

Mortality and material deprivation: a space-time analysis

Mortalità e deprivazione materiale: una analisi spazio-temporale

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Riassunto: Viene analizzato il legame tra condizione socio-economica e mortalità per tumore al polmone nella popolazione maschile della Toscana, a livello comunale, nel periodo 1971-94, facendo uso di un modello spazio-temporale Bayesiano con covariate tempo dipendenti. In particolare si intende indagare se tra la manifestazione di un certo livello di deprivazione materiale e quella della mortalità vi sia o meno un tempo di latenza, quindi se la mortalità è legata alla deprivazione materiale di dieci anni prima (esposizione a fattori di rischio), oppure a quella presente (problemi di accesso al sistema sanitario).

Keywords: Space-time models, Hierarchical Bayesian models, Material deprivation, Time-dependent covariates.

1. Introduction

The relationship between socioeconomic factors and health has been studied in many circumstances, mainly on aggregated data. Some studies suggest that, in terms of control for potential confounding, knowledge of the socioeconomic factors is crucial. In fact, a strong association of these and mortality, on one side, and, of these and exposure to environmental hazards, on the other side, has been repeatedly observed; see for example St Leger (1995). However it's important to define the proper time lag on which socioeconomic factors affect mortality.

Socioeconomic factors can be resumed in a material deprivation index. Material deprivation indicators usually refer to the prevalence of subject characteristics such as unemployment, low education, living in a small dwelling, overcrowding, not having a car; e.g. see Townsend *et al.* (1988).

In this paper, we present a space-time hierarchical Bayesian model to investigate the contribution of socioeconomic factors to the mortality for lung cancer on males in Tuscany in the period 1971-94. We consider socioeconomic factors observed in 1961, 1971, 1981 and 1991 and we look for the presence of a temporal lag between these and mortality.

2. Space-time models with time dependent covariates

Lung cancer death certificates are considered for males residents in 287 municipalities of Tuscany Region (Italy) from 1971 to 1994. Data have been collected and made available by the Tuscany Regional Government under the research project *Tuscany Atlas of Mortality 1971-1994* for different calendar period (1971-74, 1975-79, 1980-84, . . . , 1990-94); see Vigotti *et al.* (2001). A set of reference rate (Italy, 1991) have been used to define expected cases for each municipality and period.

Data on material deprivation have been composed from census data collected from ISTAT on the years 1961, 1971, 1981 and 1991. In particular the used variables are the proportions of population with unfavorable events such: unemployment, low education (less than 6 years of schooling), not having the property of the house, and absence of bathroom in the flat.

We describe space-time pattern of mortality risk for lung cancer. The estimates are obtained using a hierarchical Bayesian model with structured random effects on space and time dimension. The effect of socioeconomic factors in different times have been considered by introducing covariates into hierarchical Bayesian models. There are two space-time misaligned processes.

The model has been specified considering two different temporal lags between census and mortality observed in calendar period 1971-74, 1980-84 and 1990-94. The first model considers a lag of zero year (not latency time exists), so defines a relation between mortality in calendar period 1971-74 and census 1971, period 1980-84 and census 1981, period 1990-94 and census 1991. The second considers mortality in 1971-74 and census 1961, mortality on 1980-84 and census 1971 and mortality in 1990-94 and census 1981; so a lag of ten year (a latency time exists between material deprivation and mortality).

We adopt the hierarchical Bayesian space-time model defined by Bernardinelli *et al.* (1995) to estimate risk for each period and for each municipality. In this model, the observed cases O_{ij} , on i -th area ($i = 1, \dots, 287$) and j -th period ($j = 1971-74, 1980-84, 1990-94$), are assumed to have a Poisson distribution with mean $E_{ij}\theta_{ij}$, where E_{ij} indicates expected cases under indirect standardization and θ_{ij} the relative risk. A random effects model is assumed for the logarithm of relative risk

$$\log(\theta_{ij}) = u_i + v_i + (z_i + r_i) p_j \quad (1)$$

Term u_i represents an unstructured spatial variability component modelled as a Normal (μ_u, λ_u) and v_i a structured spatial variability term modelled, conditional to $v_{\neq i}$ terms, as a Normal $(\bar{v}_i, \lambda_v n_i)$, where $\bar{v}_i$ is the mean of the i -th adjacent areas terms and n_i their number (conditional autoregressive model). These terms define the component of the pure spatial model of Besag *et al.* (1991). The term p_j indicates period: equal to zero when $j = 1971-74$ and one and two respectively when $j = 1980-84$ and $j = 1990-94$. Time differences for each i -th area are assumed both spatially structured and unstructured: $z_i \sim \text{Normal}(\mu_z, \lambda_z)$ and $r_i \mid r_{\neq i} \sim \text{Normal}(\bar{r}_i, \lambda_r n_i)$, where $\bar{r}_i$ denotes the mean of i -th adjacent areas terms and n_i their number, as before. Non informative Inverse Gamma are assumed for hyperparameters λ and non informative Normal for μ . The posterior distribution for the parameters are approximated by Monte Carlo Markov Chain methods; for the software see Spiegelhalter *et al.* (2000); check for achieved convergence was performed following Gelman and Rubin (1992).

