015. The explanatory variables (air pollutants and pollen types) are also shown in the different models. Shaded in light blue are the equations with good correlation.

Year 2015	Allergic Conjunctivitis (F71)			Allergic Rhinitis (R97)		
Alcalá de Henares	36.2228 238/244 0.0000	NO ₂ PM ₁₀	<i>Olea</i> <i>Pinus</i> <i>Populus</i>	81.4060 218/244 0.0000	NO ₂ PM ₁₀ SO ₂	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Alcobendas	36.3459 240/244 0.0000	-	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i>	88.7679 221/245 0.0000	NO ₂ PM ₁₀	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Populus</i> <i>Ulmus</i>
Aranjuez	23.5347 239/243 0.0000	-	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i>	69.2531 218/242 0.0000	O ₃ PM ₁₀	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Platanus</i>
Coslada	12.7012 231/234 0.0000	-	<i>Olea</i> <i>Pinus</i>	72.1250 202/233 0.0000	O ₃ PM ₁₀	<i>Olea</i> <i>Pinus</i> <i>Populus</i> <i>Ulmus</i>
Madrid: Barrio de Salamanca	28.8782 244/247 0.0000	CO SO ₂	<i>Pinus</i> <i>Platanus</i> <i>Populus</i>	84.3415 232/247 0.0000	NO ₂ PM _{2.5} CO SO ₂	<i>Cupressac.</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i>
Madrid: Ayuntamiento	41.8218 240/247 0.0000	-	<i>Olea</i> <i>Pinus</i> <i>Populus</i>	95.6963 192/247 0.0000	NO ₂ PM ₁₀	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Madrid: Facultad de Farmacia	30.5163 239/245 0.0000	O ₃ PM ₁₀ PM _{2.5}	<i>Olea</i> <i>Pinus</i> <i>Populus</i> <i>Ulmus</i>	89.3865 210/245 0.0000	PM ₁₀ PM _{2.5}	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Getafe	45.2195 237/238 0.0000	-	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i>	93.7818 196/240 0.0000	NO ₂ PM ₁₀	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Populus</i> <i>Ulmus</i>
Leganés	25.7501 226/230 0.0000	O ₃	<i>Olea</i> <i>Pinus</i> <i>Populus</i>	87.0863 186/231 0.0000	O ₃	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Las Rozas	28.9397 235/243 0.0000	O ₃	<i>Olea</i> <i>Pinus</i>	68.6671 232/243 0.0000	-	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Collado Villalba	24.8589 210/214 0.0000	PM _{2.5}	<i>Olea</i> <i>Pinus</i>	50.4156 216/221 0.0000	PM _{2.5} SO ₂	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>

R² adjusted for degrees of freedom. No. observations without outliers/no. total observations; *p*-value of the model.

Table A3. Results of the calculations of the multiple linear regression fits performed for each of the 2 allergic pathologies of this study (named with the CIAP-2 codes), in each of the 11 zones of the Palinocam Network, which constitute the geographical reference of this study, for the year 2016. The explanatory variables (air pollutants and pollen types) are also shown in the different models. Shaded in light blue are the equations with good correlation.

YEAR 2016	Allergic Conjunctivitis (F71)			Allergic Rhinitis (R97)		
Alcalá de Henares	46.8835 242/243 0.0000	O ₃ NO ₂ PM ₁₀ CO SO ₂	<i>Olea</i> <i>Pinus</i> <i>Ulmus</i>	67.6029 224/243 0.0000	PM ₁₀ CO SO ₂	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Ulmus</i>
Alcobendas	32.0685 238/241 0.0000	O ₃	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i>	52.5677 234/244 0.0000	NO ₂	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Aranjuez	40.4370 215/218 0.0000	O ₃ PM ₁₀	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i>	75.2956 208/225 0.0000	O ₃ PM ₁₀	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i>
Coslada	29.2340 201/205 0.0000	O ₃ PM ₁₀	<i>Cupressac.</i> <i>Olea</i>	38.4723 195/209 0.0000	NO ₂ PM ₁₀	<i>Olea</i> <i>Platanus</i> <i>Ulmus</i>
Madrid: Barrio de Salamanca	62.6635 243/247 0.0000	O ₃ NO ₂ SO ₂	<i>Cupressac.</i> <i>Olea</i>	81.5532 223/247 0.0000	O ₃ NO ₂ SO ₂	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Ulmus</i>
Madrid: Ayuntamiento	57.3406 238/241 0.0000	O ₃ CO SO ₂	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Populus</i>	78.1677 228/242 0.0000	O ₃ CO SO ₂	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Platanus</i>
Madrid: Facultad de Farmacia	50.3492 232/241 0.0000	O ₃ PM ₁₀ PM _{2.5} CO	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Populus</i> <i>Ulmus</i>	68.4025 229/244 0.0000	O ₃ SO ₂	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Ulmus</i>
Getafe	33.2699 220/225 0.0000	NO ₂	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Ulmus</i>	59.6612 205/227 0.0000	PM ₁₀	<i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Leganés	32.9728 230/232 0.0000	O ₃ NO ₂	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Ulmus</i>	64.1719 216/233 0.0000	PM ₁₀	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Las Rozas	23.1648 223/231 0.0000	NO ₂	<i>Olea</i>	74.2674 221/243 0.0000	O ₃ PM ₁₀	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Populus</i> <i>Ulmus</i>
Collado Villalba	19.6389 286/188 0.0000	O ₃ SO ₂	<i>Cupressac.</i> <i>Pinus</i>	61.1132 180/195 0.0000	O ₃ NO ₂ PM _{2.5}	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Ulmus</i>

R² adjusted for degrees of freedom. No. observations without outliers/no. total observations; *p*-value of the model.

Table A4. Results of the calculations of the multiple linear regression fits performed for each of the 2 allergic pathologies of this study (named with the CIAP-2 codes), in each of the 11 zones of the Palinocam Network, which constitute the geographical reference of this study, for the year 2017. The explanatory variables (air pollutants and pollen types) are also shown in the different models. Shaded in light blue are the equations with good correlation.

