QUANTITATIVE RESEARCH

Emergency department visits for asthma in relation to the Air Quality Health Index: A case-crossover study in Windsor, Canada

Mieczysław Szyszkowicz, PhD,[1] Termeh Kousha, PhD[1]

ABSTRACT

OBJECTIVES: In this study, associations of short-term changes in ambient air pollution with emergency department (ED) visits for asthma were examined in hospitals in the area of Windsor, Ontario. Ambient air pollution quality was represented by the Air Quality Health Index(AQHI), calculated using a formula that combines the concentrations and the relative health impacts of three ambient air pollutants: ozone , nitrogen dioxide and fine particulate matter.

METHODS: Data on ED visits were retrieved from the National Ambulatory Care Reporting System. Only patients two years of age and older were considered. A time-stratified case-crossover design was applied to 6,697 ED visits for asthma for the period of April 2004 to December 2010. Odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) for ED visits associated with increased (by one unit) levels of AQHI were calculated by applying conditional logistic regression.

RESULTS: Positive and statistically significant results were observed between AQHI levels and ED visits for asthma. For all patients the largest value, OR=1.17 (CI: 1.09, 1.26), was obtained for exposures lagged by 9 days in the warm season (April-September). Effects among children 2 to 14 years of age were observed for same-day exposure (lag 0), with an OR=1.11(CI: 1.01, 1.21).

CONCLUSION: Exposure to ambient air pollution in Windsor increases the risk of ED visits for asthma. When the adverse effects of air pollutants are increased, patient visits to the ED depend on the patient's age.

KEY WORDS: Air pollution; air quality health index, asthma; emergency department

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2014;105(5):e336-e341.

Ambient air pollution is one of the recognized environmental risk factors for respiratory health conditions, including asthma. Asthma is a common chronic inflammatory disease of the airway that has the following symptoms: wheezing, coughing, chest tightness and shortness of breath. It is categorized clinically according to the frequency of symptoms. Existing studies conducted in Canada[1-3] and elsewhere[4] have found associations of day-to-day variations in ambient air pollution levels with the exacerbation of asthma.

The city of Windsor, Ontario, is recognized as having poorer air quality in relation to other cities in Canada.[5] Among the different sources of air pollutants in Windsor, two are particularly noteworthy: i) upwind sources that include coal-powered electrical energy generating stations and other industrial sources located in Michigan and the Ohio Valley in the US (cross-border emissions) and ii) local industrial pollution and emissions from Canada-US transportation corridors. The Windsor-Detroit Gateway is the busiest international trade corridor in North America, over 16 million cars and trucks passing through it every year.[6]

This report summarizes a time-stratified case-crossover study of associations between short-term changes in ambient air pollution levels and emergency department (ED) visits for asthma in Windsor-area hospitals. In this case-crossover study, each individual case is considered as one separate event.[7] This is a different approach from time-series methodology, in which events are summarized and usually represented as number of counts per day.

Health Canada and Environment Canada embarked on a joint initiative in 2001 to develop a new air-health index to scale health risks in relation to ambient air pollution concentrations. This new index, the Air Quality Health Index (AQHI), was defined on the basis of the combined effects on mortality of three ambient air pollutants (ozone, O_3; nitrogen dioxide, NO_2; and fine particulate matter, $PM_{2.5}$). In this study, the AQHI was used as an indicator of asthma risk, i.e., as an exposure measurement.

METHODS

Data on ED visits for asthma in Windsor were retrieved from the National Ambulatory Care Reporting System (NACRS), a reporting system for ED cases in Canada.[8] The system captures more than 97% of the ED visits in the province of Ontario, where Windsor is located. The NACRS database is administered at Health Canada. SAS Guide 4.2 software (SAS Institute, Cary, NC) was used to retrieve the corresponding values related to ED visits and basic information (sex, age) on patients. Asthma visits by location within

Authors' Affiliation

Population Studies Division, Health Canada, Ottawa, ON

Correspondence: Dr. Mieczysław Szyszkowicz, Health Canada, 200 Eglantine Driveway, Ottawa, ON K1A 0K9, Tel: 613-948-4629, E-mail: mietek.szyszkowicz@hc-sc.gc.ca

Acknowledgements: The authors appreciate the efforts of Health Canada in maintaining the National Ambulatory Care Reporting System database. In addition, the authors acknowledge Environment Canada for providing the air pollution data from the National Air Pollution Surveillance Network, for use in this study.

