Jewell Approach

Erica Billig

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The overall goal is to use active surveillance to target high-risk households, which is thought to be more efficient than random targeting. However, it is unclear whether this would be more efficient than treating houses around an infected house. Below I have summarized the approach along with questions that remain.

1. Data needed
   - Covariate data
     - location
     - ?
   - Observed data
     - detection of bugs at time points (N_i)
     - spray time of houses (R_i)
   - Unobserved data
     - infection times of notified houses (I_i)
     - infected houses that are not yet detected

2. Transmission function

   Transmission rate between infected i and susceptible j and observed (notified) i and susceptible j respectively:

   $$\beta_{ij} = ?$$
   $$\beta^*_{ij} = ?$$

   In Jewell, this is a function of Euclidean distance, cows, and sheep. Allows for difference in case the transmission rate varies once the house is known to be infected. Do we need two functions for this?

   They include time-dependent infectivity function $h(\cdot)$ describing how the infectivity increases as the length of infection increases. Could this be a logarithmic function for bugs?

   Thus, total infection pressure becomes

   $$\tau_j = \beta_0 + \sum_{I_i < I_j < N_i} \beta_{ij} \cdot h(I_j - I_i) + \sum_{N_i < I_j < R_i} \beta^*_{ij}$$

3. Likelihood

   Rate of notification conditional on an infection is $F_D(d) =?$
   f_D is the distribution of $D_i = N_i - I_i$. In homogenous mixing Markov model, $f_d \sim exp(\lambda)$. $F_D(d) = \int_d^\infty f_D(y)dy$ (as far as my understanding – this should be the cdf but seems to be 1-cdf). Jewell uses a variation of the exponential distribution.

$$\begin{aligned} f(\mathbf{I}, \theta | \mathbf{N}, \mathbf{R}) &= \prod_{j=1, j\neq k}^{[\mathbf{I}]} (\tau_j(I_j^-)) exp\Big(- \int_{I_k}^{T_{obs}} \Big(\sum_{j=1 j\neq k}^{[\mathbf{S(T_{obs})}]} \tau_j(t) \Big) dt \Big) \\ & \times \prod_{j=1}^{m} f_D(N_j - I_j) \times \prod_{j=m+1}^{[\mathbf{I}]} (1 - F_D(T_j - I_j)) \times prior \end{aligned}$$

   where

$$T_j = \begin{cases} T_{obs} & \text{if j is currently presumed susceptible but is unknowingly infected} \\ C_j & \text{if j is sprayed before infestation status is known} \end{cases}$$

   k = initial infection (the likelihood is conditional on index case). We don't know the index case, so how do we handle?

   What about prior? The Jewell paper uses Gamma prior for θ. Synthetic likelihood results for prior?

4. Other questions

   - multiple approaches to 'pull' from for bandit approach?
   - divide areas into zones?
   - How to establish method to surveys? Is this to decide where to survey or treat?