Year 2017	Allergic Conjunctivitis (F71)			Allergic Rhinitis (R97)		
Alcalá de Henares	33.3049 229/232 0.0000	O ₃ NO ₂ PM ₁₀ SO ₂	<i>Pinus</i> <i>Ulmus</i>	74.1775 216/243 0.0000	SO ₂	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Alcobendas	34.8674 196/199 0.0000	-	<i>Cupressac.</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i>	57.3809 229/231 0.0000	PM ₁₀	<i>Cupressac.</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Aranjuez	35.2306 213/219 0.0000	NO ₂	<i>Pinus</i> <i>Populus</i> <i>Ulmus</i>	75.2956 223/237 0.0000	NO ₂	<i>Olea</i> <i>Pinus</i> <i>Populus</i>
Coslada	36.2440 188/194 0.0000	-	<i>Olea</i> <i>Pinus</i> <i>Ulmus</i>	43.1929 229 0.0000	PM ₁₀	<i>Olea</i> <i>Pinus</i> <i>Populus</i> <i>Ulmus</i>
Madrid: Barrio de Salamanca	37.5341 233/237 0.0000	O ₃ NO ₂ PM ₁₀ CO SO ₂	<i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>	64.9077 240/244 0.0000	O ₃ PM ₁₀ PM _{2.5} CO SO ₂	<i>Pinus</i> <i>Populus</i> <i>Ulmus</i>
Madrid: Ayuntamiento	44.8531 198 0.0000	O ₃ NO ₂ CO SO ₂	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>	79.6635 198/213 0.0000	O ₃ NO ₂ CO SO ₂	<i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Madrid: Facultad de Farmacia	45.2764 198/201 0.0000	NO ₂ CO SO ₂	<i>Olea</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>	35.2626 244 0.0000	O ₃	<i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Getafe	33.3967 202/206 0.0000	NO ₂	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Platanus</i>	88.2661 196/232 0.0000	O ₃	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i>
Leganés	38.8571 225/226 0.0000	PM ₁₀	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i>	93.0111 189/234 0.0000	O ₃	<i>Cupressac.</i> <i>Olea</i> <i>Pinus</i> <i>Platanus</i> <i>Populus</i> <i>Ulmus</i>
Las Rozas	18.7629 214/220 0.0000	NO ₂	<i>Cupressac.</i> <i>Olea</i> <i>Populus</i>	54.0020 225/238 0.0000	O ₃ NO ₂	<i>Olea</i> <i>Pinus</i> <i>Populus</i> <i>Ulmus</i>
Collado Villalba	15.5476 185/190 0.0000	O ₃ SO ₂	-	51.7683 236/239 0.0000	O ₃ SO ₂	<i>Olea</i> <i>Pinus</i> <i>Populus</i> <i>Ulmus</i>

R² adjusted for degrees of freedom. No. observations without outliers/no. total observations; *p*-value of the model.

Appendix B. Equations of the Models Calculated by Multiple Linear Regression Performed for Each of the Two Allergic Pathologies of This Study

Table A5. Equations of the models calculated by multiple linear regression performed for each of the 2 allergic pathologies of this study (named with the CIAP-2 codes), in each of the 11 zones of the Palinocam Network, which constitute the geographical reference of this study, for the year 2014. Shaded in light blue are equations with good correlation ($R^2 > 30\%$).

Year 2014	Allergic Conjunctivitis (F71)	Allergic Rhinitis (R97)
Alcalá de Henares	$\text{Conj. Alcalá de Henares 2014} = 2.40861 + 0.00990264 \cdot \text{O}_3 + 1.17065 \cdot \text{CO} + 0.0982771 \cdot \text{SO}_2 + 0.0159068 \cdot \text{Olea} + 0.00588988 \cdot \text{Pinus} - 0.000279655 \cdot \text{Platanus} + 0.00398211 \cdot \text{Populus}$	$\text{Rinitis Alcalá de Henares 2014} = 3.77305 + 0.464244 \cdot \text{SO}_2 + 0.252759 \cdot \text{Olea} + 0.0191948 \cdot \text{Pinus} + 0.0102529 \cdot \text{Populus}$
Alcobendas	$\text{Conj. Alcobendas 2014} = 2.29367 + 0.0059735 \cdot \text{NO}_2 + 0.0380305 \cdot \text{Olea} + 0.00694923 \cdot \text{Pinus} + 0.00274156 \cdot \text{Populus} + 0.0176663 \cdot \text{Ulmus}$	$\text{Rinitis Alcobendas 2014} = 2.61931 - 0.0284217 \cdot \text{PM}_{10} + 0.68717 \cdot \text{SO}_2 + 0.199479 \cdot \text{Olea} + 0.0435527 \cdot \text{Pinus} + 0.0029474 \cdot \text{Platanus} + 0.0312817 \cdot \text{Populus}$
