Simulation Study models

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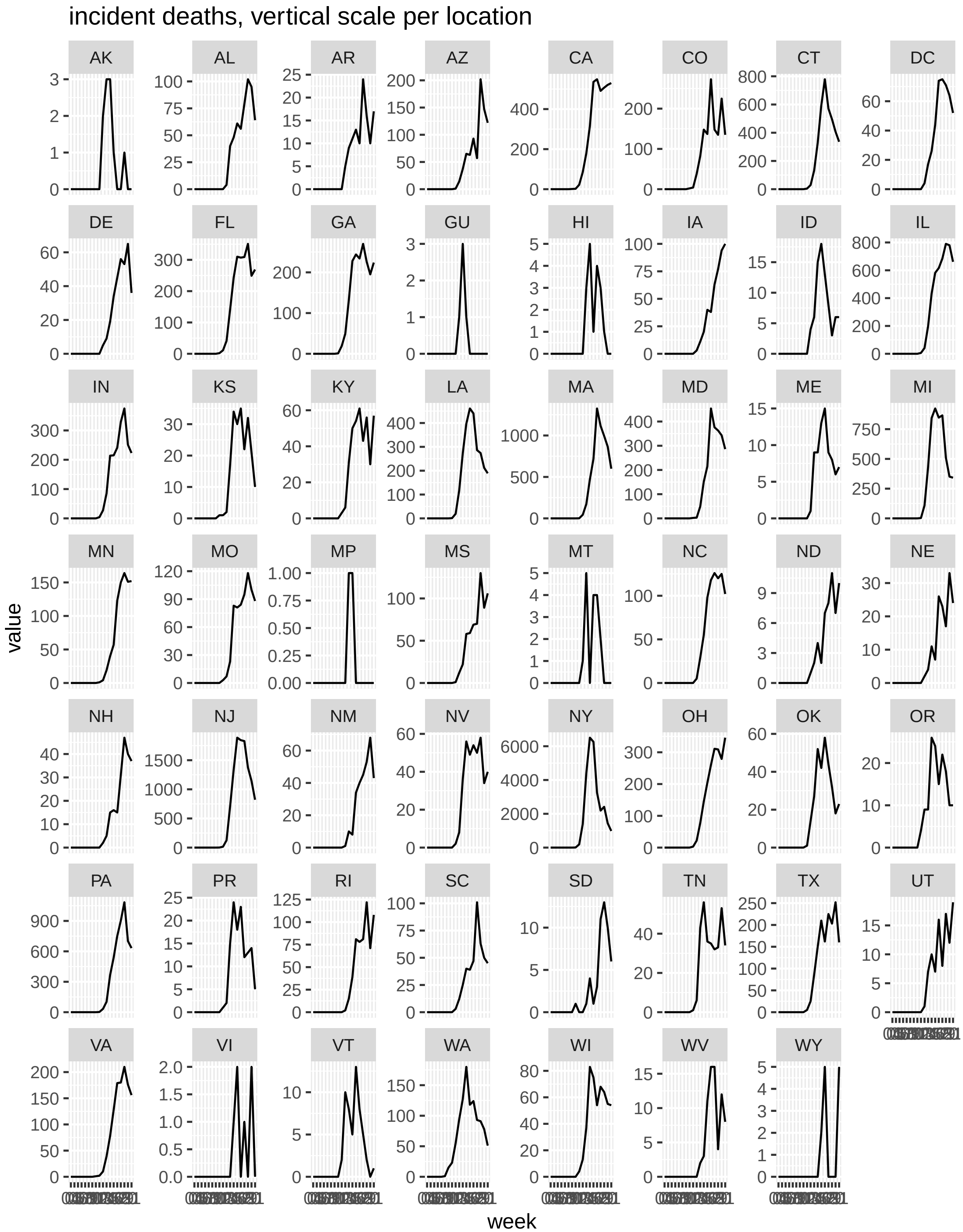
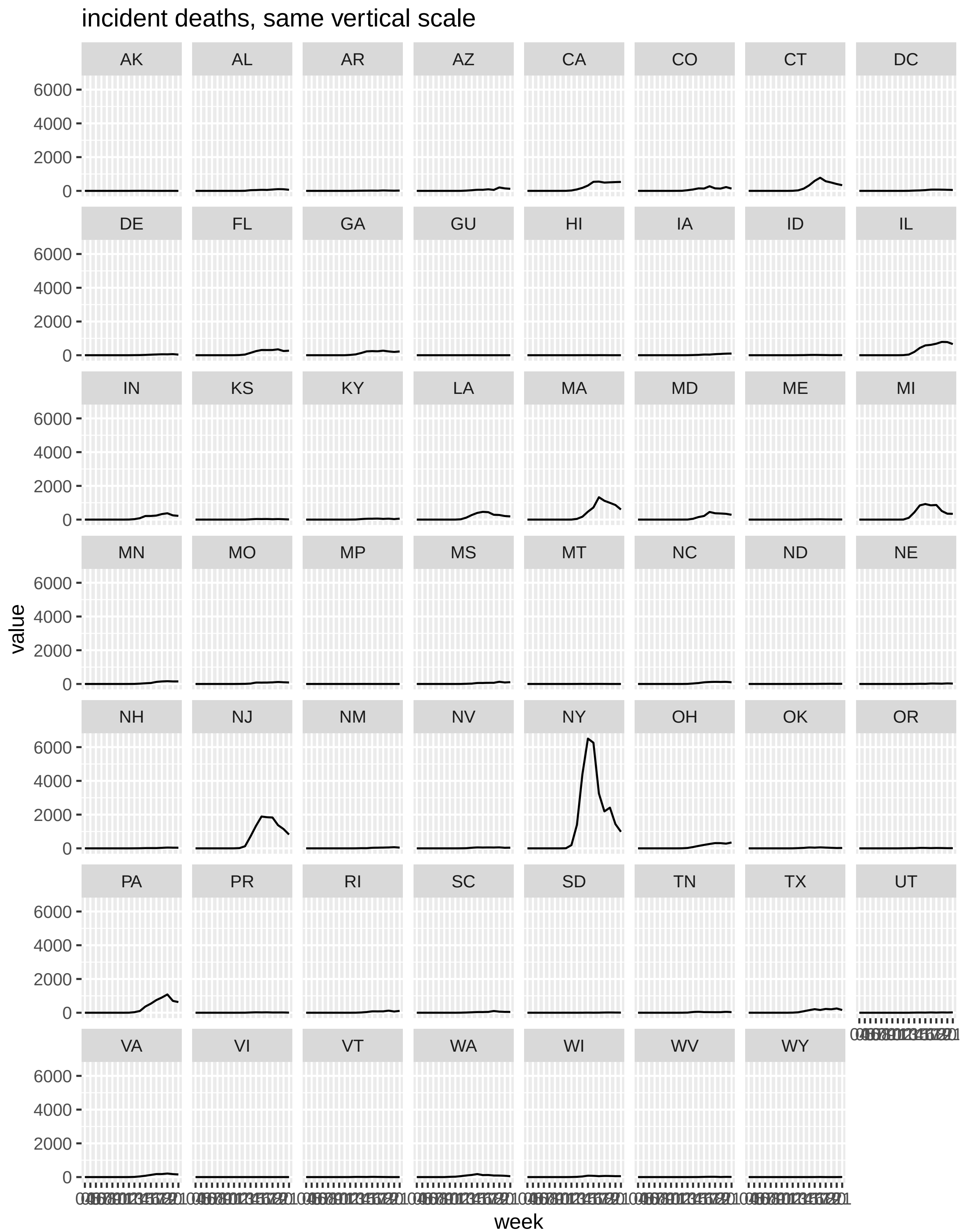
Some Exploratory Plots




