Asthma Exacerbations in the Pediatric Emergency Department at a Tertiary Hospital: Relationship with Environmental Factors

Running title: Asthma exacerbations in the pediatric emergency department.

Marques-Mejías MA[1], Tomás-Pérez M[1,2], Hernández I[1], López I[1], Quirce S[1,2,3]

[1]Department of Allergy, Hospital Universitario La Paz, Madrid, Spain.
[2]Department of Allergy, Hospital La Paz Institute for Health Research (IDIPAZ), Madrid, Spain.
[3]CIBER de Enfermedades Respiratorias CIBERES, Madrid, Spain.

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.18176/jiaci.0364

doi: 10.18176/jiaci.0364

Correspondence author:
M. Andreína Marques-Mejías
Mariaandreina.marques@salud.madrid.org
Department of Allergy, Hospital Universitario La Paz.
Paseo de la Castellana, 261.
Madrid, Spain.

Word count: 2.458.
Tables: 1.
Figures: 3.

Conflict of interest:
The authors declare no conflict of interest during the realization of this study.

Funding: no funding was received for this project.

doi: 10.18176/jiaci.0364

Abstract

Introduction: Children with asthma suffer from recurrent respiratory symptoms and exacerbations due to multiple environmental factors. The aim of this study is to describe the prevalence and triggers of asthma exacerbations and their management in cohort of pediatric patients attended in an emergency department (ED).

Methods: This was an observational, retrospective, single center study, conducted in the pediatric ED of the Hospital Universitario La Paz (Madrid, Spain) in 2015. Children with asthma exacerbations attending the ED were included in the study after a thorough search using our institution informatics database. Pollen and atmospheric mold spore counts as well as pollution data were collected for that period from official websites. Multiple logistic regression was used to assed the association between daily pollution (determine by levels NO_2, PM_{10}, O_3, pollen and mold counts) and asthma admissions in the ED.

Results: During 2015, 50,619 patients attended the ED of our hospital. Of these, 2,609 (5%) had the diagnosis of asthma exacerbation/bronchospasm. The 21.7% of the cases required hospital admission. The main triggers of asthma exacerbations were respiratory infections in 1,841 of cases (70.6%). A significant correlation was found between grass pollen counts and ED admissions ($p<10^{-4}$). A positive correlation was also found between ED admissions and NO_2 0.58 (95% 0.02 to 0.87) and PM_{10} 0.75 (95% 0.31 to 0.93) ($p<0.05$).

Conclusion: Environmental factors such as grass pollen counts and pollution (NO_2 and PM_{10}) are associated with more ED admissions.

Key words: Pediatric Asthma. Asthma Exacerbations. Air Pollutants. Asthma Management.

Resumen

Introducción: Los niños con asma presentan síntomas respiratorios y exacerbaciones recurrentes debido a múltiples factores ambientales. El objetivo de este estudio es describir la prevalencia y los desencadenantes de las exacerbaciones del asma y su manejo en una cohorte de pacientes pediátricos atendidos en un servicio de urgencias (SU).

Métodos: Se trata de un estudio observacional, retrospectivo, unicéntrico, dirigido en urgencias pediátricas del Hospital Universitario La Paz (Madrid, España) en 2015. Los pacientes con diagnóstico de exacerbación de asma fueron seleccionados a partir de una búsqueda informática. La información referente a niveles de pólenes, hongos y contaminación fue recogida en portales digitales oficiales. Se realizó una regresión logística múltiple para evaluar la asociación entre la contaminación diaria (determinada por los niveles NO_2, PM_{10}, O_3, recuentos de polen y hongos) y las admisiones por asma en el servicio de urgencias.