Conflict of Interest: None to declare.

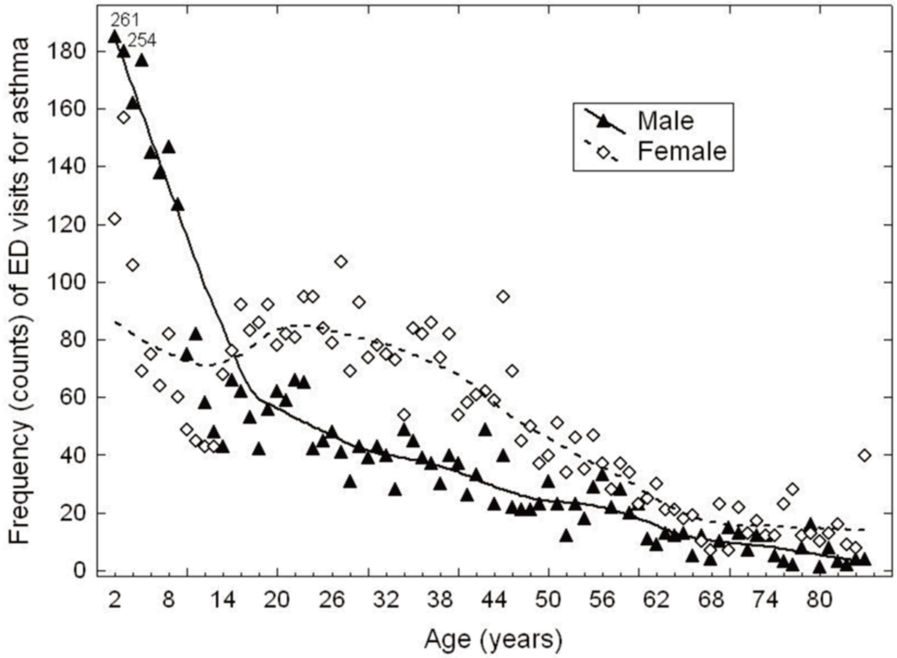

Figure 1. Frequencies of emergency department (ED) visits for asthma by age and sex, Windsor (April 1, 2004-December 31, 2010)

the city of Windsor were identified using the first three alphanumeric characters of available postal codes for each patient's home address. For this purpose, the 21 different three-character strings were determined.

The International Classification of Diseases 10^{th} (ICD-10) revision coding was applied to identify discharge diagnoses of asthma. In our initial approach, the first three characters of ICD-10 codes were considered for determining the frequency of ED visits for asthma. The only identified string related to asthma was ICD-10 code J45. The NACRS database was then queried only for this code (J45) and only for the Windsor postal codes for the period of April 1, 2004, to December 31, 2010. In addition, data on ED visits for influenza (using the ICD-10 codes J09, J10 and J11) were retrieved and the daily counts of visits created.

Available air pollution data were retrieved from the AQHI database from April 1, 2004, to December 31, 2010. Environment Canada's weather archives (http://climate.weatheroffice.gc.ca/) supplied data for selected weather variables, which were recorded hourly. In this study, only two meteorological variables were used: ambient temperature (dry bulb) and relative humidity. The daily mean as an average of hourly readings (an average of 24 measurements) was used to represent values of these weather parameters. In the final models, the weather variables were used in a spline form as confounders.

The data on ambient air pollution were supplied by Environment Canada (http://www.ec.gc.ca/rnspa-naps/). Data on O_3, NO_2 and $PM_{2.5}$ were acquired. Hourly data from two operating monitors were averaged to obtain one value per hour. To represent ambient air pollution concentrations, the AQHI values were used, which are represented on a scale of 1-10 (where 1-3=low risk, 4-6=moderate risk, 7-10=high risk, >10=very high risk). The AQHI was introduced in Canada as a tool to communicate air pollution levels to the public. It was constructed as the sum of excess mortality risks associated with individual pollutants, with risks estimated from a time-series analysis of air pollution and mortality in Canadian cities.[9] To communicate values on recent exposure and consequently the quality of ambient air (and forecasting for the near future), the values of the AQHI are calculated hourly on the basis of trailing 3-hour-average pollutant concentrations for O_3, NO_2 and $PM_{2.5}$. The AQHI values were calculated according to the formula presented in the publication on the definition and characteristics of this index:[9]

$$AQHI=10/10.4*100*(\exp(0.000871*NO_2)+\exp(0.000537*O_3)+\exp(0.000487*PM_{2.5})-3)$$

