

ENVIRONMENTAL DETERMINANTS

The association between asthma-related emergency department visits and pollen and mold spore concentrations in the Bronx, 2001–2008

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Abstract

Background: The incidence of asthma morbidity and mortality is highest among minority inner-city populations. Among New York City's five boroughs, the Bronx has the highest rate of asthma-related hospitalizations and mortality. Outdoor air pollutants have been associated with increased asthma-related ED visits (AREDV) in this borough. **Objective:** To better understand the contribution of pollen and mold to asthma severity in the Bronx. **Methods:** The numbers of daily adult and pediatric AREDV and asthma-related hospitalizations (ARH) from 2001 to 2008 were obtained from two Bronx hospitals. AREDV and ARH data were acquired retrospectively through the Clinical Looking Glass data analysis software. Daily counts for tree, grass and weed pollen and mold spore counts from March 2001 to October 2008 were obtained from the Armonk counting station. All data were statistically analyzed and graphed as daily values. **Results:** There were a total of 42 065 AREDV and 10 132 ARH at both Bronx hospitals. There were spring and winter peaks of increased AREDV. Tree pollen counts significantly correlated with total AREDV ($\rho = 0.3639$, $p < 0.001$), and pediatric ($\rho = 0.33$, $p < 0.001$) and adult AREDV ($\rho = 0.28$, $p < 0.001$). ARH positively correlated with tree pollen counts (Spearman $\rho = 0.2389$, $p < 0.001$). **Conclusions:** There exists a significant association between spring AREDV and ARH and tree pollen concentrations in a highly urbanized area such as the Bronx. Early anticipation of spring pollen peaks based on ongoing surveillance could potentially guide clinical practice and minimize asthma-related ED visits in the Bronx.

Keywords

Aerobiology, asthma, epidemiology, mold, morbidity, pollen

History

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Introduction

Asthma is a common disease that globally affects ~300 million people, with ~15–17 million affected people in USA. The incidence of asthma morbidity and mortality is on the rise in USA and is highest among minority inner-city populations [1–3]. Among New York's five boroughs, the Bronx has the highest rate of asthma-related hospitalizations and mortality [1,4,5]. The annual asthma-related hospitalization rate in the Bronx is 0.57% as compared to the US rate of 0.14% [4,5]. The reasons underlying this marked increase in severity are presently unclear, but understanding the cause of this increase would be important in guiding clinical practice and prevention.

In order to better understand the contribution of outdoor air quality to the severity of asthma in the Bronx, we previously analyzed the relationship between asthma emergency visits for the whole borough, and various air-quality indices for the year 1999 [6]. We found that there were distinct peaks of increased asthma-related ED visits that occurred in the winter,

spring and fall. Similar seasonal peaks in asthma exacerbations have been reported in many other localities [7–9]. Not surprisingly, outdoor air pollutants such as nitrogen oxides and sulfur dioxide were associated with increased asthma emergency visits in the cold weather. However, it was interesting that the most prominent peak of daily asthma emergency visits occurred in the spring and appeared to overlap with daily pollen counts.

Tree pollen counts have been linked to asthma-related symptoms in other areas [10–14]. However, this association appeared to be an unusual finding given the highly urbanized, relatively low tree density nature of much of the Bronx. It was important to determine if this pollen association was a reproducible event. We therefore tracked daily asthma-related emergency department (ED) visits for the Bronx for multiple years (1 January 2001–31 December 2008) and analyzed their association with pollen and mold counts.

Methods**Participants and background**

Study participants were males and females of all ages, including pediatric patients (i.e. individuals <18 years old). All individuals were patients requiring asthma-related

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emergency department visits or inpatient admissions at each of the two hospitals listed below during the specified study period. The data collection period was from 1 January 2001 to 31 December 2008. Only the daily number of asthma-related emergency department visits, asthma-related hospitalizations and no personally identifiable information were used for our statistical analysis.

Emergency department visits and hospitalizations

We conducted a retrospective search of adult and pediatric asthma-related emergency department visits (AREDV) and asthma-related hospitalizations (ARH) from two major Bronx hospitals (Montefiore Medical Center's Moses and Weiler divisions). Daily adult and pediatric AREDV and ARH during the time period of 1 January 2001 to 31 December 2008 were collected using the Clinical Looking Glass analysis software with the primary diagnosis of asthma (ICD-9 code 493). If there were multiple AREDV and ARH for the same medical record number within 1 January to 31 December of a particular year, we counted all of these visits for that particular year.

