Cornell Conference on Emergency Response Logistics
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Overview of Presentations with Annotations on Modeling Methodology & Content

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Dear Conference attendees:
We want to extend a very big "Thank you" to all who attended, especially those who trekked across the country/continent for the meeting. We have given an informal capsule summary of each presentation below.

In addition, we have added our initial impression of four features of the models discussed:

- **the modeling methodology used (e.g., discrete event vs. agent-based simulation, dynamic programming, etc.)**
- **the setting (e.g., hospital, pre-hospital, community)**
- **the general content area (e.g., epidemiological model, public health response logistics, etc.)**
- **and the model type, which may be either**
  - ***strategic* (e.g., how does the system currently function)**
  - ***tactical* (e.g., if I were to do X or Y how would the system respond)**
  - **or *real-time command and control*.**

We are sure that there are errors in these characterizations, and we welcome corrections by the model authors/presenters!

DAY 1

1a. Aaron Bair, MD, ***Computer modeling of emergency medical services***

Aaron introduced his simulation model of emergency department activity, EDSIM 2.12, which contains over 12,500 hierarchical computational modules representative of UC-Davis Medical Center Emergency Department [see Connelly LG and Bair A, Discrete Event Simulation of Emergency Department Activity: A Platform for System-level Operations Research", http://www.aemj.org/cgi/reprint/11/11/1177.pdf]. The model features stochastic inputs for clinical activity such as lab turnaround times derived from an extensive review of over 3000 representative patients drawn from a UCDMC ED cohort. Aaron and his colleagues have used the model to examine various triage strategies, nurse allocation strategies during shortages, impact of crowding on quality of care. He is now working with colleagues both in and out of UC-D to develop hospital-wide and regional models of care.

Method:	discrete event simulation
Setting:	hospital
Content:	routine and emergency hospital activities
Type:	strategic

1b. Lynn Yang, ***Pandemic influenza surge modeling project***

Lynn introduced the Sandia Livermore BioDAC model, a simulation environment that allows public health planners to play through a biological attack scenario in order to determine impact of response strategies. The simulation incorporates information on disease agent and atmospheric spread, population density, environmental sampling, and both civilian and military response. The BioDAC has driven exercises to help stakeholders understand system performance and consequences of actions taken [see http://www.sandia.gov/news-center/news-releases/2002/gen-science/antiterror.html].

Method:	difference equation and discrete event simulation
Setting:	community, public health, hospital
Content:	mass prophylaxis and hospital-based care
Type:	strategic and tactical

Lynn also introduced a new project funded by the State of California, ‘Pandemic Influenza Surge Model for Health Care Planning and Response,’ which will involve contributions from BioDAC, the UCDMD model, and Cornell University.

Method:	difference equation, discrete event simulation, queuing theory
Setting:	community, public health, hospital
Content:	mass prophylaxis and hospital-based care
Type:	strategic and tactical

2. Irene Eckstrand, PhD, ***Modeling consortia: The MIDAS experience***

Irene introduced the MIDAS (Modeling Infectious Disease Agent Study) Consortium by demonstrating, through a discussion of phylogenetic, ecological, and other linkages, that networks are critical to understanding living things, from viruses to humans. Standard Susceptible Infected Recovered (SIR) models are insufficient to capture disease progression through communities because they fail to take into account the underlying network that describes how humans interact on a routine basis. Agent based models move individual agents from one "container" to another according to their schedules. Variants include "gravity models" that track demand and location of patients and activity models that map where a patient may be going over time. To model disease spread in this context one needs to know:
Natural history
Characteristics of pathogen, vector, host
Major contexts of transmission
Census demographics
Synthetic, historical and molecular data
Quality and timeliness of surveillance
Population dynamics
Genetic variation and evolution
Effects of specific control measures
Efficacy and logistic constraints on control measures
Climate and environmental context

The MIDAS models, funded by the National Institute of General Medical Sciences, address epidemiological questions ("Where will the virus spread next?") policy questions ("Is there anything that can be done to prevent the local spread of H5N1?"), and investment questions, ("Since vaccines will probably be unavailable and prophylactic antivirals will have a greater impact on transmission, how much should we purchase?"). Having multiple modeling teams has permitted extensive cross-verification of model outputs, but the issues of validation for such complex model are daunting [see https://www.epimodels.org/midas/about.do].

Method:	agent-based simulation
Setting:	community, public health
Content:	disease transmission
Type:	strategic

3. Eva Lee, PhD, ***Optimization modeling of health facilities***

Eva described the RealOpt© optimization and simulation model that she developed with researchers from GIT and the Centers for Disease Control and Prevention. The goal of this project was to develop a model to rapidly assess labor and resource requirements for setting up emergency response Points of Dispensing (PODs). Field tests showed the need for on-the-fly analysis, but optimization software available was too slow to accommodate this. Major RealOpt© capabilities include: an intelligent graphical tool to design custom floor plans for POD with minimal crossed paths; the ability to determine optimal labor resources required and their most efficient placement; a graphical tool for optimal POD placement to address either population distribution or overall time constraints; and the ability to perform disease propagation analysis and derive dynamic response strategies.

