

Associations between grass and weed pollen and emergency department visits for asthma among children in Montreal

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Abstract

Context and objective: Asthma among children is a major public health problem worldwide. There are increasing number of studies suggesting a possible association between allergenic pollen and exacerbations of asthma. In the context of global climate change, a number of future climate and air pollution scenarios predict increases in concentrations of pollen, an extension of the pollen season, and an increase in the allergenicity of pollen. The goal of the present study is to evaluate the short-term effects of exposure to grass and weed pollen on emergency department visits and readmissions for asthma among children aged 0–9 years living in Montreal between April and October, 1994–2004.

Methodology and results: Time-series analyses were carried out using parametric log-linear overdispersed Poisson models that were adjusted for temporal variations, daily weather conditions (temperature, atmospheric pressure), and gaseous air pollutants (ozone and nitrogen dioxide). We have found positive associations between emergency department visits and concentrations of grass pollen 3 days after exposure. The effect of grass pollen was higher on emergency department readmissions as compared to initial visits. Weak negative associations were found between weed pollen (including ragweed pollen) and emergency department visits 2 days after exposure.

Conclusion: The data indicate that among children, emergency department visits increased with increasing concentrations of grass pollen.

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1. Introduction

Climatic conditions have a large influence on the environment and on vegetation, and it appears likely that climate change will affect growth and the reproduction cycle of vegetation and the production of pollen (D'Amato et al., 2005; Beggs and Bambrick, 2005). Particularly

sensitive to temperature, duration of sunshine, and ambient CO₂, the production of pollen has increased with the 0.6 °C increase in the global average temperature at the surface of the earth over the past 100 years (Root et al., 2003). Additionally, studies have shown an earlier start to the pollen season, an increase in the number of growing days, and greater pollen production (Ziska and Caulfield, 2000; Breton et al., 2006; Thibaudon et al., 2005).

With the anticipated longer growing seasons and higher concentrations of pollen, attention has now turned to understanding the effects of pollen on respiratory health problems, such as asthma and allergic rhinitis (Breton et al., 2006). There is mounting evidence that asthma has a multifactorial pathology, and may include interactions

Abbreviations: AIC, Akaike Information Criterion; CI, confidence interval; df, degrees of freedom; MPC, mean percent change; NO₂, nitrogen dioxide; O₃, tropospheric ozone; QHIP, Québec Health Insurance Plan.

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between genetic and environmental factors (Demoly et al., 2005; Van Den Akker-Van Marle et al., 2005). Consequently, it is difficult to identify the role of each risk factor in the development of the disease (Annesi-Maesano, 1999). In order for atopic asthma or allergic conditions to develop, it seems that both a genetic predisposition and exposure to an allergen, such as pollen, is required (Gilmour et al., 2006). The hypothesis that allergenic pollen exacerbates asthma has been studied widely, although the epidemiological data are not entirely consistent. Emergency department visits for asthma have been found to be associated positively with ambient concentrations of pollen (Lierl and Hornung, 2003; Tobias et al., 2003; Dales et al., 2004), with concentrations of pollen from ragweed (Salvaggio and Seabury, 1971), and from grass (Rosas et al., 1998). On the other hand, Carlsen et al. (1984) and Khot et al. (1988) did not find a positive association between pollen from grass and emergency department visits or hospitalizations and Delfino et al. (1996) also did not find evidence of a relationship between symptoms of asthma and concentrations of pollen from ragweed. As well, in other studies (Rossi et al., 1993; Dales et al., 2000), no associations between concentrations of different species of pollen, or groups of species (trees, weeds, grasses, total pollen) and symptoms, emergency department visits, or hospitalizations were observed. Interpreting the wide spectrum of results from these studies, taken as a whole, is very difficult because of chance, differing statistical methods, disparate study populations, complexity of the pollen data, and varying health indicators and treatment of potential confounding factors. In particular, it has been found that exposure to air pollution (e.g., ozone, nitrogen dioxide) can increase the number of inflammatory cells in bronchoalveolar lavage fluid that could potentially alter lung function, including increased non-specific airway hyper-responsiveness (Saxon and Diaz-Sanchez, 2005). Chen et al. (2004) found that a subgroup of asthmatic subjects was at greater risk to increased sensitivity to aeroallergens after exposure to ozone. Furthermore, air pollution acts directly on vegetation by increasing levels of allergenic proteins in the grains (Emberlin, 1998). The amount of pollen produced is also influenced by air pollution; for example, in controlled experiments plants grown at elevated levels of CO₂ had greater biomass and produced more pollen (Wayne et al., 2002; Ziska and Caulfield, 2000).

