

# BYM models

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```
require('diseasemapping')

## Loading required package: diseasemapping

data('kentucky')
kentucky = terra::unwrap(kentucky)
```

## Incidence rates

```
if(FALSE) {
  # must have an internet connection to do the following
  larynxRates= cancerRates("USA", year=1998:2002,site="Larynx")
  dput(larynxRates)
} else {
  larynxRates = structure(c(0, 0, 0, 0, 1e-06, 6e-06, 2.3e-05, 4.5e-05, 9.9e-05,
    0.000163, 0.000243, 0.000299, 0.000343, 0.000308, 0.000291, 0.000217,
    0, 0, 0, 1e-06, 1e-06, 3e-06, 8e-06, 1.3e-05, 2.3e-05, 3.5e-05,
    5.8e-05, 6.8e-05, 7.5e-05, 5.5e-05, 4.1e-05, 3e-05), .Names = c("M_10",
    "M_15", "M_20", "M_25", "M_30", "M_35", "M_40", "M_45", "M_50",
    "M_55", "M_60", "M_65", "M_70", "M_75", "M_80", "M_85", "F_10",
    "F_15", "F_20", "F_25", "F_30", "F_35", "F_40", "F_45", "F_50",
    "F_55", "F_60", "F_65", "F_70", "F_75", "F_80", "F_85"))
}

get rid of under 10's

larynxRates = larynxRates[grep("_ (0|5)$",names(larynxRates), invert=TRUE)]

compute Sexpected

kentucky = diseasemapping::getSMR(
  popdata=kentucky,
  model = larynxRates,
  casedata=larynx,
  regionCode="County")
```

# The BYM model

The Besag, York and Mollie model for Poisson distributed case counts is:

$$\begin{aligned}Y_i &\sim \text{Poisson}(O_i \lambda_i) \\ \log(\mu_i) &= X_i \beta + U_i \\ U_i &\sim \text{BYM}(\sigma_1^2, \sigma_2^2)\end{aligned}$$

- $Y_i$  is the response variable for region  $i$
- $O_i$  is the 'baseline' expected count, which is specified
- $X_i$  are covariates
- $U_i$  is a spatial random effect with a spatially structured variance parameter  $\sigma_1^2$  and a spatially independent variance  $\sigma_2^2$

## BYM with penalised complexity prior

'propSpatial = c(u=0.5, alpha=0.8)' means  $pr(\phi < 0.5) = 0.8$ , which is different from the specification of 'pc.prec'

```
kBYMpc = try(
  bym(
    formula = observed ~ offset(logExpected) + poverty,
    kentucky,
    prior = list(
      sd=c(u=1, alpha=0.05),
      propSpatial = c(u=0.5, alpha=0.8)),
    verbose=TRUE), silent=TRUE)
```

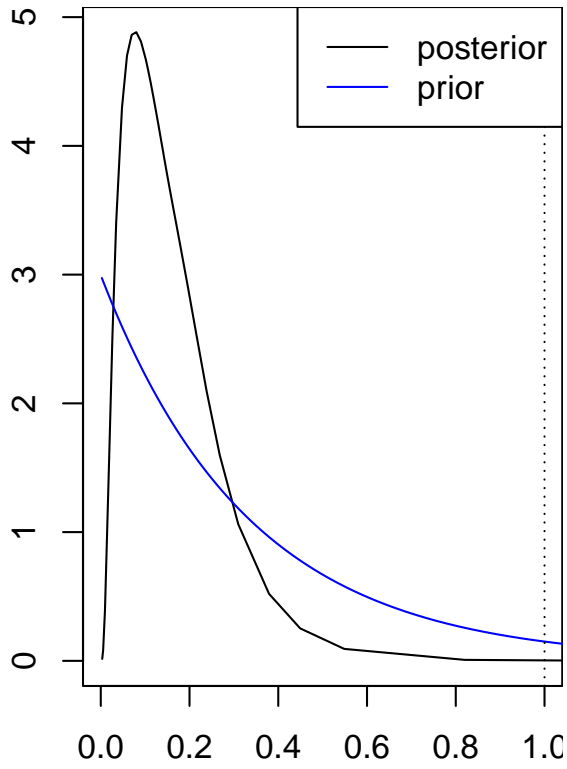
Here penalized complexity priors are used with  $pr(\sqrt{\sigma_1^2 + \sigma_2^2} > 1) = 0.05$  and

$$pr(\sigma_1 / \sqrt{\sigma_1^2 + \sigma_2^2} < 0.5) = 0.8.$$

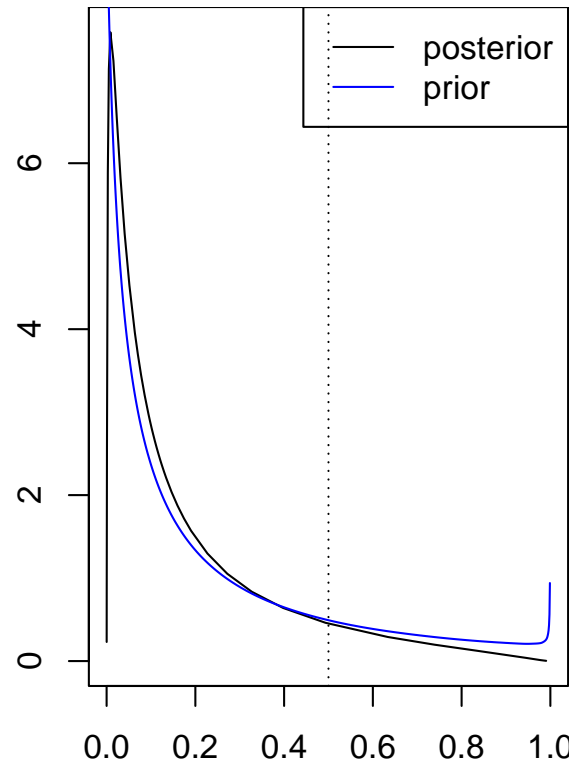
```
if(!is.null(kBYMpc$parameters))
  knitr::kable(kBYMpc$parameters$summary[,c(1,3,5)], digits=3)
```

|             | mean  | 0.025quant | 0.975quant |
|-------------|-------|------------|------------|
| (Intercept) | 0.087 | -0.360     | 0.544      |
| poverty     | 0.009 | -0.012     | 0.030      |
| sd          | 0.157 | 0.026      | 0.449      |
| propSpatial | 0.189 | 0.005      | 0.739      |

