Estimate of true COVID-19 infections in US Counties

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Background

- Goal
  - Predict the true number of people infected with the COVID-19 virus in each county in the US
- Data
  - COVID-19 infection data per county (4/20/20)
  - County-level predictors (2738 of 3007 counties)
    - Log population density, infection increase over previous 2 days, socio-economic vulnerability index, number of retirement homes
  - State-level predictors
    - Cook Partisan Voting Index, hospitals per person, number of tests administered per person

Model Structure

$$Confirmed_i \sim NegBinom(r, \frac{r}{m_i})$$

r = size, m_i = mean

$$m_i = \underbrace{pop_i * \lambda_i}_{\text{true \# infected}} * \theta_j$$

λ_i = true rate of infection

θ_i = underestimation proportion

State level

$$\theta_j \sim Beta(rr, p_j, rr * (1 - p_j))$$

rr = size, p_j = mean

$$p_j = inv\_logit(Z_j\gamma)$$

$$\gamma_p \sim Double\_Exp(0, \sigma_\gamma)$$

LASSO prior

$$\gamma_1 \sim Normal(-2.28, 0.368)$$

Informative prior

County level

$$\lambda_i = inv\_logit(X_i\beta)$$

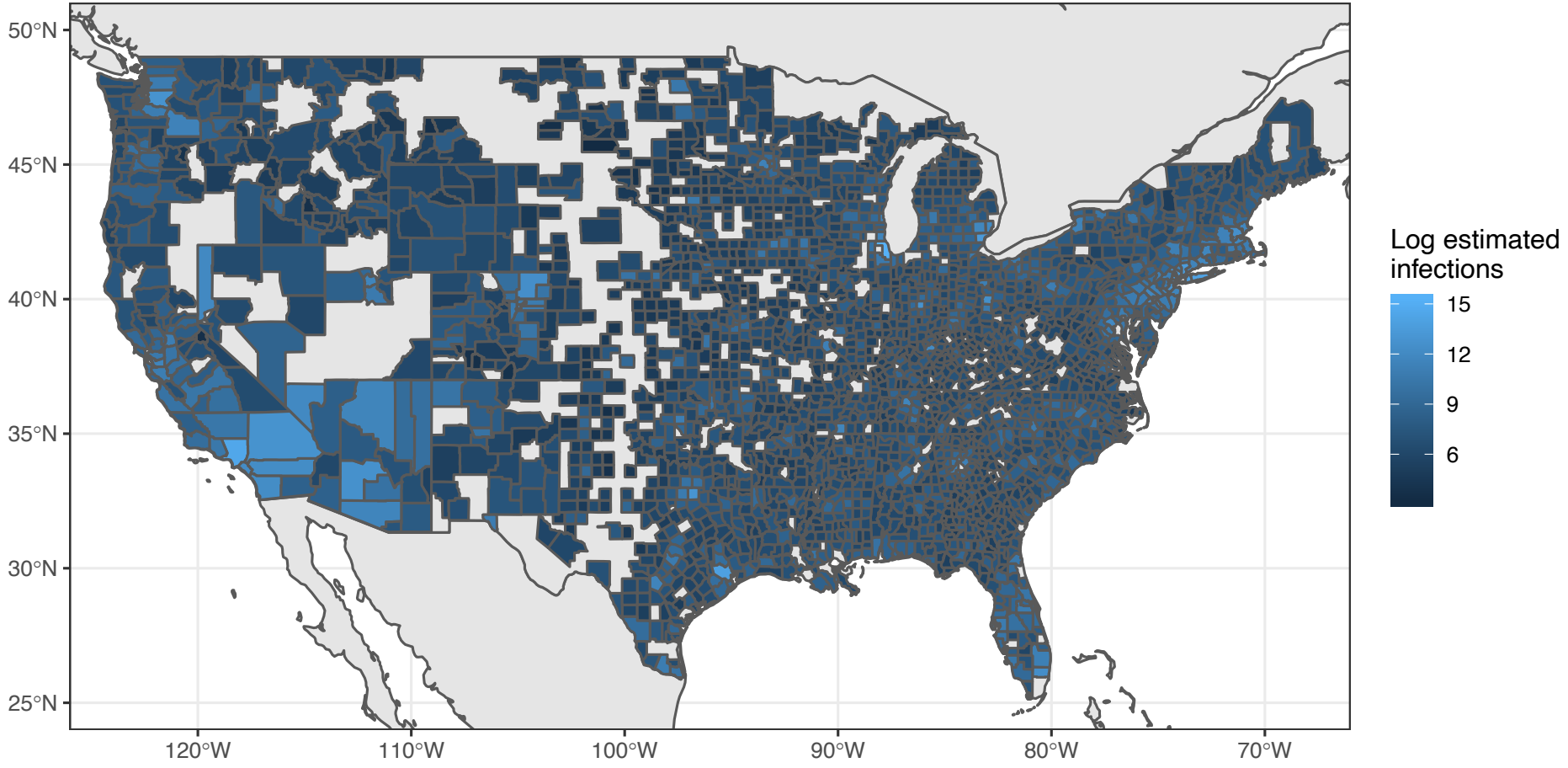
$$\beta_k \sim Double\_Exp(0, \sigma_\beta)$$

LASSO prior

Details

- B-splines
  - Univariate b-splines with 5 df
  - Tensor product multivariate splines
  - Splines thinned based on max value
- Informative prior for underestimation proportion (θ)
  - Based on the range of antibody testing from New York State recently reported
  - Better estimate of true # of infections
- Problems estimating both true infection rate and underestimation proportion at county level
- Model fit with Stan
  - 20,000 sampling iterations

Results


50°N
45°N
40°N
35°N
30°N
25°N
120°W
110°W
100°W
90°W
80°W
70°W
Log estimated infections
15
12
9
6

Estimated number of true infections for select counties

County	Lower HDI	Upper HDI
AZ_Maricopa	17,692	906,079
CA_Los Angeles	98,301	8,669,920
GA_Fulton	52,901	124,507
IL_Cook	646,152	5,223,719
NC_Mecklenburg	31,716	72,620
NC_Wake	20,946	48,657
NY_Westchester	194,720	968,815
WA_King	32,534	1,035,048