Resultados: En el 2015 fueron atendidos en urgencias pediátricas de nuestro hospital 50.619 niños. De éstos, 2.609 (5%) tenían diagnóstico de exacerbación asmática/broncoespasmo. El 21,7% de los casos requirió ingreso. Los principales desencadenantes fueron las infecciones 70,6%. La relación entre picos de polinización de gramíneas y admisión en urgencias fue significativa ($p<10^{-4}$) igualmente una correlación positiva fue obtenida entre episodios de broncoespasmo y NO_2 0.58 (95% 0.02 a 0.87) y PM_{10} 0.75 (95% 0.31 a 0.93) ($p<0.05$).

Conclusión: Factores ambientales como el recuento de polen de gramíneas y partículas contaminantes (NO_2, PM_{10}) se asocian con un mayor número de episodios de broncoespasmo atendidos en urgencias.

Palabras clave: Asma Pediátrica, Exacerbaciones Del Asma, Contaminantes Ambientales, Manejo de Asma.

doi: 10.18176/jiaci.0364

INTRODUCTION

Asthma prevalence in the European Union is currently estimated in 9.4% in children. [1] Its incidence continues to increase around the world [2] representing an important economic burden by direct and indirect costs in Western countries. Big part of the costs is related to emergency department (ED) care and hospitalizations. [3,4] In Spain, asthma exacerbation episodes represent 5% of pediatric ED visits, and even 10-15% at certain times of the year. [5,6]

An asthma exacerbation can be defined as an increase in airway inflammation that causes airflow limitation and triggers asthma symptoms (wheezing, short of breath, coughing or chest tightness). It can be considered as severe if requires systemic corticosteroids and/or assistance in emergency departments or hospitalization. [7,8]

Children are more susceptible than adults to negative health effects of pollutants. [9,10] In many cohorts, a positive association between exposure to pollutants and mild to severe asthma exacerbations has been demonstrated. It has been directly linked to reduced lung function [7,9-11]

The air pollutants more frequently associated with severe exacerbations are daily levels of nitrogen dioxide (NO_2), particulate matter (PM_{10})[12,13], oxone (O_3) and airborne pollen [14]. A thorough understanding of the relationship between asthma exacerbation and factors such as allergic inflammation, infections and pollution is still missing. [15]

The aim of this study is to describe the prevalence of episodes of asthma exacerbation and their management in an emergency attended cohort of pediatric patients in Madrid. Secondary analyses were made to predict probable triggers involved. This is the largest cohort of pediatric population analyzed regarding ED admissions management and its relation with environmental factors in Spain in the last 10 years.

MATERIALS AND METHODS

This was an observational, retrospective, single center study, conducted in the pediatric ED at Hospital Universitario La Paz (Madrid, Spain) during one year (Jan 1–Dec 31, 2015). An informatics search of patients was performed under the words: difficulty breathing, wheezing and/or dyspnea. Those with a diagnosis of asthma exacerbation

doi: 10.18176/jiaci.0364

were enrolled in the study. Data on each visit were collected from the ED informatics system and the hospital medical records. The variables included were: sex, age, treatment received in the ED, need for hospitalization, month of the year of admission, probable cause of symptoms, and referral to allergy or pneumology departments. From the medical records of the pediatric allergy department, information on allergy tests performed during the follow-up visits was obtained.

Pollen and mold spore counts as well as environmental pollution data were collected also for that period (Jan 1- Dec 31, 2015) from the aerobiology committee of the Spanish Allergy and Clinical Immunology (SEAIC) website (https://www.polenes.com/home) and from Madrid city council's website in its air quality section (http://www.mambiente.munimadrid.es/opencms/opencms/calaire), respectively. Air pollutants (NO_2) and fine particulate matters with 10 µm diameter (PM_{10}) were monitored from the Plaza Castilla station, one of the main ones of the city (2.7 km from the hospital), calculating a media per day, week and month during that period. For pollen and fungus data, monthly average of concentrations of Gramineae, Cupressaceae, *Olea europaea* were recorded in grains per cubic meter (g/m^3) and *Alternaria alternata* in spores per cubic meter.

