Inference Robustness and Identifiability Analyses for Infection Models

James Koopman[1]

[1] *University of Michigan, 1415 E. Washington Heights Ann Arbor, MI, 48109*
jkoopman@umich.edu

Mathematical and computer simulation models of infectious diseases can advance science and inform policy. A logical methodology for using models to these ends entails 1) analyzing models to see whether inferences regarding these ends are robust to realistic relaxation of simplifying model assumptions and 2) determining whether data makes inferences about science or policy identifiable. For both advancing science or informing policy, identifiability needs to be assessed not just with regard to parameters, but with regard to decisions about policy choices or alternatives for representing the true state of the real world. Algorithms for pursuing these ends will be discussed. Three types of models are relevant to infections: 1) Within host models of infection and immunity processes 2) Models of infection transmission and spread through populations 3) Microbial fate and transport models. Realistic relaxation of simplifying assumptions for a within host model may involve adding population elements or fate and transport elements to a model. For example, the dose timing of a host may depend upon transmission conditions. Likewise, to make a population model more realistic, one may need to add within host elements that affect how individuals with different levels of immunity respond to different population transmission levels or fate and transport elements that affect how much pathogen from one person reaches another. Multi-scale models thus help advance science or inform policy. Adding within host elements to transmission models can conceivably increase identifiability of policy or science decisions, especially if within host data can be obtained. Likewise, adding population transmission or fate and transport to within host models can be beneficial. The explosion of big within-host data generating technologies and new sources of big data gathered on populations increase the value of multi-scale models. Such models and data will contribute more to science and policy when multi-scale analyses incorporate both inference robustness and decision identifiability assessments.

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References

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