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

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http://www.rogerclarke.com/EC/CVMP {.html, .pdf}

**Bled eConference – 29 June 2021**





## 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 = <u>Susceptible</u> (can contract the disease)
  - E = <u>Exposed</u> (infected, not yet infectious)
  - I = <u>Infective</u> (capable of transmitting the disease)
  - R = <u>Recovered</u> (now immune)
  - D = <u>Dead</u>
- **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**

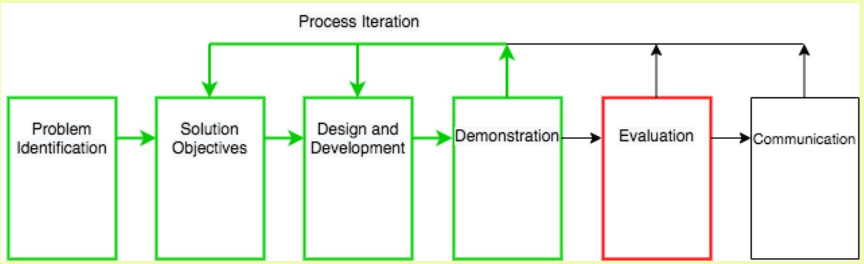



## The Research Goal

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




## Design Science Research Method




After Peffers et al. 2007




## 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

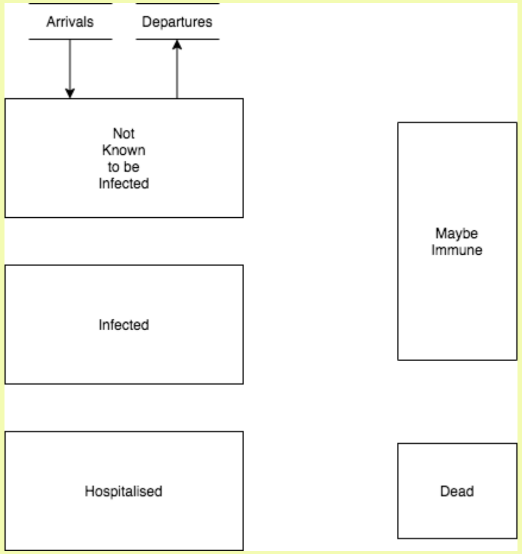
# Public Health Policy Management Needs

- **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**





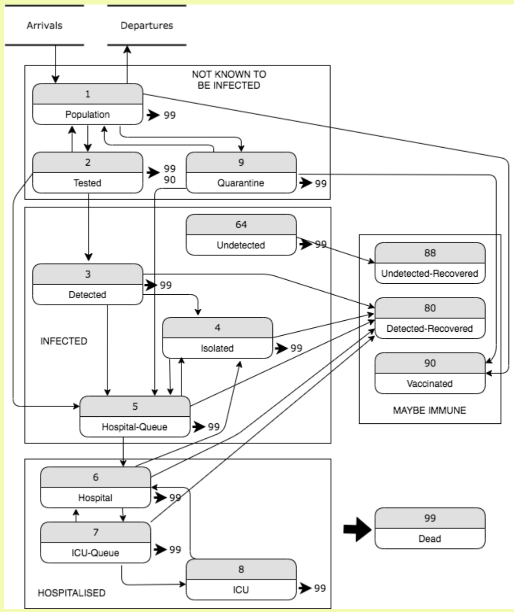
# Model of April 2020







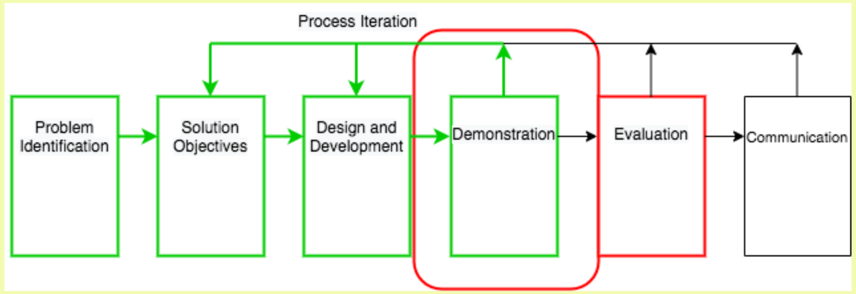

# Model of April 2020








# 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





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





## 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

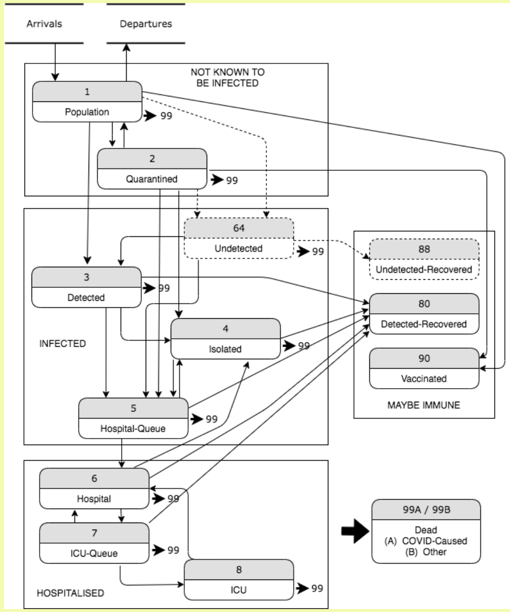
## Implications for Instrumentalist Researchers

- With 8 months' experience, model refinement was needed





## Revised Model of Early 2021








## 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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