Issue Brief
No. 10

Bioterrorism
and Health System Preparedness

Mass Prophylaxis: Building Blocks for Community Preparedness

The Agency for Healthcare Research and Quality (AHRQ) is the lead agency charged with supporting research designed to improve the quality of health care, reduce its cost, address patient safety and medical errors, and broaden access to essential services. AHRQ sponsors and conducts research that provides evidence-based information on health care outcomes; quality; and cost, use, and access. The information helps health care decisionmakers—patients and clinicians, health system leaders, and policymakers—make more informed decisions and improve the quality of health care services.

In the event of a bioterrorist attack or the outbreak of a naturally occurring disease, communities may be faced with the need to administer mass prophylaxis to their citizens. The goal will be twofold: to administer the appropriate antibiotic or vaccine to everyone who needs it in time to protect them from becoming infected, and to limit hospital admissions to those who are symptomatic and in need of treatment. Developing the capability for such a response is a major challenge for local health systems and for the communities they serve.

Background

Over the past 5 years, the Agency for Healthcare Research and Quality (AHRQ) has funded five projects conducted by the Weill Medical College of Cornell University to provide tools that local planners can use to prepare their communities for mass prophylaxis. The first project was the development under an AHRQ contract of a computer simulation model for planning a city-wide response to a bioterrorist attack. Four additional products have grown or are growing out of that original model:

- *Community-Based Mass Prophylaxis: A Planning Guide for Public Health Preparedness*
- *Bioterrorism and Epidemic Outbreak Response Model (BERM)*
- *Regional Hospital Caseload Calculator (RHCC) Model*
- *Modeling the U.S. Health System's Epidemic Response Capacity*

The *Planning Guide* explains the components that a community must have in place to prepare for mass prophylaxis. *BERM*, a companion piece to the *Planning Guide*, is an interactive database for planners to calculate the number of facilities and staff they will need in their communities to administer mass prophylaxis. The *Regional Hospital Caseload Calculator* starts with a given community's capability to administer mass prophylaxis and computes, on a daily basis, the number of people who can be reached with prophylaxis and the number of people who will become ill

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and require hospitalization. The project that is currently underway, *Modeling the U.S. Health System's Epidemic Response Capacity*, will start with the capability to administer mass prophylaxis, add local hospital bed capacity, and calculate pre-hospital response, hospital-based response, and the need for assistance from outside the region. Taken together, these four tools constitute the building blocks for community preparedness for mass prophylaxis.

Community-Based Mass Prophylaxis: A Planning Guide for Public Health Preparedness

The cornerstone of the Weill/Cornell research on building community preparedness for mass prophylaxis is *Community-Based Mass Prophylaxis: A Planning Guide for Public Health Preparedness*. Local officials—including policymakers, public health and emergency management planners, and non-public health emergency response professionals—can use the *Planning Guide* to determine how mass prophylaxis fits into emergency planning and what resources are needed to make mass prophylaxis work. The *Guide* is also of interest to State and Federal government officials and members of industry, academia, the media, and non-governmental organizations, all of whom play roles in supporting the response to public health emergencies.

The *Planning Guide* has four sections, each for a different audience. "Section One: Overview of Mass Prophylaxis" is directed to a general audience, including policymakers. It explains the "who, what, where, when, and how" of planning for mass prophylaxis. Actual administration of prophylaxis will be conducted in Dispensing/Vaccination Centers or Clinics (DVCs). "Section Two: Fundamentals of DVC Design" and "Section Three: Examples of Antibiotic Dispensing and Vaccination Clinic Plans" are directed to public health and emergency management planners who will be responsible for establishing and operating DVCs. "Section Four: Clinic Management/Command Structure" is directed to non-public health emergency response professionals who will be involved in coordinating response following the guidelines of the National Incident Management System (NIMS).

Section One: Overview of Mass Prophylaxis

Effective public health response to a bioterrorist attack or a natural disease outbreak depends on four factors:

- Recognition of the outbreak.
- Rapid mobilization of resources to the affected area.
- Dispensing of antibiotics or vaccines to the affected population.
- Follow-up with patients to confirm that the intervention has been appropriate and effective.

In the past 5 years the Federal government has taken steps to increase capacity for response to disease outbreak. The Centers for Disease Control and Prevention (CDC) operates a number of mechanisms to facilitate recognition. CDC also manages the Strategic National Stockpile, which contains medical supplies that can be deployed rapidly to treat thousands of patients who might be affected. The Federal Emergency Management Agency (FEMA) in the Department of Homeland Security manages the National Disaster Medical System, which was established to provide rapid response capability. All of these Federal assets, however, are intended to supplement, not supplant, comprehensive local planning and operations for mass prophylaxis.