Pollen and mold spore counts

Daily counts for tree, grass and weed pollen and mold spores from 1 March 2001 to 15 October 2008 were obtained from Fordham University's Louis Calder Center Aero-Allergen Monitoring Station in Armonk, NY, ~21 miles north of the Montefiore Medical Center in the Bronx. This station is the closest certified pollen and mold counting facility to the Bronx that supplied pollen counts most consistently over the entire 8-year period. Pollen and mold spore counting at this site was performed using a Burkhard sampler, which yielded a microscopic slide for each day; the center's certified technicians then counted at least one horizontal traverse to calculate particles per cubic meter. On days when pollen counts were not available, pollen counts were designated to be missing, and those days were excluded from the analysis.

Statistical methods

All data were statistically analyzed using STATA/SE 11.2 software. Univariate analysis revealed the non-parametric

distribution of all pollen counts, as well as AREDV and ARH numbers. Two extreme outliers of tree pollen counts that exceeded 10000 were removed from the analysis. Daily pollen and mold spore counts were correlated with AREDV and ARH during the years 2001–2008 using the Spearman rank test. All correlation analysis was done on non-missing values for pollen or mold counts and AREDVs or ARHs from the same day. For the association between quartiles of total pollen counts and number of ED visits, we used the *t*-test with unequal variances.

Results

AREDV and ARH

Counts of pediatric and adult AREDVs were available on all days from 1 January 2001 to 31 December 2008. There were a total of 42 065 AREDV and 10 132 ARH at both Bronx hospitals. More than half of AREDVs were pediatric visits ($n = 22\,717$). The number of asthma ED visits varied throughout the year; these were highest during the winter months (December–January) and lowest during the summer months (July–August), and this general pattern was similar in all the years (2001–2008) (Figures 1 and 2). However, as we previously reported, the general decline in asthma ED visits from January to July was interrupted each year by a spike in visits that peaked around the beginning of May (Figure 1, arrows). In 4 of the 8 years (2001, 2006, 2007 and 2008), the number of daily asthma ED visits during each of the spring peaks exceeded the maximum daily ED visit numbers seen during the prior or subsequent winter peak. The graph for the year 2001 was expanded to more clearly illustrate these two peaks (Figure 1, inset). Total ARH also showed similar patterns (Figure 2).

Relationship between asthma-related ED visits, pollen counts and mold counts

During the 8 year observation period, pollen and mold counts were only available for the months of March through October. Only one observation of pollen and mold counts was available for November. From March through October, pollen numbers were counted on 46% ($SD \pm 11\%$) of days every month and mold spores were counted on 23% ($SD \pm 8\%$) of

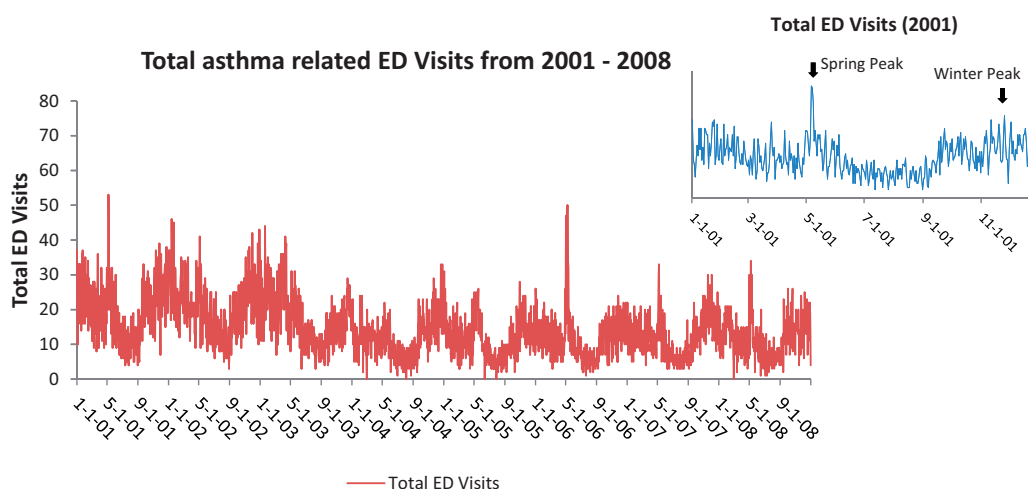


Figure 1. Total asthma-related ED visits from 2001–2008.

