Bayesian-spatial distributed lag non-linear models: A temperature-mortality case study in Barcelona

Marcos Quijal-Zamorano[1,2]; Miguel A. Martinez-Beneito[3]; Joan Ballester[1]; Marc Marí-Dell'Olmo[4,5,6]

Affiliations:

1 ISGlobal, Barcelona, Spain

2 Universitat Pompeu Fabra (UPF), Barcelona, Spain

3 Departament d'Estadística i Investigaciò Operativa, Dr. Moliner 50, 46100, Burjassot, Valencia, Spain

4 Agència de Salut Pública de Barcelona (ASPB), Pl. Lesseps 1, 08023 Barcelona, Spain

5 Institut d'Investigació Biomèdica Sant Pau (IIB SANT PAU), Sant Quintí 77-79, 08041 Barcelona, Spain

6 Centro de Investigación Biomédica en Red de Epidemiología y Salud Pública (CIBERESP), Av. Monforte de Lemos, 3-5, 28029 Madrid, Spain

In the context of climate change and increasing temperatures, the interest in the health effects of environmental exposures has remarkably increased. The development of the distributed lag non-linear models (DLNM) has become rapidly the referent framework when studying temperature-mortality short-term associations. DLNMs facilitates the modelling of the non-linear and lagged effect of temperatures on mortality. However, the small-area analysis of temperature-mortality is still scarce. In that sense, here we present four models. The first two models generalize standard DLNMs to a Bayesian framework, using a case-crossover design (model 1) and the common DLNM time-series configuration, where time trend and seasonality are modelled by using splines (model 2). We propose models 3 and 4 specifically for dealing with unstable estimates from small numbers in small-area analyses. These two models are extensions of model 1 and model 2 respectively, where we use Leroux models to spatially-smooth in one-stage approaches the coefficients of the exposure-response relationships for each small area. We apply all proposed models to a case-study for assessing the temperature-mortality relationships in the 73 neighborhoods of Barcelona during summer months. 39.569 deaths were considered in the period 2007-2016, 19 of them corresponding to the neighborhood with the lowest number of deaths and 1.454 deaths to the one with the highest number. Curves defining the relative risks of mortality were unstable and unreliable in the independent models, with regions with extremely high and low risks distributed all over the city. Spatial models benefit from adjacent regions to smooth the association and reveal hidden spatial patterns of risk. In addition, the flexibility of these Bayesian models allowed us to explore the results of these epidemiological models in new intuitive ways. This novel multidimensional approach brings the opportunity to estimate ecological temperature-mortality models in a smaller spatial scale to better understand the socioeconomic and built environment factors driving the effect of temperature on human health.

Keywords: temperature, mortality, Bayesian, distributed lag non-linear models, spatial models, small-area.