Aranjuez	$\text{Conj. Aranjuez 2014} = 5.58843 - 0.0448535 \cdot \text{PM}_{10} + 0.0401327 \cdot \text{Olea} + 0.028219 \cdot \text{Pinus} + 0.0019985 \cdot \text{Platanus} + 0.0291316 \cdot \text{Populus}$	$\text{Rinitis Aranjuez 2014} = 8.53245 - 0.102362 \cdot \text{PM}_{10} + 0.263186 \cdot \text{Olea} + 0.267681 \cdot \text{Pinus} + 0.00688102 \cdot \text{Platanus} + 0.145667 \cdot \text{Populus}$
Coslada	$\text{Conj. Coslada 2014} = 3.02071 - 0.023589 \cdot \text{PM}_{10} + 0.166056 \cdot \text{SO}_2 + 0.0467642 \cdot \text{Olea} + 0.00505253 \cdot \text{Platanus}$	$\text{Rinitis Coslada 2014} = 5.75564 - 0.0244713 \cdot \text{O}_3 - 0.0275449 \cdot \text{NO}_2 + 0.19221 \cdot \text{SO}_2 + 0.301004 \cdot \text{Olea} + 0.0294862 \cdot \text{Pinus} + 0.0112604 \cdot \text{Platanus} + 0.0402549 \cdot \text{Populus}$
Madrid: Barrio de Salamanca	$\text{Conj. Dr Subiza 2014} = 3.23775 - 0.0175466 \cdot \text{PM}_{10} + 0.046146 \cdot \text{SO}_2 + 0.0080177 \cdot \text{Olea} + 0.0210936 \cdot \text{Pinus} + 0.00842425 \cdot \text{Populus}$	$\text{Rinitis Dr Subiza 2014} = 5.54601 - 0.0237458 \cdot \text{O}_3 - 0.0206398 \cdot \text{PM}_{10} - 1.83221 \cdot \text{CO} - 0.00163816 \cdot \text{Cupressaceae} + 0.201401 \cdot \text{Pinus} + 0.003833 \cdot \text{Platanus} + 0.0714994 \cdot \text{Populus}$
Madrid: Ayuntamiento	$\text{Conj. Madrid Ayto. 2014} = 1.85084 + 0.0126874 \cdot \text{O}_3 + 0.0142874 \cdot \text{NO}_2 - 0.0241711 \cdot \text{PM}_{10} + 0.519188 \cdot \text{CO} + 0.00173709 \cdot \text{Cupressaceae} + 0.0147096 \cdot \text{Olea} + 0.00576557 \cdot \text{Pinus}$	$\text{Rinitis Madrid Ayto. 2014} = 2.65561 - 0.033439 \cdot \text{PM}_{10} + 0.575377 \cdot \text{CO} + 0.0915793 \cdot \text{SO}_2 + 0.118181 \cdot \text{Olea} + 0.0641696 \cdot \text{Pinus} + 0.0062071 \cdot \text{Platanus} + 0.0628631 \cdot \text{Populus} + 0.00734233 \cdot \text{Ulmus}$
Madrid: Facultad de Farmacia	$\text{Conj. C. Univ. 2014} = 2.0544 - 0.0341644 \cdot \text{PM}_{2.5} + 1.52642 \cdot \text{CO} + 0.0302227 \cdot \text{Olea} + 0.00379825 \cdot \text{Pinus} + 0.00110456 \cdot \text{Populus}$	$\text{Rinitis C. Univ. 2014} = 3.04379 - 0.0161096 \cdot \text{O}_3 - 0.0550717 \cdot \text{NO}_2 - 0.0297734 \cdot \text{PM}_{10} + 7.95735 \cdot \text{CO} + 0.132457 \cdot \text{Olea} + 0.0340849 \cdot \text{Pinus} + 0.000378666 \cdot \text{Platanus} + 0.00502403 \cdot \text{Populus}$
Getafe	$\text{Conj. Getafe 2014} = 2.33043 + 0.0084754 \cdot \text{PM}_{10} + 0.00984124 \cdot \text{Olea} + 0.035601 \cdot \text{Pinus} + 0.0219243 \cdot \text{Populus}$	$\text{Rinitis Getafe 2014} = 7.52355 - 0.0507698 \cdot \text{O}_3 - 0.0312783 \cdot \text{NO}_2 + 0.207129 \cdot \text{Olea} + 0.402391 \cdot \text{Pinus} + 0.454893 \cdot \text{Populus}$
Leganés	$\text{Conj. Leganés 2014} = 4.09909 + 0.0531827 \cdot \text{Olea} + 0.0726626 \cdot \text{Pinus} + 0.0190364 \cdot \text{Populus} + 0.0321291 \cdot \text{Ulmus}$	$\text{Rinitis Leganés 2014} = 5.52633 - 0.0377773 \cdot \text{O}_3 - 0.0329411 \cdot \text{PM}_{10} + 0.585505 \cdot \text{Olea} + 0.277888 \cdot \text{Pinus} + 0.0271988 \cdot \text{Platanus} + 0.329656 \cdot \text{Populus}$
Las Rozas	$\text{Conj. Las Rozas 2014} = 4.28606 - 0.0279598 \cdot \text{PM}_{10} + 0.0629651 \cdot \text{Olea} + 0.0115961 \cdot \text{Populus}$	$\text{Rinitis Las Rozas 2014} = 7.50453 - 0.0161811 \cdot \text{O}_3 - 0.0719195 \cdot \text{PM}_{10} + 0.178187 \cdot \text{Olea} + 0.243054 \cdot \text{Pinus} + 0.00706709 \cdot \text{Platanus} + 0.118195 \cdot \text{Populus} + 0.328916 \cdot \text{Ulmus}$
Collado Villalba	$\text{Conj. Villalba 2014} = 2.33 - 0.0123333 \cdot \text{NO}_2 + 0.16122 \cdot \text{SO}_2 + 0.000573903 \cdot \text{Cupresaceae} + 0.00633343 \cdot \text{Populus}$	$\text{Rinitis Villalba 2014} = 4.70884 - 0.0675055 \cdot \text{PM}_{10} + 0.868791 \cdot \text{SO}_2 + 0.00427925 \cdot \text{Cupresaceae} + 0.0412718 \cdot \text{Pinus}$