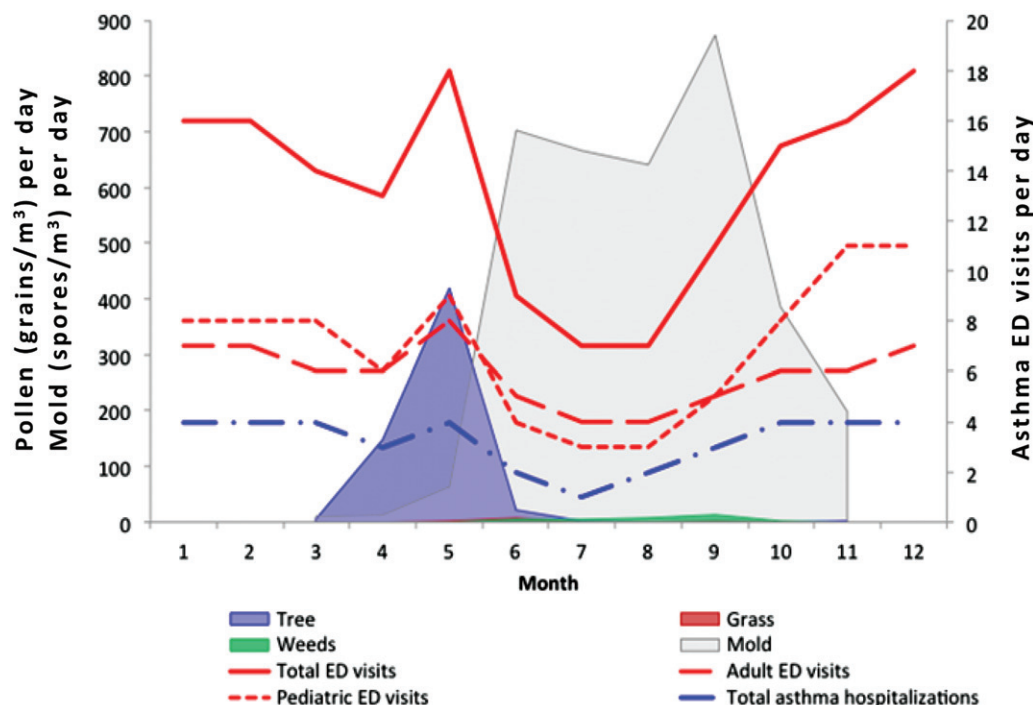


Figure 2. Median pollen, mold counts, asthma-related ED visits and asthma hospitalizations 2001–2008.

days every month. Figure 2 shows the median monthly number of pollen counts, mold spore counts, AREDV and ARH based on available data from years 2001 through 2008 (Figure 2). Tree pollen counts significantly correlated with total AREDV ($\rho=0.3639$, $p<0.001$), and pediatric ($\rho=0.33$, $p<0.001$) and adult AREDV ($\rho=0.28$, $p<0.001$). To minimize possible confounders (e.g. temperature, humidity, etc) related to the change of climate between March and October, we also analyzed the correlation of tree pollen counts and AREDVs during only May, when tree pollen counts reached the highest levels. In May, tree pollen counts significantly correlated with the total number of AREDVs ($\rho=0.21$, $p=0.012$) and pediatric AREDVs ($\rho=0.28$, $p<0.001$), but not with adult AREDVs ($\rho=0.07$, $p=0.39$). In contrast, there was no positive correlation between AREDVs and mold spore counts, weed pollen counts or grass pollen counts.

Relationship between asthma-related hospitalizations and pollen counts

We also observed a similar relationship between total ARH and pollen counts (Figure 2). The numbers of ARH were available on all days during the 8-year observation period. ARHs positively correlated with tree pollen counts (Spearman $\rho=0.2389$, $p<0.001$), but not with grass, weed or mold counts.

Analysis of the association between asthma-related ED visits and total pollen counts

We analyzed the association between AREDV and total pollen counts by grouping pollen counts into quartiles (Figure 3). When comparing the mean daily AREDVs in the highest quartile (i.e. pollen counts exceeding 100 grains/m³) of

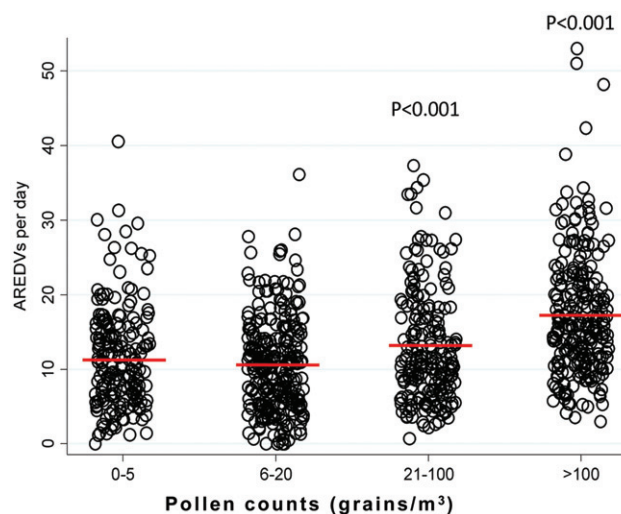


Figure 3. Association between asthma ED visits and total pollen counts.

pollen counts with the mean daily AREDVs of all other quartiles (i.e. pollen counts ≤ 100 grains/m³), we found a strong association between high pollen counts and increased asthma ED visits. Daily pollen counts in the highest quartile of pollen counts corresponded to a mean of 17.1 ($\pm$ SD 8.2) AREDVs, while all other quartiles of pollen counts collectively corresponded to a mean of 11.4 ($\pm$ SD 6.6) AREDVs (Figure 3).