The material deprivation effect has been considered introducing a specific term on model (1)

$$\log(\theta_{ij}) = u_i + v_i + (z_i + r_i) p_j + \beta x_i(t) \quad (2)$$

where $x_i(t)$ represents the material deprivation index for the i -th area at t -th calendar time (censuses 1961, 1971, 1981, 1991). The coefficient β is modelled as a non informative Normal distribution and defines the relation between material deprivation and mortality. An alternative formulation is to consider terms β_j , temporally structured (using a first-order random walk with independent gaussian increments) or β_i , spatially structured; for a review on space varying coefficient models see Assunção (2002).

3. Results

The distribution of relative risks of mortality for lung cancer is highly spatially structured with north-west areas at higher risk. Surprisingly, material deprivation index shows a similar strong spatial distribution with higher values in the north-west part of the region and on the coast; see for example Figure 1.

Figure 1: Spatial distribution of (a) relative risk for lung cancer males, period 1971-74 (b) material deprivation index at census 1961

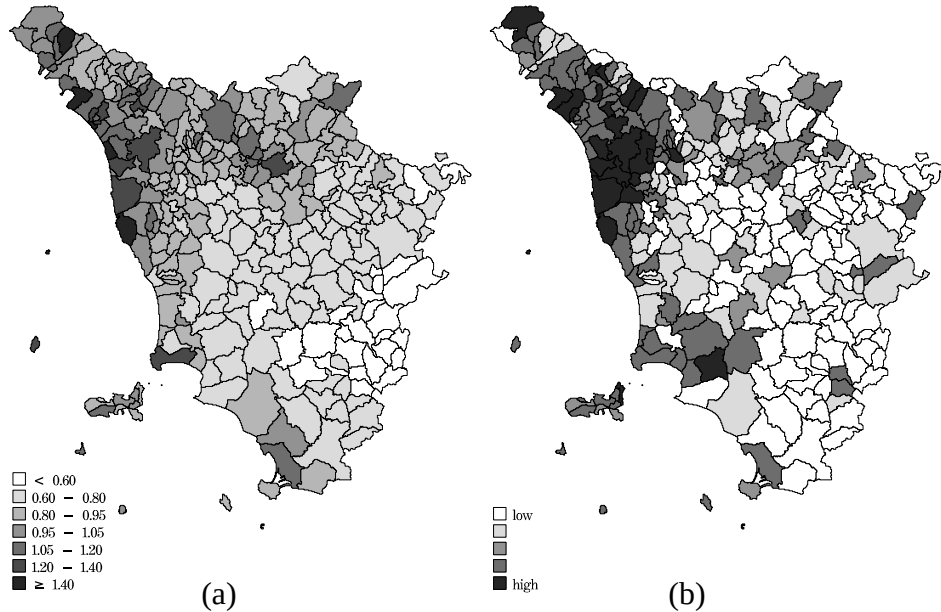


Figure 2 describes the posterior distributions for the β coefficient of the two considered model (with different time lag specification). The mean value for β , when a lag of ten year has been considered, is 0.190 with a standard deviation of 0.029, corresponding to a relative risk of 1.21 (95% credibility interval 1.14-1.28). For a lag of zero year (not latency time exists) the mean value is 0.028 (standard deviation 0.007) corresponding to a relative risk of 1.03 (95% credibility interval 1.01-1.04). It is found that mortality for lung cancer (males) and material deprivation are clearly associated only when a latency time of ten years has been taken into account. For a more complex analysis that considers other temporal lags, see Dreassi (2002).

4. Conclusion

We have assumed that mortality differentials among areas, after removing space-time effects, could be associated with material deprivation. However, the relationship between an individual's cumulative exposure to a risk agent and the spatial pattern of the associated socioeconomic factors is complex: on the transformation process of an input map of socioeconomic conditions into an output map of cancer mortality, additional distortion must be taken into account.

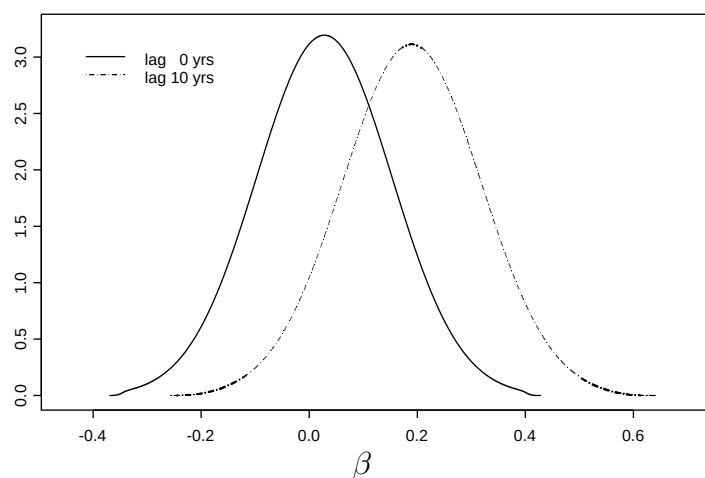
However, the absence of a clear association between mortality for lung cancer and material deprivation assessed at the same time period (lag zero) suggests that factors related

to the Health Systems played a minor role.

On the contrary, the strong evidence of an association with deprivation level at least ten years before mortality being recorded, stems for a correlation between material deprivation and exposure to etiologic factors. Consistently with some recent literature on socioeconomic inequalities in health, our results support the hypothesis that economically disadvantaged population groups are more exposed to risk factors, i.e. tobacco smoke.

The barriers to utilization of health service and to obtain appropriate care for people lying in a poor material condition can probably affect other causes of death than lung cancer (e.g. ischemic heart diseases), for which effective therapy do not exists (for both affluent and deprived people).

Figure 2: Posterior distribution of the β coefficients



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