incident deaths, same vertical scale
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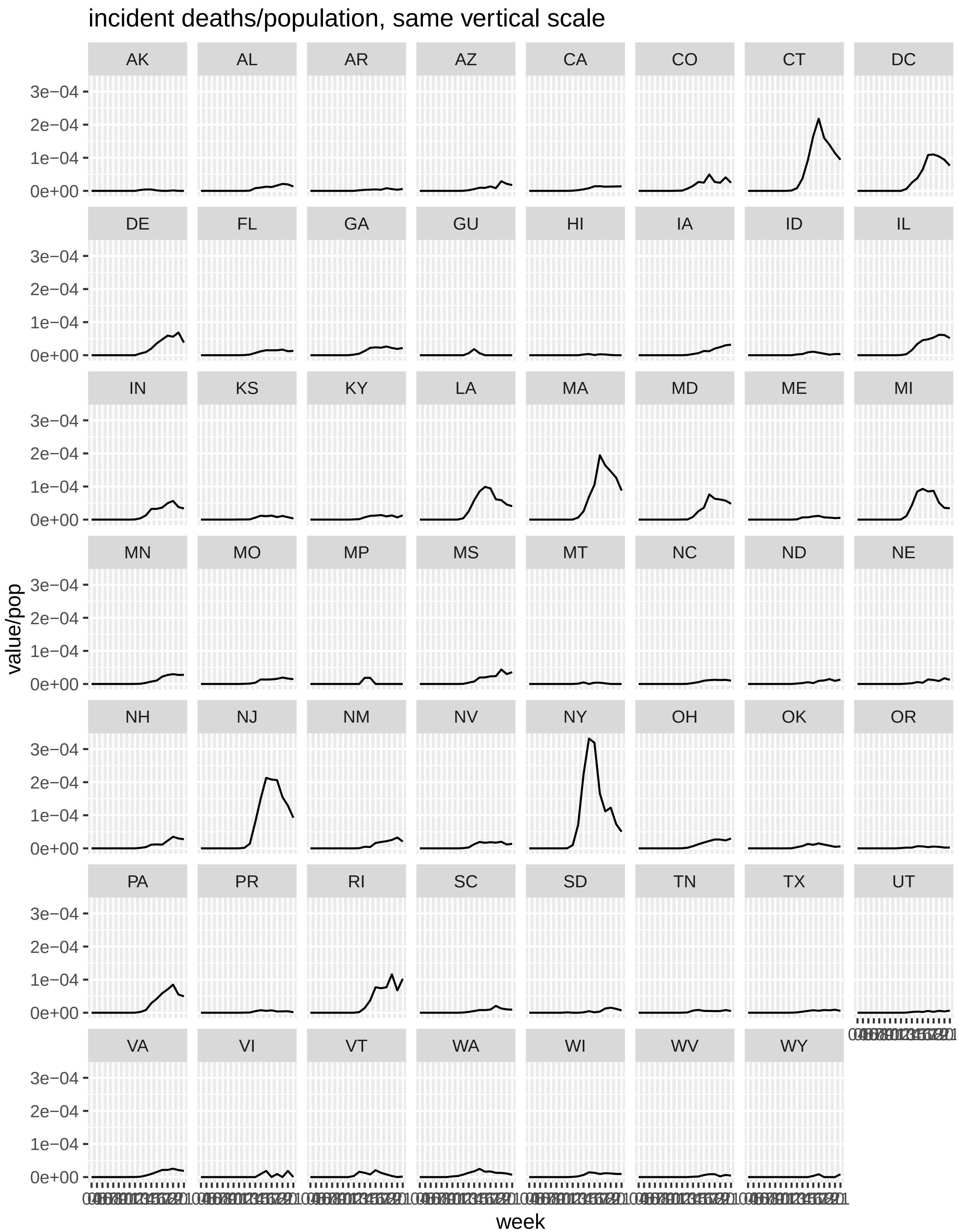