Discussion

Our study demonstrated a distinct peak of asthma-related ED visits that occurred in the Bronx during the spring. A positive correlation was found between spring asthma-related ED

visits and pollen counts in our previous study, which examined asthma ED visits in the Bronx for 1 year [6]. This study further examined this correlation by evaluating this association every year during an 8-year period, and our data support the link between an increase in asthma-related ED visits and increased spring pollen levels. For each of the years examined, we found that there was a large, spring increase in asthma-related ED visits in the Bronx that closely correlated with high spring tree pollen counts. It is noteworthy that in the Bronx, grass and weed pollen counts tend to be significantly lower than tree pollen counts, which may explain their lack of effect on asthma ED visits in this area. However, mold spore counts are relatively high in the Bronx, but they peak in the summer months (Figure 2) when asthma ED visits are at their lowest level, indicating that there is not a simple association between mold spore counts and asthma ED visits.

Tree pollen counts, allergen sensitization and exposure have been linked to increased asthma-related symptoms in the recent literature [10–13]. Darrow et al. [14] demonstrated that *Quercus* tree pollen and Poaceae grass pollen independently contributed to the asthma morbidity in Atlanta, and observed a 10% to 15% increase risk of asthma-related ED visits on the highest pollen concentration days. Tree pollen released each spring is an important cause of seasonal allergy symptoms. This is evidenced by health department surveillance data that demonstrate that the peak of allergy medication sales in New York City occurs in late April to early May, which coincides with peak concentrations of certain tree pollens including maple, birch, ash and oak [15]. This peak in allergy medication sales has also been found to occur ~1 week prior to the spring peak of asthma-related emergency department visits [14]. Busse et al. [16] reported that the administration of omalizumab (anti-IgE) was associated with decreased spring-related asthma exacerbations in several localities in the US. It is possible that this decrease is due at least in part to a reduction in spring pollen-induced allergic asthma similar to what we have observed in our study.

Our study demonstrates that increased spring pollen levels likely contribute to the spring asthma peak. However, we acknowledge that several possible limitations may exist in the context of our study. We only used one pollen collecting station that was ~21 miles from both hospitals. However, previous studies have demonstrated that pollen can travel up to 25 miles [17,18]. We calculated projected AREDV without accounting for other factors that can trigger asthma exacerbations, including changes in temperature, prevalence of viral respiratory infections, and outdoor air pollution. Lee et al. previously suggested that human rhinovirus most likely caused moderate to severe asthma in infants during the months of December to February and least likely caused asthma during the months of April to August. There was a steadily decreasing probability of virus-induced asthma between March and July, therefore speaking against the argument that viral respiratory disease may trigger the observed May peak of AREDVs or ARHs [19]. These findings suggest that increased pollen levels may play a larger role than viral respiratory infections in contributing to the large peak in AREDV and ARH in the spring. In addition, we did not analyze other factors that may affect asthma-related visits in this patient population such as limited access

to care and medication compliance, gender and high-risk ethnic groups [20]. We were not able to obtain the patients' body mass index, which is another potentially confounding variable as there are studies that demonstrate that urban children with asthma in the overweight and obese categories have an increased susceptibility to indoor pollutants [21]. However, none of these patient-specific variables are likely to significantly change in the 2-month period when we observe the spike in asthma ED visits and hospitalizations. In addition, this study represents data retrospectively collected within 8 years and is limited to data collected in the Bronx. Prospective data collection over a longer time-frame is necessary and should include other geographic areas, particularly rural and less industrialized areas. We also recognize the diagnostic (e.g. by retrospectively searching asthma-related primary and secondary ICD-9 codes) and geographic (e.g. by not linking each patient's home in relation to the closest obtained air-quality result) limitations. Our outcomes analysis software enabled us to search by ICD-9 code, and did not provide any information regarding the confirmation of the asthma diagnosis. However, in this regard, in a separate analysis, we had compared COPD-related ED visits and found no association with pollen counts.

This study demonstrates that in the Bronx, which is a highly urbanized and low vegetation area, there is a distinct spring peak of increased asthma-related ED visits that is closely associated with increased tree pollen counts. Based on these results, we conclude that in a highly urbanized area such as the Bronx, there exists a significant association between spring asthma-related ED visits and pollen concentrations. Early anticipation of spring pollen peaks based on ongoing surveillance could potentially guide clinical practice and minimize asthma-related ED visits in the Bronx.

Declaration of interest

The authors have no financial, consulting or personal relationship(s) disclosures to report. No external scientific writing assistance was obtained, and no grant funding has supported this manuscript.

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