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AIR POLLUTION AND EMERGENCY DEPARTMENT VISITS FOR CHEST PAIN AND WEAKNESS IN EDMONTON, CANADA

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Abstract
Objectives: Chest pain or weakness can be first signal of health problems. Many studies demonstrate that these conditions can be related to air pollution. This work uses time-series data to investigate the association. **Material and Methods:** This is a study of 68 714 emergency department (ED) visits for chest pain (ICD-9: 786) and of 66 092 ED visits for weakness (ICD-9: 780). The hierarchical method was applied to analyse the associations between daily counts of ED visits for chest pain and weakness (separately) and the levels of the air pollutants and meteorological variables. The counts of visits for all patients, males and females were analysed separately by whole period (I–XII), warm (IV–IX) and cold (X–III). **Results:** The results are presented in the form of the excess risks associated with an increase in the interquartile range (IQR) for the pollutant. Chest pain: 2.4% (95% CI: 1.0–3.9) for CO, females, I–XII; 3.8% (95% CI: 0.0–7.8) for NO_2, males, IV–IX; 4.5% (95% CI: 0.9–8.3) for O_3 (1-day lagged), males, IV–IX; 2.8% (95% CI: 0.5–5.2), for PM_{10}, males, X–III; 2.0% (95% CI: 0.0–4.0), for SO_2, females, X–III; 2.1% (95% CI: 0.2–4.0) for $PM_{2.5}$, all, X–III. Weakness: 2.1% (95% CI: 0.4–3.7) for CO (2-day lagged), males, X–III; 3.4% (95% CI: 1.0–5.9) for NO_2 (2-day lagged), males, X–III; 2.4% (95% CI: 0.9–3.9) for SO_2, females, I–XII; 4.6% (95% CI: 1.0–8.2) for O_3 (1-day lagged), females, IV–IX. **Conclusions:** Obtained findings provide support for the hypothesis that ED visits for chest pain and weakness are associated with exposure to ambient air pollution.

Key words:
Emergency department visit, Chest pain, Weakness, Air pollution, Temperature, Relative humidity

INTRODUCTION

Chest pain is a common presentation to the emergency department (ED). Non-specific chest pain or weakness can be early signals of cardio-pulmonary disease. This study is based on 10 years daily summarized counts of ED visits for chest pain and weakness. The study takes in account ambient air pollution exposures and meteorological factors. ED data were linked to concentrations of ambient air pollutants and weather variables. We constructed models for different air pollutants: gases (SO_2, NO_2, CO and O_3) and particulate matters ($PM_{2.5}$ and PM_{10}) — particles with median aerodiameter of 2.5 and 10.0 μm or less, respectively. The goal is to verify a hypothesis that environmental exposures (exposure to air pollution and/or to meteorological conditions) may be associated with ED visits for chest pain or weakness. Chest pain or weakness can be early signals of cardio-pulmonary symptoms.

There are no studies on the associations between ED visits for chest pain or weakness and ambient air pollution. Here we use a time-series methodology to assess associations between air pollution and chest pain and weakness sufficiently serious to warrant an ED visit. A large number of time series studies of air pollution already exist, but

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these mostly assess mortality, morbidity, hospital admissions and emergency department admissions for respiratory and cardiovascular health outcomes. In this work we fit in a trend to assess other endpoints than the traditional cardio-pulmonary health outcomes. As we have already mentione there is no such study: ambient air pollution and ED visits for chest pain or weakness.

MATERIALS AND METHODS

Data on ED visits were supplied by Capital Health for all five Edmonton area hospitals and covered the period between April 1, 1992 and March 31, 2002. ED visits for chest pain were identified based on a discharge diagnosis of chest pain using the International Classification for Diseases 9th revision (ICD-9), rubric 786 [1]. The visits were date-tagged at the day of arrival to the ED. In total, the analysis is based on 68 714 ED visits for chest pains over a span of 3652 days. This represented approximately 2.3% of all (n = 2 946 714) recorded and diagnosed ED visits to these hospitals over the study period.

From the same data base we extracted all cases related to ED visits for weakness based on a discharge diagnosis of weakness using the ICD-9 codes, rubric 780 [1]. In this case, we had 66 092 ED visits for weakness, which is approximately 2.2% of all recorded and diagnosed ED visits.

Environment Canada supplied hourly data for selected weather variables; this included: relative humidity, temperature (dry bulb) and atmospheric pressure (sea level). For our study we created a daily average of 24 measurements. After preliminary analysis, in our models we used only temperature and relative humidity as weather factors.

