

Results of the spatial BYM model in Stan

1 Implementation of the BYM model.

```
data {
  int<lower=1> N; // Número total de municipios
  int<lower=0> Obs[N]; // Casos observados en cada municipio
  vector[N] Exp; // Casos esperados de cada municipio

  int<lower=N> LengthNeigh; // Número de bordes en el gráfico
  //Sparse coding of the Adjacency matrix:
  //(Edges are coded as pairs (Vertex_i,Vertex_j) with Vertex_i<Vertex_j)
  int NeighLow[LengthNeigh]; // Vertex_i
  int NeighHigh[LengthNeigh]; // Vertex_j
}

parameters {
  real m; // intercept
  vector[N-1] sp_raw; // Efecto aleatorio espacial (CAR)
  vector[N] het; // Efecto aleatorio heterogéneo (Normal)

  real<lower=0> sd_sp; // SD efecto CAR
  real<lower=0> sd_het; // SD efecto Normal
}

transformed parameters {
  vector[N] sp;
  for (i in 1:(N-1)) sp[i] = sp_raw[i];
  sp[N] = -sum(sp_raw);
}

model {
  vector[N] log_mu;

  real auxSp;
  real auxHet;

  // sp modeled as a car.normal process
  //sp[NeighHigh]~normal(sp[NeighLow],sd_sp);
  auxSp=-0.5*dot_self(sp[NeighHigh]-sp[NeighLow]);
  //het~normal(0.0,sd_het);
  auxHet=-0.5*dot_self(het);
  //target += 0.5*sum(log(EigenMap))+auxSp+auxHet;
  target += auxSp+auxHet;

  // Verosimilitud
  log_mu = log(Exp)+m+sd_sp*sp+sd_het*het;
  Obs ~ poisson_log(log_mu);
}

generated quantities {
```

```

vector[N] SMR;
SMR=exp(m+sd_sp*sp+sd_het*het);
}

```

2 Fitting the model to Spain's mortality data.

```

### Preámbulo ###
library(rstan)
library(rstan)
library(spdep)
library(R2WinBUGS)
library(RColorBrewer)
load("/home/migue/Trabajo/EstudiosSeattle/DatosSinTemporal.Rdata")
Paleta.RR <- brewer.pal(9, "BrBG")[9:1]
Paleta.P.RR <- brewer.pal(9, "RdYlBu")[9:1]

# Precálculos con la matriz de vecindad
aux <- list()
for (i in 1:length(CartoMuniSinIslas.nb)) {
  aux[[i]] <- CartoMuniSinIslas.nb[[i]][CartoMuniSinIslas.nb[[i]] > i]
}
NeighLow <- rep(1:length(CartoMuniSinIslas.nb), sapply(aux, length))
NeighHigh <- unlist(aux)
D.W <- matrix(0, ncol = length(CartoMuniSinIslas.nb), nrow = length(CartoMuniSinIslas.nb))
D.W[cbind(NeighLow, NeighHigh)] <- -1
D.W[cbind(NeighHigh, NeighLow)] <- -1
diag(D.W) <- -apply(D.W, 1, sum)
EigenMap <- eigen(D.W, symmetric = TRUE, nly.values = TRUE)$values
save(EigenMap, NeighLow, NeighHigh, file = "BYM.Veci.Stan.Rdata")
# load('/home/migue/Trabajo/EstudiosSeattle/1.-Espacial/BYM/Stan/BYM.Veci.Stan.Rdata')

# Modelo de BYM en Stan
tcomp02 <- system.time(mod.BYM <- stan_model("BYM.stan"))
# Compilación 56 segundos
save(mod.BYM, file = "mod.Stan.BYM.Rdata")
# load('/home/migue/Trabajo/EstudiosSeattle/1.-Espacial/BYM/Stan/mod.Stan.BYM.Rdata')

# Función que ejecuta BYM en Stan
Ejecuta.BYM.Stan <- function(Sexo, Causa) {
  Obs <- MorTabu[Sexo, Causa, ]
  Esp <- Esperados[Sexo, Causa, ]

  datos <- list(NeighLow = NeighLow, NeighHigh = NeighHigh, LengthNeigh = length(NeighHigh),
    N = length(Obs), EigenMap = EigenMap, Obs = Obs, Exp = Esp)
  param <- c("SMR", "m", "sd_sp", "sd_het")
  Res.t <- system.time(Res <- sampling(object = mod.BYM, data = datos, chains = 3,
    iter = 4400, warmup = 400, thin = max(1, floor(3 * (4400 - 400)/1000)),
    cores = 3, pars = c("SMR", "m", "sd_sp", "sd_het")))

  Res.BYM[[Sexo]][[Causa]] <- list()
  Res.BYM[[Sexo]][[Causa]]$tiempo <- Res.t
  Res.BYM[[Sexo]][[Causa]]$summary <- Res