Table A6. Equations of the models calculated by multiple linear regression performed for each of the 2 allergic pathologies of this study (named with the CIAP-2 codes), in each of the 11 zones of the Palinocam Network, which constitute the geographical reference of this study, for the year 2015. Shaded in light blue are the equations with good correlation.

YEAR 2015	Allergic Conjunctivitis (F71)	Allergic Rhinitis (R97)
Alcalá de Henares	$\text{Conj. Alcalá de Henares 2015} = 4.23837 + 0.00829035 \cdot \text{NO}_2 - 0.0194256 \cdot \text{PM}_{10} + 0.00809025 \cdot \text{Olea} + 0.00451705 \cdot \text{Pinus} + 0.00322061 \cdot \text{Populus}$	$\text{Rinitis Alcalá de Henares 2015} = 7.12693 - 0.0291138 \cdot \text{NO}_2 - 0.0696167 \cdot \text{PM}_{10} + 0.348377 \cdot \text{SO}_2 + 0.0145914 \cdot \text{Olea} + 0.0420941 \cdot \text{Pinus} + 0.000332904 \cdot \text{Platanus} + 0.0324311 \cdot \text{Populus} + 0.00674974 \cdot \text{Ulmus}$
Alcobendas	$\text{Conj. Alcobendas 2015} = 2.93725 + 0.00165945 \cdot \text{Cupressaceae} + 0.00611777 \cdot \text{Olea} + 0.0107505 \cdot \text{Pinus}$	$\text{Rinitis Alcobendas 2015} = 4.0499 + 0.0263104 \cdot \text{NO}_2 - 0.0498357 \cdot \text{PM}_{10} + 0.00421091 \cdot \text{Cupressaceae} + 0.0417754 \cdot \text{Olea} + 0.0658953 \cdot \text{Pinus} + 0.0472061 \cdot \text{Populus} + 0.0442628 \cdot \text{Ulmus}$
Aranjuez	$\text{Conj. Aranjuez 2015} = 4.73249 + 0.00360289 \cdot \text{Cupressaceae} + 0.0200686 \cdot \text{Olea} + 0.0334984 \cdot \text{Pinus}$	$\text{Rinitis Aranjuez 2015} = 6.12889 + 0.0176288 \cdot \text{O}_3 - 0.0592419 \cdot \text{PM}_{10} + 0.0322748 \cdot \text{Cupressaceae} + 0.0929328 \cdot \text{Olea} + 0.0824035 \cdot \text{Pinus} + 0.00796778 \cdot \text{Platanus}$
Coslada	$\text{Conj. Coslada 2015} = 2.91468 + 0.00871182 \cdot \text{Olea} + 0.00261002 \cdot \text{Pinus}$	$\text{Rinitis Coslada 2015} = 6.10009 - 0.0209715 \cdot \text{O}_3 - 0.0303473 \cdot \text{PM}_{10} + 0.0550139 \cdot \text{Olea} + 0.0664378 \cdot \text{Pinus} + 0.0839156 \cdot \text{Populus} + 0.0362424 \cdot \text{Ulmus}$
Madrid: Barrio de Salamanca	$\text{Conj. Dr. Subiza 2015} = 3.58602 + 0.918597 \cdot \text{CO} - 0.0565139 \cdot \text{SO}_2 + 0.005037 \cdot \text{Olea} + 0.00618568 \cdot \text{Pinus} - 0.000317081 \cdot \text{Platanus} + 0.0109761 \cdot \text{Populus}$	$\text{Rinitis Dr. Subiza 2015} = 5.03904 - 0.0372761 \cdot \text{NO}_2 + 0.0473705 \cdot \text{PM}_{2.5} + 8.55992 \cdot \text{CO} - 0.312566 \cdot \text{SO}_2 + 0.0185806 \cdot \text{Olea} + 0.0508514 \cdot \text{Pinus} - 0.00158334 \cdot \text{Platanus} + 0.0945692 \cdot \text{Populus}$
Madrid: Ayuntamiento	$\text{Conj. Madrid Ayto. 2015} = 2.78732 + 0.003951 \cdot \text{Olea} + 0.00646449 \cdot \text{Pinus} + 0.00390124 \cdot \text{Populus}$	$\text{Rinitis Madrid Ayto. 2015} = 2.43047 + 0.0180021 \cdot \text{NO}_2 - 0.0183193 \cdot \text{PM}_{10} + 0.0313119 \cdot \text{Olea} + 0.0483613 \cdot \text{Pinus} - 0.000424581 \cdot \text{Platanus} + 0.0359161 \cdot \text{Populus} + 0.0857214 \cdot \text{Ulmus}$
Madrid: Facultad de Farmacia	$\text{Conj. C. Univ. 2015} = 1.83189 + 0.00748608 \cdot \text{O}_3 - 0.0244403 \cdot \text{PM}_{10} + 0.0578763 \cdot \text{PM}_{2.5} + 0.00265066 \cdot \text{Olea} + 0.00440758 \cdot \text{Pinus} + 0.00100114 \cdot \text{Populus} + 0.00635186 \cdot \text{Ulmus}$	$\text{Rinitis C. Univ. 2015} = 2.42687 - 0.0352455 \cdot \text{PM}_{10} + 0.0515255 \cdot \text{PM}_{2.5} + 0.0162319 \cdot \text{Olea} + 0.0212251 \cdot \text{Pinus} - 0.000682023 \cdot \text{Platanus} + 0.0211407 \cdot \text{Populus} + 0.019654 \cdot \text{Ulmus}$
Getafe	$\text{Conj. Getafe 2015} = 2.94396 + 0.00265267 \cdot \text{Cupressaceae} + 0.00627522 \cdot \text{Olea} + 0.0119141 \cdot \text{Pinus}$	$\text{Rinitis Getafe 2015} = 4.16868 + 0.0210962 \cdot \text{NO}_2 - 0.0483303 \cdot \text{PM}_{10} + 0.00491983 \cdot \text{Cupressaceae} + 0.034932 \cdot \text{Olea} + 0.199734 \cdot \text{Pinus} + 0.197449 \cdot \text{Populus} + 0.107743 \cdot \text{Ulmus}$
Leganés	$\text{Conj. Leganés 2015} = 4.14382 + 0.00615045 \cdot \text{O}_3 + 0.0124928 \cdot \text{Olea} + 0.0111315 \cdot \text{Pinus} + 0.00782831 \cdot \text{Populus}$	$\text{Rinitis Leganés 2015} = 3.78239 - 0.00882641 \cdot \text{O}_3 + 0.0137477 \cdot \text{Cupressaceae} + 0.0164699 \cdot \text{Olea} + 0.0960254 \cdot \text{Pinus} + 0.0903898 \cdot \text{Platanus} + 0.160773 \cdot \text{Populus} + 0.166864 \cdot \text{Ulmus}$
Las Rozas	$\text{Conj. Las Rozas 2015} = 3.41945 + 0.00844659 \cdot \text{O}_3 + 0.0161981 \cdot \text{Olea} + 0.00491137 \cdot \text{Pinus}$	$\text{Rinitis Las Rozas 2015} = 6.25927 + 0.103669 \cdot \text{Olea} + 0.0664513 \cdot \text{Pinus} - 0.00451606 \cdot \text{Platanus} + 0.177871 \cdot \text{Populus} + 0.208099 \cdot \text{Ulmus}$
Collado Villalba	$\text{Conj. Villalba 2015} = 1.87227 + 0.0347689 \cdot \text{PM}_{2.5} + 0.0211501 \cdot \text{Olea} + 0.00240513 \cdot \text{Pinus}$	$\text{Rinitis Villalba 2015} = 4.45941 + 0.148789 \cdot \text{PM}_{2.5} - 0.727222 \cdot \text{SO}_2 + 0.12383 \cdot \text{Olea} + 0.0175134 \cdot \text{Pinus} + 0.0366885 \cdot \text{Platanus} + 0.0866515 \cdot \text{Populus} + 0.299687 \cdot \text{Ulmus}$

Table A7. Equations of the models calculated by multiple linear regression performed for each of the 2 allergic pathologies of this study (named with the CIAP-2 codes), in each of the 11 zones of the Palinocam Network, which constitute the geographical reference of this study, for the year 2016. Shaded in light blue are the equations with good correlation.

