

ASTHMA IN THE EMERGENCY DEPARTMENT

Association between Tree Pollen Counts and Asthma ED Visits in a High-Density Urban Center

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Background. Asthma exacerbation patterns are cyclic in nature and often correlate with air particle concentrations. **Objective.** To examine the relationship between asthma-related emergency department (ED) visits and outdoor air quality for pediatric and adult patients in a high asthma prevalence area, the New York City borough of the Bronx. **Methods.** Numbers of daily asthma-related adult and pediatric ED visits during one complete year (1999) were obtained from the seven major Bronx hospitals. Daily values of nitrogen oxides (NO_x), ozone (O_3), sulfur dioxide (SO_2), and pollen counts were acquired. **Results.** Asthma-related ED visit numbers were highest in December–January and lowest in July. There were three distinct peaks of increased asthma ED visits: winter (December–January), spring (late April–May), and fall (October). The spring peak was the most striking and coincided with high tree pollen counts (tree pollen: $r = 0.90$, $p = .03$). We observed a positive correlation between asthma ED visits in the winter and SO_2 and NO_x levels. Winter peaks of SO_2 and NO_x in early December appeared to precede the winter asthma peak. **Conclusions.** The spring asthma peak is closely associated with increased tree pollen counts, and the asthma increase at this time is likely due to allergic reactions to pollen. No significant associations could be established with the fall peak. The winter peak correlates with elevated SO_2 and NO_x levels.

Keywords asthma, emergency department, pollen, pollutants

INTRODUCTION

Asthma is an increasing problem throughout the developed world, especially in urban centers (1–3). Asthma prevalence is very high in New York City, and the borough of the Bronx has one of the highest levels of asthma morbidity in the United States (4). In urban areas such as the Bronx, there are multiple factors related to living conditions that may contribute to increased asthma prevalence. Anecdotally, individuals often claim that their asthma worsens even when they only visit or return to the Bronx, which raises speculation about the association between outdoor environmental factors and asthma morbidity. In other locations, the prevalence of asthma varies throughout the year, and these variations have been associated with changes in air quality, pollen counts, temperature, mold spores, and epidemics of viral respiratory illnesses (5). Specifically, air pollutants such as nitrogen oxides (NO_x), sulfur dioxide (SO_2), and ozone (O_3) have been associated with asthma exacerbations (5–9). In addition, pollen count levels and particulate material 2.5 μm in size (PM 2.5) have also been linked to increased asthma symptoms (8, 10).

The recently published New York City Community Air Survey (NYCCAS) documented high winter levels

of NO_x , SO_2 , and PM 2.5 within the Bronx (11). With its urban population, high asthma prevalence, and multiple types of pollution, the Bronx presents an interesting model for studying environmental factors influencing asthma morbidity. We therefore tracked asthma-related emergency department (ED) visits for the entire borough during one whole year and analyzed their association with distinct air-quality indices to determine some of the factors that might be causing the high prevalence and morbidity of this disease.

METHODS

Participants and Background

Study participants were males and females of all ages, including pediatric patients (i.e., individuals less than 18 years old). All individuals were patients requiring asthma-related ED care at each of the hospitals listed below during the specified study period. The data collection period was from 1 January 1999 to 31 December 1999. Only ED visit numbers, and no personally identifiable information, were collected.

ED Visits

The ED visit data were collected from seven Bronx hospitals evenly dispersed throughout the borough: Montefiore Medical Center (Moses and Weiler divisions), Jacobi Medical Center, Our Lady of Mercy Hospital, North Central Bronx Hospital, Lincoln Hospital,

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Bronx-Lebanon Hospital (Fulton and Grand Concourse divisions), and St. Barnabas Hospital. Average ED visit numbers were analyzed separately for the adult and pediatric populations. All patient data were collected through the identification of primary and secondary asthma-related (i.e., 493) International Classification of Diseases—9th edition (ICD-9) codes that were obtained by searching hospital computer databases or manual entries by ED staff. Single data entry into each hospital's medical records was performed by medical coding personnel after ED physicians had evaluated patients and identified the presenting ICD-9 codes.