STATISTICAL ANALYSES

Descriptive statistics, including median and interquartile ranges for continuous variables and frequency and percentage for categorical variables were provided to describe the study population. The ANOVA or Wilcoxon rank-sum was used to identify differences between groups for continuous variables. Pearson chi-square was used to determine categorical variables. Multiple logistic regression was used to assed the association between daily pollution (determine by levels of NO_2, PM_{10} and O_3) and asthma admissions in the ED. Independent variables were air pollutants (NO_2, PM_{10} and O_3), levels of pollen and fungus. The ED admission was considered as the dependent variable. Statistical significance was determined by $p<0.05$. All the analyses were made using statistical software SPSS R version 3.4.3, platform: x86_64-w64-mingw32/x64 (64-bit), running under: Windows 10 x64 (build 16299).

This study was approved by the Ethics Committee of the Hospital Universitario La Paz in its first version, code HULP: PI-2347.

RESULTS

During 2015, 50,619 patients attended the ED of our hospital. Of these, 2.609 (5%) had the diagnosis of asthma exacerbation/bronchospasm. The distribution by sex was 1,534 (58.8%) boys and 1,075 (41.2%) girls ($p<10^{-4}$). Children included were between 0 and 15 years old, with an age average of 3.59 (SD: 3.11).

The majority of cases resolved with ambulatory assistance (78.3%), while 21.7% required admission. The mean age of admitted patients was 3.2 years old (SD 2.87). Two or more episodes were registered in 607.8 (23.3%) of the patients, 23 (0.9%) of them had between six and eight episodes during that year. The number of repeated episodes by month of the year is shown in table 1.

The most employed treatment was short-acting beta2 agonists in 85.1% of cases, followed by systemic corticosteroids in 54.7%. Inhaled corticosteroids were used in 1.8% and other treatments such as anticholinergics, oxygen and antipyretics were used in 41.7% of the sample. Up to 10.8% of the patients did not receive any treatment at the ED due to absence of symptoms during medical assessment and/or previous medication at home or in other health centers.

The main triggers of exacerbations were infections in 1,841 (70.6%) of the cases, followed by unknown factors in 748 (28.7%). The rest of the possible causes were cutaneous exposure to allergens (0.6%) and food allergy (0.1%). Although there was no a systematic microbiological confirmation of the suspected respiratory infections, most of them are believed to be secondary to viruses by epidemiological data and clinical characteristics.

During 2015, the highest number of patients attended for asthma exacerbations was registered in December, November, May and October, in descendant order ($p<10^{-4}$). The highest percentage of patients that were being followed in allergy departments and attended the ED was registered in May (34.1%) followed by February (29.2%) and April (28.6%), which is statistically significant compared to the number of patients registered in the rest of the year ($p<10^{-4}$). (Figure 1)

doi: 10.18176/jiaci.0364

A total of 596 out of 2,609 (22.8%) patients were evaluated in allergy departments. The most prevalent sensitizer in these children was pollen 275/596 (46.1%), followed by animal dander 136/596 (22.8%), molds 61/596 (10.2%) and house dust mites 39/596 (6.5%). In 14.3% of the sample, no sensitization was found at the time of evaluation.

A statistically significant ($p<10^{-4}$) relationship was found between grass pollen counts and ED admissions, whereas no correlation was found between ED admissions and other pollens (*Cupressus arizonica, Olea europaea*) and molds (*Alternaria alternata*) counts. (Figure 2)

A positive correlation was found between NO_2 0.58 (95% 0.02 to 0.87) and PM_{10} 0.751 (95% 0.31 to 0.93) and bronchospasms. Also, a lineal regression model among this air pollutants reinforced these findings (Figure 2). On the other hand, a weak negative correlation was found between O_3 and bronchospasms -0.67 (95% -0.9 to -0.17) (Figure 3).

