The "Rebirth plan" for Sardinia and its side-effects on mortality. An ecological study

Extended abstract

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Introduction

Since Italian unification, Sardinia has been one of the most economically backward regions in the Peninsula. The agriculture suffered from an extreme fragmentation in landholding, due to the pursuit of exasperated egalitarianism in hereditary successions (Oppo 2004). The other main economic activity was shepherding, mainly practised in the mountainous interior zones around Nuoro. Depending upon the terrain and the quality of the pasture either cattle, sheep or goats were bred. As noted by Weingrod and Morin (1971) for most shepherds the herds were too small, and the rented pastures too expensive, to produce milk efficiently. Therefore many shepherds produced essentially for the subsistence.

The unique economic activity ascribable to the industrial sector was mining. In particular, coal extraction in the Sulcis, lead and zinc mining in the Iglesiente (both in south-west Sardinia), in addition to scattered quarrying elsewhere gave employment up to the 9% of the population at the peak of mining employment in 1939 during the fascist regime.

In the aftermath of the World War II, the Italian Government decided to launch an ambitious program of public incentives to favour the industrialization of Southern Italy with the creation of *Cassa per il Mezzogiorno* (Fund for Southern Italy), a financial institution aimed at financing the improvement of infrastructures and sustaining industrial activity by furnishing cheap credit. Sardinia was obviously identified as an objective for the program. This led in 1962 to the so called *Piano di rinascita* (plan for the Rebirth of Sardinia) which in contrast to the Cassa's policy of favouring the modernization of the agrarian activity and infrastructural investments, was mainly focused in promoting the localization of heavy industry in the island.

Originally, 18 sites (after reduced to 15), the so called *zone omogenee* were identified as appropriate zones for spending the huge amount of public and private investments programmed for the project (around 1800-2000 billions Italian lire according to King (1977)). Figure 1 reports the map of the zone designated for the localization of the industrial plants.

Figure 1. Zone omogenee for industrial development

Source: King (1977)

One of the largest European petrochemical complex was built in Porto Torres (a coastal village in the Super-zone of Sassari in figure 1) in the first half of the Sixties. Contemporary, an oil refinery was built in Sarroch (near the capital town of the island Cagliari). Other smaller scale industrial activities were constructed in Sassari, Olbia, Macomer, Siniscola, Oristano, Portoscuso (situated in the area near Iglesias), Tortoli-Arbatax, Villacidro (Cagliari super zone). Finally, in 1969 another large chemical plant was localized in Ottana (between the area of Macomer and the zone of Nuoro). Given the poor environmental awareness of the epoch, the industrial plants financed by the Rebirth Plan were generally highly pollutant.
Indeed, two of these industrial sites, Porto Torres and Portoscuso, have been recently classified according to the Italian law as "Siti di Interesse Nazionale", that is, territories identified as contaminated in relation to both the quantity and dangerousness of the present pollutants and for the impact they can have on the surrounding environment, in terms of health and ecological risks. In addition to industrial sites also the military base of La Maddalena (an island in the North East of Sardinia) is considered at high environmental risk.
The aim of this paper is to investigate the long-term consequences on mortality of the Sardinian plan of rebirth by the means of a spatial analysis carried out at the municipal level both on the eve of the industrialization process (from 1951 to 1961) and after 20 years, 30 years, 40 years and 50 years from the beginning of the plan.
We believe that a better understanding of the long-term consequences of the Sardinian process of industrialization should be informative also for similar plans that are currently developed in African countries.[1]
In the following we will present both the implemented methodology and some preliminary findings regarding the pre-industrialization phase.

Methodology

A transversal study of small areas has been carried out for the 377 Sardinian municipalities (the administrative borders are the current ones) used covering the period 1951- 1961, 1992-1997, 1998-2003, 2004-2009 and 2010-2015. Death entries, broken down by municipality, year and sex, were used as case source.
Mortality and population data came from the official statistics produced by the Italian National Institute of Statistics (ISTAT). All the data prior to 1961 have been informatized by ourselves since there exist only hard copies of the materials.
Standardized mortality ratios (SMRs) were calculated as the ratio of observed to expected deaths. To calculate the number of expected cases, age and sex specific mortality rates for Sardinia as a whole, were multiplied by the corresponding municipal population.
Smoothed municipal relative risks (RRs) with their corresponding 95% credibility intervals and posterior probabilities (PRPs), that smoothed RR was greater than one, were calculated using the conditional autoregressive model proposed by Besag, York and Mollie (1991). This model fits a Poisson spatial model with two types of random effects, a non-structured effect that takes into account the municipal heterogeneity, and a structured effect, the spatial term, that considers municipal contiguity. To define area contiguity we used the adjacent municipal boundaries.
The model takes the following form:

$$O_i \sim Po(E_i \lambda_i)$$

$$\eta_i = \log(\lambda_i) = \alpha + h_i + b_i$$

[1] https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Brochure_Industrialiser_l_Afrique-En.pdf

Where λ_i is the RR in area i, O_i is the number of observed cases, E_i is the number of expected cases, α is the intercept, h_i is the municipal heterogeneity and b_i is the spatial term.
The non-spatial random effect (heterogeneity) is assumed to be normally distributed with zero mean and constant variance. For the random effect, which reflects spatial variability, an autoregressive CAR conditional model has been used (Clayton et al 1993).

