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Risk assessment of the respiratory health effects due to air pollution and meteorological factors in a population from Drobeta Turnu Severin, Romania

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Abstract

In the present study we considered two modeling approaches: in the first approach, the hospital admission with chronic respiratory diseases as dependent variable, the environmental data and the days of the week as independent variables in a Poisson regression model were used; in the second approach the annual variation was accounted for and the variable "day" was introduced numbering the day and modeled with a spline. The basic assumption was that total suspended particulate may have a damaging effect that is possibly modified by air temperature and air humidity. The obtained results offer a new contribution regarding protective effect of air humidity and seasonal influences on the relation air pollution – respiratory health.

Keywords*:* respiratory ailments, air pollution, meteorological factors, risk assessment, adverse and protective effects

1. Introduction

Various epidemiological studies proved that respiratory morbidity is significantly affected by meteorological conditions as well as atmospheric pollutant levels. [1]. Hospital admission data were used recently in the HEAPSS study that analyzed the effects of air pollution on respiratory health in several urban areas throughout Europe [2]. Common subgroups include age group, gender, and preexisting disease or health condition [3]. Asthma, chronic bronchitis and chronically obstructive pulmonary disease may be considered to create susceptibility as preexisting respiratory disease. Under certain condition total suspended particles can be used as an indicator for the pollution with fine particulate matter [4]. The paper presents an analysis of the relationship between meteorological data, total suspended particles and daily hospital admissions of patients with respiratory ailments using two modeling approaches. The data are provided from Drobeta Turnu Severin, Romania.

2. Problem Statement, background

Epidemiological studies on acute effects include population size, years covered, concentrations of pollutants, correlations among variables, confounding variables such as weather, seasons, day of the week and whether smoothing techniques were used, either parametric or non-parametric. Time-series studies are subject to strong seasonal, day of the week variations and long term trend [5]. A problem that arises and creates difficulties in concentration – risk relationship analysis is represented by strong seasonal variation and yearly trend. The relationship between respiratory morbidity, meteorological factors and air pollution is modeled in statistical approaches using Poisson regression analysis [6]. Potential confounders such as ambient temperature, humidity, wind velocity and wind direction, and the days of the week may adjust the generalized models. The seasonal variation and yearly trend are analyzed using the software package R [7].

3. Paper approach

3.1. Methodology

3.1.1. Material

Drobeta Turnu Severin, a city situated in southwest Romania, close to the river Danube, has got 103000 inhabitants (2004) and a continental temperate climate with Mediterranean influences. During a period of 4 years (01.01.2000-31.01.2003) different environmental and data of hospital admissions were daily measured. The air pollution data (daily average of total suspended particulate matter, TSP in µg/m³) are provided by the Public Health Authority Mehedinți. Meteorological data are from the Meteorological Regional Direction Craiova and comprise daily minimum temperature (Tmin in °C), daily average temperature (Tave in °C), daily maximum temperature (Tmax in °C), relative humidity (relHum in %), wind velocity (WV in m/s), and wind direction. The health data (ICD10 code) comprise the number of admissions to the County Hospital Drobeta Turnu Severin regarding three different respiratory diseases (asthma-A 345, chronic bronchitis-CB 341-342, chronically obstructive pulmonary disease-COPD 344) as well as the number of total patients.

3.1.2. Methods

The applied Poisson regression belongs to the group of generalized linear models (GLM, freeware R). Environmental data are considered as follows: One of the measured meteorological parameters, relative humidity, is the per cent ratio between water vapour pressure and saturation vapour pressure. To quantify the total amount of water inhaled during breathing, absolute humidity is used. This is the content of water vapour in the air, measured in g/m³. If there were more than one wind directions per day, the direction was specified as "variable". If the wind velocity, measured in m/s, was smaller than or equal to 1m/s, it was taken as calm. Missing TSP data are imputed by means of a special Kalman filter, which acts as a low pass for periods longer than 100 days. Besides the value of the current day of an environmental factor, also the value of the previous day or of two days ago could have an influence on the hospital admissions of the current day (time lag effect). The basic assumption that TSP may have a damaging effect is, possibly, modified by air temperature and air humidity. In the first approach, models of the following type were examined:
$\ln(\mu_i) \approx \beta_o + \beta_1 dow_i + \beta_2 TSP_i + \beta_3 absHum_i + \beta_4 Tave_i, \quad i = 1, 2, \ldots, n$, with μ_i the expected number of patients, *dow* the day of the week and *absHum* the absolute humidity.

In a second modeling approach, the annual variation was accounted for and the variable "day" was introduced for numbering the days and modelled with a spline(s): $\ln(\mu_i) \approx \beta_o + \beta_1 dow_i + \beta_2 TSP_i + \beta_3 absHum_i + \beta_4 Tave_i + s(day)$

Both, the hospital admission data and the risk factors follow seasonal fluctuations. Statistically significant results of the first approach may be explained that both variables have the same yearly variation. Therefore, generalized additive models and generalized linear models with natural splines were applied. Age and gender groups of the patients permit a classification into subgroups, and a specific sensitivity analysis was possible in the second approach. All models were compared by the criterions AIC and explained deviance, which is the fraction of deviance in the data that is explained by the model.

3.2. Results& discussions

For asthma, chronic bronchitis and chronically obstructive pulmonary diseases the results are described in the following:

3.2.1. Asthma

In the first approach (Table 1) TSP has an adverse effect on asthma (TSP coeff.=0.0167). The relative risk for a rise of 10 µg/m^3 TSP amounts to exp(-0.0167) ≈1.017. The absolute humidity modifies this effect and is protective (absHum:TSP coeff.= -0.0022). Relative risk of this modification is exp(-0.0022) ≈0.008, for a fixed TSP value and a rise of 1g H_2O/m^3. The investigation of a threshold value is presented in Figure 1. The considered values are 0, 10, 20, …, 180 µg/m^3. The gray plot represents the relative risk for TSP alone, and the black plot the relative risk modified by absolute humidity. The entire relative risk of TSP and its interaction with absolute humidity is given by a product of both risks (cross in Figure 1).