The goal of the present study was to determine whether there was an association between concentrations of pollen from grass and weeds (more specifically ragweed) and emergency department visits for exacerbations of asthma among children 9 years of age and younger in Montreal, Canada, between 1994 and 2004. Moreover, we attempted to verify the sensitivity of the findings to the inclusion of weather and air pollution in the models and the effect of combining data from initial emergency department visits and those from repeat visits that could introduce bias in the analyses (Chen et al., 2005).

2. Data and methodology

2.1. Study population

The Island of Montreal comprised the study population. In 2001, it possessed an area of 500 km² and was home to 1,812,723 inhabitants (Statistics Canada, 2001) who have extremely diverse socio-economic and cultural profiles. The population is served by a network of 20 hospitals for which there is universal coverage through the Québec Health Insurance Plan (QHIP).

The QHIP database allowed the identification of all visits to emergency departments for asthma among children under the age of 9 years who were residents of Montreal between 1994 and 2004 (April 1–October 31) in all Montreal hospitals. Asthma was defined according to the initial assessment of the attending emergency physician (diagnostic code 493 according to the 9th revision of the World Health Organization's International Classification of Diseases). We were able to identify whether the emergency department visit for asthma was first made by the patient during the study period or was a readmission.

2.2. Exposure data

2.2.1. Pollen data

Daily concentrations of pollen were obtained from the Aerobiology Research Laboratory. Based in Ontario, this private company manages a national network of aeroallergen collectors employing “GRIPST-2000” type rotary impact samplers. In Montréal, the sampler is located in the municipality of LaSalle, situated roughly 1 km from the north shore of the Saint-Lawrence River, and it was installed 2.45 m above the ground. The sampling season covers the period from April 1 until October 31, which is the primary period for pollen to be released. The samples were collected daily, in the morning, and classified by species or groups of species. The data were provided as a daily average concentration (number of grains per cubic meter over the preceding 24 h). About 12% of the data were missing over the study period (1994–2004). Allergies from airborne particles are caused by certain tree, weed and grass pollen as well as fungal spores; the chemical makeup and the size of pollen are the basic factors that determine the allergenic power of a species (Aerobiology Research Laboratories (ARL), 2005). For this study, the pollen-generating species were grouped into three classes: grasses (including cereal crops); weeds (including ragweed); and ragweed alone. Grasses are an important source of allergenic pollen but only few of species are considered highly allergenic. However, because of the difficulty in identifying the different species (e.g., wheat, rye, corn, grass from lawns) under a microscope, all species were grouped together (ARL, 2005). Weeds release important amounts of pollen into the air, and ragweed represents one of the most important allergens of North America. In Montreal, ragweed accounts for almost one-third of all airborne pollen collected annually (Durand and Comtois, 1989).

2.2.2. Confounding variables

Potentially confounding factors included air pollutants and meteorological factors. The air pollution data comprised bi-hourly measurements of a number of criteria gaseous pollutants (sulfur dioxide, carbon monoxide, nitrogen dioxide (NO₂), ozone (O₃)) at fixed-site monitoring stations in Montreal. We chose to include two of these as covariates in the substantive analysis: NO₂ was measured at eight stations and O₃ was measured at nine stations using chemiluminescence (Thermo electron 14 V). Because of missing data for particles (measured approximately every sixth day) we did not include the latter pollutant in the analyses. We used in the study daily maximal concentrations of these pollutants.

Weather data were obtained from the Meteorological Service of Canada (Environment Canada) from recordings made at Pierre Elliott Trudeau International Dorval on the Island. We used daily values of minimum and maximum temperature, maximum air pressure, and change in maximum air pressure from the previous day.

