NME
2021
Network Modeling for Epidemics

DAY 4:
SIMULATING DISEASE TRANSMISSION ON DYNAMIC NETWORKS W/ EXOGENOUS FEEDBACK

NME WORKSHOP

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Changing network size and composition

- As social networks change in size (say, for instance, as a village of n = 5,000 nodes grows to n = 10,000 nodes), which of the following do you think is generally preserved?

  - Number of edges? e
  - Mean degree? $2e/n$
  - Density? $e/\binom{n}{2}$

Changing network size and composition

- Applying the coefficients as is from a given *stergm* fit to a network of changing size will lead to preservation of density across time
- For one-mode networks: preserving mean degree instead requires a simple transformation of the edges coefficient in the formation model:

$$\theta_{new} = \theta_{old} + \ln(N_{old}) - \ln(N_{new})$$

- This is mathematically equivalent to partitioning the original edges term into an offset equal to ln(*N*) and a residual, and then updating the offset as *N* changes.
- EpiModel handles this for you
- If you are going to code your own models outside EpiModel, you must handle this

Changing network size and composition

- As network composition changes, balancing will happen automatically – the explicit pairing of individuals requires this.
- Nevertheless – one does not have always have straightforward control over this
  - e.g. with just an edges term in the model, two sexes will automatically “meet in the middle”
- Can change parameterizations to obtain different dynamic behavior
  - worth thinking through the behavior you expect, and what you see for your model
- Some theory to guide you can be found in Morris (1991), Koehly, Goodreau and Morris (2004), Krivitsky, Handcock and Morris (2011)

Relational dissolution through node departure

- We fit our dynamic network using static data, with a process for dissolving relationships governed by a coefficient derived from relational duration
- All of this was done in a context that contained no information about deaths or other forms of node departures – i.e. processes that also terminate relationships
- If we simply layer departures on to our model (even with the size correction on the previous slide) we will see two measures drop down below the expected values we want:
  - relationship durations
  - number of relationships
- Some aspects of this might be desired
  - e.g. if we could interview dead people we might find their past relationships to be shorter than those of the same birth cohort in our sample who are still alive
- but others are likely not.

Relational dissolution through node departure

- An approximate correction for this is:

1. Calculate dissolution coefficients as before (without considering death or other departures from the population)
2. Estimate formation coefficients conditional on these dissolution coefficients.
3. Calculate new dissolution coefficients that reflect the log-odds of a relationship sustaining conditional on both actors remaining, which equals:

$$logit\left[1 - \frac{P(E_t) - P(N_t)}{P(\neg N_t)}\right]$$

where:

$P(E_t)$ = the overall prob. of a tie dissolving at time *t* from any cause = 1/D

$P(N_t)$ = the prob. of either incident node departing at time *t*

Relational dissolution through node departure

- The complicating factor is that $P(N_t)$ may very well change over time as your disease prevalence changes
- But then again, it's probably OK for relationship lengths to shorten, and network density to decline, slightly as deaths increase
- Again, EpiModel handles this for you
- If you are going to code your own models outside EpiModel, you must handle this
- Bigger point:

DIAGNOSE THE HECK OUT

OF YOUR SIMULATIONS!!!

Review of offsets and corrections

When approximating the fit of a formation STERGM conditional on dissolution STERGM...	...subtract dissolution coefficients from corresponding formation ones (`edapprox=TRUE`)
When network size N changes and you want to preserve mean degree...	...add the *ln* of the old N and subtract the *ln* of the new N to the edges coefficient in the formation model (or equivalently, use an edges offset and update it with *ln* of new N)
To adjust for node departures in simulating from a STERGM model estimated from a cross-sectional network and durations	...use $\text{logit}\left[1-\frac{P(E_t)-P(N_t)}{P(\neg N_t)}\right]$ in calculating your dissolution coefficients