We further analyzed the effect of the studied environmental factors by dividing our sample into three groups; 1) Children between 0-3 years old presented a weak but significant positive correlation between PM_{10} (0.028), grass pollen counts (0.02) and bronchospasms. 2) Children between 4-7 years old had also a week correlation between PM_{10} (0.034), grass pollen counts (0.01) and bronchospasms. 3) Children between 8-14 years old were affected by PM_{10}, NO_2 and also by O_3. We found a positive significant correlation between them [PM_{10} (0.060), O_3 (0.027), NO_2 (0.029)]. Regarding pollen counts, there was a significant though weak correlation between Cupressaceae and grass pollen counts and ED admissions. (0.011).

In more than half of the patient population, there was no recorded follow-up by either allergy or pneumology departments (57.6%). Up to 11.1% of the patients were followed-up in allergy departments, 20% in pneumology departments and 11.2% in both of them. Of the admitted patients, 50.7% have regular check-up visits by specialists (allergist or pneumologist). Of this percentage, 22.9% are followed up by allergist only.

doi: 10.18176/jiaci.0364

DISCUSSION

The increase of hospital admissions for wheezing or asthma attacks represents a growing health care problem in developed countries, causing important costs to health systems [4,16]. Since 2016, after the Melbourne thunderstorm asthma study, specialists around the world have been paying more attention to ED admissions in other to detect high risk population [17]. In this sense, children continue to be a vulnerable population during these types of episodes.

The treatment of asthma exacerbations is complex since many patients continue to have asthma related symptoms at home once they have been discharge from the ED [18]. The rising of asthma exacerbations denotes a suboptimal continued management of the disease [18-21].

In our sample, more than 20% of the children had more than one episode of asthma exacerbation in one year. This reinforces the importance of regular check-ups and adjustment of regular controller treatment in these patients. These adjustments should be done accordingly to the triggers involved in the exacerbations, the medical history and treatment response observed in the ED.

One of the current hypothesis for the origin and persistence of wheeze in children involves the interactions between inflammatory pathways triggered by exposure to aeroallergens and respiratory pathogens that disturb the normal development of the airway tissues [22,23]. At the same time, these changes can lead to phenotypic alterations that probably predispose to subsequent development of persistent wheeze [22,23]. This theory proposes that the risk for development of persistent wheeze and asthma is amplified if early sensitization is accompanied by severe lower respiratory tract infections during the first years of life [3,24].

Regarding the infections that affect children, RSV prevalence is estimated in pediatric population around 50% during the first year of life [25]. Sigurs et al. [26] investigated the relation between RSV and asthma demonstrating a statistically significant increase in asthma frequency in 47 children with RSV in comparison with a control group. Across the world, early spring, fall and winter are the seasons usually affected by RSV outbreaks [9]. More than 70% of asthma exacerbations attended in our hospital for one year are due to infections. This leads us to relate the previous statements with our findings (mean

doi: 10.18176/jiaci.0364

age of the sample 3 years old and highest percentage of asthma exacerbations in the months of December, November, May and October), but a microbiological confirmation is needed in further cohorts to clarify the origin of those infections [26].

The biological effects of pollutants and other air contaminants as pollen or mold spores are enhanced in children, because of the immaturity in the immune system and proper physiological characteristics such as low body weight and higher respiratory frequency [27-29]. The latter allow them to inhale greater amounts of pollutants with the subsequent inflammation of smaller airways [28-29], which can be potentiated if there is any other concurrent factor, such as infections or air pollutant peaks during pollination seasons.

Regarding air pollution its effects in the airway varies accordingly with the molecular weight of the particles. NO_2, PM_{10} and O_3, particles have been linked to adverse effects in the airways [17,30,31]. In our study, we found a significant correlation between NO_2 and PM_{10} and bronchospasm. Haven said this, it has been suggested that the effect of PM_{10} relays in the particles with less than 2.5 μm because they can remain in the atmosphere for longer periods and can access the respiratory track easier than bigger ones [31]. Ozone is responsible for producing almost a 10% increase in risk of ED visits especially in children between 6-19 years old [17]. Though we could not find any strong correlations, the most susceptible group to ozone was children 8-15 years old which matches previous reports [17]. For the total population we found an inverse correlation, probably related to other factors that also affect the paediatric population. Moreover, because we could not extract the values from the same measurement tools (NO_2, PM_{10}, O_3).