YEAR 2016	Allergic Conjunctivitis (F71)	Allergic Rhinitis (R97)
Alcalá de Henares	$\text{Conj. Alcalá de Henares 2016} = 2.96577 + 0.0146291 \cdot \text{O}_3 - 0.039471 \cdot \text{NO}_2 - 0.0360995 \cdot \text{PM}_{10} + 1.9648 \cdot \text{CO} + 0.422145 \cdot \text{SO}_2 + 0.0156964 \cdot \text{Olea} + 0.00392375 \cdot \text{Pinus} + 0.0103779 \cdot \text{Ulmus}$	$\text{Rinitis Alcalá de Henares 2016} = 7.64494 - 0.0597229 \cdot \text{PM}_{10} - 2.34824 \cdot \text{CO} + 0.315084 \cdot \text{SO}_2 + 0.0767299 \cdot \text{Olea} + 0.0340128 \cdot \text{Pinus} + 0.0010159 \cdot \text{Platanus} + 0.00963014 \cdot \text{Ulmus}$
Alcobendas	$\text{Conj. Alcobendas 2016} = 1.58446 + 0.0155469 \cdot \text{O}_3 + 0.00711892 \cdot \text{Olea} + 0.013982 \cdot \text{Pinus} + 0.000898522 \cdot \text{Platanus} + 0.0705046 \cdot \text{Ulmus}$	$\text{Rinitis Alcobendas 2016} = 5.48734 - 0.0230581 \cdot \text{NO}_2 + 0.0540523 \cdot \text{Olea} + 0.0364821 \cdot \text{Pinus} + 0.00188877 \cdot \text{Platanus} + 0.0282753 \cdot \text{Populus} + 0.113392 \cdot \text{Ulmus}$
Aranjuez	$\text{Conj. Aranjuez 2016} = 2.96997 + 0.0385846 \cdot \text{O}_3 - 0.0440273 \cdot \text{PM}_{10} + 0.0095607 \cdot \text{Cupressaceae} + 0.00610799 \cdot \text{Olea} + 0.0319611 \cdot \text{Pinus}$	$\text{Rinitis Aranjuez 2016} = 6.45539 + 0.0235824 \cdot \text{O}_3 - 0.0699425 \cdot \text{PM}_{10} + 0.0303666 \cdot \text{Olea} + 0.407084 \cdot \text{Pinus} - 0.00259892 \cdot \text{Platanus} + 0.046904 \cdot \text{Populus}$
Coslada	$\text{Conj. Coslada 2016} = 2.1648 + 0.0162959 \cdot \text{O}_3 - 0.0222277 \cdot \text{PM}_{10} + 0.0129802 \cdot \text{Cupressaceae} + 0.0263845 \cdot \text{Olea}$	$\text{Rinitis Coslada 2016} = 4.5441 + 0.0326155 \cdot \text{NO}_2 - 0.0656781 \cdot \text{PM}_{10} + 0.194056 \cdot \text{Olea} + 0.0142736 \cdot \text{Platanus} + 0.106303 \cdot \text{Ulmus}$
Madrid: Barrio de Salamanca	$\text{Conj. Dr. Subiza 2016} = 0.6764 + 0.023179 \cdot \text{O}_3 - 0.0194538 \cdot \text{NO}_2 + 0.196805 \cdot \text{SO}_2 + 0.00224361 \cdot \text{Cupressaceae} + 0.00470516 \cdot \text{Olea}$	$\text{Rinitis Dr. Subiza 2016} = 4.12916 - 0.0110379 \cdot \text{O}_3 - 0.0253404 \cdot \text{NO}_2 + 0.162986 \cdot \text{SO}_2 + 0.0284 \cdot \text{Olea} + 0.0462978 \cdot \text{Pinus} + 0.00351487 \cdot \text{Platanus} + 0.0485908 \cdot \text{Ulmus}$
Madrid: Ayuntamiento	$\text{Conj. Madrid Ayto. 2016} = 1.61625 + 0.0222953 \cdot \text{O}_3 + 2.24977 \cdot \text{CO} - 0.199205 \cdot \text{SO}_2 + 0.00525725 \cdot \text{Cupressaceae} + 0.0058745 \cdot \text{Olea} + 0.00599447 \cdot \text{Pinus} + 0.00893342 \cdot \text{Populus}$	$\text{Rinitis Madrid Ayto. 2016} = 3.69279 + 0.011519 \cdot \text{O}_3 + 3.72727 \cdot \text{CO} - 0.302268 \cdot \text{SO}_2 + 0.00513676 \cdot \text{Cupressaceae} + 0.0465967 \cdot \text{Olea} + 0.0290837 \cdot \text{Pinus} + 0.00224351 \cdot \text{Platanus}$
Madrid: Facultad de Farmacia	$\text{Conj. C. Univ. 2016} = 1.86857 + 0.013339 \cdot \text{O}_3 - 0.0445371 \cdot \text{PM}_{10} + 0.0729635 \cdot \text{PM}_{2.5} - 1.73512 \cdot \text{CO} + 0.00160145 \cdot \text{Cupressaceae} + 0.00644291 \cdot \text{Olea} + 0.00429256 \cdot \text{Pinus} + 0.00116814 \cdot \text{Populus} + 0.0264636 \cdot \text{Ulmus}$	$\text{Rinitis C. Univ. 2016} = 5.4361 - 0.0108206 \cdot \text{O}_3 - 0.671928 \cdot \text{SO}_2 + 0.0527902 \cdot \text{Olea} + 0.0174819 \cdot \text{Pinus} + 0.000439388 \cdot \text{Platanus} + 0.0559243 \cdot \text{Ulmus}$
Getafe	$\text{Conj. Getafe 2016} = 2.89958 - 0.0166156 \cdot \text{NO}_2 + 0.00491307 \cdot \text{Cupressaceae} + 0.00939816 \cdot \text{Olea} + 0.108475 \cdot \text{Pinus} + 0.150895 \cdot \text{Ulmus}$	$\text{Rinitis Getafe 2016} = 5.07577 - 0.0211913 \cdot \text{PM}_{10} + 0.218014 \cdot \text{Pinus} + 0.00326111 \cdot \text{Platanus} + 0.0521344 \cdot \text{Populus} + 0.446517 \cdot \text{Ulmus}$
Leganés	$\text{Conj. Leganés 2016} = 3.62747 + 0.0204684 \cdot \text{O}_3 - 0.017224 \cdot \text{NO}_2 + 0.00682665 \cdot \text{Cupressaceae} + 0.00937517 \cdot \text{Olea} + 0.0243383 \cdot \text{Pinus} + 0.144681 \cdot \text{Ulmus}$	$\text{Rinitis Leganés 2016} = 6.45878 - 0.0720104 \cdot \text{PM}_{10} + 0.0957015 \cdot \text{Olea} + 0.218444 \cdot \text{Pinus} + 0.00394421 \cdot \text{Platanus} + 0.106283 \cdot \text{Populus} + 0.273986 \cdot \text{Ulmus}$
Las Rozas	$\text{Conj. Las Rozas 2016} = 4.29248 - 0.0355218 \cdot \text{NO}_2 + 0.0321573 \cdot \text{Olea}$	$\text{Rinitis Las Rozas 2016} = 7.64122 - 0.0170217 \cdot \text{O}_3 - 0.0621082 \cdot \text{PM}_{10} + 0.0146606 \cdot \text{Cupressaceae} + 0.165591 \cdot \text{Olea} + 0.0160246 \cdot \text{Pinus} + 0.0601069 \cdot \text{Populus} + 0.755135 \cdot \text{Ulmus}$
Collado Villalba	$\text{Conj. Villalba 2016} = 1.2054 + 0.0145275 \cdot \text{O}_3 + 0.334985 \cdot \text{SO}_2 + 0.00653564 \cdot \text{Cupressaceae} + 0.00431684 \cdot \text{Pinus}$	$\text{Rinitis Villalba 2016} = 6.64457 - 0.0268991 \cdot \text{O}_3 - 0.0530995 \cdot \text{NO}_2 + 0.0461128 \cdot \text{PM}_{2.5} + 0.0135144 \cdot \text{Cupressaceae} + 0.0667968 \cdot \text{Olea} + 0.0553359 \cdot \text{Pinus} + 0.144609 \cdot \text{Platanus} + 0.587917 \cdot \text{Ulmus}$

Table A8. Equations of the models calculated by multiple linear regression performed for each of the 2 allergic pathologies of this study (named with the CIAP-2 codes), in each of the 11 zones of the Palinocam Network, which constitute the geographical reference of this study, for the year 2017. Shaded in light blue are the equations with good correlation.

