Spatial model for cardio-respiratory diseases hospital admission in Torino province

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Abstract. *We analyse the association between atmospheric pollution and hospital admissions for respiratory and cardiovascular causes in the province of Torino in 2004. The proposed model, which is fitted using INLA, includes fixed effects at municipality level and spatially structured random effects for pollutants. Preliminary results suggest a higher risk of cardiovascular and respiratory hospitalization for young and old females. The risk of hospitalization in males is significantly higher for younger, while for cardiovascular hospitalization the risk is lower for the oldest. Summer days are associated with a higher risk for both cardiovascular and respiratory cases.*

Keywords. *INLA; Bayesian modelling*

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1 Introduction

Some of the most important recent studies on emergency hospital admission rates for respiratory and cardiovascular conditions confirm the adverse effects of airborne pollutants. Many studies, including the American National Morbidity, Mortality and Air Pollution Study (NMMAPS) [4], the European Air Pollution and Health Project (APHEA) [1, 8], the Meta-analysis of the Italian studies on short-term effects of air pollution (MISA) [3] and the Environmental Modular Advanced Compact System project (EMECAS) [2], found statistically significant increased risk of cardiovascular and respiratory events as a result of a rise in particulate matter, sulphur dioxide and/or nitrogen dioxide air pollution levels, especially in the elderly population [6]. The main objective of this study is to analyse the association between urban pollution and hospital admissions for respiratory and cardiovascular causes among residents in the province of Torino in 2004.

2 Data

Data on hospital admissions were obtained from the hospital discharge registers. The analysis was based on a total of 39402 residents in the province of Torino hospitalised for respiratory diseases (ICD 460-519, N=12743) or cardiovascular causes (ICD 390-459, N=26659) in 2004, aggregated by municipality, day and sex. Patients hospitalised in the same period with a different diagnosis were considered as controls. Particulate matters (PM_{10}) measured in $\mu g/m^3$ was considered as predictor of urban pollution along with NO_2 and CO. Given the strong correlation between pollution levels and season, daily air temperature (in Kelvin degrees), week-day and season of admission to hospital (classified as summer/winter [1]) were considered as predictors for the seasonality. As suggested by the literature [3], lags 0-3 were considered in the analysis. As the hospital discharge data only include the town of residence of the patient (and not his/her address), exposure has been assessed at the municipality level. Daily exposure to airborne pollutants of the population has been estimated using two data sources: daily-average pollutant concentrations (measured by the national monitoring networks of the EU member states) and population density at 1 km spatial resolution. In order to map the daily pollutant concentration at the same spatial resolution of the population density, the multivariate space-time model introduced in [5] has been implemented. Daily exposure for each municipality has been assessed by weighting the estimated pollutant concentration with respect to the population density.

3 Spatial model for hospital admission

We implement a spatial model using the daily number of hospitalization (for a given cause) $y(s_j,t)$ in a given municipality $j = 1,\ldots,315$ in a specific day $t = 1,\ldots,366$ as response variable, assuming:

$$y(s_j,t)|\theta(s_j) \sim \text{Poisson}(\mathsf{E}(s_j,t)\theta(s_j,t))$$

where $\theta(s_j,t)$ represents the relative risk (RR) of hospitalization in municipality j at time t and $\mathsf{E}(s_j,t)$ is the expected number of cases. The linear predictor is specified on the logarithm scale and it includes fixed effects at individual and municipality level, a spatially structured random effect and an unstructured component:

$$\begin{aligned}\log\theta(s_j,t) &= x_{\mathsf{Temp}}(s_j,t)\beta^{\mathsf{Temp}} + x_{\mathsf{Age}}(s_j,t)\beta^{\mathsf{Age}} + x_{\mathsf{Holiday}}(t)\beta^{\mathsf{Holiday}} + x_{\mathsf{Summer}}(t)\beta^{\mathsf{Summer}} \\ &+ x_{PM_{10}}(s_j,t)\beta_{PM_{10}}(s_j) + x_{CO}(s_j,t)\beta_{CO}(s_j) + x_{NO_2}(s_j,t)\beta_{NO2}(s_j) + v(s_j) + u(s_j)\end{aligned}$$

where $x_{\mathsf{Temp}}(s_j,t) = \{\text{Temp\_low}(s_j,t), \text{Temp\_high}(s_j,t)\}$ represents temperature (T) on the hospitalization day with

$$\text{Temp\_low}(s_j,t) = \begin{cases} T_t & \text{if } T_t < 275.33 \\ 0 & \text{otherwise} \end{cases} \qquad \text{Temp\_high}(s_j,t) = \begin{cases} T_t & \text{if } T_t \geq 296.26 \\ 0 & \text{otherwise} \end{cases}$$

Age has been categorized as $x_{\mathsf{Age}} = \{\mathsf{Age} < 15, 15 \leq \mathsf{Age} \leq 64, \mathsf{Age} > 64\}$ and Holiday and Summer are dummy variables. Inclusion of PM_{10}, CO and NO_2 concentration allows to assess the potential impact of environmental contaminants on human health. The terms $u(s_j)$ and $v(s_j)$ represent the Besag-York-Mollie (BYM) specification with $u(s_j)$ being a spatially structured residual, modelled using an intrinsic conditional autoregressive structure (iCAR), and $v(s_j)$ representing the unstructured residual, modelled using an exchangeable prior.