The relationship we found between air pollutants and ED pediatric admissions in the scatter-plot diagrams is similar to the ones obtained by other cohorts in Spain [32-33].

In industrialized countries, the prevalence of sensitization to pollen has increased over the last decades, which might be due to the interaction between pollen grains and air pollutants mainly present in large cities [30,34]. Pollen concentrations have been previously linked to increases in ED visits. In Madrid, three cohorts have demonstrated this association in the past 20 years [14,35,36]. Our results confirm the importance of grass pollen allergens as relevant triggers of asthma attacks during springtime, particularly as the pollination peaks in May (34% of allergic patients were attended in the ED due to exacerbations during this month). This percentage is probably underestimating the amount

doi: 10.18176/jiaci.0364

of sensitised patients that are attending the ED due to the low amount of referrals to our unit (22.3% in total).

Interestingly, we did not find any correlation between the other pollen families considered to this study (*Cupressus arizonica, Olea europaea*) or molds (*Alternaria alternata*) and ED admissions. Further investigations must be design to explore other possible factors that could explain these findings.

One of the main limitations to study asthma in paediatric population is the lack of objective diagnostic tools and the diagnosis is usually made on clinical grounds. Because this is a retrospective study, some elements of the ED visits could not be recorded thoroughly, such as classification of the episodes by severity. Moreover, a proper follow-up of these patients needs to be done in order to clearly assess the probable causes that are eliciting multiple exacerbations.

Data regarding pollutants was extracted from two different measurement tools: Plaza Castilla Station (NO_2, PM_{10}) and Barrio El Pilar station (O_3) and the actual address of the patients was not registered. Though both included living areas considered for this analysis, since we do not know the distance from patients' homes and measurement tools we also cannot estimate individual data regarding exposure to pollutants. This might also determine the differences of our sample with previous published data.

The study was conducted in one of the biggest pediatric ED in Madrid, allowing us to expect that a one-year sample of attention in this type of pediatric ED can be extrapolated to other tertiary hospitals. However, the same results probably cannot be generalized to smaller health care institutions, not only because of the heterogeneity of treatment protocols, but also due to the expected variability in terms of air-pollutants exposure. Individual data should also be recorded regarding exposure to irritants: smoke).

Despite the limitations of this observational retrospective study, the results allow us to remark, once again, the complex interaction between the multiple factors that can affect asthma in the pediatric population. In addition, this large study stresses the need of a multidisciplinary approach in the follow-up of pediatric patients with asthma exacerbations.

doi: 10.18176/jiaci.0364

Acknowledgements

The authors would like to acknowledge PhD. José Delgado for his support and work in the statistical analysis of the sample.

REFERENCES

1. Selroos O, Kupczyk M, Kuna P, Lacwik P, Bousquet J, Brennan D, et al. National and regional asthma programmes in Europe. European Respiratory Review. 2015;24:474-83.

2. Koné AJ, Rivard M, Laurier C. Impact of follow-up by the primary care or specialist physician on pediatric asthma outcomes after an emergency department visit: the case of Montreal, Canada. Pediatr Asthma Allergy Immunol. 2007;20:23-35.

3. Wang LY, Zhong Wheeler L. Direct and indirect costs of asthma in school-age children. Prev Chronic Dis. 2005;2:11.

4. Gergen, PJ. Understanding the economic burden of asthma. J Allergy Clin Immunol. 2001:107:445-85.

5. Mintegui Raso S, Benito Fernández J, González-Balenciaga M, Landluce A. Consequences of the strenght treatment of children with asthma in pediatric emergency department on to in-hospital admission. Emergencias 2003;15:345-50.