```
## map images will be cached in /var/folders/jg/qlm9ks895mg7y2y27yrl_bqw0000gn/T//Rtmpj
```

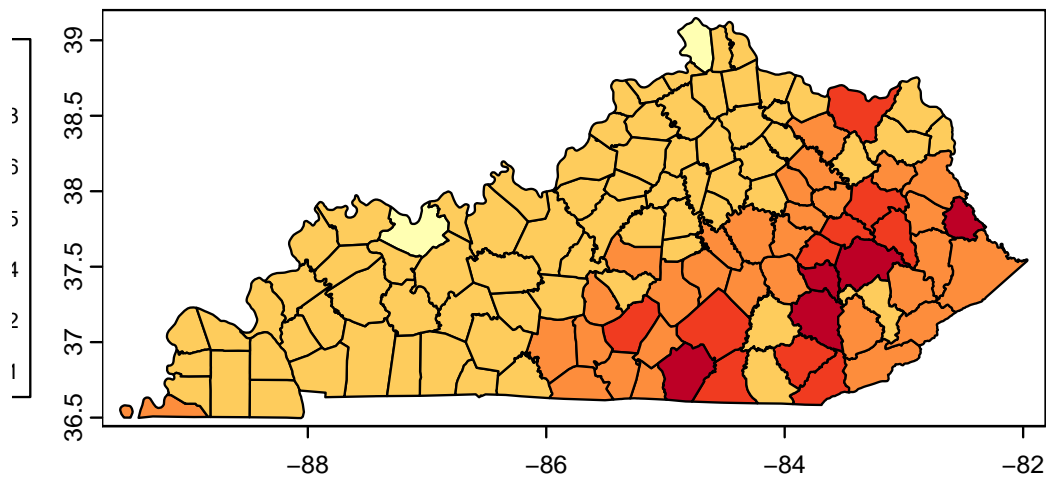


(a) sd

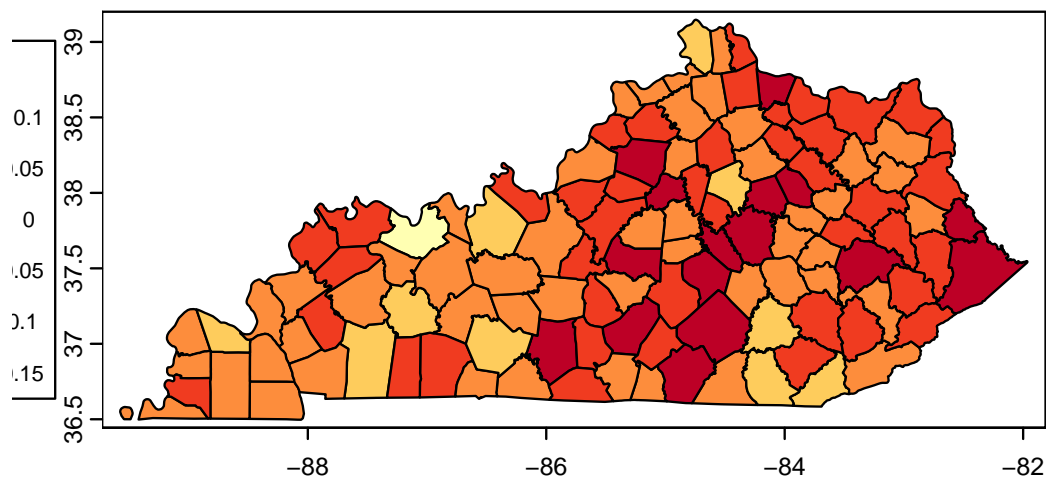


(b) prop spatial

Figure 1: PC priors variance parameters



(a) fitted



(b) random

Figure 2: Random effects and fitted values