2.3. Statistical methods

Standard time-series analyses were used to quantify the health risks associated with pollen (Dales et al., 2000; Stieb et al., 2000; Goldberg et al., 2001, 2006; Tobias et al., 2004). With emergency department visits for asthma being relatively rare, we assumed that the logarithms of the daily number of visits were distributed as a Poisson variate. As overdispersion is often the result of a greater variation in the distribution than expected by the Poisson model, we thus used quasi-likelihood estimation in Generalized Linear Models (in S-PLUS; MathSoft Inc., 2002) to model the logarithm of daily counts of visits as functions of the predictor variables (pollen concentrations, air pollution, weather) (Chen et al., 2005; Goldberg et al., 2006).

Natural cubic splines were used to model the continuous independent variables. Because varying temporal cycles (annual, monthly, weekly, day-of-the-week, and long-term trends) introduced autocorrelation into the outcome data (Richardson, 2000), it was necessary to eliminate these systematic variations through the use of a temporal filter. This filter was developed for each model with the number of degrees of freedom (df) of a natural cubic spline function that minimized Bartlett's statistic, a measure of whether the filtered time-series was consistent with a white noise process (Priestly, 1981). We assessed the Bartlett statistic across the range from 50 to 180 df. This process also led to the least amount of serial autocorrelation evaluated across the partial autocorrelation function.

After selecting the temporal filter, we assessed a number of models that included the following covariates: daily maximum temperature; 3-days average maximum temperature; daily maximum air pressure; daily minimum temperature; and change in maximum air pressure over the previous 24 h. The model that minimized the AIC was selected as our final model, and the air pollution variables (daily maximum ozone concentrations, daily maximum carbon dioxide concentrations) were then added as linear covariates. In developing these models, we included the covariates as natural cubic spline functions across a range of degrees of freedom (from 0 to 5 df) and inspected the goodness-of-fit (through the AIC

statistic) and visual inspection of the resulting exposure–response functions (Cao et al., 2006). All models were consistent with linearity.

Specifically, we evaluated two different combinations of covariates: (1) maximum temperature, maximum pressure, maximum O₃, maximum NO₂, and (2) minimum temperature, change in pressure over the previous 24 h, maximum O₃, and maximum NO₂. We did not find any important differences in the estimates of effect for pollen between these two sets of covariates.

We investigated the effect of a change in concentrations of atmospheric pollen on emergency department visits for the same day, the following day (lag 1 days), and for lags 2–5 day. The effects of air pollution and weather were evaluated at the same lag as was concentrations of pollen.

Once the final models were selected, the percentage change in the mean number of emergency department visits due to asthma for an increase of 10 pollen grains per cubic meter was calculated (referred to as mean percentage change, MPC), assuming a linear relationship. The interval 10 grains/m³ corresponds to actual day-to-day variations in concentrations of pollen and was thus chosen so that the final results would be plausible and more easily understood. The 95% confidence intervals (95% CI) associated with the MPC were calculated, assuming that the regression coefficient was distributed with a standard error corrected for a non-Poisson dispersion (Goldberg et al., 2006).

3. Results

The results are based on a total of 43,780 emergency department visits from asthma. A total of 22,756 visits were recorded as a first or sole visit (51.9% of the total) over the study period, while 21,024 visits (48.3% of the total) represented readmissions with the same diagnostic code as a previous visit (Table 1). There was a secular decrease in the annual number of emergency department visits, with 5156 visits in 1994 as compared to 2427 in 2004 (Fig. 1).

Table 1

Visits and readmissions to emergency departments from asthma among children aged 0–9 years in Montreal between April and October, 1994–2004

	Total number	Number of days without visits	Average	Median	Variance	Centiles			Maximum
						25	50	75	
First visits	22,756	20	9.67	8	38.57	5	8	13	39
Readmissions	21,024	26	8.93	8	34.93	5	8	12	41
Girls—total visits	15,376	58	6.53	6	19.03	3	6	9	25
Boys—total visits	28,404	9	12.07	11	51.79	7	11	16	46
Total visits	43,780	3	18.60	17	115.27	11	17	25	71