In this equation, the exp(x) is an exponential function, i.e., a function that is the inverse of the natural logarithmic function. This quantity was used to represent the level of exposure. The AQHI incorporates 24 values per day. As our unit of study is one day, the daily average of 24 values determined over the course of a day was used to represent the value for a specific day. The formula for the AQHI is given by a continuous function, and so we assume that our values are a good representation of the corresponding daily value. Another approach is to use daily maximum or another characteristic (median). The mean value accurately represents daily exposure as it incorporates information based on 24 values.

As our main statistical method to analyze cases (separate events at the individual level) vs. considered exposure, the case-crossover (CC) design was used.[10] By definition, the CC technique uses the cases as their own controls on a set of predefined control days (referent periods) proximate to the time they became cases. A time-stratified approach to determine controls has been accepted and widely adopted, and has been shown to produce unbiased conditional logistic regression estimates.[7,11] In the design, the controls are matched to case periods by day of week for the case period (day). In such constructed models, the effect of day of week is already adjusted for by the design employed. The asthma day was selected as the case period, and the control period consisted of all days falling on the same day of the week in the same month and

Table 1. Characteristics of emergency department visits for asthma, Windsor (April 1, 2004-December 31, 2010)

Characteristic	Number of visits	%	Male	Female
Age				
2-14	2151	32.1	1393	758
15-39	2629	39.3	976	1653
40-59	1313	19.6	453	860
60+	604	9.0	201	403
Sex				
Male	3023	45.1		
Female	3674	54.9		
Total/year	6697			
2004	830	12.4	390	440
2005	1060	15.8	471	589
2006	1038	15.5	482	556
2007	996	14.9	452	544
2008	1004	15.0	450	554
2009	933	14.0	402	531
2010	836	12.5	376	460

Table 2. Characteristics of ambient air pollution represented as Air Quality Health Index daily mean values, Windsor (April 1, 2004-December 31, 2010)

Year	Mean	N	SD	Minimum	Maximum	Q25	Median	Q75
2004	3.1	275	0.9	1.3	6.6	2.5	2.9	3.6
2005	3.4	365	1.0	1.3	6.9	2.7	3.2	3.9
2006	3.2	365	0.8	1.5	6.0	2.6	3.0	3.6
2007	3.3	365	0.9	1.5	6.4	2.7	3.1	3.8
2008	3.2	363	0.7	1.6	6.1	2.7	3.1	3.6
2009	2.9	364	0.7	1.2	5.2	2.5	2.8	3.3
2010	3.1	365	0.7	1.5	5.8	2.6	3.0	3.6
Total	3.2	2462	0.8	1.2	6.9	2.6	3.0	3.6

year as the case period. Matched sets for one ED visit consisted of one case and three or four control periods, depending on the day of the week and the number of days in the considered month. For example, the case day of Tuesday, November 2, 2010, would be matched with four days as control period, as follows: November 9, 16, 23 and 30, i.e., all other Tuesdays but the asthma day. Thus, in this situation we have a case day and associated exposure on November 2 and no-case (control) days and associated exposure on November 9, 16, 23 and 30. The time-stratified design was applied because it is not subject to time trend bias. It controls for day of the week, seasonality and inter-subject variability.[7,11] Statistical models were constructed using conditional logistic regression with strata as an individual person. The calculations were performed for all patients and by age subgroups: 2-14, 15-39, 40-59 and 60 years of age and older. For all patients, the calculations were done also by season: warm (April-September), cold (October-March).

A p value <0.05 was considered statistically significant in all presented statistical results. The results were reported as odds ratios (ORs) and their corresponding 95% confidence intervals (CI). The values of ORs are reported for a one-unit increase in the concentration represented as the AQHI value. Since daily temperature and relative humidity may also affect acute outcomes of asthma, we adjusted for these two variables. In the constructed models, we used indicator (1 vs. 0) for the days with ED visits for influenza to adjust for influenza season, when respiratory conditions are affected by viruses and infections. Temperature and relative humidity were used in the form of natural splines with four degrees of freedom. Exposures lagging from 0 (the case day) to 10 days were considered.