6. Ballestero Y, De Pedro J, Portillo N, Martínez-Mugica O, Arana-Arri E, Benito J. Pilot Clinical Trial of High-Flow Oxygen Therapy in Children with Asthma in the Emergency Service. J Pediatr. 2018;204-10.

7. O'Connor GT, Neas L, Vaughn B, Kattan M, Mitchell H, Crain E, et al. Acute respiratory health effects of air pollution on children with asthma in US inner cities. J Allergy Clin Immunol. 2008;121:1133-9.

8. Samoli E, Nastos PT, Paliatsos AG, Katsouyanni K, Priftis KN. Acute effects of air pollution on pediatric asthma exacerbation: Evidence of association and effect modification. Environ Res. 2011;111:418-24.

9. Burbank A, Peden D. Assessing the impact of air pollution on childhood asthma morbidity: how, when, and what to do. Curr Opin Allergy Clin Immunol. 2018;18:124-31.

10. Tétrault LF, Doucet M, Gamache P, Fournier M, Brand A, Kosatsky T, et al. Severe and Moderate Asthma Exacerbations in Asthmatic Children and Exposure to Ambient Air Pollutants. Int. J. Environ. Res. Public Health. 2016;13:771.

11. Just J, Ségala C, Sahraoui F, Priol G, Grimfeld A, Neukirch F. Short-term health effects of particulate and photochemical air pollution in asthmatic children. Eur Respir J. 2002;20:899-906.

12. Peel JL, Tolbert P, Klein M, Busico K, Flanders D, Todd K, et al. Ambient air pollution and respiratory emergency department visits. Epidemiology. 2005;16:164-74.

13. Sunyer, J, Spix C, Quenel P, Ponce-de-León A, Pönka A, Barumandzadeh T, et al. Urban air pollution and emergency admissions for asthma in four European cities: the APHEA project. Thorax. 1997;52:760-5.

14. Galán I, Prieto A, Rubio M, Herrero T, Cervigón P, Cantero JL, et al. Association between airborne pollen and epidemic asthma in Madrid, Spain: a case-control study. Thorax. 2010;65:398-402.

15. Heymann P, Carper H, Murphy D, Platts-Mills T, Patrie J, McLaughlin A, et al. Viral infections in relation to age, atopy and season of admission among children hospitalized for wheezing. J Allergy Clin Immunol. 2004;114:239-46.

16. Loyano P, Sullivan SD, Smith DH, Weiss KB. The economic burden of asthma in US children: estimates from the National Medical Expenditure Survey. J Allergy Clin Immunol. 1999;104;957-63.

17. D'Amato G, Annesi-Maesano I, Cecchi L, D'Amato M. Latest news on relationship between thunderstorms and respiratory allergy, severe asthma, and deaths for asthma. Allergy. 2018. Accepted manuscript.

18. Stempel DA, Roberts CS, Stanford RH. Treatment patterns in the months prior to and after asthma-related emergency department visit. Chest. 2004;126:75-80.

19. Quirce S, Delgado J, Entrenas LM, Grande M, Llorente C, López A, et al. Quality indicators of asthma care derived from the Spanish Guidelines for Asthma Management (GEMA 4.0): A Multi-disciplinary team report. J Investig Allergol Clin Immunol. 2017;27:69-73.

20. Pola-Bibian B, Domínguez-Ortega J, Vilá-Nadal G, Entrala A, González Cavero L, Barranco P, et al. Asthma exacerbations in a tertiary hospital: Clinical features, triggers and risk factors for hospitalization. J Investig Allergol Clin Immunol. 2017;27:238-45.

21. Akinbami LJ, Moorman JE, Bailey C, Zaharan HS, King M, Johnson CA, et al. Trends in asthma prevalence health care use, and mortality in the United States, 2001-2010. NCHS data brief, 2012;94:1-8.

22. Sporik R, Holgate ST, Cogswell JJ. Natural history of asthma in childhood: a birth cohort study. Arch Dis Child, 1991;66:1050-3.

