

# 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)
```

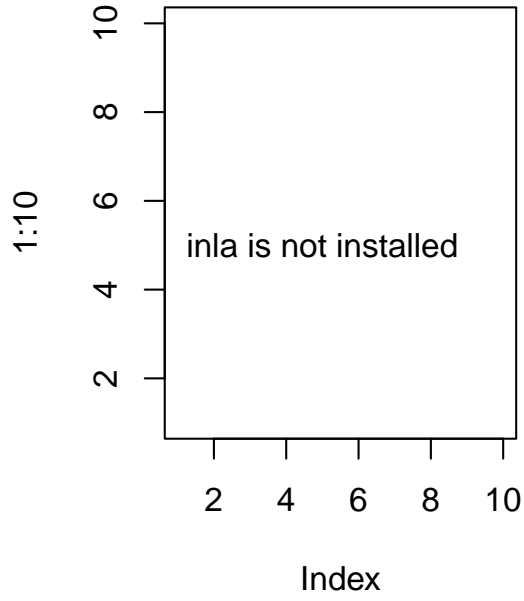


Figure 1: PC priors variance parameters

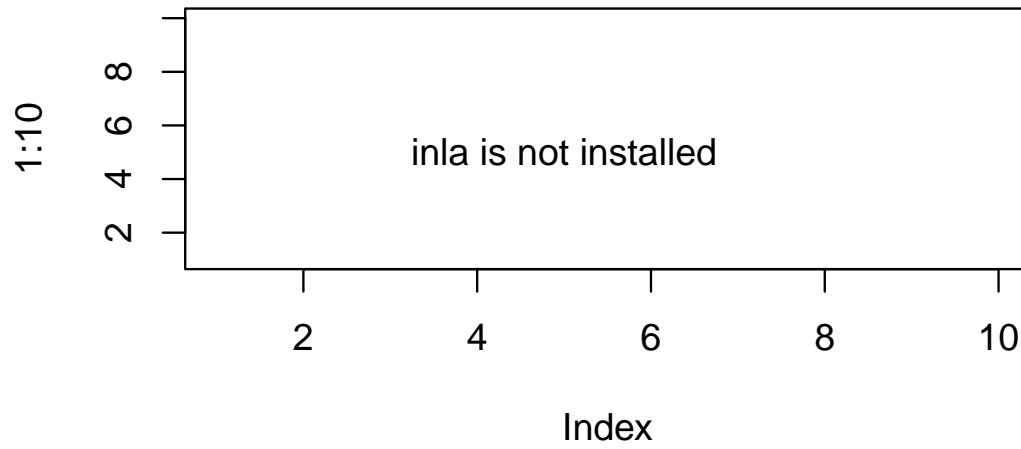


Figure 2: Random effects and fitted values