Air Quality and Pollen Counts

The air-quality data were obtained from the Bureau of Air Quality Surveillance of the New York State Department of Environmental Conservation, which has several stations that collect air-quality data. NO_x (which include NO, NO₂, and N₂O) and O₃ data were measured as daily averages and acquired from the New York City Botanical Garden station in the Bronx. The SO₂ data were also measured as daily averages and obtained from the New York City IS 155 station, which is near the Bronx Botanical Garden station. Pollen count data were acquired from the Long Island Jewish Medical Center, which is located in the New York City borough of Queens, about 10 miles from the Bronx. Pollen counting at this certified site was performed using a Burkhard sampler, which yielded a microscope slide for each day; the center's certified technicians then counted at least one horizontal traverse to calculate particles per cubic meter. We identified peak months/seasons of pollen counts and individual air particle (i.e., NO_x, SO₂, O₃) concentrations. As the Bronx represents a relatively compact geographic area, we postulated that air particle and pollen concentrations may have minimal variation throughout the locale.

Statistical Methods

All data values except for pollen counts were converted into weekly means for statistical analysis and graphical

display. Pollen counts were analyzed as daily values. Statistical analyses were performed after dividing the year into 12-week blocks of winter, spring, summer, and fall. The final 4 weeks of the year were considered as the winter season. One of our primary aims was to determine peak months/seasons of asthma-related ED visits among adults as well as children. We also sought to correlate our ED visit data with pollen counts and air particle concentrations. Statistically significant cutoff values were set at $p < .05$. All statistics were analyzed through STATA 11.0 (College Station, TX, USA).

RESULTS

ED Visits—Comparison between Hospitals

Composite asthma-related ED visits were at their highest in January, then decreased during the summer months, then increased again beginning in mid-August to finally peak in December. Overlying this general pattern of a gradual decrease and increase, there were three main peaks of asthma-related ED visits in December–January (weeks 1–3 and 49–51), late April–May (weeks 17–21), and late September–October (weeks 37–40) (Figure 1). This general pattern was similar among the seven Bronx hospitals. The peaks were identified as observed ED visit numbers that exceeded the 99.9% confidence interval for a particular time interval (Figure 2).

ED Visits—Comparison between Age Groups

Adult asthma-related ED visits peaked in January, then declined in April, then peaked in May, remained at a low level during the summer, then increased in September, and then increased again in December (Figure 3). Pediatric asthma-related ED visits also followed this general pattern (Figure 3).

The pattern of winter, spring, and fall peaks was observed in both adult and pediatric patients (Figure 3). During the winter peak, adult asthma-related ED visits outnumbered pediatric visits. During the spring peak,

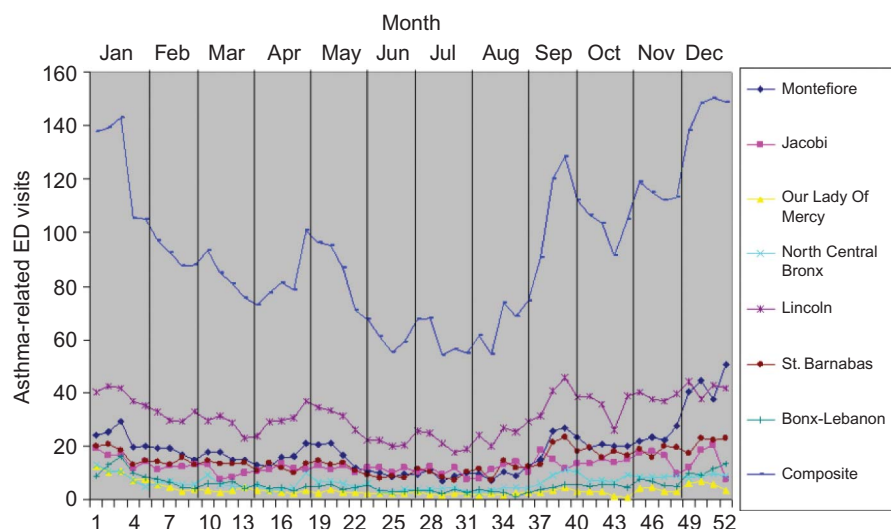


FIGURE 1.—Composite asthma-related ED visits for seven major hospitals in Bronx, NY, USA.