23. Wiesch D, Meyers D, Bleeker E. Genetics of asthma. J Allergy Clin Immunol. 1999; 104:895-901.

24. Toni D, Terry Y. Respiratory syncytial virus. Pediatr Rev.1998;19:55-61.

25. Sigurs N, Bjarnason R, Sigurbergsson F, Kjellman B. Respiratory syncytial virus bronchiolitis in infancy is an important risk factor for asthma and allergy at age 7. Am J Respir Crit Care Med. 2000;161:1501-7.

26. Sigurs, N. A cohort of children hospitalized with acute RSV bronchiolitis: impact on later respiratory disease. Paediatr Respir Rev. 2002;3:177-83.

27. EPÁs Office of environmental Health Hazards Assessment and the American Lung Association of California. Air pollution and children's health. A fact sheet. California, USA, 2003.

28. Díaz J, Linares C, Tobías A. Short-term effects of pollen species on hospital admissions in the city of Madrid in terms of specific causes and age. Aerobiologia 2007;23:231-38.

29. Bouazza N, Foissac F, Urien S, Guedj R, Carbajal R, Tréluyer JM, et al. Fine particulate pollution and asthma exacerbations. Arch Dis Child. 2017;0:1-4.

30. D´Amato M, Cecchi L, Annesi-Maesano I, D´Amato G. News on Climate Change, Air Pollution, and Allergic Triggers of Asthma. J Invest Allergol Clin Immunol. 2018;28:91-97.

31. Diaz J, García R, Ribera P. Modelling of air pollution and its relationship with mortality and morbidity in Madrid, Spain. Int Arch Occup Environ Health 1999;72:366-76.

32. Pablo-Romero M, Román R, González Limón JM, Praena-Crespo M. Effects of fine particles on children's hospital admissions for respiratory health in Seville, Spain. Journal of Air & Waste Mangement Association. 2015;65:436-44.

33. Klinnert M, Nelson H, Price M, Adinoff A, Leung D, Mrazek D. Onset and persistence of Childhood Asthma: Predictors from infancy. Pediatrics, 2001;108:69.

34. D'Amato, G. Enviromental urban factors (air pollution and allergens) and the rising trends in allergic respiratory diseases. Allergy. 2002;57:30-33.

35. Tobías A, Galán I, Banegas JR. Short-term effects of airborne pollen concentrations on asthma epidemic. Thorax 2003;58:708-10.

36. Linares C, Díaz J, Tobías A, De Miguel JM, Otero A. Impact of urban air pollutants and noise levels over daily hospital admissions in children in Madrid: a time series analysis. Int Arch Occup Environ Health. 2006; 79:143-152.

doi: 10.18176/jiaci.0364

Table 1. Nº of recurrent asthma exacerbation episodes in children that attended the ED at Hospital Universitario La Paz during 2015.

Month	Nº of recurrent episodes	%
January	76	10.7
February	50	7.0
March	58	8.1
April	69	9.7
May	88	12.3
June	40	5.6
July	14	2.0
August	9	1.3
September	62	8.7
October	107	15.0
November	86	12.1
December	54	7.6

Figure 1. Number of patients with asthma exacerbations who attended the ED during 2015.