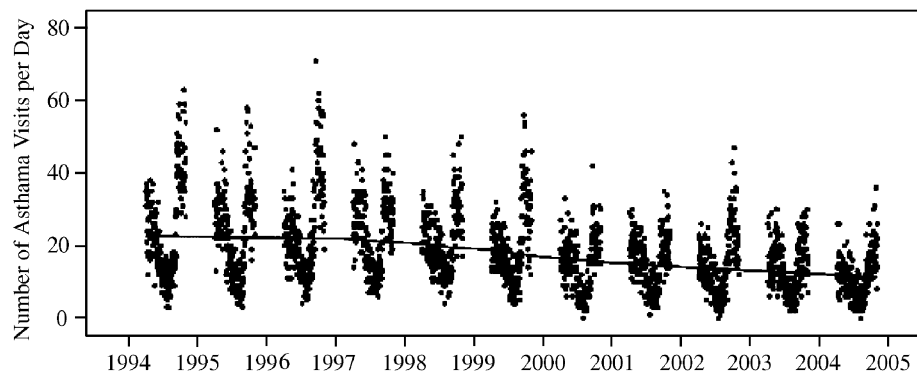


Fig. 1. Scatter plot of daily number of total visits to emergency departments from asthma among children aged 0–9 years, Montreal, April–October, 1994–2004. The solid line is the LOESS smooth representing the long-term trend in the data (span of 50% of the data). The total number of days in the time series is 2354.

Table 2

Distribution of concentrations of pollen and selected weather and air pollution variables measured in Montreal between April and October, 1994–2004

	Number of days of observations	Mean	Variance	Minimum	Centiles			Maximum
					25	50	75	
Ragweed (grains/m ³)	2134	13.74	1433.50	0	0	0	5	379
Weeds (grains/m ³)	2058	26.80	2686.11	0	0	5.39	28.80	408.82
Grasses (grains/m ³)	2213	6.61	163.04	0	0	1.10	6.84	106.49
Maximum temperature (°C)	2335	20.12	51.43	−5.10	15.20	21.40	25.70	36.20
3-day average temperature (°C)	2312	20.10	45.99	−0.97	15.34	21.53	25.30	35.33
Minimum temperature (°C)	2345	9.82	44.80	−14.50	4.90	10.70	15.10	24.60
Maximum barometric pressure (mbar)	2354	1013.30	40.71	992.40	1009.30	1013.10	1017.40	1036.70
Change in barometric pressure over the previous 24 h (mbar)	2354	0.02	25.13	−18.90	−3.30	0.25	3	21.10
Maximum concentration of ozone (µg/m ³)	2354	91.35	1028.03	16	69	88	108	299
Maximum concentration of nitrogen dioxide (µg/m ³)	2354	86.95	741.20	22	67	84	102	248

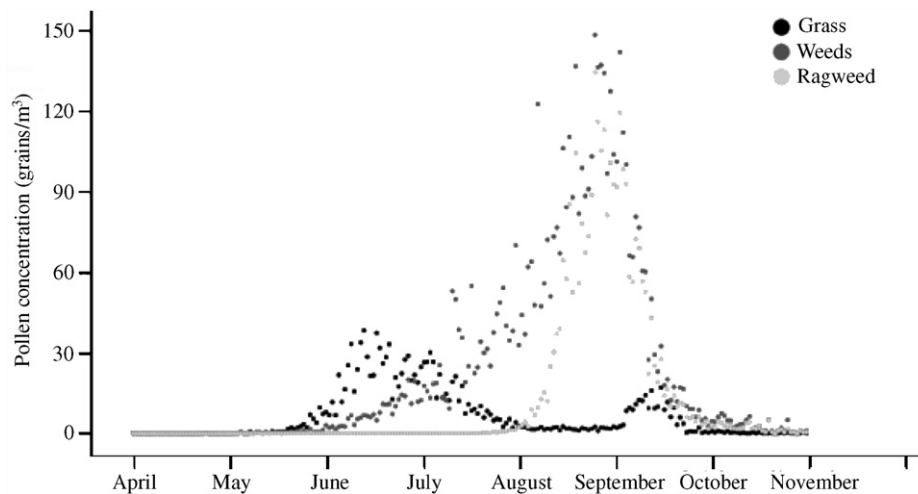


Fig. 2. Distribution of the concentration of pollen from grasses and weeds (including ragweed), Montreal, April–October, 1994–2004.

The distribution of emergency department visits from asthma is shown in Table 1 and the pollen data, meteorological variables, and atmospheric pollutants are summarized in Table 2. According to the averages calculated for the 11 years of the study (Fig. 2), the grasses produced pollen mostly between May 31 and September 22; the weeds between June 11 and October 14, with the ragweed season lasting from August 6 until September 28. Although Montreal has a rather temperate climate, during the study period (April–October), the daily average maximum temperature was fairly high (20.1 °C).

