Analysis of Short-term Influences of Ambient Aeroallergens on Pediatric Asthma Hospital Visits in Cincinnati Area

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Abstract

Rationale: The association between hospital admissions of pediatric asthma and concentrations of individual aeroallergen species is not well understood. Two different modeling approaches were evaluated and compared. These were generalized linear model (GLM) and generalized additive model (GAM).

Methods: Records of daily asthma visits were retrieved from Cincinnati Children's Hospital Medical Center. Selected aeroallergens were total pollen, ragweed pollen, oak/maple pollen, pinus pollen, total fungi, *Aspergillius* fungus, *Alternaria* fungus, *Cladosporium* fungus. The daily aeroallergen concentrations were measured, and the daily ozone and $PM_{2.5}$ concentrations, daily temperature and humidity data were obtained from the available databases. Poisson regression was used to examine the relationship. Factors known to be related with asthma occurrence were modeled first and the residuals were then analyzed with respect to the aeroallergen concentrations. GLM modeled the nonlinear covariate effects through indicator variables, while GAM modeled this through smoothing functions. Lagged effects of aeroallergens on asthma were examined as well.

Results: GLM and GAM provided similar findings. The aeroallergens found to be significantly related (P <0.05) with asthma were oak/maple pollen, ragweed pollen, pinus pollen, *Alternaria* fungus. Their relative risks on asthma admission for a 100/m^3 increase in concentration were in the range of 1.03 - 1.50. Their effects were delayed by 3 or 5 days

Conclusion: Different aeroallergen species have different relative risks on pediatric asthma exacerbation. Both GLM and GAM are capable of analyzing the time series studies in environmental health research, however, GAM is a more flexible and parsimonious approach than GLM in model fitting.

Methods

- The period for this time series study was from March to October, 2002
- Generalized linear model
  - Nonlinear covariate effects of season, weather and other air pollutants were modeled categorically through indicators
    - Initial category number was picked from scatter plots, where daily asthma visit is plotted against the covariates respectively
    - Type I analysis was used to judge the significance of adding extra number of categories
- Generalized additive model
  - Nonlinear covariate effects were modeled through cubic smoothing spline
    - Smoothing parameter was optimally selected from generalized cross validation function (GCV)
- Autocorrelation between residuals were examined
- Sensitivity of results to extreme values was checked

Results

Table 1. Summary of Asthma Patient Population

ICD9_Diagnosis	Mean Age	Age Min - Max	# Subject
493_Asthma	9.4	1.4 - 17.0	105
493.1_ Asthma, unspecified with status asthmaticus	7.0	1.7 – 11.6	13
493.9_ Asthma, unspecified	7.2	1.0 – 18.0	986
493.91_ Asthma, unspecified with status asthmaticus	7.8	1.1 – 17.7	148

Figure 1. Daily Asthma Visits over Study Time. Temporal Pattern is Indicated

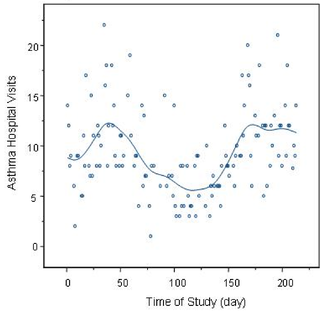


Figure 2. Daily Asthma Visits over Temperature. Temporal Pattern s Indicated

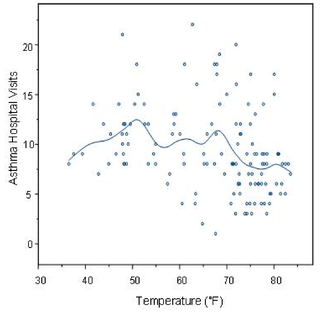
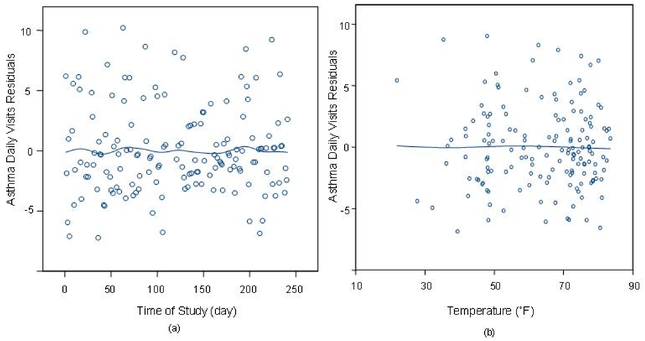


