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# Modeling Social Responses to Bioterrorism Involving Infectious Agents

by

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# 1 Introduction

On May 29-30, 2003, a meeting on “Modeling Social Responses to Bioterrorism Involving Infectious Agents” was held at DIMACS, the Center for Discrete Mathematics and Theoretical Computer Science, at Rutgers University in Piscataway, New Jersey. The aim of the meeting was to improve current models of bioterrorism events, and thereby provide better support for preparation and response policies, by incorporating relevant social dynamics. We sought to bring together a small group of interesting people with a variety of backgrounds that seem relevant to the problem and to lay the foundation for an interdisciplinary “working group” that would pursue some of the research and implementation ideas that resulted. This report summarizes the major themes at the workshop and discusses some of the recommendations that came out of it.

Models of infectious-disease epidemiology generally assume a fixed social landscape, in which the public consists of passive bystanders and rational actors who comply with health authorities. It is not clear how well this assumption applies to epidemics of any dread disease, much less ones following terrorist attacks, or the extent to which its validity depends on effective communication by authorities and cooperating media. Some analogies (e.g., Three Mile Island, AIDS or West Nile virus) suggest that episodes of mass panic or hysteria would be rare and localized, while actions based on perceived self-interest (e.g., evacuation, queries from the worried-well, antibiotic stockpiling) would be widespread. Acts of spontaneous altruism and mutual aid, as well as criminal opportunism and civil disruption, would also occur.

Insofar as changes in social behavior under stress affect the success of medical and public-health interventions, models used to design them would be improved by incorporating relevant social dimensions. The absence of formalized models of social behavior may help to explain the absence of social phenomena in models of infectious diseases or public responses to disease outbreaks. It could be that the inclusion of such phenomena is an elusive goal, however worthy. Nonetheless, this working group meeting brought together a remarkable group of experts to explore the development of inter-disciplinary methods appropriate to this task. Participants in the meeting included university researchers in the mathematical sciences (computer science, mathematics, operations research, statistics), the biological sciences (including epidemiology), the social sciences (economics, sociology, political science, anthropology) and public health, representatives of federal, state, and local agencies and national labs, and representatives of companies dealing with public health, risk communication, and emergency preparedness.

The meeting was part of the DIMACS “Special Focus” on Computational and Mathematical Epidemiology. For more information about DIMACS, see http://dimacs.rutgers.edu; for more information about the special focus, see http://dimacs.rutgers.edu/SpecialYears/2002_Epid/. A detailed program and list of meeting participants can be found at the Workshop website at http://dimacs.rutgers.edu/Workshops/Modeling/.

# 2 Themes of the Meeting

A number of presentations at the meeting dealt with human behavior observed in crises (earthquakes, hurricanes, chemical accidents, etc.). Other talks dealt with issues of how to communicate with the public both prior to and during a public health crisis. Several talks on more traditional infectious-disease modeling addressed such topics as SARS, plague, and smallpox. Several important common themes arose:

## 2.1 Modeling Public Health Decision-making

We need to connect epidemiologic models that represent a microbe and its spread through a population with models of social networks, transportation flows, etc., that represent critical processes within the population. One powerful approach would be to model the public-health/biodefense decision-making processes at the intersection. Furthermore, since these decision-makers are responsible for the analysis, communication and response that can minimize or amplify the adverse consequences of an event, they are logical consumers for these models.

In those models, we need to distinguish between what the decision-maker does and what the decision-maker should do. What are the common pitfalls? What can we learn from what decision-makers actually do in order to help them make better decisions? What do decision-makers need to understand about the interaction of social processes and disease spread – before, during, and after an event? What political and other options are open to them?

In modeling decision-making, we should also distinguish the mechanics of the process from the objectives from the alternatives:

* The mechanics of the process can be addressed through models of epidemiology, social networks, and response operations, which involve different parameters (which ones? Are there proxy effects?), and both micro-level modeling and aggregation;

* Decision-making objectives might include minimizing the time to control/eliminate the disease, minimizing casualties, minimizing the number of people affected, minimizing economic damage (how measured?), minimizing social disruption, and/or minimizing loss of freedom, and/or minimizing actual or perceived discrimination;

* The range of alternatives should be addressed last, and should include available resources, organizational structure/dynamics, and incentives. There may be temporal constraints on options, efficacy may change with time, and political realities may affect the domain of possible alternatives.

Public officials often mistake rational reactions by the public in emergency situations for panic, but experience suggests that irrational reactions may be more frequent among public officials than in the public at large. Thus official communications may lead to counterproductive feedback loops. Our models should consider the social consequences of official over-reaction and under-reaction. Model builders and model users should recognize that there are strategic objectives in public-health responses beyond disease control and these are sometimes intimately related to social responses. They include capacity to absorb disruption. Often, "individuals rise to the occasion, while organizations fail to live up to expectations." It is of critical practical importance that models capture the time lags in response, relative to the time scale of an event, that arise from decision-making processes. There is a tradeoff between speed of decision-making and accuracy of judgments. Decisions should be made quickly while maintaining credibility.

## 2.2 The Importance of Risk Communication

Risk communication is a critical concept, with rules of thumb accumulated through experience (e.g., don't use best-case scenarios in very bad situations), and having a somewhat theoretical basis. Infectious-disease agents are often invisible (vs. water, fire, etc.), so risk communication should address public uneasiness by focusing on our capacity to detect, and measure, and control them.