Table 3 summarizes the results of the analysis of the association between concentrations of pollen and aggregated emergency department visits. The incorporation of weather and air pollution variables did not greatly affect the associations described above between concentrations of pollen and emergency department visits for asthma.

Of the three types of pollen that were investigated, only those from grass were found to have a significant positive

association with emergency department visits, and only at lag 3 days (MPC = 1.73%; 95% CI: 0.24–3.25%). The results of analyses addressing the type of emergency department visit (first visit or readmission) were slightly different from the findings from the aggregated visits (Fig. 3): significant positive associations were found for first visits and grasses at lag 3 days (MPC = 2.08%; 95% CI: 0.28–3.91%) and also at lag 5 days (MPC = 1.91%; 95% CI: 0.09–3.76%); and a positive association was found for readmissions and grass pollen at lag 4 days (MPC = 2.37%; 95% CI: 0.30–4.49%).

On the other hand, significant negative associations were found between weed pollens and emergency department visits: on the second day after exposure, we found an MPC of −0.54% (95% CI: −0.93% to −0.15%) and on the third day after exposure we found an MPC of −0.66% (95% CI: −1.07% to −0.25%). Analyses designed to isolate the role of ragweed on emergency department visits did not show associations that differed significantly from those of weed pollen.

Table 3

Mean percent change in total visits to emergency departments from asthma among children, evaluated for an increase of 10 grains/m³ of Pollen, Montreal, April–October, 1994–2004

Adjusted only for temporal trends				Model 1			Model 2		
MPC (%)		95% CI (%)		MPC (%)	95% CI (%)		MPC (%)	95% CI (%)	
<i>Ragweed</i>									
0	0.17	−0.38	0.72	0.08	−0.48	0.63	0.06	−0.50	0.62
1	0.19	−0.35	0.73	0.11	−0.43	0.66	0.14	−0.41	0.68
2	−0.47	−1.07	0.09	−0.41	−0.96	0.14	−0.39	−0.93	0.16
3	−0.63	−1.17	−0.08	−0.61	−1.15	−0.06	−0.61	−1.15	−0.06
4	0	−0.53	−0.53	0	−0.52	0.53	0.02	−0.51	0.55
5	−0.56	−1.08	−0.03	−0.46	−0.79	0.06	−0.49	−1.01	0.02
6	−0.66	−1.17	−0.14	−0.65	−1.16	−0.13	−0.66	−1.18	−0.15
<i>Grasses</i>									
0	0.59	−0.86	2.06	0.31	−0.48	−1.15	0.31	−1.16	1.79
1	0.41	−1.04	1.89	0.05	−1.41	1.54	0.26	−1.2	1.74
2	0.09	−1.39	1.6	0.05	−1.42	1.55	0.18	−1.29	1.67
3	2.06	0.57	3.57	1.67	0.18	3.19	1.73	0.24	3.25
4	1.41	−0.09	2.94	0.87	−0.64	2.39	0.95	−0.55	2.48
5	1.58	0.08	3.1	1.29	−0.2	2.81	1.43	−0.06	2.95
6	0.8	−0.7	2.31	0.83	−0.67	2.34	0.82	−0.67	2.33
<i>Weeds</i>									
0	0.04	−0.36	0.44	−0.02	−0.43	0.39	−0.02	−0.43	0.39
1	0.23	−0.17	0.62	0.08	−0.32	0.49	0.07	−0.34	0.48
2	−0.47	−0.87	−0.06	0.54	−0.93	−0.15	−0.54	−0.93	−0.15
3	−0.58	−0.98	−0.17	−0.63	−1.04	−0.23	−0.66	−1.07	−0.25
4	0.07	−0.32	0.46	−0.08	−0.47	0.32	−0.07	−0.47	0.32
5	−0.31	−0.7	0.08	−0.37	−0.75	0.02	−0.38	−0.77	0.01
6	−0.3	−0.68	0.08	−0.32	−0.7	0.07	−0.32	−0.7	0.06

Model 1: Adjusted for minimum temperature, change in barometric pressure over the previous 24 h, maximum O₃, maximum NO₂, evaluated as linear terms. Model 2: adjustment for maximum temperature, maximum barometric pressure, maximum O₃, maximum NO₂, evaluated as linear terms. The statistical model was $E[\log(Y_i)] = \alpha + ns(i, df) + \text{factor}(\text{month}) + \text{factor}(\text{day of the week}) + \text{factor}(\text{year}) + (\beta_1 \times \text{weather}) + (\beta_2 \times \text{pollutants}) + (\beta_3 \times \text{pollen})$, where i is the day being studied and df is the number of degrees of freedom in the time filter. MPC: mean percent change; CI, confidence interval.

