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Associations of pollen and cardiovascular disease morbidity in Atlanta during 1993–2018

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Background: Pollen exposure is associated with substantial respiratory morbidity, but its potential impact on cardiovascular disease (CVD) remains less understood. This study aimed to investigate the associations between daily levels of 13 pollen types and emergency department (ED) visits for eight CVD outcomes over a 26-year period in Atlanta, GA.

Methods: We acquired pollen data from Atlanta Allergy & Asthma, a nationally certified pollen counting station, and ED visit data from individual hospitals and the Georgia Hospital Association. We performed time-series analyses using quasi-Poisson distributed lag models, with primary analyses assessing 3-day (lag 0–2 days) pollen levels. Models controlled for temporally varying covariates, including air pollutants.

Results: During 1993–2018, there were 1,573,968 CVD ED visits. Most pairwise models of the 13 pollen types and eight CVD outcomes showed no association, with a few exceptions potentially due to chance.

Conclusion: We found limited evidence of the impact of pollen on cardiovascular morbidity in Atlanta. Further study on pollen exposures in different climactic zones and exploration of pollen-pollution mixture effects is warranted.

Keywords: Environmental epidemiology; Pollen; Cardiovascular disease; Ambient air pollution

Introduction

Pollen exposure is associated with substantial respiratory morbidity, with one-quarter of adults in the United States affected by pollen-related seasonal illnesses such as allergic rhinitis, asthma, and wheezing.[1] The possibility has been raised that pollen may also impact cardiovascular disease (CVD) risk. The allergic immune response triggered upon exposure leads to increased inflammation and histamine release, both of which play a role in the pathogenesis of some cardiovascular conditions.[2,3] However, the evidence of pollen being associated with CVD is limited. Only a few studies have examined associations between pollen and cardiovascular mortality[4,5] and emergency department (ED) visits[6–8] with mixed results. These studies were based on a small number of pollen species and relatively short study periods, and only one study was based in the United States.[4–8] Here we investigate associations between daily levels of 13 types of pollen and ED visits for CVD over a 26-year period (1993–2018) in Atlanta, GA using a time-series study design.

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The data for this analysis can be requested from the National Allergy Bureau and Georgia Hospital Association. Code to replicate the results can be acquired through the corresponding author.

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Methods

Morbidity data

ED visit data acquisition has been described in detail elsewhere.[9–12] Briefly, at the start of the study period (1993–2004), patient-level hospital billing record data for emergency room visits were acquired from individual hospitals. In subsequent years, data for all hospitals were acquired from the Georgia Hospital Association. Using primary International Classification of Diseases diagnosis codes, we identified cases as having one of the following cardiovascular outcomes: hypertension, ischemic heart disease, dysrhythmia, congestive heart failure, stroke, peripheral vascular disease, myocardial infarction, or all CVDs (see Supplemental Table 1; http://links.lww.com/EE/A263). Cases were aggregated by day to obtain the daily number of visits for each outcome.

What this study adds:
This study contributes to our limited understanding of the relationship between short-term pollen exposures and cardiovascular disease morbidity through a comprehensive 26-year analysis of daily pollen levels and emergency department visits for various cardiovascular outcomes in Atlanta, GA. The findings reveal that most pollen types are not acutely associated with cardiovascular morbidity. This research enhances our comprehension of the complex interplay between environmental factors and cardiovascular disease. Given the single location of this study, there is a need for further investigation in diverse geographic regions and consideration of pollen mixture effects.