Observations:

- We have integer counts of deaths

- scaling by population is helpful.

Models

SIRD fit separately by state

Notation:

- N = population for location
- $y(t)$ = count of deaths for location at time t
- $s(t)$ = proportion of population susceptible at time t
- $i(t)$ = proportion of population infected at time t
- $r(t)$ = proportion of population recovered at time t
- $d(t)$ = proportion of population dead at time t

Model:

$$
\begin{aligned}
y(t) &\sim \text{Negative Binomial}\left(\{d(t) - d(t-1)\}N, \phi\right) \\
\frac{d}{dt}s(t) &= -\beta s(t)i(t) \\
\frac{d}{dt}i(t) &= \beta s(t)i(t) - \gamma i(t) - \mu i(t) \\
\frac{d}{dt}r(t) &= \gamma i(t) \\
\frac{d}{dt}d(t) &= \mu i(t)
\end{aligned}
$$

Priors:

$$
\begin{aligned}
d(0) &= 0.0 \\
\tilde{s}(0) &\sim \text{Normal}(\nu_s, \sigma_s^2) \\
\nu_s &\sim \text{Normal}(7.0, 2.0) \\
\sigma_s &\sim \text{Gamma}(1, 1) \\
\tilde{i}(0) &\sim \text{Normal}(\nu_s, \sigma_s^2) \\
\nu_i &\sim \text{Normal}(0.0, 2.0) \\
\sigma_i &\sim \text{Gamma}(1, 1) \\
\tilde{r}(0) &= 0.0 \\
\begin{bmatrix} s(0) \\ i(0) \\ r(0) \end{bmatrix} &= \text{softmax}\left(\begin{bmatrix} \tilde{s}(0) \\ \tilde{i}(0) \\ \tilde{r}(0) \end{bmatrix} \right) \\
\log(\beta) &\sim \text{Normal}(\nu_\beta, \sigma_\beta^2) \\
\nu_\beta &\sim \text{Normal}(0.33, 2) \\
\sigma_\beta &\sim \text{Gamma}(1, 1) \\
\log(\gamma) &\sim \text{Normal}(\nu_\gamma, \sigma_\gamma^2) \\
\nu_\gamma &\sim \text{Normal}(-0.7, 2) \\
\sigma_\gamma &\sim \text{Gamma}(1, 1) \\
\log(\mu) &\sim \text{Normal}(\nu_\mu, \sigma_\mu^2) \\
\nu_\mu &\sim \text{Normal}(-7.5, 2) \\
\sigma_\mu &\sim \text{Gamma}(1, 1) \\
\log(\phi) &\sim \text{Normal}(\nu_\phi, \sigma_\phi^2) \\
\nu_\phi &\sim \text{Normal}(1, 2) \\
\sigma_\phi &\sim \text{Gamma}(1, 1)
\end{aligned}
$$