```

```

Res.BYM[[Sexo]][[Causa]]$RR <- summary(Res)$summary[1:7907, 1]
Res.BYM[[Sexo]][[Causa]]$P.RR <- apply(extract(Res, pars = "SMR"),
    2, function(x) {
        mean(x > 1)
    })
}

Res.BYM <- list(Hombres = list(), Mujeres = list())

indice <- as.numeric(dimnames(MorTabu[1, , ])[[1]][apply(MorTabu[1, , ], 1,
    sum) >= 10000])

for (i in indice) {
    Ejecuta.BYM.Stan(1, i)
}

save(Res.BYM, file = "Res.BYM-Stan.Rdata")

```

3 Descriptive principals.

Cause	Time	sigma_phi	sigma_theta	max.Rhat	min.n_eff
(9) Mouth and pharynx	12771.5	0.3324 [0.2937,0.3738]	0.0888 [0.0357,0.1288]	1.01	206.32
(10) Esophagus	18398.2	0.2975 [0.2655,0.3317]	0.0418 [0.0021,0.0893]	1.01	418.72
(11) Stomach	9940.8	0.6501 [0.3024,1.2971]	1.1499 [0.0018,3.3961]	11492.20	1.50
(12) Colon	21527.7	0.2411 [0.2116,0.2712]	0.1 [0.0798,0.1175]	1.02	189.49
(13) Rectum	12967.5	0.2021 [0.1633,0.2451]	0.1207 [0.0939,0.1461]	1.02	116.42
(14) Liver	17310.4	0.3112 [0.2738,0.3476]	0.1455 [0.1225,0.1687]	1.01	449.19
(15) Pancreas	15805.9	0.211 [0.158,0.2532]	0.063 [0.0225,0.1205]	1.19	5.31
(16) Other digestives	9252.6	0.1995 [0.1489,0.2486]	0.0506 [0.0026,0.1082]	1.01	205.27
(17) Larynx	7458.8	1.8507 [0.3094,4.8495]	0.2298 [0.0196,0.5317]	137.98	1.50
(18) Lung	9648.9	0.3099 [0.1668,0.3821]	0.4069 [0.0626,1.0564]	122.30	1.50
(22) Other skin	14664.7	0.279 [0.2005,0.3505]	0.3528 [0.004,0.9742]	113.94	1.50
(28) Prostate	12660.3	0.1992 [0.1722,0.2263]	0.0591 [0.0255,0.0834]	1.01	482.81
(30) Kidney	16245.7	0.2908 [0.2437,0.338]	0.0438 [0.0024,0.0973]	1.01	300.24
(31) Bladder	22685.0	0.3053 [0.2735,0.3405]	0.079 [0.041,0.108]	1.02	402.43
(33) Brain	14553.7	0.1478 [0.1089,0.1891]	0.0876 [0.0522,0.1184]	1.02	141.77
(35) Poorly defined	14773.3	0.2246 [0.1966,0.2548]	0.0975 [0.0753,0.1181]	1.01	491.53
(36) Other lymphatics	23796.1	0.4418 [0.1429,0.9853]	0.6513 [0.0506,1.8031]	263.69	1.50
(37) Leukemias	13819.2	0.1452 [0.1072,0.1887]	0.0681 [0.0244,0.1009]	1.03	126.68
(41) Other tumors	13115.9	0.3008 [0.2598,0.3423]	0.0477 [0.0037,0.0977]	1.02	440.12
Median	14553.7	0.29	0.09	1.02	189.49