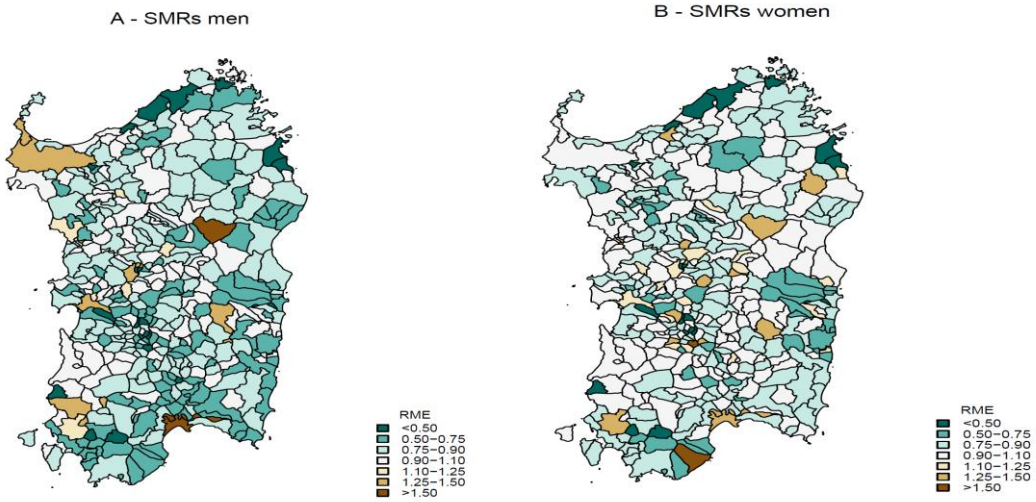
The Bayesian estimation of the models was obtained using Markov Chain Monte Carlo (MCMC) simulation methods, through the Gibbs Sampling algorithm via free distribution software WinBUGS. Convergence of the estimators was achieved before 100.000 iterations for three Markov chains, with a burn-in of 10.000 iterations. The convergence was ensured by the algorithm proposed by Brooks and Gelman (1998) and the effective sample size of chains.

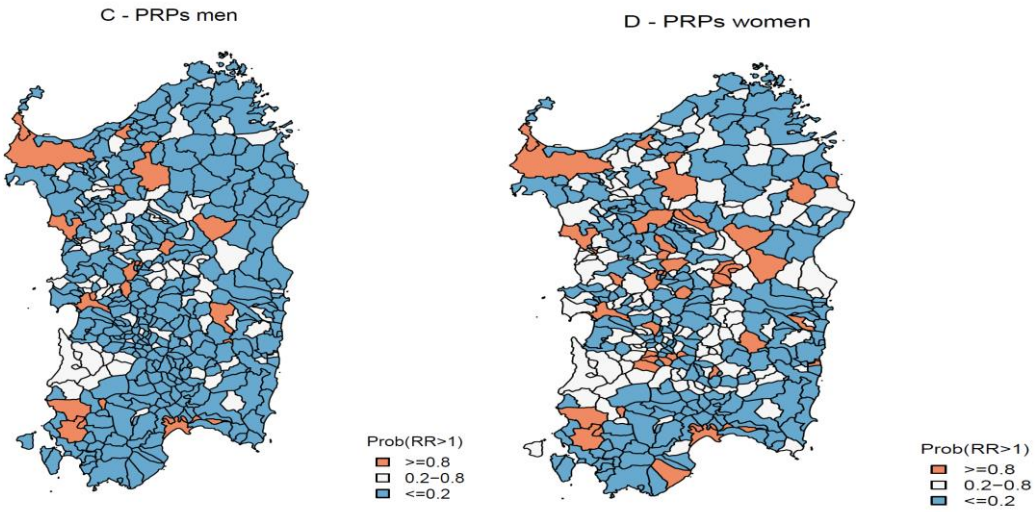
The free software R was used to create municipal maps of SMRs, smoothed RR estimates and posterior probabilities that smoothed RR was greater than one (PRPs). To calculate PRPs we used the criterion proposed by Richardson et al. (2004)considering PRPs greater than 0.8 as statistically significant. Regarding PRPs, following the criterion proposed by Richardson et al (2008), we will consider as "municipalities with high mortality risk" those with a value equal or greater than 0.8, and as "municipalities with low mortality risk" those with a value equal or less than to 0.2.

Preliminary results

Figure 2 (a, b, c ,d) represents for the period 1951-1961 respectively municipal SMRs for male population, the SMRs for women, and posterior probabilities (PRPs) that smoothed the RRs when greater than one for men and for women.

Figure 2. Mortality in Sardinia on the eve of the industrialization process





For men, Figure 1-A shows higher SMRS in the urban areas (Sassari, Cagliari, Nuoro, Oristano, Carbonia (the main town of the Sulcis), Iglesias, Seui (a village in the province of Nuoro where a colliery was active until 1958), Bosa (a coastal village at the border between the province of Sassari and Nuoro where tanneries were active). The pattern of mortality observed in SMRs is maintained for PRPs (Figure 2 -C). The female spatial mortality pattern is very similar to that identified for men (Figure 2 – B). The Urban context and mining sites are the area with higher mortality also for women. Maps produced for more recent periods (not reported here) show that the largest increase in mortality rates in the period 1992-2015 has been recorded in the industrial area of Porto Torres.

LONGPOP
This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 676060

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