Figure 3. Selected Diagnostic Plots of Residuals from Generalized Linear Model. a) Residual of Daily Hospital Visits versus Time of Study, b) Residual of Daily Hospital Visits versus Daily Temperature



Note: The humidity was excluded due to insignificance. Covariates of study time, temperature, ozone and $PM_{2.5}$ were respectively divided into 4, 8, 3 and 3 categories.

Table 2. Significant Aeroallergen Predictors from GLM

Aeroallergen (Lag Days)	Relative Risk (95% CI)	Estimated Increase in Daily Asthma Visits (95%CI)
Oak/Maple Pollen (3)	1.27 (1.07-1.51)	27% (7%-51%)
Pinus Pollen (5)	1.34 (1.20-1.49)	34% (20%-49%)
Alternaria Fungus (5)	1.03 (1.006-1.05)	3% (0.6% -5%)

Figure 4. Selected Diagnostic Plots of Residuals from Generalized Additive Model. a) Residual of Daily Hospital Visits versus Time of Study, b) Residual of Daily Hospital Visits versus Daily Temperature

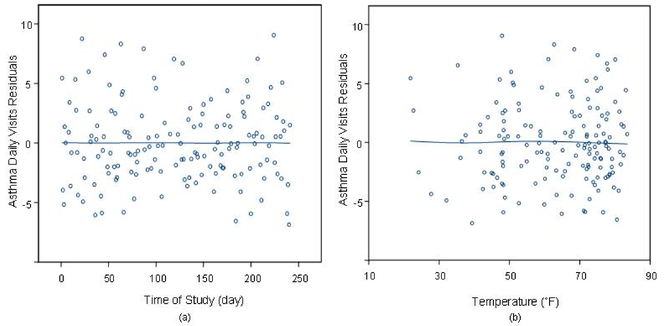


Table 3. Significant Aeroallergen Predictors from GAM

Aeroallergen (Lag Days)	Relative Risk (95% CI)	Estimated Increase in Daily Asthma Visits (95%CI)
Oak/Maple Pollen (3)	1.23 (1.02-1.48)	23% (2%-48%)
Ragweed Pollen (5)	1.54 (1.02-2.33)	54% (2%-133%)
Pinus Pollen (5)	1.34 (1.24-1.45)	34% (24%-45%)
Alternaria Fungus (5)	1.08 (1.01-1.15)	8% (1% - 15%)

Table 4. Degrees of Freedom for the Covariates in the Fitted GLM and GAM

Covariate	Degrees of Freedom (GLM)	Degrees of Freedom (GAM)
Time	3	2.2608
Temperature	7	1.0004
Ozone	2	1.0050
PM_{10}	2	2.0083

Note: Selection of smoothing parameter through GCV was done automatically by computer.

Conclusions

- Different types of pollen and fungal spores have different influences on the childhood asthma exacerbation, and their delayed effects vary
- Both GLM and GAM provide good fit; estimated coefficients are similar for the significant predictors found in the two models
- GAM is a more flexible and parsimonious approach than GLM; covariate control in GAM is more efficient and straightforward
- Estimation in GAM is more powerful due to the reduced degrees of freedom in model fitting
- Dose response can be explored further with the smoothing functions in GAM

Future Work

- Bayesian hierarchical model to compute regional/national relative risk of aeroallergen on pediatric asthma
- Bayesian hierarchical regression to investigate the influences of city-specific factors on the relative risk
- Synergistic effects between aeroallergens and other pollutants

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