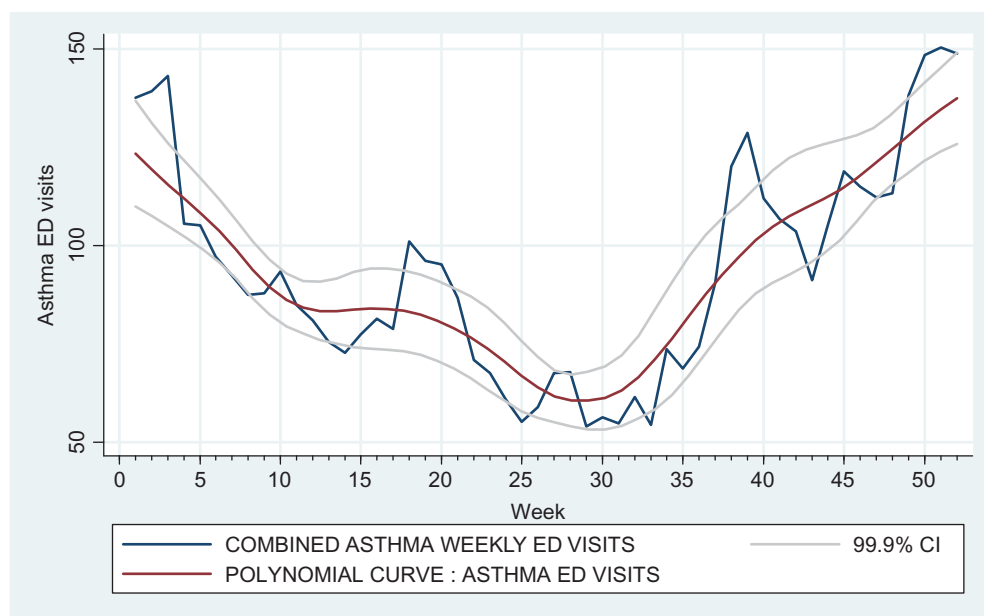


FIGURE 2.—Polynomial regression curve with 99.99% of confidence interval for combined asthma-related ED visits defining ED peaks.

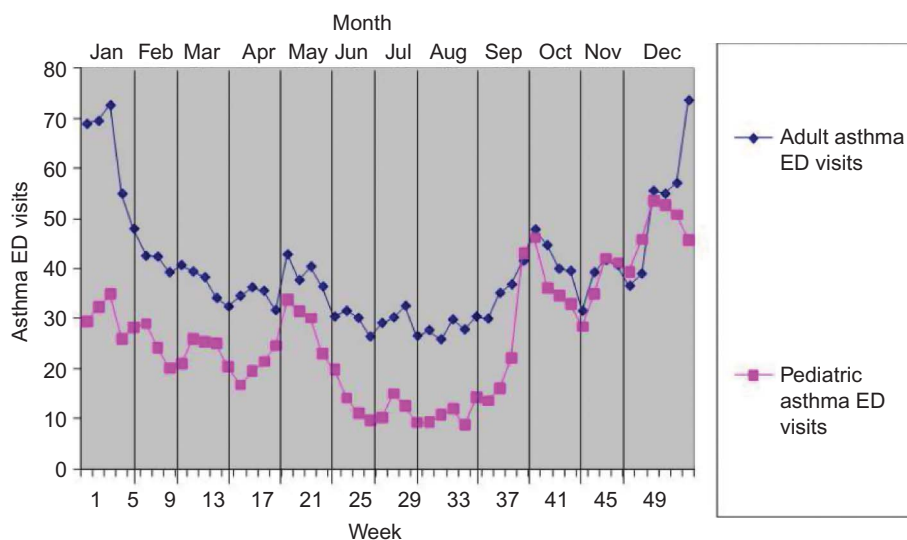


FIGURE 3.—Adult versus pediatric asthma-related ED visits in Bronx, NY.

adult visits were only slightly higher than pediatric visits. During the fall peak, pediatric visits slightly outnumbered adult visits.