4. Discussion

We investigated the potential impact of exposure to three types of pollen upon emergency department visits for asthma among children 9 years of age and under. We also investigated the possible confounding effect of selected gaseous air pollutants on these associations and considered the possibility that concentrations of pollen were associated more strongly to emergency department readmissions than to initial visits. We found that daily increases in emergency department visits from asthma were associated with higher concentrations of pollen from grass species 3 days after exposure (lag 3 days). Additionally, further analyses of initial emergency department visits and readmissions revealed a significant positive effect at lag 4 days (for readmissions) and lag 5 days (for initial visits). Negative associations were found between pollen from weeds and emergency department visits for all species of weeds (initial visits and readmissions) and for ragweed alone (initial visits only) with a delay of 2–3 days. We found little confounding effects from concentrations of O₃ or NO₂.

Some of the results found in this study are consistent with other epidemiological studies and with clinically

understood mechanisms. The positive association observed for the grasses is consistent with some other studies that accounted for the influence of air pollution (Rosas et al., 1998; Lewis et al., 2000; Tobias et al., 2003) and one that did not (Newson et al., 1998). Furthermore, the lag periods that we observed suggest that the asthma response due to pollen has a delay of about three days. This observation agrees with the results of other studies which have shown similar delays (Tobias et al., 2004; Cakmak et al., 2005). The observed lag is also consistent with the attempts at self-medication that typically precede emergency department visits (Tobias et al., 2004). Canny et al. (1989) reported that 84% of the asthmatic children had symptoms for 72 h or less prior to arriving at the emergency department.

The significant negative association uncovered between emergency department visits and the concentration of pollens from weeds, more specifically ragweed, does not support the hypothesis that exposure to strong concentrations of allergenic pollens is a risk factor for the development of asthma. Other studies have also shown negative associations between pollen from grasses (Burr et al., 2003) and tree species (Stieb et al., 2000) and the