RESULTS

Figure 1 shows the number of ED visits for asthma by age and sex. For the patients older than 85 years of age, their age was represented as 86 (i.e., all cases for older patients were summarized and assigned to 86 years of age for graphical purposes only). The number of visits for all patients and for males and females was as follows: all=6,697, males=3,023 and females=3,674. Patients younger than two years of age were not considered, as the diagnosis of asthma for children of this age is often confused with that of bronchiolitis.

Table 1 summarizes the statistical characteristics for asthma by the considered age group, sex and year of the study. The NACRS database is composed of separate SAS data files containing yearly data, the year being considered as the fiscal year. One such file represents data for one year (say, 2004) for the period of April (2004) to March (2005); thus, data for the year 2004 are only for the period of April 1, 2004, to December 31, 2004. If repetition of records was observed, i.e., a repeat of ED visits for the same patient on the same day, only the first visit on a specific day was considered. Table 2 presents the characteristics of the AQHI daily mean values. As the data on ambient air pollutants were available until December 31, 2010, our analysis was done for the period of April 1, 2004 to December 31, 2010, i.e., 2,466 days in the study period, so that the study period for the ED visits and the environmental data coincided.

The ED visits for asthma occurred on days with the following frequencies: 0 visits, 215 days (8.7% of all days); 1 visit, 492 days (20%); 2 visits, 594 days (24.1%); 3 visits, 441 days (17.9%); and 4 visits, 328 days (13.3 %) of all 2,466 days in the study. The median value for ED visits for asthma was 3. There were 1,968 days (79.8%) without ED visits for influenza, 316 days with 1 visit per day (14.6%) and 73 days with 2 visits per day (3.0%). Influenza infection may cause worsening asthma symptoms. Thus, days with ED visits for influenza were flagged. Influenza cases were not analyzed but, rather, were used as an indicator factor in the constructed models.

Calculations were then repeated for each of the four considered age groups. For the youngest (2-14 years of age), OR=1.11 (CI: 1.01, 1.21) for same-day exposure (lag 0). For the second considered age group, patients of 15-39 years of age, the results were as follows: OR=1.10 (CI: 1.02, 1.19), lag 5; OR=1.13 (CI: 1.05, 1.22), lag 8; and OR=1.12 (CI: 1.02, 1.20), lag 10. For the third age group, patients of 40-59 years of age, OR=1.13 (CI:1.01, 1.26). For 60 years of age and older, the lower limits of the estimated 95% CIs were less than 1.

As the lag of 8-10 days is very intriguing, an additional analysis was performed using a time-series approach. Daily counts were defined as the daily summary of individual events, and a Poisson regression was applied. Specifically, the distributed lag non-linear models (DLNM) technique with constraints on the coefficients for lagged values was used.[12] The DLNM technique is an extension of a regression model to define the relationship between a set of predictors (here, a lagged AQHI from 0 to 10 days) and an outcome (here, asthma). The established relationships accommodate the temporal structure of dependency, and a specific occurrence of an exposure event affects the health outcomes for a lapse of time beyond the event moment. The results generated by the DLNM technique confirmed the association for lags (data are not shown).

In addition, for all patients the ORs were calculated for daily maximum of AQHI and for the three component pollutants used to determine the AQHI values ($PM_{2.5}$, O_3, represented as an 8 hour maximum, and NO_2). Figure 2 summarizes the results. The

