Responding To An Infection Transmission Emergency

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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