Dekalb County, which used RealOpt for an exercise, was more efficient than other counties using different models. This was due to minimizing the amount of time spent getting patients to dispensing points, as well as the more efficient floor plans of the facilities, which were laid out in order to minimize crossing paths [see http://www.gatech.edu/news-room/release.php?id=458].

Method:	graph and network optimization, simulation
Setting:	public health
Content:	mass prophylaxis
Type:	tactical

4. Margret Brandeau, PhD, ***Modeling disease interventions for anthrax***

Margaret described a dynamic compartment model developed at Stanford to investigate the logistics of local versus national materiel caches—specifically antibiotic stockpiles for defense against bioterrorism attacks—from the perspective of efficiency and maximal population protection. The surprising finding from the model is that the willingness and ability of the public to access PODs is one of the crucial limiting factors in any large-scale mass prophylaxis campaign [see http://www.liebertonline.com/doi/abs/10.1089/bsp.2006.4.244].

Creating this model involved extensive evidence reviews of national and regional supply chains for critical materiel, development of disease progression models based on original case record reviews, and application of model-based results to consider alternative policies. Users can calculate outcomes (deaths, queue lengths, etc) for any given policy, calculate the cost effectiveness of alternative policies, and evaluate the effects of a given policy under different sets of assumptions. Future extensions may include incorporation of other elements of the supply chain and application to other agents aside from anthrax.

Method:	difference equation
Setting:	community, public health, and hospital
Content:	mass prophylaxis and emergency hospital activities
Type:	strategic and tactical

5. Michael Samsa & Matt Berry, ***Modeling logistics systems for public health***

Michael and Matt presented three models developed and/or enhanced at Argonne National Labs for emergency response logistics. Michael presented the ELIST:

Enhanced Logistics Intra- Theater Support Tool (originally created by the Department of Defense) and the RESTORE models. ELIST is a simulation model that solves routing problems on road networks of changeable configurations. It addresses the following questions::
Will force/supply arrive on time?
Is there sufficient infrastructure?
Have enough assets been assigned and properly allocated?
What are the potential bottlenecks that could cause a problem?
What are the alternative logistic solutions?

The model requires inputs of sets of personnel and material and specification of what, where and when things are required and how they might be delivered (e.g. a road map) [see http://www.dis.anl.gov/msv/elist.html and http://www.dis.anl.gov/msv/documents/ELIST%20brochure%204%2013%2007.pdf]. RESTORE models the dependencies for repairing damaged infrastructure.

Method:	simulation
Setting:	community, public health, and hospital
Content:	logistics
Type:	tactical

Matt presented the Community Vaccination Mass Dispensing Model (CVMDM), which predicts the impact of a mass dispensing campaign upon an entire population given supply chain and mass dispensing constraints. This was built using a system dynamics core and an SEIR disease model to explore the attainability of a set deadline for coverage and to determine the most effective allocation of personnel and logistical resources required.

Method:	discrete time simulation (system dynamics model)
Setting:	community, public health, and hospital
Content:	mass prophylaxis and emergency hospital activities
Type:	strategic and tactical

DAY 2

6. Rocco Casagrande, PhD, ***Realistic consequence modeling***

Rocco described a number of varied projects that he and his colleagues have undertaken for a variety of Federal partners, most of which revolve around determining the number of expected casualties caused by a biological attack given a range of response parameters (Project Aaron), modeling the functioning of disease surveillance systems (Project Exodus), and creating casualty-generation models for a variety of natural and terrorism-related scenarios (AHRQ Surge Model). He described the process of deriving and implementing dose-effect relationship for events ranging from anthrax attacks to nuclear blasts, tracking people and buildings, atmospheric transportation models, chemical physics data, prophylaxis efficacy, and a number of other factors. Rocco demonstrated how he uses Google Earth to determine building sizes, population densities, and cars on the street (in conjunction with city data on traffic throughput). All of these factors determine the number of casualties generated by a particular type of attack. Finally, he described a "modeling to improve modeling" study that he has undertaken to improve the estimation of microbe decay during hypothetical aerosol attacks [see http://gryphonscientific.com/fieldsofinterest/homelandsecurity/homelandsecurity.html].

Methods:	spreadsheet modeling and difference equations
Setting:	community and public health
Content:	agent characteristics, physiology, atmospheric effects
Type:	strategic

6. Silas Smith, MD, ***Agent-based modeling of health systems***

Silas described the PLAN-C model (Planning responses to Catastrophes) of the NYU Center for Catastrophe Preparedness and Response, which uses an agent-based simulation developed in concert with their mathematics colleagues at the Courant Institute. They have created a number of response scenarios including a spill simulation that gives a concentration over time of various aerosols as well as statistics about human behavior (e.g., which direction people will run after an emergency) and a dose response curve to determine patient outcomes. The model includes both emergency department and full hospital patient treatment modules and can model different agent-generated arrival rates to different hospitals over time. The model can be manipulated to change transportation and treatment capacity and outputs like mortality can be matched to processes and occupancy [see www.bioinformatics.nyu.edu/Projects/planc and http://cs.nyu.edu/mishra/PUBLICATIONS/07.Holomas.pdf].