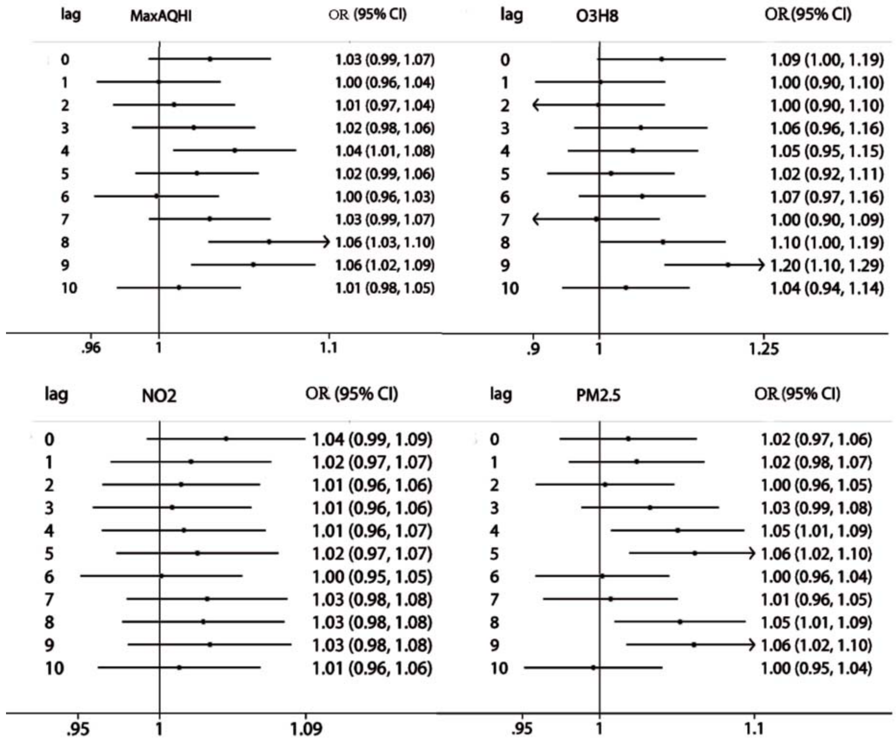

Figure 2. Estimated odds ratios (ORs) with 95% confidence intervals (CIs) for one unit increase for maximum of Air Quality Health Index (AQHI) and for one interquartile range increase for the considered three air pollutants (O_3, NO_2 and $PM_{2.5}$), Windsor (April 1, 2004-December 31, 2010)

estimated ORs are reported for one interquartile range (IQR) (IQR=75th-25th percentile) increase in air pollutant levels and one unit increase in the maximum of AQHI values. The figure shows that O_3 and $PM_{2.5}$ dictate the pattern of responses to exposure represented as the AQHI.

For a sensitivity analysis and to further investigate the association with large lags (9, 10), additional calculations by age group were performed. Table 3 represents the results for these defined age groups. The results suggest that for younger patients the effect of same-day exposure (lag 0) is the strongest. Table 3 shows the ORs and their corresponding 95% CIs for the defined age groups for the whole study period. The results suggest several things: 1) younger patients are sensitive to same-day exposure; 2) for the 15-39 age group, the delayed exposure (8-10 days) has observable effects; 3) for the 40-59 group, the effect persists for lag 9; and 4) for those older than 60 years of age, there are no effects at all.

Table 4 summarizes the results from the CC method for all patients in the warm (April-September) and cold (October-March) seasons. The first column shows the results for the year and may be compared with the results in Figure 2 (mean AQHI vs. max AQHI). Positive and statistically significant results were obtained for lags 0, 9 and 10, the largest, OR=1.17 (CI: 1.09, 1.26), being lag 9 in the warm season. Only one positive result was obtained for the cold season (October-March) for a 4-day lag. For the ED visits for asthma in the warm period, two lags, lag 0 and lag 9 (or 10), played a major role on days in the April-September period.

DISCUSSION

Positive and statistically significant relationships were observed between ED visits for asthma and air quality as measured using the AQHI values. This suggests that reductions in ambient air pollutant levels could reduce asthma morbidity. Using the AQHI values to plan ahead for any outdoor physical activities could reduce this morbidity. Since the results suggest that, for the youngest people, same-day exposure has the strongest effect, exposure prevention based on early announcement of the AQHI value would be most helpful. In contrast, older people experience more delayed effects (lag 8-10), so they may need to check the Environment Canada website (http://www.ec.gc.ca/cas-aqhi) to determine whether they are at risk and may need to avoid exposure. The AQHI is also broadcast on the weather network in many areas, and forecasts appear in some newspapers. When the index is elevated, announcements may also be made on radio and television news, particularly if an air quality advisory is also issued. It is important to keep in mind that the health effect might occur even a few days later.