Relationship between Asthma-Related ED Visits and Pollen Counts in the Spring

We observed that the spring peak of asthma-related ED visits corresponded with the spring increase in pollen counts in our area. Pollen first started to appear in March, peaked in the spring, decreased in the summer, and demonstrated a very small peak in September (Figures 4 and 5). There was a large peak in pollen counts from mid-April to early June with the highest concentration occurring in early May (Figure 4). Tree pollen is the predominant pollen in the Bronx during the spring, and comprises nearly 99% of all pollen levels from March to May. Spearman correlations between pollen and asthma

ED visits throughout the entire spring block demonstrated a moderate correlation ($r = 0.6620$, $p = .012$). The correlation was further strengthened during the spring peak between weeks 17 and 21 ($r = 0.9$, $p = .0374$).

Relationship between Asthma-Related ED Visits and Pollen Counts in the Fall

Our data did not demonstrate a significant association between asthma-related ED visits and pollen counts in the fall. Fall pollen counts are much lower than the spring counts (i.e., spring peak levels of 1800 grains/mm³ compared to fall peak counts of 75 grains/mm³) (Figures 4 and 5). The fall asthma peak appeared to begin 2 weeks after pollen counts had decreased, and no strong correlation to pollen count could be made ($r = 0.1331$, $p = .68$). Of note, ragweed and mugwort are the predominant pollen types in the Bronx in the late summer and fall.

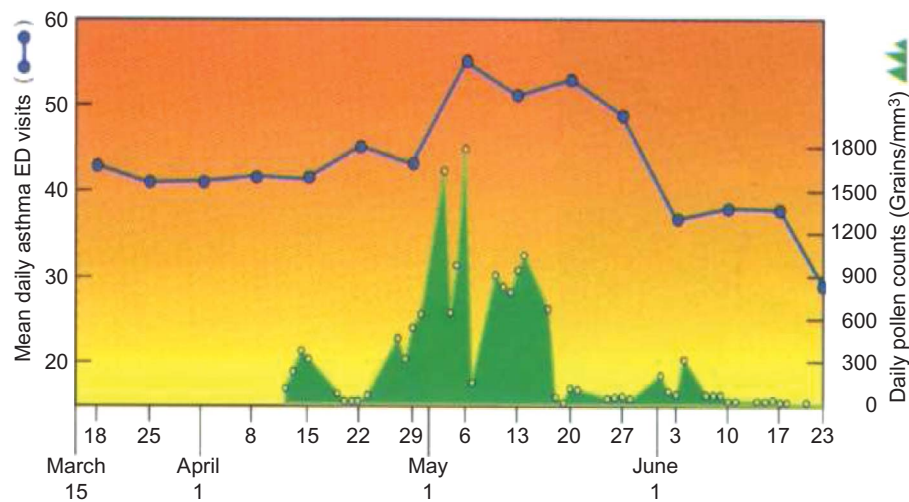


FIGURE 4.—The spring asthma-related ED visit peak is associated with increased tree pollen counts.

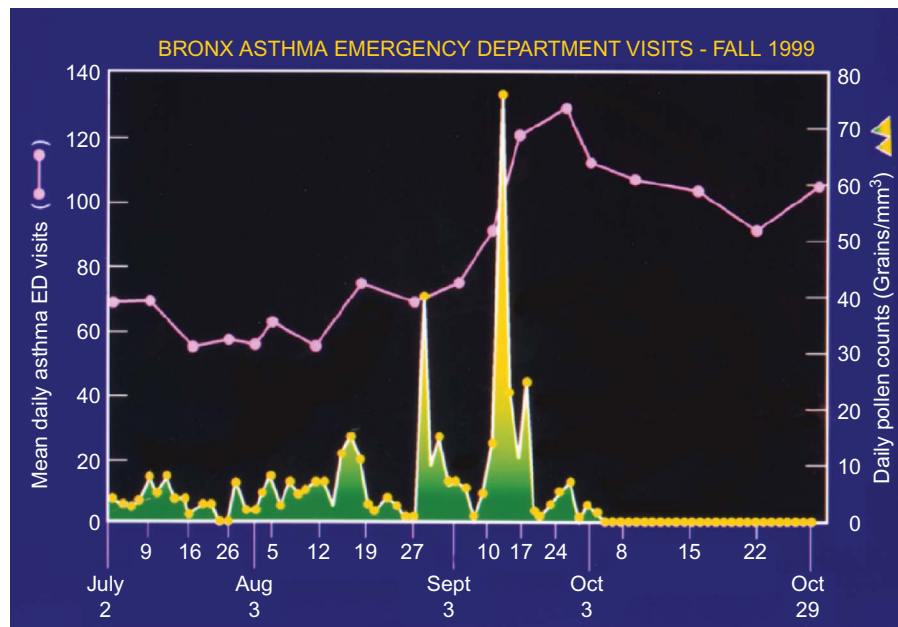


FIGURE 5.—Fall pollen counts are lower than spring counts.

