URBAN AIR POLLUTION AND EMERGENCY VISITS FOR RESPIRATORY COMPLAINTS IN PISA, ITALY

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ABSTRACT

Emergency room visits for respiratory complaints, considered an indicator of deterioration of respiratory health, have been positively correlated to traffic-related air pollution. This is an ecological study for evaluating the association between daily levels of urban air pollutants and emergency visits for respiratory complaints, in children and elderly residing in Pisa, Italy. Daily records on respiratory complaints visits to emergency department were selected from computerized registries, and paper medical reports were identified. Pollutant daily means were computed from hourly values obtained from public network. Poisson regression, allowing for over-dispersion and auto-correlation was used to evaluate the percent change in daily visits associated to variations of air pollution measure. Among children an increase in emergency visits of 10% (95%CL: 2.3;18.2) was associated with a 10 $\mu g/m^3$ increase of PM_{10} air level of the previous day and an increase of 11.8% (95%CL:1.4;23.3) was associated with an analogous increment for NO_2 of two days before. Among elderly the same increment of PM_{10} level of two days before was correlated with a 8.5% (95%CL:1.5;16.1) increase in the risk of recurring to emergency department for respiratory complaints; this risk increased to 26.5% (95%CL: 3.4;54.8) if the daily level of CO of four days increased by 1 mg/m^3. Evidence of such less severe health outcomes highlighted by this small study but also by larger ones, on short and long term time units, in different climatic countries suggest the need for actions to improve air quality in any urban context.

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INTRODUCTION

Increase in the levels of air pollution may start and/or aggravate respiratory symptoms and may result in an urgent visit to the local hospital emergency room department. Since only the more serious Emergency Room Visits (ERVs) are likely to be hospitalised, ERVs can be considered as an indicator of deterioration of public respiratory health. To date, few studies have analysed health outcomes such as family doctor visits or ERVs due to respiratory symptoms. Children and the elderly are mainly investigated as they are considered the most susceptible to these exposures. Results indicate that proximity of residences to roadsides, exposure to high rates of road traffic, particularly to truck traffic, increases the risk of respiratory symptoms (Ciccone et al., 1998). Recent papers, based either on short-term or long-term effects designs (Atkinson et al., 1999; Martins et al., 2002; Gehring et al., 2002; Orazzo et al., 2001), found positive associations among traffic-related air pollutants and the risk of respiratory symptoms. In children living in non-urban towns in the Netherlands, respiratory symptoms were not associated with air pollution although they were correlated with a reduced respiratory function (Hoek et al., 1999). Traffic air pollution seems to be more dangerous to respiratory health of children if added to other environmental or socio-economic risk factors. In Sao Paulo, Brazil prevalence of respiratory symptoms among children of low-income families was similar to all other children in the low pollution area but it was much higher in areas with medium-high pollution levels (Ribeiro, 1989). Twelve years later in 1998 in the area of Sao Paulo, Brazil where both PM and SO_2 levels decreased, there was a reduction in the prevalence of respiratory symptoms (Ribeiro and Cardoso, 2003). This is an ecological study with the aim of evaluating the association between daily levels of urban air pollutants and ERVs for respiratory complaints, in children and elderly residing in the town of Pisa, Italy.

METHODS

Health data

Pisa hospital is centrally located in town, near the leaning tower. At the registration desk data, on patient's name, visit date and symptoms are routinely recorded on computer. Records on daily ERV for respiratory complaints were selected, by a medical doctor, from the ERV computerized registries for the year 2000. For each patient the paper medical report was identified to collect data on age, residence and presence of an anamnesis. Only residents of Pisa including children up to 10 years, and elderly over 65 years were considered.

Patients with influenza or influenza syndrome were excluded as well as those who visited the department six times or more in the year. Complaints were later coded by a co-author (FC) following the ICD 9 (International Classification of Disease, Ninth Revision), as due to asthmatic attack (ICD 9=493), dry cough (ICD 9=468), and acute bronchitis (ICD 9=466). However the ERV where analyzed as a whole, and not divided by groups of symptoms. Elderly with dyspnoea were excluded from the analyses as this symptom was associated to various pathologies; moreover the daily trend of dyspnoea was quite different from those of the other symptoms taken all together. Weekly data on influenza epidemics for the whole Tuscany Region were obtained from the Regional Health Agency and were used to estimate the daily curve of influenza incidence. The influenza epidemics occurred between December 1999 and January 2000.