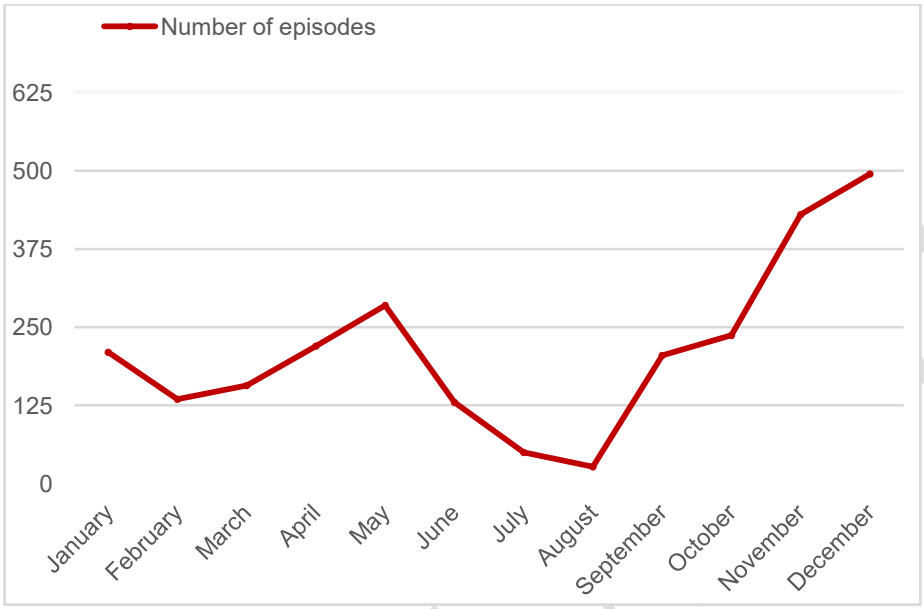

Figure 2. Correlation between pollens (Gramineae, *Cupressus arizonica, Olea europaea*), *Alternaria alternata* and ED admissions.

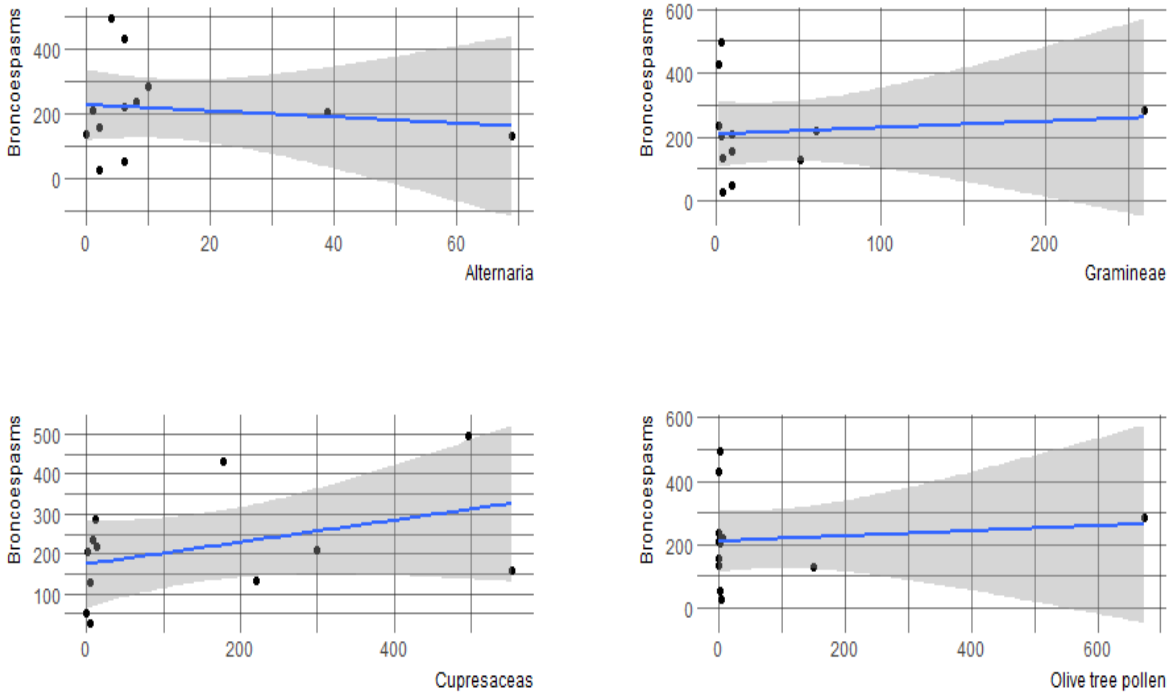

Figure 3. Correlation between air pollutants (NO_2, PM_{10}, O_3) and ED admissions.