YEAR 2017	Allergic Conjunctivitis (F71)	Allergic Rhinitis (R97)
Alcalá de Henares	$\text{Conj. Alcalá de Henares 2017} = 0.2043 + 0.013279 \cdot \text{O}_3 + 0.0173224 \cdot \text{NO}_2 - 0.0178132 \cdot \text{PM}_{10} + 0.0851092 \cdot \text{SO}_2 + 0.00367505 \cdot \text{Pinus} + 0.00360876 \cdot \text{Ulmus}$	$\text{Rinitis Alcalá de Henares 2017} = 4.90354 + 0.218878 \cdot \text{SO}_2 + 0.0513575 \cdot \text{Olea} + 0.103624 \cdot \text{Pinus} - 0.000661739 \cdot \text{Platanus} + 0.0152474 \cdot \text{Populus} + 0.0134222 \cdot \text{Ulmus}$
Alcobendas	$\text{Conj. Alcobendas 2017} = 1.077 + 0.00162916 \cdot \text{Cupressaceae} + 0.0162923 \cdot \text{Pinus} + 0.000270003 \cdot \text{Platanus} + 0.00259565 \cdot \text{Populus}$	$\text{Rinitis Alcobendas 2017} = 5.81581 - 0.0417343 \cdot \text{PM}_{10} + 0.00354546 \cdot \text{Cupressaceae} + 0.179554 \cdot \text{Pinus} + 0.00150506 \cdot \text{Platanus} + 0.0265313 \cdot \text{Populus} + 0.0437454 \cdot \text{Ulmus}$
Aranjuez	$\text{Conj. Aranjuez 2017} = 2.70784 - 0.04185 \cdot \text{NO}_2 + 0.00200776 \cdot \text{Platanus} + 0.0151771 \cdot \text{Populus} + 0.00919236 \cdot \text{Ulmus}$	$\text{Rinitis Aranjuez 2017} = 8.77332 - 0.0963044 \cdot \text{NO}_2 + 0.0280901 \cdot \text{Olea} + 0.326171 \cdot \text{Pinus} + 0.0489541 \cdot \text{Populus}$
Coslada	$\text{Conj. Coslada 2017} = 0.974225 + 0.00352566 \cdot \text{Olea} + 0.0299685 \cdot \text{Pinus} + 0.0056005 \cdot \text{Ulmus}$	$\text{Rinitis Coslada 2017} = 5.66421 - 0.0250607 \cdot \text{PM}_{10} + 0.0221339 \cdot \text{Olea} + 0.166768 \cdot \text{Pinus} + 0.014263 \cdot \text{Populus} + 0.0398317 \cdot \text{Ulmus}$
Madrid: Barrio de Salamanca	$\text{Conj. Dr. Subiza 2017} = 1.23543 + 0.00762449 \cdot \text{O}_3 - 0.00655382 \cdot \text{NO}_2 + 0.0085295 \cdot \text{PM}_{10} + 0.604397 \cdot \text{CO} - 0.0415367 \cdot \text{SO}_2 + 0.00964157 \cdot \text{Pinus} + 0.00025201 \cdot \text{Platanus} + 0.0069944 \cdot \text{Populus} + 0.00653255 \cdot \text{Ulmus}$	$\text{Rinitis Dr. Subiza 2017} = 4.94774 + 0.0397006 \cdot \text{O}_3 + 0.0858913 \cdot \text{PM}_{10} - 0.193267 \cdot \text{PM}_{2.5} + 3.39946 \cdot \text{CO} - 0.228414 \cdot \text{SO}_2 + 0.19884 \cdot \text{Pinus} + 0.0300994 \cdot \text{Populus} + 0.02338 \cdot \text{Ulmus}$
Madrid: Ayuntamiento	$\text{Conj. Madrid Ayto. 2017} = 0.524412 + 0.00715802 \cdot \text{O}_3 - 0.00832579 \cdot \text{NO}_2 + 0.746422 \cdot \text{CO} + 0.0530285 \cdot \text{SO}_2 + 0.00133064 \cdot \text{Olea} + 0.00444176 \cdot \text{Pinus} + 0.000203663 \cdot \text{Platanus} + 0.00481164 \cdot \text{Populus} + 0.000954275 \cdot \text{Ulmus}$	$\text{Rinitis Madrid Ayto. 2017} = 2.05654 + 0.0370297 \cdot \text{O}_3 - 0.0350075 \cdot \text{NO}_2 + 2.64359 \cdot \text{CO} + 0.26627 \cdot \text{SO}_2 + 0.0106977 \cdot \text{Olea} + 0.0974525 \cdot \text{Pinus} + 0.00164756 \cdot \text{Platanus} + 0.0197672 \cdot \text{Populus} + 0.00592791 \cdot \text{Ulmus}$
Madrid: Facultad de Farmacia	$\text{Conj. C. Univ. 2017} = 0.897934 - 0.0128953 \cdot \text{NO}_2 + 1.18665 \cdot \text{CO} + 0.0392537 \cdot \text{SO}_2 + 0.0035618 \cdot \text{Olea} + 0.000283357 \cdot \text{Platanus} + 0.00160207 \cdot \text{Populus} + 0.015807 \cdot \text{Ulmus}$	$\text{Rinitis C. Univ. 2017} = 3.25033 + 0.0179129 \cdot \text{O}_3 + 0.0225915 \cdot \text{Pinus} + 0.000782341 \cdot \text{Platanus} + 0.0096035 \cdot \text{Populus} + 0.0308381 \cdot \text{Ulmus}$
Getafe	$\text{Conj. Getafe 2017} = 1.18116 - 0.00353675 \cdot \text{NO}_2 + 0.000792842 \cdot \text{Cupressaceae} + 0.00153814 \cdot \text{Olea} + 0.0271362 \cdot \text{Pinus} + 0.000238874 \cdot \text{Platanus}$	$\text{Rinitis Getafe 2017} = 4.78794 - 0.0139295 \cdot \text{O}_3 + 0.0148007 \cdot \text{Cupressaceae} + 0.0277251 \cdot \text{Olea} + 0.583839 \cdot \text{Pinus} + 0.00479987 \cdot \text{Platanus} + 0.272969 \cdot \text{Populus}$
Leganés	$\text{Conj. Leganés 2017} = 1.6248 - 0.00754923 \cdot \text{PM}_{10} + 0.00535808 \cdot \text{Cupressaceae} + 0.00310843 \cdot \text{Olea} + 0.0258094 \cdot \text{Pinus} + 0.00255877 \cdot \text{Platanus} + 0.00596642 \cdot \text{Populus}$	$\text{Rinitis Leganés 2017} = 4.11626 - 0.00934336 \cdot \text{O}_3 + 0.0175185 \cdot \text{Cupressaceae} + 0.0374322 \cdot \text{Olea} + 0.1971 \cdot \text{Pinus} + 0.0594415 \cdot \text{Platanus} + 0.127839 \cdot \text{Populus} + 0.0437632 \cdot \text{Ulmus}$
Las Rozas	$\text{Conj. Las Rozas 2017} = 1.96023 - 0.0131409 \cdot \text{NO}_2 + 0.001933 \cdot \text{Cupressaceae} + 0.00580799 \cdot \text{Olea} + 0.0171685 \cdot \text{Populus}$	$\text{Rinitis Las Rozas 2017} = 13.0301 - 0.0600579 \cdot \text{O}_3 - 0.0697771 \cdot \text{NO}_2 + 0.0270439 \cdot \text{Olea} + 0.314956 \cdot \text{Pinus} + 0.153636 \cdot \text{Populus} + 0.132212 \cdot \text{Ulmus}$
Collado Villalba	$\text{Conj. Villalba 2017} = 0.346089 + 0.0112038 \cdot \text{O}_3 + 0.175183 \cdot \text{SO}_2$	$\text{Rinitis Villalba 2017} = 0.25258 + 0.0614253 \cdot \text{O}_3 + 1.08222 \cdot \text{SO}_2 + 0.0468887 \cdot \text{Olea} + 0.0594364 \cdot \text{Pinus} + 0.117748 \cdot \text{Populus} + 0.0436549 \cdot \text{Ulmus}$