Pollutants and meteorological data

Hourly data (from 0:00 to 24:00) on particulate matter up to 10μ in aerodynamic diameter (PM_{10}), nitrogen dioxide (NO_2), carbon monoxide (CO), temperature (T), relative humidity (RH) were obtained from the monitoring network system of Pisa. Missing temperature and relative humidity values were obtained from the Botanic Garden of Pisa University. The Regional Agency for Agricultural & Park Development and Innovation (ARSIA) provided data on daily maximum rain which measures millimetres of water collected during the longest period of continuous rain in the same day. Data were available from the 6 monitoring stations as follows: 3 stations for NO_2 (range of Pearson correlation coefficient ρ=0.43-0.44), 2 stations for PM_{10} (ρ=0.86), 2 for CO (ρ=0.81). Daily averages were computed if 75% of the hours were present. PM_{10} was measured by β-radiometry, NO_2 by chemioluminescence, and CO by infrared.

Statistical methods

Robust Poisson regression in a GAM model, allowing for over-dispersion (McCullagh, 1989), was used to evaluate the percent change in the daily number of ERV associated with the variations of the air pollution

measure. Non parametric smooth functions (loess) of the day of study, mean temperature, mean humidity, maximum rain and influenza epidemics were used. Other confounding variables included in the model were indicator variables for day of the week and holidays. Final core models included: time trend, holidays, days of the week, influenza cases on the previous day, millimetres of maximum rain two days before, temperature and relative humidity both at two days before. The window size for time was selected in order to minimize the Portmanteau statistic of the firth 60 partial autocorrelations of residuals. The span selection for the other covariates was based on the Akaike Information Criterion (AIC) while the selection of lags to introduce in the model was based on the Likelihood Ratio statistic. At the end we again examined the span for time and minimized the partial autocorrelations of the core model residuals. For time component four d.f./year were selected to fit the model of each age group. Finally the autocorrelations and partial autocorrelations of the core model residuals were checked. A linear term for pollutant was used and pollutant effects were investigated up to five days lags. Parameters were estimated using restrictive criteria as suggested by Dominici et al. (2002).

RESULTS

Approximately 94 000 citizens reside in Pisa including 6 200 children below 10 years of age and 20 800 adults over 65 years. 966 ERVs due to respiratory symptoms were recorded: 533 among children and 433 among elderly, excluding the symptom of dyspnoea. In both age groups more than 94% of the patients visited the ER department only once. Among children, respiratory complaints were mainly due to dry cough, while among elderly all the symptoms were almost equally represented. Pollutant concentrations were moderate and time trends, not reported here, do not show pronounced peaks. PM_{10} and CO decreased in summer while NO_2 levels did not vary along the year. Table 1 shows the distribution of all studied variables while correlation among pollutants and meteorological variables are presented in Table 2.

Table 1. Pollutants, meteorological and health variables, Pisa, 2000.

Pollutant		**unit**	**mean**	s.d.	**Min**	Median	**Max**
PM_{10}	24h	$\mu g/m^3$	**35.4**	15.8	**9.5**	31.6	**100.1**
NO_2	24h	$\mu g/m^3$	**45.6**	11.0	**21.3**	44.8	**74.0**
CO	24h	mg/m^3	**1.5**	0.7	**0.3**	1.4	**3.5**
Meteo							
Temp	24h	°C	**15.8**	6.1	**1.1**	15.6	**27.0**
Rel.Hum	24h	%	**82.7**	11.1	**42.8**	83.6	**99.6**
Max Rain	24h	mm	**2.2**	7.1	**0.0**	0.0	**90.6**
E.R.visit							
Children	24h	count.	**1.4**	1.3	**0**	1	**6**
Elderly	24h	count	**1.2**	1.1	**0**	1	**6**

Table 2: Correlations between daily values of pollutants and meteorological variables, Pisa, 2000.

	PM_{10}	**CO**	**R.H.**	**Temp.**	**Max Rain**
NO_2	**0.58**	**0.62**	*-0.01*	**-0.40**	**-0.19**
PM_{10}	**1**	**0.70**	**0.22**	**-0.42**	**-0.23**
CO		**1**	**0.42**	**-0.77**	*-0.03*
R.H.			**1**	**-0.40**	**0.36**
Temp.				**1**	*-0.08*

Bolded number are statistically significant $p<0.05$.