Methods:	agent-based simulation
Setting:	community, public health, and hospital
Content:	mass patient movement, mass prophylaxis, hospital activity
Type:	strategic and tactical

7. Shane Henderson, PhD, ***Optimization modeling of health transportation***

Shane brought the audience up to date on the use of dynamic programming approaches to improve the placement and re-deployment of emergency service vehicles in real time. He described the use of a set covering formulation to determine where ambulances should be repositioned when an ambulance is on a run, admitting that existing static allocation models are hard to beat. Still, motivated in part by the ambulance system in Auckland, where utilization was very high and congestion and routing is a major problem, Shane and others, including Armann Ingolfsson, who was in the audience, have tried a number of approaches to achieve improved dynamic relocation using integer programming, nesting heuristics, and approximate value dynamic programming. [See http://portal.acm.org/citation.cfm?id=324898.325361]

Methods:	integer and approximate value dynamic programming
Setting:	emergency medical services
Content:	vehicle location
Type:	tactical and real-time command and control

8. Ed Chan, PhD, ***Evaluation of public health models***

Ed described his work at RAND, carried out for the CDC (represented by Bernard Benake in the audience) evaluating three models for POD activity, RealOpt©, the Weill Cornell BERM model, and the University of Maryland Clinic Planner. Ed described the process of developing quality and operational standards for POD activities in order to support planning and accountability, and noted that models must be designed to match the ability of public health practitioners to use them. Ed joked that the choice of the model didn't matter as much as the way that the use of the model fits the needs of the user and the limitations of the modeling approach [see http://www.rand.org/pubs/working_papers/WR455/].

Methods:	verification and validation
Setting:	public health
Content:	mass prophylaxis
Type:	strategic and tactical

9. Nathaniel Hupert, MD, MPH, Jack Muckstadt, PhD, David Murray, PhD, ***Integration of public health models for health system preparedness***

Nathaniel briefly described the history of public health modeling at Cornell, ranging from mass prophylaxis (the Bioterrorism and Epidemic Response Model, BERM) to hospital inventory and workforce protection modeling. He focused on the current AHRQ Surge Model project, for which he collaborated with content experts at DHHS to develop a detailed resource consumption model for hospital-based care of pandemic influenza patients. Jack described the long-term objective of the combined Weill Cornell Medical/Cornell University Operations Research activities, namely the creation of an integrated response logistics model that would span scenario selection, casualty generation, community and public health activities, and hospital-based activities. A major obstacle to creating this type of model is access to data on condition-specific resource consumption and length of stay for hospitalized patients. David then demonstrated the latest version of the integrated model, which is a data-driven simulation running in a Windows environment. The future model will be run on a large-scale cluster at Intel Corp.

Methods:	discrete event simulation
Setting:	public health and hospital
Content:	mass prophylaxis and routine and emergency hospital activity
Type:	strategic and tactical

Questions and Comments

We ended the conference with a series of questions about obstacle and recommended next steps, to which the attendees responded in small groups. The results are highlighted below:

Critical questions regarding modeling:

1. Accuracy and availability of data
2. Resolution of the model—what is the best balance of applicability vs. fidelity to reality?
3. Should models be particular to certain environments or locales?
4. How do we convey the importance of a model to other health care professionals?
5. Should models be aimed at operations or training?
6. How can we better model the effectiveness of public risk communication strategies and education strategies?
7. Can we better model behavior of patients and first responders? What behaviors are important enough to warrant modeling?
8.

Thoughts about data/model sharing:

1. Develop a web page as a repository for models, publications, and expertise
2. Use such a site to identify what data we need as a group? Then develop a strategy for working together to collect this data

Thoughts about modeling standards/conventions:

1. Can/should we develop standards for models: in interfaces, in data?
2. Can/should we develop a stamp of approval so that the community at large knows the model has been certified by a qualified group?
3. How do we address other modeling groups (e.g., JHU PACER group, http://www.pacercenter.org/

Thoughts about dissemination:

1. Create a listserv
2. Develop an edited volume of data/papers/models for distribution to the group.
3. Have an annual meeting, perhaps in a different venue, involving broader audience (social scientists, public health officials, logisticians)
4. Create a public health logistics modeling consortium modeled on others (e.g., MIDAS, CISNET)

Thoughts about funding sources:

1. DHHS
    - AHRQ, NIH/NIGMS, ASPR
2. DHS
3. DoD
4. NSF
5. National Supercomputing Center
6. Industry
    - Pharma
    - Logistics
        - WalMart
    - Tech
    - BENS
        - Business executives for national security

Possibilities for education:

1. Undergraduate and graduate programs
2. Executive or continuing education style training programs
3. Training programs for public health workforce