The hourly data on ambient air pollutants concentrations were obtained from a few monitoring stations in Edmonton. These data were also supplied by Environment Canada as part of the National Air Pollution Surveillance Network [2]. We defined the daily concentration level for any specific monitor station as an average of 24 measurements taken at hourly intervals. The daily shared exposures of the population were expressed as mean values among stations.

To relate short-term effects of air-pollution and weather factors to the number of daily ED visits for chest pain and weakness we applied a generalized linear mixed models (GLMM) methodology [3]. We first defined clusters based on the following triplet (year, month, day of week). Our clusters may have 4 or 5 observations (days). The clusters have a hierarchical structure: days are nested in days of the week, which are nested in months, and months are nested in years. The days of the same day of the week, in the same month and in the same year belong to the same cluster. We applied a Poisson model to clustered counts. In our models we assumed fixed slope and random intercept on the constructed clusters. The method was already proposed to analyse air pollution impact on health outcomes [4]. Among existing software which realizes this method we have chosen the *glmmPQL* function from the R statistical package [5].

Relative risks of chest pain and weakness ED visits attributable to the single pollutant and weather factors using current day exposure level, 1-day and 2-day lagged shared exposure levels were estimated for an increase in value of current day interquartile range (IQR). Results are expressed as excess risk (%RR = (RR-1)×100%, where RR is relative risk): percentage changes in daily visits associated with the pollutant and weather factors. The 95% confidence intervals (95% CI) were also calculated.

RESULTS

The results are presented in four tables and two figures. Table 1 contains the number of ED visits for chest pain and weakness by age and sex. Chest pain: Of the 68 714 total visits in the study, 51.1% (n = 35 134) occurred among males. Between 1992 and 2002, the percentage of the number of ED visits for chest pain, by month, ranged from 7.6% in June to 9.2% in March. Percentage of total visits by days of the week changed from 13.8% on Fridays to 15.6% on Mondays. Weakness: Of the 66 092 total visits in the study, 48.7% (n = 32 180) occurred among males. Between 1992 and 2002, the percentage of the number of ED visits for weakness, by month, ranged from 7.7%

Table 1. Frequency of emergency department visits for chest pain (ICD-9 = 786) and weakness (ICD-9 = 780) by age group and gender. Edmonton (April 01, 1992 – March 31, 2002)

Age of respondents (years)	Chest				Weakness			
	n	%	Female n	Male n	n	%	Female n	Male n
0–20	7 400	10.8	3 678	3 722	21 685	32.8	10 772	10 913
20–30	8 780	12.8	4 234	4 546	7 040	10.7	3 839	3 201
30–40	11 150	16.2	5 014	6 136	7 746	11.7	3 860	3 886
40–50	12 119	17.6	5 471	6 648	6 669	10.1	3 196	3 473
50–60	10 007	14.6	4 837	5 170	5 144	7.8	2 412	2 732
60–70	8 116	11.8	3 962	4 154	5 203	7.9	2 420	2 783
70–80	7 093	10.3	3 778	3 315	6 460	9.8	3 460	3 000
80–105	4 049	5.9	2 606	1 443	6 145	9.3	3 953	2 192
Total	68 714	100.0	33 580	35 134	66 092	100.0	33 912	32 180

in April (7.9% in September) to 8.9% in July. The percentage of total visits by days of the week changed from 13.6% on Tuesdays to 15.2% on Sundays.

Table 2 contains a summary on ambient air pollutants and weather components. Ambient air pollutant concentrations and meteorological parameters were used to show environmental characteristics in Edmonton in the time period of the study. In the table the number of days for which the values were available was shown. The models constructed by the hierarchical method are based on single pollutant and two weather factors: temperature and relative humidity. The models were evaluated for different configurations of weather parameters. The best fit was obtained for temperature and relative humidity. The both parameters are often used in other studies.