While the definition and use of the AQHI are based on mortality (the coefficients in its formula represent the risk of death), its relation to morbidity has not yet been fully evaluated. As stated by Abelsohn and Stieb,[13] the AQHI can be used to teach patients with asthma to reduce the health risk from air pollution exposure.[13] As our results show that current-day exposure for the youngest individuals has the strongest effects, this implies that a good prediction of the AQHI levels is very important.

The findings presented in this paper are similar to those of a previous study on the association between ambient air pollution and ED visits for respiratory conditions in Atlanta, Georgia.[14] Using the extensive air quality data from 31 hospitals in Atlanta for the period of January 1, 1993, through August 2000, Peel and co-workers have contributed to the evidence of an association of several correlated gaseous and particulate pollutants, including O_3, NO_2, CO, $PM_{2.5}$ and organic carbon, with specific respiratory

Table 3. Odds ratios (OR) and 95% confidence intervals (CI) for lags from 0 to 10 days, by predefined age group, Windsor (April 1, 2004-December 31, 2010)

	Age							
	2-14		15-39		40-59		60+	
Lag	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
0	1.11*	1.01, 1.21	1.03	0.96, 1.12	1.07	0.97, 1.20	0.96	0.83, 1.13
1	1.02	0.93, 1.12	1.05	0.97, 1.14	0.97	0.87, 1.08	0.99	0.85, 1.16
2	1.01	0.92, 1.10	1.06	0.98, 1.14	0.91	0.82, 1.02	0.99	0.85, 1.16
3	1.09*	1.00, 1.18	1.01	0.93, 1.09	1.03	0.92, 1.14	0.94	0.80, 1.10
4	1.06	0.98, 1.16	1.02	0.95, 1.11	1.04	0.93, 1.16	1.09	0.93, 1.29
5	1.02	0.93, 1.11	1.10*	1.02, 1.19	1.00	0.90, 1.12	1.14	0.97, 1.33
6	1.01	0.93, 1.10	1.07	0.99, 1.15	0.95	0.86, 1.06	1.02	0.87, 1.20
7	1.01	0.93, 1.10	1.12*	1.04, 1.21	0.97	0.87, 1.08	0.90	0.77, 1.05
8	1.04	0.95, 1.13	1.13*	1.05, 1.22	1.04	0.94, 1.16	0.88	0.76, 1.03
9	1.11*	1.01, 1.21	1.09*	1.01, 1.18	1.13*	1.01, 1.26	0.90	0.77, 1.05
10	0.99	0.91, 1.09	1.10*	1.02, 1.20	0.97	0.87, 1.08	0.93	0.80, 1.09

Note: Estimations obtained with covariates: temperature, relative humidity and influenza seasons indicator.

Table 4. Odds ratios (OR) and 95% confidence intervals (CI) for lags from 0 to 10 days, by time period (year, warm season and cold season) for all patients, Windsor (April 1, 2004-December 31, 2010)

Period (day)	Year		Warm season		Cold season	
Lag	OR	95% CI	OR	95% CI	OR	95% CI
0	1.05*	1.00, 1.11	1.10*	1.03, 1.18	1.02	0.95, 1.09
1	1.02	0.97, 1.07	1.03	0.96, 1.10	1.02	0.95, 1.09
2	1.01	0.96, 1.06	1.01	0.94, 1.09	1.01	0.94, 1.08
3	1.03	0.98, 1.08	1.02	0.95, 1.09	1.05	0.98, 1.13
4	1.05*	1.00, 1.10	1.04	0.97, 1.11	1.09*	1.01, 1.17
5	1.05*	1.00, 1.10	1.08*	1.01, 1.15	1.03	0.96, 1.11
6	1.02	0.97, 1.07	1.05	0.98, 1.12	0.99	0.92, 1.06
7	1.03	0.98, 1.08	1.04	0.97, 1.11	1.03	0.96, 1.10
8	1.06*	1.01, 1.11	1.12*	1.05, 1.20	1.00	0.93, 1.07
9	1.08*	1.03, 1.13	1.17*	1.09, 1.26	0.99	0.93, 1.06
10	1.02	0.97, 1.07	1.11*	1.03, 1.19	0.94	0.87, 1.00

Estimations obtained with covariates: temperature, relative humidity and influenza seasons indicator.

conditions. They have shown that the risk ratios for asthma visits were generally positive and strongest with a lag of 5 to 8 days (see Figure 1 in Peel et al.[14]).

