Explorations and Experiments on INLA with NHANES data

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# Outline

* INLA ***Integrated Nested Laplace Approximations***
* Describe the class of models INLA can be applied to
* Look at simple examples in R-INLA.

## INLA

* Integrated Laplace Approximation
* Introduced by Rue, Martino and Chopin (2009).
* Posteriors are estimated using numerical approximations.
  + It is a deterministic approach to approximate  
    Bayesian inference for latent Gaussian models (LGMs)
  + INLA is both faster and more accurate than MCMC
* three key components required by INLA:
  + the LGM framework
  + the Gaussian Markov random field (GMRF)
  + the Laplace approximation

## Latent Gaussian Models (LGM) framework

* LGMs have a wide-ranging list of applications and most structured Bayesian models
  + Regression models, the most extensively used subset of LGMs.
  + Dynamic models, Spatial models and Spatial-temporal models
* Although the likelihood function does not have to be Gaussian,  
  each latent parameter must be a Gaussian given its hyperparameter in LGM.
* the assumption must be hold:  
  for example, if we have two parameters

## Latent Gaussian Models (LGM) framework

* then, we have the latent effect follows Gaussian:
* extended for additive models
  + relax the assumption of linear relationship
  + introduce random effects

## Latent Gaussian Models (LGM) framework

instead of using , we apply the precision matrix

## Guassian Markov Random Fields (GMRFs)

* the latent field should not only be Gaussian  
  but also Guassian Markov Random Field
  + We say is a GMRF if it has a multivariate normal density  
    with additional conditional independence  
    (also called the “Markov property”).
  + One common thing between different GMRFs:  
    they all have a sparse precision matrix.
    - Sparse matrix provides a huge computational benefit  
      when making Bayesian inference.
    - “Magic” in INLA: The joint distribution of of GMRF is also a GMRF
    - Precision matrix consists of sums of  
      the precision matrices of the covariates and model components.

## *Additional notes AR(1)*

* band matrix example AR(1)

* conditional independent for

## *Additional notes AR(1)*

* conditional independent for