Table 3 and 4 represent the estimated excess relative risks (%RR) and their 95% confidence intervals (95% CI). The percentage changes in daily ED admissions are in relation to an increase in the interquartile range (IQR) of each pollutant. The calculated risks were adjusted for the effects of temperature and relative humidity. In the tables only positive statistically significant results are shown. The tables also present detailed specifications for gender and period. Chest pain: (Table 3) elevated risks observed between levels of air pollution and chest pain for CO, NO_2, and O_3 (1-day lag) were 2.4% (95% CI: 1.0–3.9), 3.8%

Table 2. Number of days, mean, standard deviation (SD), median, interquartile range (IQR, the 75th–25th percentile values) of daily average concentrations of the ambient air pollutants and meteorological factors, Edmonton (April 01, 1992 – March 31, 2002)

Variable (unit)	Days	Mean	SD	Median	IQR
CO (ppm)	3 652	0.7	0.4	0.6	0.4
NO_2 (ppb)	3 652	21.9	9.4	19.7	12.8
SO_2(ppb)	3 616	2.6	1.8	2.2	2.3
O_3 (ppb)	3 652	18.6	9.3	17.8	14.0
PM_{10} (μg/m^3)	2 813	22.6	13.1	19.4	15.0
$PM_{2.5}$ (μg/m^3)	1 444	8.5	6.2	7.2	6.2
Temperature (°C)	3 652	3.9	11.9	5.4	17.9
Relative humidity (%)	3 652	66.0	13.6	66.1	18.5

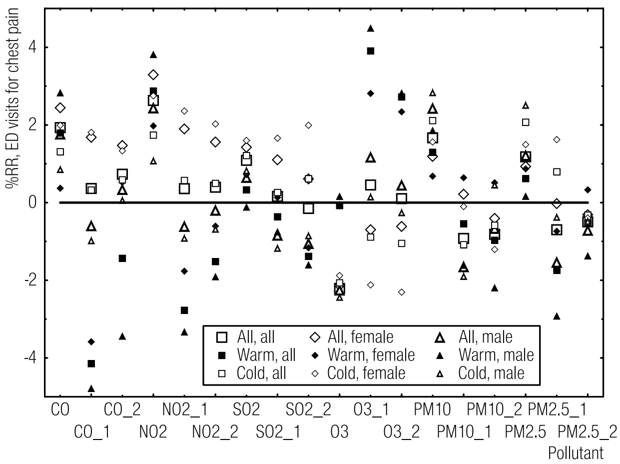

Fig. 1. Chest pain: The percentage changes in the relative risk (%RR) by the pollutants (lagged by none, 1 and 2 days), sex and season.

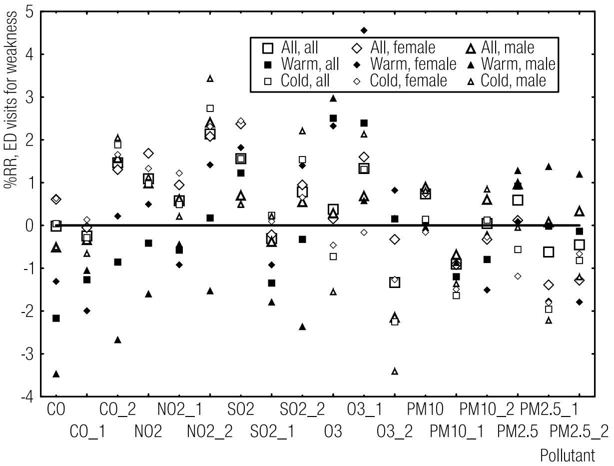

Fig. 2. Weakness: The percentage changes in the relative risk (%RR) by the pollutants (lagged by none, 1 and 2 days), sex and season.

Table 3. The excess risks (%RR) and 95% confidence intervals (95% CI) for ED visits for chest pain by pollutants, period and gender

Pollutant	Period, patients	% RR	95% CI
CO	I–XII, all	1.9	0.9–3.0
CO	X–III, all	1.3	0.2–2.4
CO	I–XII, female	2.4	1.0–3.9
CO	X–III, female	2.0	0.4–3.6
CO	I–XII, male	1.8	0.4–3.1
CO_1	I–XII, female	1.7	0.3–3.1
CO_1	X–III, female	1.8	0.2–3.4
CO_2	I–XII, female	1.5	0.1–2.9
NO_2	I–XII, all	2.6	1.3–4.0
NO_2	X–III, all	1.7	0.1–3.4
NO_2	IV–IX, all	2.9	0.0–5.8
NO_2	I–XII, female	3.3	1.4–5.2
NO_2	X–III, female	2.8	0.5–5.1
NO_2	I–XII, male	2.4	0.6–4.3
NO_2	IV–IX, male	3.8	0.0–7.8
NO2_1	X–III, female	2.4	0.1–4.7
NO2_1	I–XII, female	1.9	0.1–3.8
SO_2	I–XII, all	1.1	0.0–2.2
SO_2	X–III, female	2.0	0.0–4.0
O3_1	IV–IX, all	3.9	1.2–6.7
O3_1	IV–IX, male	4.5	0.9–8.3
O3_2	IV–IX, all	2.7	0.0–5.5
PM_{10}	I–XII, all	1.7	0.5–2.8
PM_{10}	X–III, all	2.1	0.5–3.8
PM_{10}	I–XII, male	2.4	0.9–4.0
PM_{10}	X–III, male	2.8	0.5–5.2
$PM_{2.5}$	X–III, all	2.1	0.2–4.0

