Responding To An Infection Transmission Emergency

Jim Koopman MD MPH
University of Michigan
Center for the Study of Complex Systems & Dept. of Epidemiology
Person to Person Transmission Emergencies

- Smallpox
  - Wide Airborne Spread
  - Introduced Case
- New Influenzae
  - Natural Pandemic Strain
  - Pathogenicity &/or Immunogenicity Altered Organism
- Rotavirus
  - Pathogenicity &/or Immunogenicity Altered Organism
Objectives of Emergency Response

• Not to stop all transmission
  – May be too risky to pursue perfection
• Reduce reproduction number as far below one as possible
• Prevent all super-spreading events
Emergency Response Activities

- Case detection – molecular diagnosis – epidemiological diagnoses – Early response is key
- Quarantine cases
- Quarantine contacts
- Close contact venues
- Treat cases to stop transmission
- Prophylaxis for high-risk population
  - Antimicrobial
  - Vaccine
Key Decisions

• To what groups should control measures be directed
  – Defined by contact
  – Defined by general role in transmission system
• What control measures should be directed to those groups
• To what contact venues should control efforts be directed
• Which groups or venues deserve special efforts to insure complete coverage
Contact Group Definition

- Contacts with possible direct transmission
  - Skin
  - Shared fomites
  - Shared air
  - Duration or intensity
- Contacts down a possible transmission chain
  - Attendees at workplace, school
  - Contacts of contacts regardless of social setting
Transmission System Role Group Definition

• Role of social grouping or contact venue in the transmission system
  – Dominant
  – Jointly Key
  – Redundant
  – Disseminating
  – Amplifying
  – Dead End
Infection Transmission System Analysis to Make Control Decisions

– Better done before the emergency
– Epidemic transmission system behavior is extremely sensitive to contact patterns
– Broadly applicable criteria established using abstract models making many simplifying assumptions need validity assessment that relaxes these assumptions
– Assessment of local contact structures and dynamics is an ideal that is not currently feasible but will be soon
  • MTSA software development supported by NIAID
Steps In A Transmission System Analysis

• Definition of control objectives, outcome criteria, feasible interventions & their dynamics & costs
• Identification of model elements needed
• Transmission system model construction
• Maximize consistency with available data
• Validity test for specific questions
  – Robustness to assumptions intrinsic to model form
  – Robustness to model conformation
  – Robustness to parameter values
Control Objectives

- Minimize mean deaths, cases, economic loss, etc.
- Minimize chances of catastrophic events
- Minimize chances that response capacities are overwhelmed
Identification of Needed Model Elements

• Alternative social units on which to focus control needed in model
• Geographic and social dimensions are essential
• Realistic contact patterns that could change analysis conclusions must be included

The biggest determinant of response choices is usually contact patterns
MTSA Model Types Permitting Transition at the Click of a Mouse

- **DC** Deterministic Compartmental: assumes infinite population size, homogeneous population groups homogeneous, instantaneous contacts, and instantaneous homogeneous mixing
- **SC** Stochastic Compartmental relaxes infinite size
- **IEH** Ind Event History relaxes homogeneous groups
- **SFN** Semi-Fixed Network: Relaxes mixing assumptions switching to universal links
- **DN** Dynamic Network: Relaxes mixing assumptions by adding duration to instantaneous links
Logistics and Resource Allocation Models

- Build on MTSA models that are Markovian and continuous time models
- Operations Research Models with Servers and Queues
  - Usually not Markovian but perhaps can be made so
- Discrete simulation good for local decision insights
- Continuous approaches good for global general insights but definitely not local insights where stochastic influenced mediated by locality dominate
Model Analysis Contributions To Preparing An Emergency Response

• Determine how good the surveillance must be

• Delineate in publications the broad principles of response using quarantine, closure, Rx, vaccine, etc
  – Extensively validate using MTSA approach to understand limitations of policy recommendations

• Study local situations to model alternative responses
  – Linked window presentation of decision boundaries to policy makers using statistical and geographic brushing
  – Validation studies for modeler use only relax assumptions using multivariate outcome topographies
Model Output That Influences Decisions

• Local decision makers find that general policy studies don’t apply to their special circumstances
• Sensitivity of transmission dynamics to contact patterns often makes this true
• Multivariate outcome topographies across multivariate parameter space can be presented using linked windows and decision boundaries
• Interactive presentation to decision maker possible using statistical model of transmission model output
Summary

- Control policy at general and local levels
- Major decisions have to do with who should receive the focus of what control efforts
- Local contact structures affect policy formulation
- A better science of infection transmission needed
- Validate of model for each use by testing sensitivity to model form, assumptions, and parameter values
- Present outcome topographies in a way that helps decision intuitions and feeling of applicability