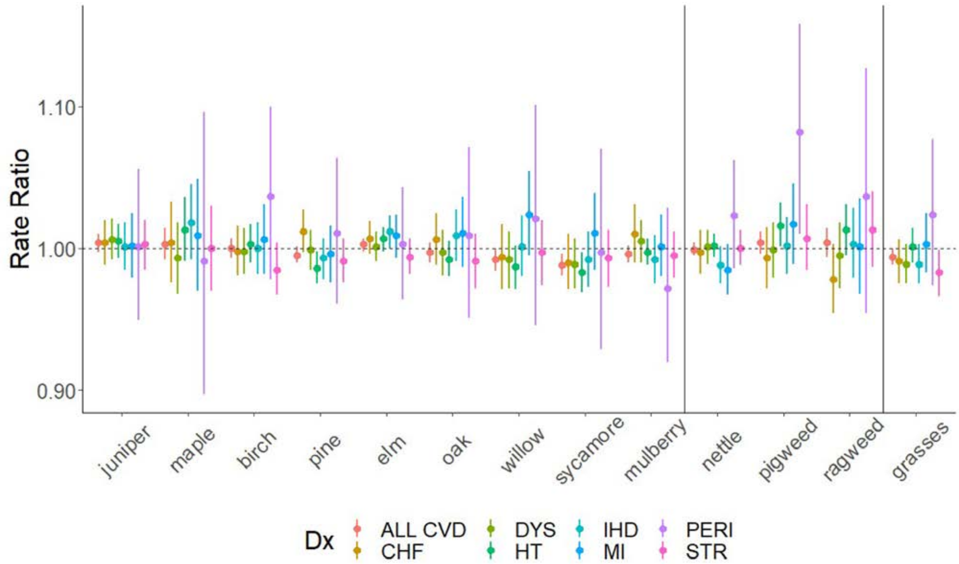

Figure 1. Rate ratios and 95% CIs per standard deviation increase in pollen taxa concentration and emergency department visits for all cardiovascular disease (CVD), hypertension (HT), ischemic heart disease (IHD), myocardial infarction (MI), congestive heart failure (CHF), peripheral heart disease (PERI), stroke (STR), and dysrhythmia (DYS).

Pollen monitoring

Daily levels of pollen (i.e., number of grains per m^3 of air) from juniper, maple, birch, pine, elm, oak, willow, sycamore, mulberry, nettle, pigweed, ragweed, and grasses were obtained from Atlanta Allergy & Asthma, which is the single National Allergy Bureau certified monitoring station in Atlanta. We selected these taxa based on their suspected allergenicity, consistent sampling throughout the study period, and because they constitute the predominant pollen taxa in Atlanta.[13–16] The relevant pollen seasons for each taxa were determined through visual inspection of the data, drawing on previous research that employed a 3-day consecutive approach to calculating season start and end dates, similar to methodologies in other studies.[15–19] Sample processing has been described in detail in Darrow et al[9] and Manangan et al.[16] More detail on these 26-year pollen data can also be found in Lappe et al.[15]

Statistical methods

Time-series analyses were conducted to examine the association between pollen exposure and ED visits for CVDs. We used log-linear quasi-Poisson regression models to estimate the association between daily pollen levels and counts of all cardiovascular ED visits and for each outcome separately, based on our prior work.[15] Primary analyses assessed associations using 3-day (lag 0–2) distributed lag models and controlled for temporal confounding using indicator variables for day of week, federal holidays, month and year, and month-by-year interaction terms. Analyses were limited to the relevant pollen seasons for each taxon, as months outside of these seasons generally had extremely low concentrations (Supplemental Figure 1; http://links.lww.com/EE/A263). We also included cubic functions for individual lags 0, 1, and 2 of daily mean temperature, obtained from the Atlanta Hartsfield International Airport weather station via the National Climatic Data Center. In sensitivity analyses, we further controlled for ambient air pollutants NO_2, PM_{10}, and O_3 in the models, and we also considered nonlinear models of exposure for the grouped pollen taxa (tree, weed, and grass). All results are presented as incidence rate ratios (RR) and 95% confidence intervals (CI) for taxa-specific standard deviation increases in pollen levels based on the full 1993–2018 study period.

Results

There were 1,573,968 CVD ED visits over the study period, which included 405,711 hypertension visits, 223,302 ischemic heart disease visits, 224,174 dysrhythmia visits, 110,961 myocardial infarction visits, 200,577 congestive heart failure visits, 17,266 peripheral heart disease visits, and 175,069 stroke visits. CVD visits were slightly higher in the winter than in the summer, with monthly average cases peaking in February and dipping in July (Supplemental Figure 1; http://links.lww.com/EE/A263). There were notable drops in ED visits on certain federal holidays, namely January 1st, December 25th, and July 4th. Spearman correlation coefficients for pollen, air pollutants, and meteorological variables show the highest correlations among tree pollen species (Supplemental Figure 2; http://links.lww.com/EE/A263).