Relationship between Asthma-Related ED Visits, NO_x , and SO_2

We observed that asthma ED visits peaked in the winter, and that NO_x and SO_2 levels also increased in the winter, thereby suggesting a positive correlation. NO_x levels peaked in January, subsequently decreased while reaching a low in August, began to steadily increase again in September, and had a very large peak in December. SO_2 levels peaked in January and February, continued to decrease until April when there was a minor peak, decreased during the summer, and began to increase in December with an associated large peak.

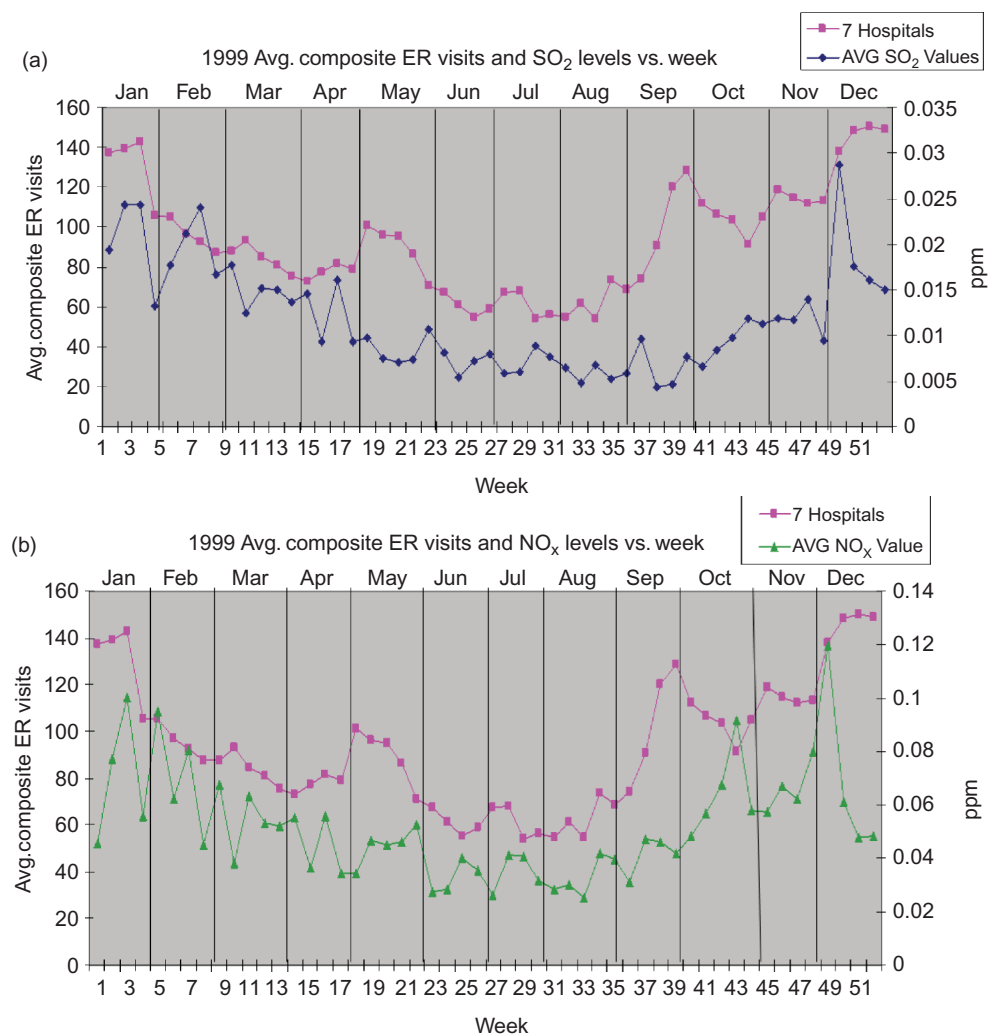
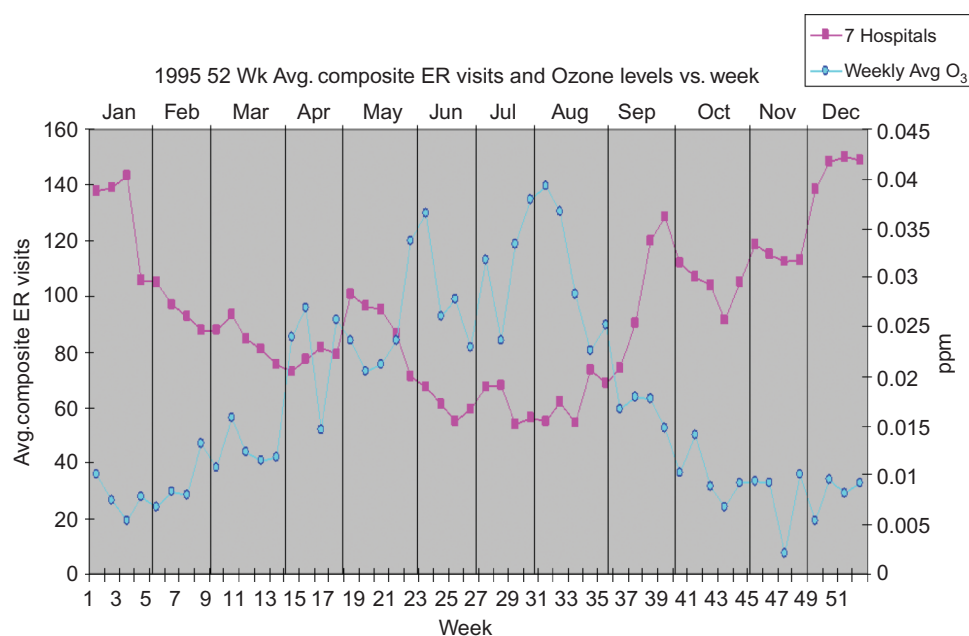
NO_x and SO_2 levels correlated with each other and were highest in the winter and lowest in the summer (Figure 6). Winter peaks of NO_x and SO_2 in early December appeared to precede the winter asthma peak. NO_x and SO_2 levels in the winter were positively correlated with daily asthma-related ED visits.

