A Simulation Model for COVID-19 Public Health Management Design and Preliminary Evaluation

Roger Clarke
Xamax Consultancy Pty Ltd, Canberra
Visiting Professor in Computer Science, ANU
Visiting Professor in Technology & Law, UNSW


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The Motivation

• During the COVID era since Mar 2020, many disciplines have mobilised to Support the Management of Public Health
  • The contributions of IT have been muted (record-keeping, very poor contact-tracing, …)
  • The contributions of the IS discipline have been very limited, almost all of it navel-gazing
  • Surely IT and IS have more to offer the world

The Nature of Public Health Management

• Population-based health protection and promotion
• Organized and directed to communities, rather than to individuals
• The Key Function:
  • Prevention and Control of Epidemics

COVID-19 Public Health Management Objectives and Constraints

• Slow the spread of the virus
• Protect particularly vulnerable sub-populations
• Ensure treatment capacity for sufferers
• Achieve sufficiently high levels of compliance
  • Work within legal constraints
  • Minimise conflict with freedoms
  • Sustain public confidence
  • Sustain the economy
Data and Information for Public Health Management

- Decision-making about public health policy depends on Information
- Information can be delivered by gathering and reporting Data, but only if it delivers value, i.e. Relevance to the Decision-Making Context
- The Context includes:
  - Individual policy-maker’s mental models
  - Multiple stakeholders’ diverse perspectives
  - Competition among values
  - A shared conception of the problem-space

Decision Support Systems (DSS) Depend on Models

- DSS:
  - Use data from operational support systems
  - Combine it with hypothetical/synthetic data
  - Enable ‘what-if’ investigations
  - Support strategic rather than tactical activities
- DSS demand clarity about models:
  - “DSS ... help decision makers utilize data and models to solve unstructured problems” (Sprague 1980, p.1)

The General Research Question

Has IT’s contribution been hampered by the absence of an ‘enterprise model’, and of ‘data models’ / ‘information architecture’?

Can we improve ROI from IT by applying insights from modelling theory and practice?

Epidemiological Modelling

- SIR / SEIR / SEIR(D) recognises few states:
  - S = Susceptible (can contract the disease)
  - E = Exposed (infected, not yet infectious)
  - I = Infective (capable of transmitting the disease)
  - R = Recovered (now immune)
  - D = Dead
- Ignores intermediate states such as quarantine, isolation, hospitalisation and ICU admission
- Fails to encompass human behavioural aspects important in disease spread and epidemic dynamics
An Appropriate Modelling Approach
Discrete-Event Simulation (DES)

- Instrumentalist / social engineering orientation
- Recognises individual Cases
- Distinguishes the cases’ possible Start-Points, States, Transitions, End-Points
- Identifies key Attributes of each case that passes through the states
- Supports Experimentation with different distributions of attribute-values
- Has architectural Flexibility and Adaptability

The Research Goal
Devise and improve a discrete-event simulation (DES) model that can assist public health management during a pandemic

Design Science Research Method

Dimensions of the Problem and the Solution
- Many strategic / controllable factors
- Far more environmental / uncontrollable factors
- Limited public health resources
- Limited legal powers to quarantine, to isolate
- Diversity of perspectives and values
- Perception of social threats to people’s lives
- Perception of economic threat to livelihoods
- Risk of mass non-compliance by the public
Public Health Policy Management Needs

- **Decision Support** for Processes that are either:
  - Consultative (group-based, leader-decided)
  - Collaborative (group-based, group-decided)
- Emergence and Revision of:
  - **Shared Understanding of Problem-Domain**
  - **Shared Terminology**
- A Model:
  - Of ‘Just-Right’ Complexity
  - With Adaptability

Model of April 2020

Alternative Means for Gathering Real-World Experience

- Case Studies (probably Retrospective)
- Field Study / Action Research (Contemporaneous)
- Monitoring of Developments Worldwide (Longitudinal)
The Primary Public Health Interventions

- Case Discovery and Management
- Facility Restrictions and Closedown
- Personal Protection
- Environmental Measures
- Physical Distancing Requirements
- Travel-Related Interventions

Behaviours Associated with Serious Failure

- Data suppression (the first few weeks in Wuhan)
- Disparagement by national leaders (USA, Brazil)
- Disregard for public health policy advice (USA)
- Denial of the efficacy of key interventions (USA)
- Support by national leaders of ‘quackery’ (USA)
- Delay in implementing constraints (Belgium, UK, Sweden)
- Inaction to attain ‘herd immunity’ (UK, Sweden)
- Weak enforcement (many countries, esp. early on)
- Premature easing (many countries, esp. after first-wave)

Actions Associated with Success

Infectee Control Measures

- Detect infectees early
- Isolate infectees immediately
- Trace close contacts fast
- Quarantine close contacts
- Closedown in/near infection hot-spots

Community-Spread Control

- Suspend large-scale events
- Suspend sustained-contact circumstances, e.g. retail

High-Risk-Segment Protection Measures

- Shield high-risk groups (aged care facilities, frontline health care staff)
- Quarantine new arrivals into the jurisdiction

Hand hygiene
- Respiratory etiquette (sneeze/cough protection)
- Avoidance of surfaces
- Face-masks – ?
- Clinical Personal Protective Equipment (PPE) in hospitals and aged-care facilities
Implications for Instrumentalist Researchers

• With 8 months' experience, model refinement was needed

• The model needs to be customised to the jurisdiction
• Many parameters are highly culturally-relative
• Many questions are analysable using the model
• Some new questions emerge from the model
• The model can be adjusted for new sub-problems (non-COVID admissions, strains with different infection profiles, specific-resource shortfalls, ‘long COVID’)

• Some quantitative experiments may pay dividends

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