A recently published study[15] also used the AQHI values (daily maximum among 24 values) to represent exposure with asthma as the health outcome. To and co-workers found that the AQHI values were significantly associated with increased use of asthma health services on the same day (lag 0) and on the following two days, depending on the category of outcome evaluated. For ED visits for asthma, they specify a 1.3% increase in the rate ratio (RR) of ED visits (RR=1.013; CI: 1.010, 1.017) after a 2 day lag. Our results are consistent with these findings, as we considered the results by age group (see Table 3); for example, for the 15-39 age group, an OR=1.06 (CI: 0.98, 1.14) was obtained – the largest effect among the results for lag 2. It should be noted that our approach to represent the daily AQHI is different: To and co-workers used the maximum of the 24 daily values and reported the results for a one unit increase; we used the average of 24 daily values and also reported the results for a one unit increase. For all patients, calculations were performed with the daily maximum of AQHI (see Figure 2).

The goal of this study was to assess the associations between the AQHI levels and asthma morbidity, measured as ED visits. The strengths of our work include 1) a relatively large number of diagnosed ED visits (6,697 cases), 2) a widely accepted statistical method (CC), 3) adjustment in the models for weather factors and influenza, 4) analysis performed for predefined age groups, 5) use of the DLNM technique to realize constrained lag distributions (time-series approach), 6) separate analyses by seasons and 7) analysis performed for both the AQHI and for the three air pollutants used to calculate the AQHI. The most significant limitation of the study related to exposure. All patients were assumed to have had the same exposure to risk, measured as the AQHI values. The pollen counts were not controlled for in the considered statistical models. Another limitation is that the patients and their health conditions are different; nevertheless, the CC design adjusts for the majority of differences due to individual characteristics. The results are different by age groups; thus, age is an important factor.

There are several similar studies that have found an association between O_3 exposure and ED visits for asthma in Canada.[1,2,16-19] With specific regard to Windsor, Ontario, for 1 day lagged exposures in certain subgroups, Lavigne et al. also reported statistically significant associations between ambient air pollution levels and emergency visits for asthma.[20]

Exposure to ambient air pollution in Windsor increases the risk of ED visits for asthma. When the adverse effects of air pollutants are increased, patient visits to the ED depend on the patient's age.

REFERENCES

1. Stieb DM, Burnett RT, Beveridge RC, Brook JR. Association between ozone and asthma emergency department visits in Saint John, New Brunswick, Canada. *Environ Health Perspect* 1996;104(12):1354-60.
2. Villeneuve PJ, Chen L, Rowe BH, Coates F. Outdoor air pollution and emergency department visits for asthma among children and adults: A case-crossover study in northern Alberta, Canada. *Environ Health* 2007;6:40.
3. Szyszkowicz M. Ambient air pollution and daily emergency department visits for asthma in Edmonton, Canada. *Int J Occup Med Environ Health* 2008;21(1):25-30.
4. Gasana J, Dillikar D, Mendy A, Forno E, Ramos Vieira E. Motor vehicle air pollution and asthma in children: A meta-analysis. *Environ Res* 2012 Jun 6. [Epub ahead of print]
5. The Weather Network. Air Quality: Air Quality Summary. 2010. Available at: http://www.theweathernetwork.com/index.php?product=airquality&airqualitycode=on&pagecontent=airqsummary (Accessed July 9, 2012).
6. Goal A: Improve our air and water quality. http://www.citywindsor.ca/residents/environment/Environmental-Master-Plan/Pages/State-of-the-Environment.aspx (Accessed July 9, 2012).
7. Wang SV, Coull BA, Schwartz J, Mittleman MA, Wellenius GA. Potential for bias in case-crossover studies with shared exposures analyzed using SAS. *Am J Epidemiol* 2011;174(1):118-24.
8. Canadian Institute for Health Information. National Ambulatory Care Reporting System (NACRS). 2010. Available at: http://www.cihi.ca/CIHI-ext-portal/internet/en/document/types+of+care/hospital+care/emergency+care/services_nacrs (Accessed July 9, 2012).
9. Stieb DM, Burnett RT, Smith-Doiron M, Brion O, Shin HH, Economou V. A new multipollutant, no-threshold air quality health index based on short-term associations observed in daily time-series analyses. *J Air Waste Manag Assoc* 2008;58(3):435-50.