Uni-pollutant analyses were carried out and statistically significant associations with ERVs were found among children for PM_{10} and NO_2 concentrations and among elderly for PM_{10} and CO. Among children the Relative Risk (RR) of an ERV, for respiratory complaints, increases by 10% (95%CL: 2.3;18.2) if the PM_{10} air level of the previous day increases by 10 $\mu g/m^3$; the RR rises by 11.8% (95%CL:1.4;23.3) for the same increment in the air level of NO_2 of two days before. No significant increase was found for CO air levels of the previous day (a variation of +18.6%; 95%CL:-6.9;51.1 for an increment of 1 mg/m^3). Among elderly, the RR of a recurring ER, for respiratory complaints, rises by 8.5% (95%CL:1.5;16.1) for the same increment in the air levels of PM_{10} of

two days before; no significant association was found with same increment in NO_2 of two days before (6.0%; 95%CL:-3.3;16.2); a significant rise of 26.5% (95%CL: 3.4;54.8) was found in the RR for an increase of 1 mg/m^3 in the daily level of CO of four days before. Results are represented in Figure 1.

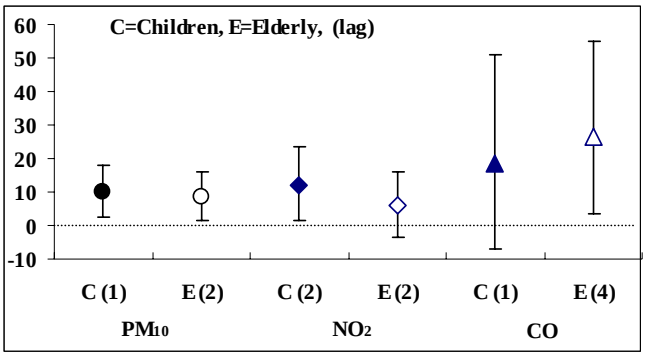

Figure 1. Percent variations of the relative risk of emergency room department visits for respiratory complaints in children (<10yrs) and in elderly (65+), for an increment of 10μg/m^3 in the daily air level of PM_{10} or NO_2 and of 1mg/m^3 of CO recorded on previous days, reported between parenthesis, Pisa, 2000.

An extensive sensitivity analysis was performed to investigate the effect on the final risk estimates of the type (loess with restricted criteria, natural spline and penalized spline) and the amount (degrees of freedom) of smoothing. This analysis showed that the results obtained from the selected model were very little sensitive to the type and to the amount of smoothing.

DISCUSSION AND CONCLUSION

This study has found a positive association between PM_{10} concentration in the urban air and emergency room visits due to respiratory complaints in children and in elderly. Limitations of the study are the shortness of the observational period and the size of the population at risk, which can explain the wide confidence intervals, and did not allow more disaggregated analyses, e.g. by sex, or age or specific respiratory complaint. These results confirm that increases of air pollution starts a process that after one or few days deteriorates the respiratory health status of children and elderly so far to require immediate medical attention. The Atkinson et al. (1999) study of 12 London hospitals in 1992-1994 found a stronger positive association between ERVs among children and SO_2, but still significant with PM_{10} or CO, while the association was not statistically significant for NO_2 and it was negative with ozone. Our results are consistent with these findings although the statistical power of our study was clearly lower. The Gehring et al. (2002) study of long term effects of exposure to traffic related air pollution on respiratory health, in a birth cohort of children below age two, found a positive association among the reports of cough without infection or dry cough at night and exposure to traffic related air pollution ($PM_{2.5}$, and NO_2). As the authors declared, although the study was designed to assess long-term effects it likely also included short-term effects. Hwang et al. (2002) studied daily clinic visits for lower respiratory tract illness by a small area design. They found that people over age 65 were the most susceptible, and estimated pollution effects decreased as the exposure time lag increased. The Italian multi-centres study on children respiratory health found a higher risk of chronic respiratory impacts among children living nearby roads with high rates of traffic particularly truck traffic (Ciccone et al., 1998). Moreover, deficits in lung function growth rate of children have been associated with their exposure to ambient air pollutant. In the second cohort of fourth grade children, larger deficits in lung function growth rate were observed in children who reported spending more time outdoors (Gauderman et al., 2002). Evidence of these less severe health outcomes highlighted by large and small studies, on short and long term time units, in different countries should be considered sufficient to start serious interventions to drastically improve the air quality in any urban context.

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