MCMC for Influenza Burden Estimation from Hospitalization Surveillance data

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Data

1. N: Total FluSurv-NET (FSN) population (given stratum, e.g. age group, state, etc.)
2. M: Total US population
3. n_H: Number of observed influenza hospitalizations with non-lethal outcome
4. n_D: Observed influenza deaths
5. t_{kj}: Numbers tested by outcome and test type (1: PCR, 2: Rapid, 3: Other, 4: No test)
6. ρ_k: Prior dist. for test sensitivities (PCR, rapid; mean, SD)

Parameters to be sampled, fully conditional likelihoods L

The prior distribution of a parameter, Θ is denoted as $\eta_\Theta(\theta)$ or $\eta(\theta)$.

m_H: True number of influenza hospitalizations (non-letal) in FSN population, unobserved

$$L(m_H|\ldots) \propto \frac{e^{-\lambda_H\, N}(\lambda_H\, N)^{m_H}}{m_H!} \times \binom{m_H}{n_H} \tau_0^{n_H}(1-\tau_0)^{m_H-n_H} \times \eta(m_H), \tag{1}$$

where the "detection probability" in those with non-lethal outcomes is $\tau_0 = \phi_0 \sum_j \pi_{0j}\sigma_{0j}$; definitions of $\phi_0, \pi_{0j},$ and σ_{0j} as given below.

m_D: total number of influenza hospitalizations (lethal) in FSN population, unobserved

$$L(m_D|\ldots) \propto \frac{(\lambda_D\, \epsilon\, N)^{m_D}}{m_D!} \times \binom{m_D}{n_D}\ (1-\tau_1)^{m_D-n_D} \times \eta(m_D), \tag{2}$$

λ_H: Hospitalization rate, non-lethal outcome

$$L(\lambda_H)|\ldots) \propto e^{-\lambda_H\, N} \lambda_H^{m_H} \times \eta_{\Lambda_H}(\lambda_H) \tag{3}$$

λ_D: Influenza mortality rate

$$L(\lambda_D|\ldots) \propto e^{-\lambda_D}\ \lambda_D, \tag{4}$$

ϵ: Outside-hospital death proportion

$$L(m_D|\ldots) \propto \frac{e^{-\lambda_D\ \epsilon\ N}(\lambda_D\ \epsilon\ N)^{m_D}}{m_D!} \tag{5}$$

ϕ_0: True influenza-positivity rate, in non lethal outcomes)

$$\begin{aligned} L(\phi_0|\ldots) &\propto \binom{m_H}{n_H}\left(\phi_0\sum_j \pi_{0j}\sigma_{0j}\right)^{n_H}(1-\phi_0\sum_j \pi_{0j}\sigma_{0j})^{m_H-n_H} \times \prod_j \binom{t_{0j}}{g_{0j}}\phi_0^{g_{0j}}\ (1-\phi_0)^{t_{0j}-g_{0j}} \\ &\propto \phi_0^{n_H}\left(1-\phi_0\sum_j \pi_{0j}\sigma_{0j}\right)^{m_H-n_H} \times \phi_0^{\sum_j g_{0j}}\ (1-\phi_0)^{\sum_j t_{0j}-g_{0j}} \end{aligned} \tag{6}$$

π_{0j}: Testing probabilities in non-lethal outcomes, by test type

$$L(\pi_{0j}|\ldots) \propto \frac{e^{-\lambda_H\ N}(\lambda_H\ N)^{m_H}}{m_H!} \times \binom{m_H}{n_H}\tau_0^{n_H}(1-\tau_0)^{(m_H-n_H)}, \tag{7}$$

g_{kj}

Unobserved number of influenza positives, by outcome k and test type j

σ_{kj}

Test sensitivity, by outcome k and test type j