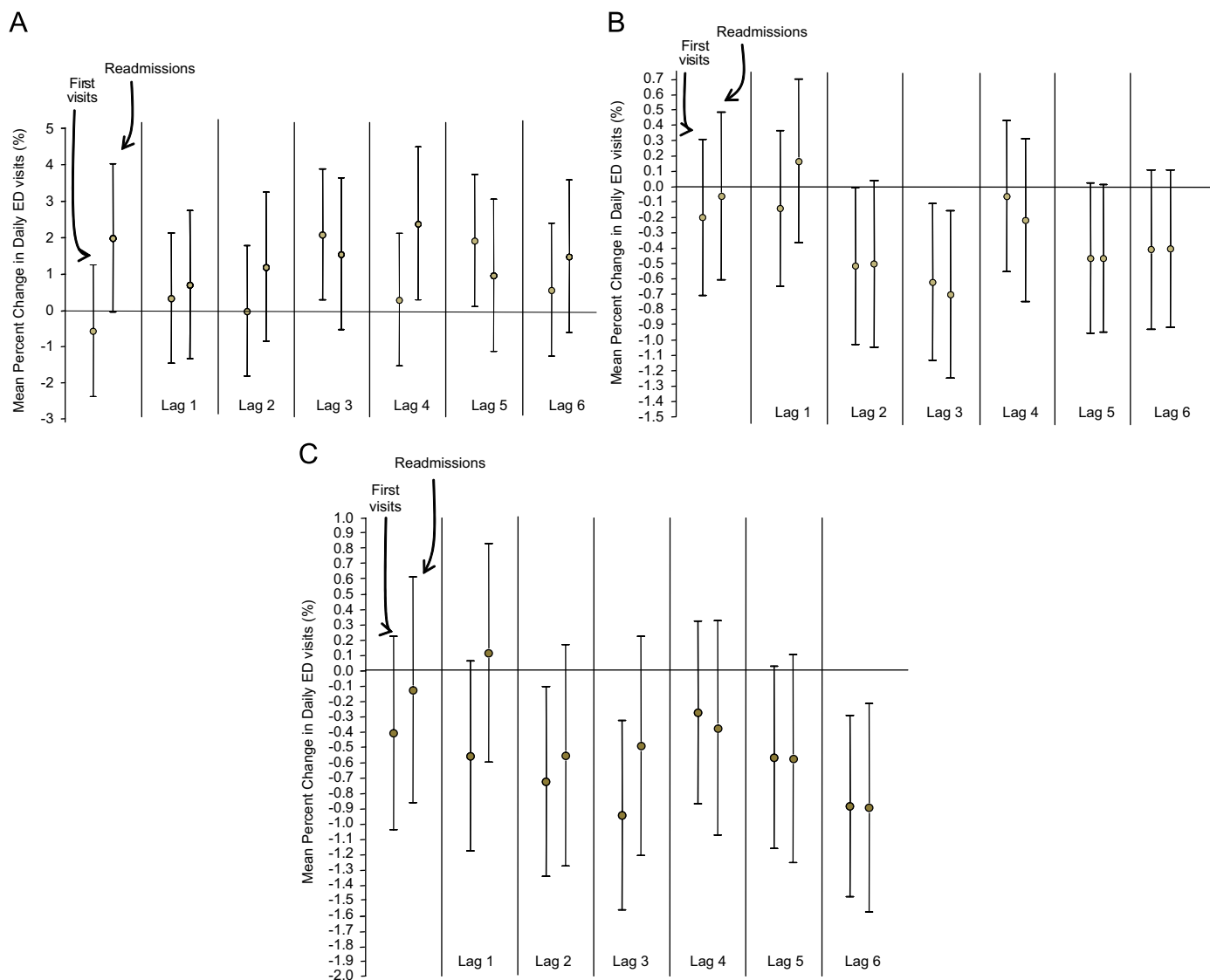


Fig. 3. Adjusted mean percent change in total visits to the emergency department from asthma among children, Montreal, April–October, 1994–2004, according to type of visit (first visit or readmission). The estimated MPC in daily emergency department visits from asthma for an increase of 10 grains/m³ of pollen is shown by the solid circles on the vertical lines (95% confidence interval): (A) pollen from grass; (B) pollen from weeds; (C) pollen from ragweed.

incidence of certain respiratory problems while other studies showed no relationship between various indicators of asthma and concentrations of pollen (Delfino et al., 1997; Epton et al., 1997; Anderson et al., 1998). This lack of consistency may be due to various causes: chance; geographical differences in the levels, types, and mixtures of allergens in the environment; prevalence of atopy in the population; the choice of the health indicator; and statistical methods.

Many authors have suggested the possibility that air pollution could confound the association between pollen and asthma (Salvaggio and Seabury, 1971; Devalia et al., 1998; D'Amato et al., 2001), and that the effects of aeroallergens may be aggravated in the presence of air pollution (Molfino et al., 1991; Tunnicliffe et al., 1994; Jorres et al., 1996). However, the association between exposure to pollen and daily emergency department visits

found in the present study did not appear to be sensitive to the gaseous pollutants considered. Specifically, the inclusion of concentrations O₃ and NO₂ as covariates did not bring about notable changes in either the strength or the direction of observed associations. These results are consistent with other studies (Rossi et al., 1993; Rosas et al., 1998; Dales et al., 2000, 2004; Lewis et al., 2000; Burr et al., 2003).

4.1. Methodological considerations

The statistical methodology used in this study is accepted widely as a standard method (Eilstein et al., 2005). The current study benefits from numerous methodological and statistical developments in time-series analysis, such as the use of natural cubic splines in the context of the Generalized Linear Models (Cao et al., 2006). With respect to

accounting for confounding factors, other variables could have been included in the model, such as wind direction, humidity, and fine particles. However, given that the pollen seasons were already short, the addition of supplementary variables would have increased the amount of incomplete data and therefore diminished the power of the analyses. This missing data problem was particularly acute for fine particles (PM_{2.5}), as they were only measured in Montreal every 6 days, and it is only recently that there is a network of monitors that measure PM_{2.5} on a daily basis. We believed that the use of ozone and nitrogen dioxide were suitable markers for air pollution. As well, both nitrogen dioxide and PM_{2.5} are correlated ($r = 0.38$ over the study period). The confounding factors that were included in the analysis were those about which we had a priori information that they could influence emergency department visits for asthma. For example, even though the role of climatic factors in exacerbating asthma is poorly understood (D'Amato et al., 2001), high and low atmospheric pressures have been linked to asthma attacks (Garty et al., 1998; Celenza et al., 1996).