Guidelines for "risk communication" can be developed, keeping in mind that "communication" implies a circuit. Public health response aims to manipulate guide social response, and can elicit positive or negative responses depending on characteristics of the sender and the receiver. However, as the 1994 plague outbreak in India showed, even MDs may not react as hoped or expected. Cultural differences may be significant influences, within or between countries. Response depends both on knowledge and perception/trust and; perspective affects perception., and response.

Leaders must deliver timely, effective messages through many channels and must do so multiple times. How can we make use of redundancy in capabilities/communication channels to improve the probability of effective public response?

How leaders communicate risk is amenable to modeling. Among other things, models must consider "receiver" trust/control variables.

## 2.3 Incorporating Social Behavior into Models

Modeling social behavior is important and relevant to planning public health responses. There is a connection between social responses to public health emergencies and the impact of public-health interventions. For instance, social responses that can ameliorate or control an epidemic include decreasing personal contacts and changing the structure of the social network.

Models can be used to suggest new policies/decisions. Taking social responses into account can lead to interesting new slants on public health policy and response planning. In modeling these responses, we should distinguish between those that occur prior to an event (preventive policies, threat reduction), those that occur during an event, and those that occur after an event (including "aftershocks"). Social responses could be quite different in the three contexts, and may call for separate strategies/policies.

Social reactions to bioterrorist attacks and other emergencies may be related to degrees of perceived control and information quality as well as to the credibility of the source. Individual and community responses may also be influenced by pre-existing lines of communication between public health decision-makers and the community. Reference to models may support public perceptions of competence and candor, as with the 2001 FMD outbreak in the UK.

There is an important distinction between collective and individual action. Some collective action might be influenced by a leader. Collective actions can be predicted. Mechanisms of collective action that we might bring into our models include

* utilitarian motivation (selective incentives)
* deontic - sense of obligation (social norms)
* authority factors (a leader can order action)

## 2.4 Social Factors to be Considered

There is an important distinction between social scientists helping modelers improve their models and modelers helping social scientists test their predictions. It is also important to distinguish social-science factors as "inputs" in models from such factors as "outputs". New modeling initiatives could be conceptualized, in part, as ones in which social variables are inputs and epidemiological variables are outputs, andor vice versa.

Social responses that need to be addressed include:

* movement
* compliance (quarantine, resistance, willingness to seek and/or receive treatment, credibility of government, trust of decision-makers)
* rumor
* rationality vs. cognitive biases (risk perception is often not rational; we need to consider herd mentality and the role of emotion)
* role of the media
* role of differences in geography or social group (race, ethnicity, language, etc.)
* subcultural heterogeneity
* expected economic impacts (delivery of goods and services)
* behavior of health care professionals; individual altruism.

Specific social factors and issues that could be added to infectious disease models include:

* More accurate modeling of person-to-person interactions
* Motivations and resultant behaviors
* Economic impacts
* Social stigmata (such as discrimination against groups thought to be special spreaders of a disease)
* Loss of freedoms as a result of public health interventions
* Mental health of individuals in the face of a bioterrorist attack.
* Disruption (as opposed to destruction)

# 3 Follow-up Activities and Research Issues

Participants were open and amenable to interdisciplinary collaborations that would bring social-scientific research into epidemiological modeling and aid public health decision-making, in particular in a biodefense context. There was considerable enthusiasm for follow-up activities. Much has been learned in the past 50 years in the experimental social sciences (e.g., prospect theory). Models (quantitative and otherwise) that utilize this knowledge are lagging, however, and are critical. Some of the suggestions that came out of the meeting were the following. They could be developed through future meetings, interdisciplinary research groups, or research projects.

## 3.1 Compiling Results of Previous Research

Results of previous research on social responses to epidemics and to other possible surrogates for bioterrorism events, such as natural disasters and industrial accidents, should be compiled and made more readily accessible to modelers and other researchers.

## 3.2 Developing Useful Examples, Scenarios, and Model Problems

Examples should be developed, in case-study, scenario, and then model form. For instance (based on recent experience), suppose a network of sensors is in place in a major metropolitan area, and gives a positive reading: now what happens? How will the chain of decision-makers respond? How will the public respond to a false positive? How bad will the consequences of a missed/delayed reading be?

## 3.3 Post-graduate Training

Multidisciplinary postdoctoral fellowships would introduce a variety of researchers and public health professionals to the issues involved. Sabbatical or mid-career retraining could serve the same purpose.

## 3.4 Educating Decision-makers about Modeling

Decision-makers need to be educated about modeling:

* What models can and cannot do
* use and abuse of models (e.g., the numbers are not absolute)
* models as communication tools. This is especially important relative to models that bring in social-science factors.
* Schematic graphical methods or pictures are often more useful to convey the results of modeling/analysis to a decision-maker. The right picture is worth 1000 words (or p-values).

## 3.5 Finding Precise Definitions of Social-scientific Concepts

An important research task is to find precise and useful definitions and ways to measure social-scientific concepts such as

* panic
* peer presure
* motivation
* behavior responses
* economic impact
* social stigmatization
* mental health
* social disruption
* economic disruption
* capacity to absorb disruption

## 3.6 Modeling Approaches

* Models should move from description to theory-driven approaches. For instance, can we make precise "leakage" from quarantine, and its causes and effects?
* Models should be designed in modular form where possible, to be more easily interconnected.
* Game-theoretic approaches, so relevant to economics, military decision-making, and societal decision-making (voting, group choice) should be explored.
* It is also worthwhile to explore similarities with financial modeling (e.g., modeling responses to seemingly irrational behavior in markets, modeling "shocks", and "behavior finance")