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Does Socio-demographic Status Influence the Effect of Pollens and Molds on Hospitalization for Asthma? Results from a Time-series Study in 10 Canadian Cities

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PURPOSE: Social status influences asthma morbidity but the mechanisms are not well understood. To determine if sociodemographics influence the susceptibility to ambient aeroallergens, we determined the association between daily hospitalizations for asthma and daily concentrations of ambient pollens and molds in 10 large Canadian cities.
METHODS: Daily time-series analyses were performed and results were adjusted for day of the week, temperature, barometric pressure, relative humidity, ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Results were then stratified by age, gender, and neighborhood family education and income.
RESULTS: There appeared to be age and gender interactions in the relation between aeroallergens and asthma. An increase in basidiomycetes equivalent to its mean value, about 300/m^3, increased asthma admissions for younger males (under 13 years of age) by 9.3% (95% CI, 4.8%, 13.8%) vs. 4.2% (95% CI, − 0.1%, 8.5%) for older males. The reverse was true among females with increased effect in the older age group: 2.3% (95% CI, 1.2%, 5.8%) in those under 13 years vs. 7.1% (95% CI, 4.1%, 10.1%) for older females. Associations were seen between aeroallergens and asthma hospitalization in the lowest but not the highest education group.
CONCLUSIONS: Our results suggest that younger males and those within less educated families may be more vulnerable to aeroallergens as reflected by hospitalization for asthma.
Ann Epidemiol 2005;15:214–218.

KEY WORDS: Asthma, Social Studies, Pollen, Fungus.

INTRODUCTION

Ambient aeroallergens have been associated with increased asthma morbidity indicated by emergency department visits (1), hospitalizations (2, 3), and death (4). Sociodemographic characteristics also influence asthma morbidity but the mechanisms are poorly understood. The prevalence of asthma is greater in boys than girls (5), older women than older men (6), and in families of lower compared with higher social status (7, 8). Whether or not these characteristics modify the effects of aeroallergens on asthma is unknown. To investigate this, we determined the association between hospitalization for asthma and aeroallergens across Canada, stratified by age, gender, income, and education.

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Received January 30, 2004; accepted June 7, 2004.

MATERIALS AND METHODS

The study population was all emergency admissions to a hospital for asthma between April 1, 1993 and March 31, 2000 in 10 of the largest Canadian cities: Calgary, Edmonton, Halifax, London, Ottawa, Saint John, Toronto, Vancouver, Windsor, and Winnipeg. The hospitalization data were provided by the Canadian Institute for Health Information (CIHI) which collects information on virtually all asthma admissions in Canada, made possible by the fact that acute care hospitals in Canada are publicly funded. There were a total of 356,605 hospital discharge records for cases in which the principal reason for hospitalization was asthma, *International Classification of Disease, 9th Revision* (ICD-9) code 493.

Air Pollution and Meteorological Data

Meteorological and air pollution data for each city were measured and supplied by Environment Canada and the National Air Pollution Monitoring System. Daily data were available for 24-hour mean and 1-hour maximum and minimum temperature, 24-hour mean relative humidity, and maximum 24-hour changes in barometric pressure. One-hour maximum concentrations of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and ozone

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1047-2797/05/$–see front matter
doi:10.1016/j.annepidem.2004.06.001

Selected Abbreviations and Acronyms

SES = socio-economic status
CIHI = Canadian Institute for Health Information
ICD-9 = *International Classification of Diseases, 9th Revision*
SO_2 = sulfur dioxide
NO_2 = nitrogen dioxide
CO = carbon monoxide
O_3 = ozone
PM10 = particulate matter less than ten microns in mean aerodynamic diameter
SO_4 = sulfate
EA = enumeration area
AIC = Akaike's Information Criteria
COH = coefficient of haze

(O_3) were available daily. Twenty-four hour concentrations of coefficient of haze (COH) were available daily but sulfates (SO_4) and 24-hour concentrations of particulate matter less than ten microns in mean aerodynamic diameter (PM10) were available only every sixth day.

Aeroallergen Data

In each city, rotational impaction methods were used to obtain 24-hour collections of aeroallergens (pollen grains and fungal spores). The particles adhering to the silicon grease-coated sample rods were analyzed to determine the number of particles present per cubic meter of air sampled. This method had been previously tested for reliability by performing counts on 15 randomly chosen fields magnified both 20 and 40 times on each rod. At each magnification, the correlation coefficient between the two rods was at least 95%. Aeroallergens were collected and analyzed in the same fashion in each city supervised by the same company, Aerobiology Associates (Ottawa, Ontario).

Sociodemographic Status

Information on sociodemographics was obtained from the 1996 Canadian Census. Each subject was assigned the sociodemographics of the enumeration area in which he/she resided. An enumeration area (EA) is the smallest standard geographic area for which census data are reported and it is enumerated by one census representative. Individuals were classified into quartiles of family education and family income. Individual information on age and gender was available from the hospitalization database.

Statistical Methods

The allergen, climate, air pollution, and asthma admission variables were measured several hundred times over the course of the study and each was expressed as a time series, methods typically employed in air pollution research (9, 10). A Poisson distribution with natural logs was assumed because hospital admissions are count data occurring relatively infrequently in the population. To remove any patterns in the time series that may cause artifactual associations between variables, each series was filtered. Each time-series model included indicator variables for the day of the week and was adjusted for temporal trends using natural spline functions with knots of 30, 90, 180, 270, and 365 days of observation. We then selected a model with the number of knots that either minimized the Akaike's information criteria (AIC) (11), or maximized the evidence that the model residuals did not display any type of structure, including serial correlation, using Bartlettt's test. Serial correlation structure in the residuals was examined after fitting models with natural spline functions. The above steps were implemented separately for each city.

The association between weather variables and asthma admissions were tested with a linear model using Generalized Additive Models with stringent convergence criteria ($\gamma < 10^{-14}$) in S-PLUS Software 2 (Insightful Corporation, Seattle, WA) (12, 13). These variables included mean daily temperature, maximum daily temperature, minimum daily temperature, change in barometric pressure, and mean relative humidity. Three lags (0, 1, and 2 days) were examined for each of these air pollutant variables. The model that minimized the AIC was selected as the predictive weather model for daily hospitalization. Holding the selected weather variables in the model, a forward stepwise regression procedure was used to identify a minimally sufficient set of air pollutant variables needed to predict daily hospitalization counts. Variables tested included mean daily SO_2, NO_2, CO, daily 1-hour maximum concentration of O_3, and COH. Again, three lags were tested and the AIC criteria employed to select the best model. Finally, each aeroallergen, with lags, was added to the model containing climate and air pollution variables. Once the final model was selected, the percent change in daily hospitalization and the accompanying standard errors in relative risks were generated across each strata of SES for each city. In the second stage, a pooled estimate across all ten cities was calculated by using a random-effects model that weights the effect estimates by the inverse sum of within- and between-city variance, thus accounting for any heterogeneity among the cities in the pooled effect estimates. We combined for each stratum the city-specific regression coefficients by $\hat{\beta}$ using the restricted maximum likelihood method of Burnett et al. (9). We assumed that $\hat{\beta_j} \sim N(\hat{\beta}, Sj + \theta)$, where $\hat{\beta_j}$ is the aeroallergen coefficient in city j, $\hat{\beta}$ is the pooled estimate from all of the cities, Sj is the estimated variance in city j, and θ is the variance of the true aeroallergen effect between cities.

Twenty-four hour concentrations of PM10 and SO4 were available only every sixth day. To test their influence on the results of the study, the analysis was repeated restricted to every sixth day.