10. Maclure M. The case-crossover design: A method for studying transient effects on the risk of acute events. *Am J Epidemiol* 1991;133(2):144-53.
11. Janes H, Sheppard L, Lumley T. Case-crossover analyses of air pollution exposure data: Referent selection strategies and their implications for bias. *Epidemiology* 2005;16(6):717-26.
12. Gasparrini A. Distributed lag linear and non-linear models in R: The package dlnm. *J Stat Softw* 2011;43(8):1-20.
13. Abelsohn A, Stieb DM. Health effects of outdoor air pollution: Approach to counseling patients using the Air Quality Health Index. *Can Fam Physician* 2011;57(8):881-87.
14. Peel JL, Flanders WD, Todd K, Mulholland JA, Ryan PB, Frumkin H. Ambient air pollution and respiratory emergency department visits. *Epidemiology* 2005;16(2):164-74.
15. To T, Shen S, Atenafu EG, Guan J, McLimont S, Stocks B, Licskai C. The Air Quality Health Index and asthma morbidity: A population-based study. *Environ Health Perspect* 2012 Oct 10. [Epub ahead of print]
16. Delfino RJ, Murphy-Moulton AM, Burnett RT, Brook JR, Becklake MR. Effects of air pollution on emergency room visits for respiratory illnesses in Montreal, Quebec. *Am J Respir Crit Care Med* 1997;155:568-76.
17. Burnett RT, Dales RE, Raizenne ME, Krewski D, Summers PW, Roberts GR, et al. Effects of low ambient levels of ozone and sulfate on the frequency of respiratory admissions to Ontario hospitals. *Environ Res* 1994;65:172-94.
18. Burnett RT, Cakmak S, Brook JR, Krewski D. The role of particulate size and chemistry in the association between summertime ambient air pollution and hospitalization for cardiorespiratory diseases. *Environ Health Perspect* 1997;105:614-20.
19. Kousha T, Rowe BH. Ambient ozone and emergency department visits due to lower respiratory condition. *Int J Occup Med Environ Health* 2014;27(1):50-59.
20. Lavigne E, Villeneuve PJ, Cakmak S. Air pollution and emergency department visits for asthma in Windsor. *Can J Public Health* 2012;103(1):4-8.

Received: April 7, 2014
Accepted: July 18, 2014

RÉSUMÉ

OBJECTIFS : Dans cette étude, nous avons examiné les associations entre les changements à court terme dans la pollution atmosphérique et les visites aux urgences dues à l'asthme dans les hôpitaux de la région de Windsor (Ontario). La qualité de l'air ambiant a été représentée par la cote air santé (CAS), calculée selon une formule combinant les concentrations et les effets sanitaires relatifs de trois polluants atmosphériques : l'ozone, le dioxyde d'azote et les particules fines.

MÉTHODE : Les données sur les visites aux urgences ont été extraites du Système national d'information sur les soins ambulatoires. Seuls les patients âgés de deux ans et plus ont été pris en compte. Nous avons appliqué un schéma « case-crossover » stratifié dans le temps à 6 697 visites aux urgences dues à l'asthme pour la période d'avril 2004 à décembre 2010. Nous avons appliqué une régression logistique conditionnelle pour calculer les rapports de cotes (RC) et leurs intervalles de confiance (IC) à 95 % correspondants pour les visites aux urgences associées à des niveaux accrus (d'une unité) de la CAS.

RÉSULTATS : Des résultats positifs et significatifs ont été observés entre les niveaux de la CAS et les visites aux urgences dues à l'asthme. Pour l'ensemble des patients, la plus grande valeur, RC=1,17 (IC : 1,09, 1,26), a été obtenue pour les expositions décalées de 9 jours durant la saison chaude (avril-septembre). Des effets chez les enfants de 2 à 14 ans ont été observés pour les expositions le jour même (0 décalage), avec un RC=1,11 (IC : 1,01, 1,21).

CONCLUSION : L'exposition à la pollution atmosphérique à Windsor accroît le risque de visites aux urgences dues à l'asthme. Quand les effets indésirables des polluants atmosphériques augmentent, les visites aux urgences varient selon l'âge des patients.

MOTS CLÉS : pollution de l'air; cote air santé, asthme; service urgences