References

1. Sedghy, F.; Varasteh, A.R.; Sankian, M.; Moghadam, M. Interaction between air pollutants and pollen grains: The role on the rising trend in allergy. *Rep. Biochem. Mol. Biol.* **2018**, *6*, 219.
2. Asher, M.I.; Montefort, S.; Björkstén, B.; Lai, C.K.; Strachan, D.P.; Weiland, S.K. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys. *Lancet* **2006**, *368*, 733–743. [CrossRef] [PubMed]
3. Huang, S.-K.; Zhang, Q.; Qiu, Z.; Chung, K.F. Mechanistic impact of outdoor air pollution on asthma and allergic diseases. *J. Thorac. Dis.* **2015**, *7*, 23–33.
4. Yin, S.; Shen, Z.; Zhou, P.; Zou, X.; Che, S.; Wang, W. Quantifying air pollution attenuation within urban parks: An experimental approach in Shanghai, China. *Environ. Pollut.* **2011**, *159*, 2155–2163. [CrossRef] [PubMed]
5. Lu, S.; Ren, J.; Hao, X.; Liu, D.; Zhang, R.; Wu, M.; Yi, F.; Lin, J.; Shinich, Y.; Wang, Q. Characterization of protein expression of *Platanus* pollen following exposure to gaseous pollutants and vehicle exhaust particles. *Aerobiologia* **2014**, *30*, 281–291. [CrossRef] [PubMed]
6. De Castro Alfageme, S. Estudio de Alérgenos de Polen en la Atmósfera de Valladolid. Ph.D. Thesis, Universidad de León, León, Spain, 2014.
7. McDonald, M.S. Correlations of air-borne grass pollen levels with meteorological data. *Grana* **1980**, *19*, 53–56. [CrossRef]
8. Bricchi, E.; Fornaciari, M.; Giannoni, C.; Greco, F.; Fascini, D.; Frenguelli, G.; Mincigrucci, G.; Romano, B. Fluctuations of grass pollen content in the atmosphere of East Perugia and meteorological correlations. *Aerobiologia* **1992**, *8*, 401–406. [CrossRef]
9. Cariñanos, P.; Foyo-Moreno, I.; Alados, I.; Guerrero-Rascado, J.L.; Ruiz-Peñuela, S.; Titos, G.; Cazorla, A.; Alados-Arboledas, L.; Díaz de la Guardia, C. Bioaerosols in urban environments: Trends and interactions with pollutants and meteorological variables based on quasi-climatological series. *J. Environ. Manag.* **2021**, *282*, 111963. [CrossRef] [PubMed]
10. Rojo, J.; Rapp, A.; Lara, B.; Fernández-González, F.; Pérez-Badia, R. Effect of land uses and wind direction on the contribution of local sources to airborne pollen. *Sci. Total Environ.* **2015**, *538*, 672–682. [CrossRef] [PubMed]
11. Reinmuth-Selzle, K.; Kampf, C.J.; Lucas, K.; Lang-Yona, N.; Fröhlich-Nowoisky, J.; Shiraiwa, M.; Lakey, P.S.J.; Lai, S.; Liu, F.; Kunert, A.T.; et al. Air pollution and climate change effects on allergies in the Anthropocene: Abundance, interaction and modification of allergens and adjuvants. *Environ. Sci. Technol.* **2017**, *51*, 4119–4141. [CrossRef] [PubMed]
12. Schiavoni, G.; D’Amato, G.; Afferni, C. The dangerous liaison between pollens and pollution in respiratory allergy. *Ann. Allergy Immunol.* **2017**, *118*, 269–275. [CrossRef] [PubMed]
13. D’Amato, G.; Vitale, C.; Sanduzzi, A.; Molino, A.; Vatrella, A.; D’Amato, M. Allergenic pollen and pollen allergy in Europe. *Allergy* **2007**, *62*, 976–990. [CrossRef] [PubMed]
14. Gutiérrez Bustillo, M.; Sáenz Laín, C.; Aránguez Ruiz, E.; Ordóñez Iriarte, J.M. Polen atmosférico en la Comunidad de Madrid. In *Documentos Técnicos de Salud Pública*; Dirección General de Salud Pública, Consejería de Sanidad, Comunidad de Madrid: Madrid, Spain, 2001.
15. Toro, F.J.; Recio, M.; Trigo, M.M.; Cabezudo, B. Predictive models in aerobiology: Data transformation. *Aerobiologia* **1998**, *14*, 179–184. [CrossRef]
16. IV Congreso Nacional de Sanidad Ambiental. *Red palinológica de la Comunidad de Madrid*; Santiago de Compostela 1996; Publicado por la Sociedad Española de Sanidad Ambiental: Toledo, Spain, 1997; pp. 83–91. ISBN 84-88439-49-0.
17. Consejería de Sanidad y Servicios Sociales. Red Palinológica de la Comunidad de Madrid. *Boletín Epidemiológico Comunidad Madr.* **1994**, *3*, 20.
18. Subiza, J.; Jerez, M.; Gavilán, M.J.; Varela, S.; Rodríguez, R.; Narganes, M.J.; Jiménez, A.; Tejada Cazorla, J.; Fernández Pérez, C.; Cabrera, M.; et al. ¿Cuáles son los pólenes que producen polinosis epidémica en el medio urbano de Madrid? *Rev. Española Alergol. Immunol. Clínica* **1998**, *13*, 107–119.
19. Palinocam Network Information. Available online: <https://www.comunidad.madrid/servicios/salud/aerobiologia-polen-esporas#red-palinocam> (accessed on 8 April 2021).
20. Chico Fernández, J.; Ayuga Téllez, E. Analysis of Pollen Concentrations from Various Tree Pollen Types and Their Interrelation with Different Airborne Pollutants in the Madrid Region (Spain). *Sustainability* **2021**, *14*, 5259. [CrossRef]
21. Subiza Garrido-Lestache, J. Pólenes alérgicos en España. *Allergol. Immunopathologia* **2004**, *32*, 121–124. [CrossRef] [PubMed]
22. Subiza, J. *Papel de la Polución en el Aumento de la Polinosis*; Centro de Asma y Alergia Subiza: Madrid, Spain, 2004; Volume 21, pp. 1–6.
23. Observatorio de Resultados del Servicio Madrileño de Salud. Consejería de Sanidad. *Comunidad de Madrid*. Available online: <http://observatorioresultados.sanidadmadrid.org/AtencionPrimariaInformes.aspx> (accessed on 28 November 2022).
24. Sociedad Española de Inmunología Clínica, Alergología y Asma Pediátrica. SEICAP. Available online: <https://seicap.es/alergia/asma-y-otras-enfermedades-alergicas/conjuntivitis-alergica/> (accessed on 13 December 2022).
25. SEAIC. *Alergológica 2015*; SEAIC: Madrid, Spain, 2017; ISBN 978-84-88014-41-2.
26. Bousquet, J.; Khaltaev, N.; Cruz, A.A.; Denburg, J.; Fokkens, W.J.; Togias, A.; Zuberbier, T.; Baena-Cagnani, C.E.; Canonica, G.W.; Van Weel, C.; et al. Allergic rhinitis and its impact in asthma (ARIA) 2008 update (in collaboration with the World Health Organization, GA(2)LEN and AllerGen). *Allergy* **2008**, *86*, 8–160. [CrossRef]