4 Preliminary results and Discussion

Tables 1 and 2 summarize the posterior distribution of fixed effects. Figure 1 shows ORs per 1 $\mu g/m^3$ increase in PM_{10} and CO concentration.

Table 1: Fixed effect posterior summaries - respiratory

	Female					Male				
	mean	sd	$q_{0.025}$	$q_{0.5}$	$q_{0.975}$	mean	sd	$q_{0.025}$	$q_{0.5}$	$q_{0.975}$
age<15	2.4501	0.1141	2.2337	2.4470	2.6820	1.6896	0.0605	1.5738	1.6884	1.8113
age>64	1.3415	0.0534	1.2400	1.3401	1.4499	0.9844	0.0293	0.9281	0.9838	1.0433
holiday	1.1149	0.1128	0.9040	1.1107	1.3475	1.1157	0.0932	0.9400	1.1127	1.3062
summer	1.2408	0.0567	1.1330	1.2393	1.3557	1.2106	0.0464	1.1219	1.2096	1.3041
T_low	1.0002	0.0002	0.9998	1.0002	1.0005	1.0002	0.0002	0.9999	1.0002	1.0005
T_high	0.9998	0.0002	0.9995	0.9998	1.0001	0.9998	0.0001	0.9996	0.9998	1.0001

Table 2: Fixed effect posterior summaries - cardiovascular

	Female					Male				
	mean	sd	$q_{0.025}$	$q_{0.5}$	$q_{0.975}$	mean	sd	$q_{0.025}$	$q_{0.5}$	$q_{0.975}$
age<15	2.1994	0.3200	1.6129	2.1835	2.8701	1.5787	0.1975	1.2126	1.5704	1.9887
age>64	1.2263	0.0313	1.1660	1.2257	1.2892	0.9485	0.0171	0.9154	0.9483	0.9825
holiday	1.1431	0.0836	0.9844	1.1408	1.3131	1.1256	0.0729	0.9867	1.1238	1.2732
summer	1.1202	0.0328	1.0572	1.1196	1.1860	1.1059	0.0299	1.0484	1.1054	1.1657
T_low	1.0000	0.0001	0.9998	1.0000	1.0002	1.0002	0.0001	1.0000	1.0002	1.0004
T_high	0.9998	0.0001	0.9996	0.9998	1.0000	1.0000	0.0001	0.9998	1.0000	1.0001

The model presented in this paper considers the effect of air pollution, upscaled at municipality level in a previous step, on cardiovascular and respiratory events. Municipality specific risk estimates for 1 $\mu g/m^3$ increase in PM_{10} adjusted for NO_2 and CO are largely comparable with estimates reported in literature, with a posterior mean ranging from 0.997 to 1.004. Both young and old females are at a higher risk of respiratory and cardiovascular hospitalization. On the other hand, only young males are associated with higher risk of both hospitalization causes, while for old males the risk is lower for cardiovascular hospitalization. Finally, risk appears to be significantly higher during the summer time. A gradient (East-West) can be noticed regarding the relative risk associated to CO, whereas Torino and surrounding municipality appear at higher risk with regard to PM_{10} levels (Figure 1).

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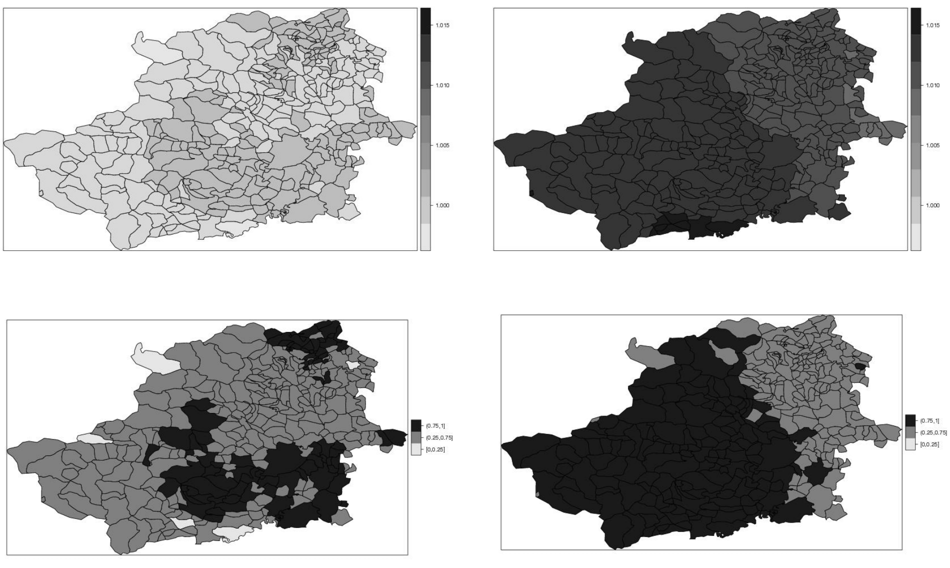

Figure 1: First row: male (cardiovascular) posterior mean of $\exp(\beta(s_j))$ for PM_{10} (left), CO (right). Second row: associated probability of $RR > 1$ for PM_{10} (left), CO (right)