Table 4. The excess risks (%RR) and 95% confidence intervals (95% CI) for ED visits for weakness by pollutants, period and gender

Pollutant	Period, patients	%RR	95% CI
CO_2	X–III, all	1.9	0.7–3.1
CO_2	I–XII, all	1.5	0.4–2.5
CO_2	X–III, male	2.1	0.4–3.7
CO_2	I–XII, male	1.6	0.2–3.0
CO_2	X–III, female	1.7	0.1–3.2
NO2_2	X–III, male	3.4	1.0–5.9
NO2_2	X–III, all	2.7	1.0–4.5
NO2_2	I–XII, all	2.1	0.7–3.6
NO2_2	I–XII, male	2.4	0.5–4.4
NO2_2	I–XII, female	2.1	0.2–4.0
NO2_2	X–III, female	2.3	0.1–4.6
SO_2	I–XII, female	2.4	0.9–3.9
SO_2	X–III, female	2.4	0.5–4.5
SO_2	I–XII, all	1.6	0.4–2.7
SO_2	X–III, all	1.6	0.1–3.1
SO2_2	X–III, male	2.2	0.1–4.4
SO2_2	X–III, all	1.5	0.0–3.1
O3_1	IV–IX, female	4.6	1.0–8.2

(95% CI: 0.0–7.8) and 4.5% (95% CI: 0.9–8.3), respectively. Particulate matter exposures were associated with an increased risk of chest pain with %RR equal to 2.8% (95% CI: 0.5–5.2), and 2.1% (95% CI: 0.2–4.0) for PM_{10} and $PM_{2.5}$, respectively. Weakness: (Table 4) elevated risks were estimated between levels of ambient air pollution and ED visits for weakness as 3.4% (95% CI: 1.0–5.9), 2.4% (95% CI: 0.9–3.9), and 4.6% (95% CI: 1.0–8.2), for NO_2 (2-day lag), SO_2, and O_3 (1-day lag), respectively. Figure 1 and 2 shows the estimated %RRs for the considered combination of the air pollutants (lagged), sex and season.

DISCUSSION AND CONCLUSIONS

In this study, the short-term effects of air pollutants, after adjusting for temperature and relative humidity, on daily ED visits for chest pain and weakness in Edmonton were found to be positive and statistically significant. Chest pain or weakness is related to exposure to air pollution. Clustering and overlapping symbols on the figures support the findings. For example the association between exposure to nitrogen dioxide and ED visits for chest pain is emphasised by the cluster of symbols (%RR) on a positive side of the coordinate system. Our results suggest it is possible that vehicular traffic, which is one of the main producer of NO_2, contributes to an increased incidence of ED visits for chest pain.

It was shown that exposure to ozone present in an aircraft cabin can be an irritant of the respiratory system resulting in chest pain [6]. The residents living in sites closest to a mine and smelter/concentrator plant in Botswana reported a higher incidence of chest pain and frequent coughing, compared to those living in another part of the study area [7]. In-office exposure to carbonless copy paper, paper dust, and fumes from photocopiers and printers can be associated with chest pain and fatigue [8].

The limitations of this study are typical of this type of research. They include the adequacy of the used model and impact of measurements error in the exposure to pollutants and weather factors and outcome variables. The outcome variables are identified on the basis of the ICD9 codes. Each ED chart was coded by an experienced medical record nosologist using triage information, nursing notes, ED records and consultation notes. We may assume that chest pain or weakness was rather properly diagnosed. Fixed-site monitors provide daily pollution exposures of ambient air pollution and are applied to represent shared population exposure. Edmonton is a large city geographically and people have different exposures. Like most other time series and case-crossover studies, our risk estimates may be biased by assigning regional measures of air pollution from fixed site-monitoring station to patients. On the other hand the results are based on well accepted study methodology among researches and with a long positive history. The proposition to use the GLMM technique in such a type of study is a relatively new concept.

Overall, this study provides support for the hypothesis that ED visits for chest pain and weakness are associated with exposure to ambient air pollution.

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