27. Strachan, D.; Sibbald, B.; Weiland, S.; Ait-Khaled, N.; Anabwani, G.; Anderson, H.R.; Asher, M.I.; Beasley, R.; Bjorksten, B.; Burr, M.; et al. 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. [[CrossRef](#)] [[PubMed](#)]
28. Arnedo-Pena, A.; García-Marcos, L.; Blanco-Quirós, A.; Martínez Gimeno, A.; Aguinaga Ontoso, I.; González Díaz, C.; Díaz Vázquez, C.; Busquets-Monge, R.; Morales Suárez-Varela, M.; Batlles Garrido, J.; et al. Time trends in prevalence of symptoms of allergic rhinitis in 13–14 years old schoolchildren in 8 areas of Spain between 1993–1994 and 2001–2002 according to the International Study of Asthma and Allergies in Childhood (ISAAC). *Med. Clin.* **2004**, *123*, 490–495. [[CrossRef](#)]
29. Kim, H.; Park, Y.; Park, K.; Yoo, B. Association between Pollen Risk Indexes, Air Pollutants, and Allergic Diseases in Korea. *Osong Public Health Res. Perspect.* **2016**, *7*, 172–179. [[CrossRef](#)] [[PubMed](#)]
30. McMichael, A.J.; Woodruff, R.E.; Hales, S. Climate change and human health: Present and future risks. *Lancet* **2006**, *367*, 859–869. [[CrossRef](#)]
31. Miyazaki, D.; Fukagawa, K.; Okamoto, S.; Fukushima, A.; Uchio, E.; Ebihara, N.; Shoji, J.; Kenichi Namb, K.; Shimizu, Y. Epidemiological aspects of allergic conjunctivitis. *Allergol. Int.* **2020**, *69*, 487–495. [[CrossRef](#)]
32. Takamura, E.; Uchio, E.; Ebihara, N.; Ohno, S.; Ohashi, Y.; Okamoto, S.; Kumagai, N.; Satake, Y.; Shoji, J.; Nakagawa, Y.; et al. The Japanese Society of Allergology. Japanese guidelines for allergic conjunctival diseases 2017. *Allergol. Int.* **2017**, *66*, 220–229. [[CrossRef](#)] [[PubMed](#)]
33. Feo Brito, F.; Mur Gimeno, P.; Martínez, C.; Tobías, A.; Suárez, L.; Guerra, F.; Borja, J.M.; Alonso, A.M. Air pollution and seasonal asthma during the pollen season. A cohort study in Puertollano and Ciudad Real (Spain). *Allergy* **2007**, *62*, 1152–1157. [[CrossRef](#)] [[PubMed](#)]
34. Brake, D.R.; Yaman, R.N.; Camargo, A.R.; Marks, L.A.; Maddux, J.T.; Ochkur, S.I.; Rank, M.A. Meteorological and environmental factors that impact pollen counts, allergenicity, and thresholds: A scoping review. *Allergy Asthma Proc.* **2023**, *44*, 229–236. [[CrossRef](#)] [[PubMed](#)]
35. Lambert, A.L.; Dong, W.; Selgrade, M.K.; Gilmour, M.I. Enhanced Allergic Sensitization by Residual Oil Fly Ash Particles Is Mediated by Soluble Metal Constituents. *Toxicol. Appl. Pharmacol.* **2000**, *165*, 84–93. [[CrossRef](#)]
36. Nielsen, G.D.; Olsen, O.; Larsen, S.T.; Løvik, M.; Poulsen, L.K.; Glue, C.; Brandorff, N.P.; Nielsen, P.J. IgE-mediated sensitisation, rhinitis and asthma from occupational exposures: Smoking as a model for airborne adjuvants? *Toxicology* **2005**, *216*, 87–105. [[CrossRef](#)]

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