Concentrations of pollen were collected at a single geographic location, and this was taken as the global exposure of a population distributed over 500 km². It has been shown that a single collector can represent the temporal variation of concentrations of pollen of a given species over a large area (Lewis et al., 2000). Furthermore, even though most of the types of pollen selected for this study were considered allergenic (Asselin et al., 1998), positive associations for first admissions and readmissions were only observed consistently for the grass group. With respect to other pollens, the absence of consistent associations could be explained by the fact that the sampler for pollen functioned only over 88% of the study period (and 68% in 1995). Given that the majority of the missing data are mostly in the fall (late September and October), the effect is particularly important for the results from the weeds group (including ragweed) which are most productive in autumn. Additionally, the weeds include more than 1000 taxa which cannot be differentiated microscopically and of which only certain taxa are highly allergenic (ARL, 2005). This type of misclassification could obscure true associations for hazardous species.

Emergency department visits in children aged 0–9 years are among the groups most affected by asthma (Silverman et al., 2003). Examination of emergency department visit use patterns includes a large spectrum of illness severity, and may therefore be a more sensitive indicator of asthma exacerbation than hospitalizations (Silverman et al., 2003). This indicator can reflect the urgent nature of health responses following an exposure if the visits take place on the same day that symptoms appear. However, such visits may be prevented amongst those patients who regularly take their asthma medications prophylactically. Indeed, better instruction of parents with regards to preventing asthma attacks and the expanding usage of steroid and combined inhalers have resulted in children requiring fewer

visits to the emergency department. Precautionary measures of this sort are especially easy to take for recurrent seasonal allergies such as pollen and may, therefore, affect our estimates of risk. The improbable negative relationship found between the species of weeds (including ragweed) and emergency department visits may conceivably be explained in part by the likelihood of patients to have already made an emergency department visit and have been treated for a reaction due to grass pollen earlier in the same season (Ravault et al., 2005).

The reliability of the diagnoses of asthma from emergency department visits and of other information drawn from the QHIP health database is very important for the interpretation of the results of this study. Some authors have raised doubts about the usefulness of information collected in medical administrative databases, such as QHIP data, primarily because this information is typically collected for reasons other than research and many such databases have been shown to contain substantial proportions of misclassification errors (Ladouceur et al., 2006). Some studies have in fact shown that front-line health professionals have a tendency to over-diagnose asthma, with a specificity of diagnosis of 60% in a study in Ontario (To et al., 2006) and 89% in the case of an American study (Ward et al., 2004). However, to date, no studies have attempted to validate the accuracy of asthma diagnoses among children in the QHIP data using the medical chart as a gold standard. Delfino et al. (1993) have analyzed the reliability of Quebec's hospitalization discharge database (Med-Echo), and found that the reliability of diagnoses for asthma was 94.9%, and that the reliability of respiratory diagnoses was higher among young patients. Overall, the QHIP data examined in this study appear to possess some weaknesses and methodological limitations, but we have assumed that it is sufficiently reliable for use in research relating emergency department visits to ambient aeroallergen levels.

In conclusion, the association between exposure to pollens from grass and increased numbers of emergency department visits due to asthma suggests an exacerbation of respiratory disease in the context of the contemporary global warming and its anticipated impacts on the production of pollen and the length of the growing season. An important extension of the ragweed pollen season in Montreal has been observed between 1994 and 2002 (Breton et al., 2006), and the evidence of its allergenicity (Comtois and Gagnon, 1988; D'Amato et al., 1998; Dales et al., 2000; Cakmak et al., 2002) suggests that it is important to pursue this research. A follow-up to this study, such as a panel study in asthmatics, would be useful in order to further investigate the observed positive and negative associations.

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