

# Results of the ‘bym\_exposure\_only\_NoPriors’ model

## Implementation of the model

```
data {
  int<lower=0> N;
  int<lower=0> N_edges;
  int<lower=1, upper=N> node1[N_edges]; // node1[i] adjacent to node2[i]
  int<lower=1, upper=N> node2[N_edges]; // and node1[i] < node2[i]

  int<lower=0> y[N]; // count outcomes
  vector<lower=0>[N] E; // exposure
}
transformed data {
  vector[N] log_E = log(E);
}
parameters {
  real beta0; // intercept

  real<lower=0> sigma_theta; // sd of heterogeneous effects
  real<lower=0> sigma_phi;

  vector[N] theta; // heterogeneous effects
  vector[N - 1] phi_std_raw; // raw, standardized spatial effects
}
transformed parameters {
  vector[N] phi;
  phi[1:(N - 1)] = phi_std_raw;
  phi[N] = -sum(phi_std_raw);
}
model {
  y ~ poisson_log(log_E + beta0 + phi * sigma_phi + theta * sigma_theta);

  target += -0.5 * dot_self(phi[node1] - phi[node2]);

  //beta0 ~ normal(0, 5);
  theta ~ normal(0, 1);
  //tau_theta ~ gamma(3.2761, 1.81); // Carlin WinBUGS priors
  //tau_phi ~ gamma(1, 1); // Carlin WinBUGS priors
}
generated quantities {
  vector[N] mu = exp(log_E + beta0 + phi * sigma_phi + theta * sigma_theta);
  vector[N] SMR = exp(beta0 + phi * sigma_phi + theta * sigma_theta);
}
```

## Fitting the model to Spain’s mortality data

```
library(rstan)
library(spdep)
# options(mc.cores = parallel::detectCores())
```

```

options(mc.cores = 3)

source("mungeCARdata4stan.R")
load("../Mortalidad nacional/DatosSinTemporal.Rdata")
Veci <- nb2WB(CartoMuniSinIslas.nb)
nbs = mungeCARdata4stan(Veci$adj, Veci$num);
N = nbs$N;
node1 = nbs$node1;
node2 = nbs$node2;
N_edges = nbs$N_edges;

tcomp02 <- system.time(mod.BYM <- stan_model("bym_exposure_only_NoPriors.stan"))
# Compilation in 64 seconds

save(mod.BYM, file = "mod.bym_exposure_only_NoPriors.Rdata")
# load("bym_exposure_only.Rdata")

Ejecuta.BYM.Stan <- function(Sexo, Causa){
  y <- MorTabu[Sexo, Causa, ]
  E <- Esperados[Sexo, Causa, ]

  datos <- list(N, N_edges, node1, node2, y, E)
  param <- c("SMR", "mu", "beta0", "sigma_phi", "sigma_theta")
  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 = param))

  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]]$P.RR <- apply(extract(Res, pars="SMR")$SMR, 2, function(x) {mean(x > 1)})
}

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

for(i in c(9:18, 22, 28, 30, 31, 33, 35:37, 41)){
  Ejecuta.BYM.Stan(1, i)
  save(Res.BYM, file = "Res.bym_exposure_only_NoPriors.Rdata")
}

```

## Descriptive principals

Cause	Time	sigma_phi	sigma_theta	max.Rhat	min.n_eff
(9) Mouth and pharynx	5047.1	0.3343 [0.2962,0.3742]	0.0878 [0.0378,0.1254]	1.01	404.32
(10) Esophagus	9216.0	0.3045 [0.2647,0.3439]	0.0378 [0.0017,0.0866]	1.15	7.02
(11) Stomach	5523.7	0.3258 [0.2998,0.3517]	0.0259 [8e-04,0.0652]	1.01	376.83
(12) Colon	6628.0	0.7876 [0.2159,1.8906]	0.1812 [0.0837,0.3415]	170.53	1.50
(13) Rectum	11291.6	0.2058 [0.1692,0.2474]	0.1203 [0.0912,0.147]	1.01	219.56
(14) Liver	6776.4	0.3117 [0.2734,0.348]	0.1465 [0.1204,0.1691]	1.01	521.39
(15) Pancreas	5638.4	0.779 [0.1835,1.928]	0.4331 [0.0223,1.1792]	402.79	1.50

Cause	Time	sigma_phi	sigma_theta	max.Rhat	min.n_eff
(16) Other digestives	5630.4	1.4865 [0.1632,4.072]	1.2295 [0.0046,3.5917]	5315.17	1.50
(17) Larynx	6735.8	0.347 [0.3037,0.3886]	0.0816 [0.0164,0.1257]	1.03	244.30
(18) Lung	5707.5	0.3605 [0.3393,0.3828]	0.0829 [0.0628,0.1004]	1.01	460.20
(22) Other skin	5467.6	0.5321 [0.1896,1.1328]	0.1359 [0.0035,0.3126]	58.43	1.50
(28) Prostate	5807.7	0.1982 [0.1719,0.2268]	0.0609 [0.0267,0.0844]	1.02	254.97
(30) Kidney	6657.6	0.2916 [0.2496,0.3363]	0.0441 [0.0027,0.0971]	1.02	331.40
(31) Bladder	6268.7	0.3064 [0.2736,0.3372]	0.0792 [0.0455,0.1083]	1.01	286.54
(33) Brain	6315.0	0.1514 [0.1152,0.1931]	0.0856 [0.0496,0.1143]	1.02	190.47
(35) Poorly defined	6394.3	0.2239 [0.1965,0.251]	0.0986 [0.0776,0.1182]	1.01	487.18
(36) Other lymphatics	11290.1	0.1766 [0.1448,0.2076]	0.0751 [0.0462,0.101]	1.01	376.15
(37) Leukemias	5128.2	0.146 [0.1087,0.1877]	0.0676 [0.025,0.1017]	1.02	155.36
(41) Other tumors	8863.7	0.2027 [0,0.341]	0.0311 [1e-04,0.0899]	150.18	1.50
Median	6315.0	0.31	0.08	1.02	244.30