The majority of models examining the various pollen-outcome pairs showed no association (Figure 1). The only associations with CVD morbidity were observed for elm and pigweed pollen, although these could be chance findings. In particular, we found that a standard deviation increase in elm pollen resulted in a 1% increase in ischemic heart disease ED visits (RR = 1.01; 95% CI = 1.00, 1.02). We also found that a standard deviation increase in pigweed pollen resulted in a 2% increase in hypertension ED visits (RR = 1.02; 95% CI = 1.00, 1.03) and an 8% increase in peripheral heart disease ED visits (RR = 1.08; 95% CI = 1.01, 1.016) (Figure 1). We similarly found no associations of CVD ED visits and pollen grouped by tree, weed, or grass species, either when modeled linearly (Supplemental Table 2; http://links.lww.com/EE/A263) or nonlinearly (Supplemental Figure 3; http://links.lww.com/EE/A263). Controlling for air pollution did not substantially change the magnitude of point estimates, although the confidence intervals became smaller for several pollen-outcome pairs. Specifically, after the inclusion of NO_2 in the models, we found associations between elm pollen and all CVD visits (RR = 1.01; 95% CI = 1.00, 1.01); and we found associations between hypertension visits and elm (RR = 1.01; 95% CI = 1.00, 1.02), mulberry (RR = 1.02; 95% CI = 1.00, 1.04), and nettle (RR = 1.06; 95% CI = 1.00, 1.12) (Supplemental Figure 4; http://links.lww.com/EE/A263).

Discussion

This 26-year study represents the longest time-series study on the relationship between pollen and cardiovascular morbidity.

Most pollen-outcome pairs we tested showed no association, with the exception being elm and pigweed pollen. As we tested ~100 associations, there is a possibility of the few observed significant associations being false positives considering our significance level of 0.05.

To our knowledge, only a few population-based studies—from the Netherlands, Finland, Canada, Australia, and the United States—have been published on pollen and cardiovascular outcomes, and three of these studies focus on cardiovascular mortality.[4–8,20] These studies reported mixed results. Brunekreef et al[4] explored associations of oak, birch, and grass pollen with CVD mortality, and found associations only with grass pollen. Jaakkola et al[5] explored associations of alder, birch, mugwort, and grass pollen with CVD mortality, and found associations only with mugwort. Al-Mukhtar et al[20] found an association between the concentration of grass and total pollen in the preceding days with the occurrence of in-hospital, but not with acute coronary syndromes during hospitalization. Weichenthal et al[7] explored grouped grass, weed, and tree pollen with myocardial infarction ED visits. While continuous pollen exposure showed no associations, categorizing pollen levels into tertiles revealed stronger associations for grouped grass pollen with myocardial infarction in the middle and upper tertile compared with the lowest tertile. Nitschke et al[6] explored grouped grass, weed, and tree pollen associations with CVD ED visits and found associations only in some months of the year. Lastly, Low et al[6] found a small increase in hospital admissions for stroke associated with same-day grass pollen counts. Despite the variability in plant species and seasonality across study locations, our findings in Atlanta similarly suggest mixed results, with no associations for most pollen-outcome pairs, including when pollen was grouped as trees, weeds, or grasses.

This study had several strengths, including a large study population, speciated pollen data, a long study period, and the use of time-series design to adjust for time-invariant confounding. This study also had several limitations. We did not have patient-level information on medication use or comorbidities, which limits our interpretation of the results. The ED data represent only the most severe CVD cases, and do not capture the majority of less severe cases that seek primary or urgent care; such cases may also be associated with pollen, and this could be an extension of future research. Additionally, there is potential for exposure misclassification, as the single monitor used to measure pollen levels may not capture spatial variations in exposure across Atlanta.

In conclusion, we found limited evidence that pollen is associated with cardiovascular morbidity in Atlanta. Further study on pollen exposures in different climactic zones and exploration of pollen mixture effects is warranted.

Conflicts of interest statement

The authors declare that they have no conflicts of interest with regard to the content of this report.

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