Relationship between Asthma-Related ED Visits and O_3

Our data demonstrated that summer O_3 levels were increased, and we attempted to correlate these with summer asthma ED visits. O_3 levels were low in January, started to increase in February with very high levels in May and July, began to decrease in August, and reached the lowest levels in November (Figure 7). In contrast to the NO_x and SO_2 data, there was no positive relationship between increased asthma-related ED visits and O_3 levels in spring or winter.

DISCUSSION

This study demonstrated three peaks (i.e., winter, spring, and fall) of asthma-related ED visits. Within the Bronx, multiple factors may contribute to these results. It is probable that the sharp increase in airborne tree pollen is associated with the spring asthma ED visit peak. It has

FIGURE 6.—Winter peaks of (a) SO_2 and (b) NO_x versus asthma-related ED visits.FIGURE 7.— O_3 levels versus asthma-related ED visits in Bronx, NY.

been shown that tree pollen may be a major contributor to asthma-related symptoms; for example, asthma patients receiving tree pollen immunotherapy experienced significant improvements in symptom scores (12). Previous studies in other localities have demonstrated an increase in asthma prevalence coinciding with increased grass pollen counts (13). There has been recent evidence documenting the link between tree pollen and asthma-related symptoms (14–17). Dales et al. (15) suggested that increases in tree pollen counts were associated with asthma-related hospitalizations in Canada; however, this study did not specifically examine ED visit data. Our study supports the link between an increase in asthma-related ED visits and increased tree pollen levels. Furthermore, in our recent study that examined asthma-related ED visits and tree pollen levels from 2001 to 2008, we demonstrated a consistent positive correlation between these two variables during the spring season.