Table 1 Estimated parameters of the Poisson model for Asthma - first approach

Variable	coeff	s.e.	p-value
Intercept	0.3169	0.1053	0.0026
Tuesday	-0.3226	0.0911	0.0004
Wednesday	-0.5215	0.0972	<0.0001
Thursday	-0.5972	0.0993	<0.0001
Friday	-1.1167	0.1194	<0.0001
Saturday	-1.7127	0.1507	<0.0001
Sunday	-1.7060	0.1507	<0.0001
TSP	**0.0167**	0.0083	0.0453
SW	0.5157	0.3041	0.0899
absHum:TSP	**-0.0022**	0.0007	0.0023

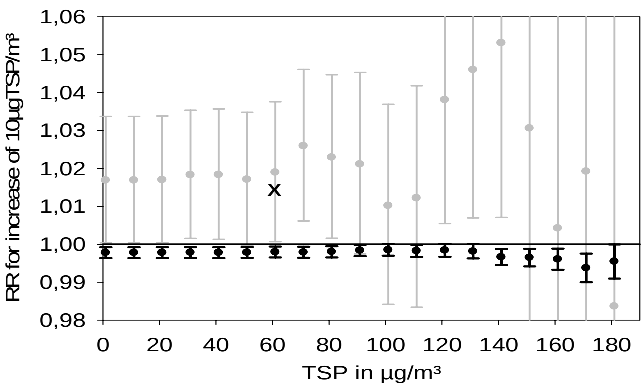

Figure 1 Concentration-risk relationship for the effect of TSP on asthma (grey) and the effect modification of absolute humidity (black); the cross indicates the total relative risk at 60 µgTSP/m³.

In the second approach, four age groups, 0-18, 19-44, 45-64 and over 65 years were considered with splines for air temperature and yearly variation. There is a significant adverse effect of TSP on the first age group (TSPlag1 0-18=0.0068), but also a significant protective effect to the second TSPlag1 19-44 = -0.0042). We have no data about allergic (intrinsic and extrinsic) and non-allergic asthma. It is clear, in the second approach that TSP are adverse in very young people. Humidity has a protective effect on older people (absHum>65 = - 0.0463).

3.2.2. Chronic bronchitis

In the first approach we did not find a significant effect of TSP on CB, but the absolute humidity in air has a protective effect at very high values (more than 6g/m^3air), which rise in significance in the second approach (coefficient - 0.0648).

3.2.3. Chronically obstructive pulmonary diseases

In the first approach a protective effect of absolute humidity on COPD was observed (absHum coeff. = -0.0347). The relative risk for a rise in 1g/m^3 H_2O is exp(-0.0347) ≈ 0.965. For COPD the protective effect of humidity is modified by TSP (absHum:TSP = -0.0011). The relative risk of this modification is rather small and so is the statistical significance: RR = exp(0.001) ≈ 1.001, p=0.08. While the pure effect of humidity to COPD resembles the protective effect of humidity on CB, for COPD patients the exposure to TSP modifies this effect and increases the risk.

4. Conclusions and future work

Comparing the applied two modeling approaches, we can conclude, that the protective effect of humidity in the first approach changes into an adverse one in the second. Moreover, a positive difference between absolute humidity of the current and the preceding day significantly elevates the risk in three age groups. If the humidity rises, then the expected number of patients increases. The seasonal variation is modeled by a spline and is illustrated in Figure 2 with the 95% confidence interval (broken lines). Since the first day is the 1.1.2000, the function has a local minimum in the summer and a local maximum in the winter. Positive values of the function indicate an increased risk (winter). If the function values are negative, then the risk is reduced (in the summer). The confidence interval is very broad, however, and often the function does not differ from zero. For time-series studies of air pollution and health effects, the bias is dependent on the nonparametric adjustment for confounding factors such as trend, seasonality, and weather [8]. This change of humidity effect suggests a great influence of seasons on respiratory diseases (especially COPD), the annual trend and temperature being involved. Closed relation between air humidity, air temperature and body-environment heat exchange may represent another way of action on the health. Adverse effect of TSP on respiratory morbidity was the same modified, applying the two modeling approaches. Risk assessment of the effect on respiratory health of the air chemical and physical factors and their interaction remains a continuous challenge.

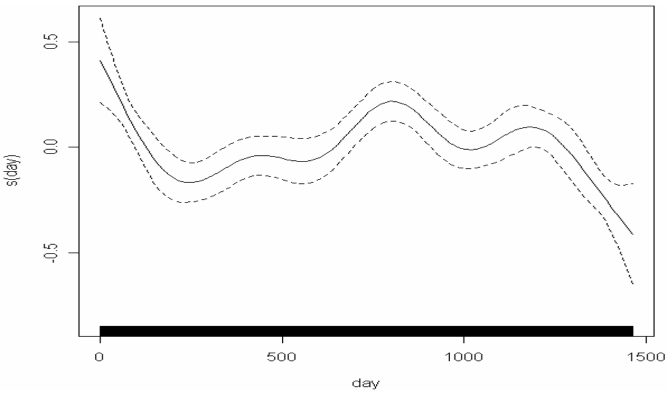

Figure 2: The estimated spline for seasonal variation in COPD admissions.

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