Uncertainty in epidemiological models of the Ebola epidemic

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1918-1920 Influenza Pandemic

500 million infected. 50-100 million deaths

2014-2015 Ebola Epidemic

28 thousand infected. 11 thousand deaths
Purpose

- Describe the role played by (real-time) model-based decision support during the Ebola response
  - Mapping out the types of uncertainty confronting modelers & decision makers (highlighting “human dimensions”)

Mathematical epidemic models

- Phenomenological models (linear regression models)
- Compartmental models (Variations of SIR model)
- Network models (Agent-based models)
Reducing 3 big uncertainties

- Transmissibility of the pathogen (basic reproduction rate)
- Effectiveness of interventions
- Scope and magnitude of the outbreak
Model-based decision support: Input/Output

**INPUT**

Data

**Model**

X

Z

Y

**OUTPUT**

Scenarios, Predictions, Recommendations, Descriptions

**Decision**

A.
B.
C.

**OUTPUT**

Intervention, Policy, Strategy
**“Uncertainty Location” in model-based decision support**

Adapted from 'Uncertainty Matrix,' (Walker et al. 2003)

<table>
<thead>
<tr>
<th>Uncertainty Location</th>
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<tbody>
<tr>
<td>1. System-definition uncertainty</td>
</tr>
<tr>
<td>2. Model-structure uncertainty</td>
</tr>
<tr>
<td>3. Input uncertainty</td>
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<tr>
<td>4. Output uncertainty</td>
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</tbody>
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System-definition uncertainty

- Air travel? National borders?
- SIR vs. SEIR vs. SEIS?
- Homogenous vs. heterogeneous mixing?

Solutions:
- Test model assumptions against real-world data
- Compare to other models
Model-structure / Parameter uncertainty

- Parameter values?
- Non-linear behaviour, feedback effects?

Solutions:
- Probabilities
- Sensitivity Analysis
Input uncertainty

- Bad data
- Lack of data
- Contradictory data
- Model outputs as data inputs

Solutions:
- Better monitoring
- Information-sharing
Output uncertainty

Model

Decision

Scenarios, Predictions, Recommendations, Descriptions

A. B. C.

Solutions:
- Communicating what we know
- Communicating what we don’t know

Communication frameworks
Ambiguity / “Interaction Uncertainty”


- Normative/Value-based
  - Divergent or oppositional worldviews, values, priorities

- Epistemological
  - e.g. Frequentist vs. Bayesian perspective

- Linguistic
  - Multiple meanings, inexactness
Tools for identifying ambiguities

- Mental Modeling (Concept Mapping)
- Discourse Analysis
- Interview Data