The cause of the fall asthma peak is likely multifactorial. As the fall pollen counts in the Bronx are about 300 times less than the spring counts, pollen allergy may only be a minor contributor to the fall asthma peak. The onset of cold weather increased indoor air exposure as patients spend more time indoors, and back-to-school respiratory infections may be more important asthma-promoting factors in addition to winter smog. Based on their data surrounding school-age children in Canada, Sears and Johnston propose that the September asthma epidemic is largely due to school return and associated rhinovirus infections (18–20). These authors speculate that in the fall young adults suffer from increased asthma symptoms, which result from children serving as vectors for viral respiratory infections (20). Jamason et al. (21) suggest that in the New York City metropolitan region weather-related factors may have a greater impact on asthma-related admissions in the fall and winter, whereas air pollution may play a greater role during the spring and summer months.

When the pollen counts approached zero in the late fall and winter, ED visit numbers continued to increase (i.e., winter peak). Possible explanations for the winter peak include cold air, increased viral respiratory infections, or exposure to indoor allergens such as dust mites, cockroaches, or mold spores, as people spend more time indoors with the windows closed (5, 17, 22, 23). Johnston explains the adult winter asthma peak through the idea of a “Christmas epidemic” through which children may transmit viral infections to older individuals during Christmas-related family gatherings; however, the specific triggers or viral respiratory infections contributing to this epidemic remain to be identified (20). Other contributing factors to the winter peak may stem from the recent NYCCAS findings regarding increased winter pollutant concentrations in the Bronx.

We observed that NO_x and SO_2 levels positively correlated with each other, were highest in the winter and lowest in the summer, and associated with increased asthma-related ED visits. These findings could be partially explained as NO_x and SO_2 are predominantly

winter-related pollutants and result from domestic heating as well as industrial sources. The NYCCAS showed that winter NO_x levels were increased in high-traffic locations and in areas with a high density of building space; these regions mainly comprised Manhattan and the Bronx (11). Similarly, higher winter SO_2 concentrations were found in high-population areas and in locations with a higher proportion of buildings burning “residual” fuel oils; again, Manhattan and the Bronx were implicated (11). Along these lines and consistent with previously published reports, asthma-related ED visits have been linked to increased levels of NO_x and SO_2 during the winter months (6, 8, 9, 22, 24–26). Interestingly, NO_x and SO_2 have been shown to have sensitizing effects with other pollutants and allergens; for example, NO_x can potentiate the effects of house dust mites in asthmatics, and SO_2 may enhance the development of an experimental asthmatic reaction (27). NO_x have also been implicated as major perennial triggers of asthma-related hospitalizations (25).

Although increased O_3 levels have been causally linked to increased asthma-related ED visits, our study failed to demonstrate a positive correlation between asthma-related ED visits and O_3 levels in the winter and spring. Regarding the positive correlation that has been well-established in the literature, chamber studies have demonstrated that O_3 inhalation resulted in cough, dyspnea, and decreased forced vital capacity in asthmatics as well as normal volunteers; these changes directly correlated with dose and duration of exposure (28, 29). Other studies have shown that recurrent exposure to O_3 was capable of enhancing the inflammatory response to inhaled allergens in asthma patients (30). Also, a positive relationship between summer O_3 levels and asthma-related ED visits was found in central New Jersey (31). Our data need to be validated with a longer time-series of observations, which would likely yield the positive association between increased O_3 levels and asthma-related ED visits that has been shown to exist.

Our study demonstrates that seasonal fluctuations in pollen and outdoor air pollutants are associated with asthma-related ED visits and that increased spring tree pollen levels likely contribute to the spring asthma peak. However, we acknowledge that several possible limitations may exist in the context of our study. This study represents data retrospectively collected within 1 year. Prospective data collection over a longer time-frame is clearly necessary. 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 that may have been present.

However, if the relationship between pollen levels and asthma symptoms can be further validated, physicians may be better able to predict and prepare for particular times of the year when asthma-related ED visits are on the rise. In light of the NYCCAS findings, suggesting increased pollutant concentrations in a high

asthma prevalence area such as the Bronx, community and environmental efforts may be necessary to curb the ongoing asthma epidemic.

CONCLUSION

This study demonstrates three distinct peaks (winter, spring, fall) of increased asthma-related ED visits. The spring asthma peak 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 asthma-related ED visits and tree pollen concentrations. More research is clearly necessary to understand the patterns by which outdoor and indoor particles exacerbate asthma symptoms.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper. There are no funding disclosures to report.

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