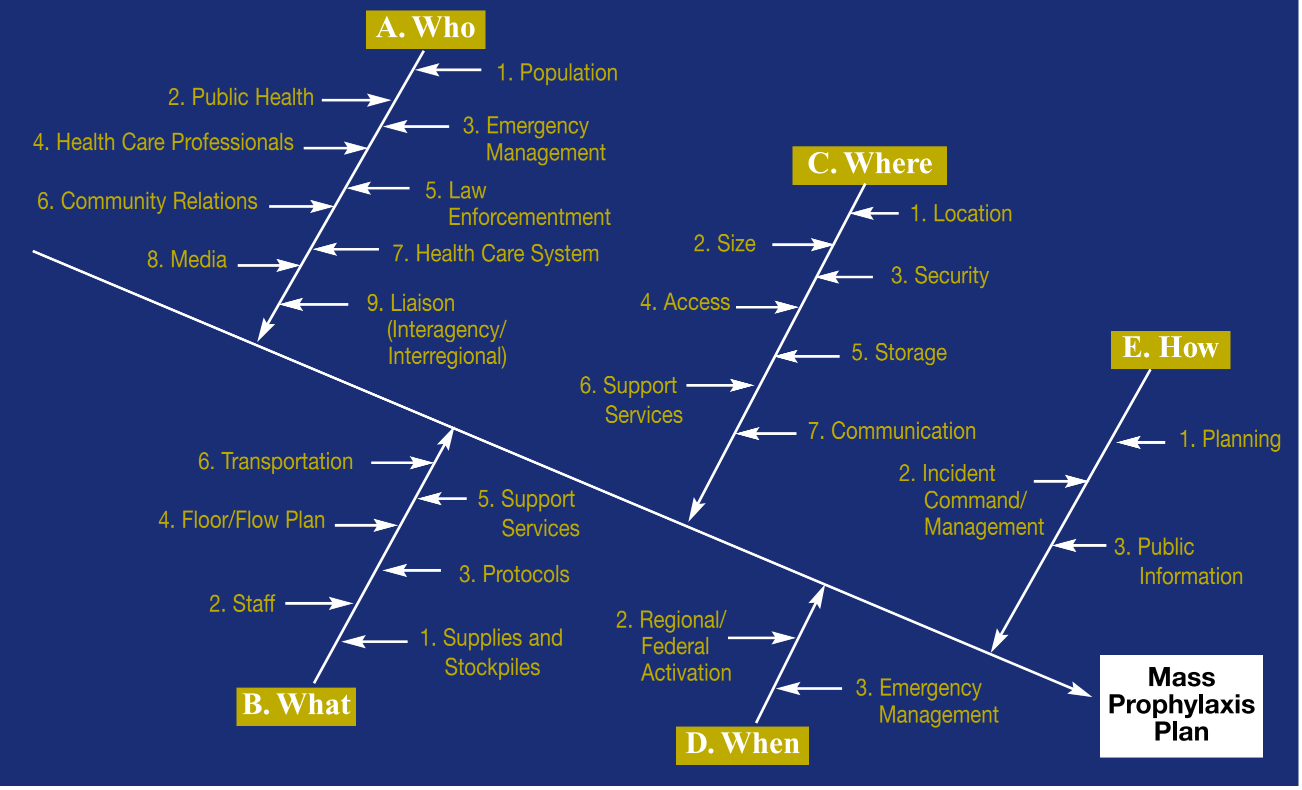
The *Planning Guide* explains how the local community can prepare for mass prophylaxis. Figure 1 displays the "who, what, where, when and how" that comprise the elements—including DVCs—of a local mass prophylaxis plan.

The "who" includes, of course, health care professionals and officials from public health and local health care systems. But planning must start with an understanding of the community's population, taking into consideration such factors as population density and whether translation services will be needed. Law enforcement officers will be needed to maintain public order at DVC sites, guard the medical stockpile, and conduct a criminal investigation if the disease outbreak is the result of an attack. Emergency management officials will be needed to coordinate response, including liaison with the local media to ensure that the information disseminated is accurate and consistent.

The "what" includes generic office and medical supplies and easily overlooked items such as coolers for the medication and tables and chairs for staff. Transportation must be considered, both to deliver supplies to the DVCs and to transport those who need medical attention to health care facilities.

The "where" includes location of the DVCs in relation to population density

Figure 1 **Elements of a Local Mass Prophylaxis Plan**



and access to transportation. In addition, DVCs will require physical facilities with a certain amount of space, storage capability, and water and electrical supplies.

The "when" may be a local decision, or the activation may come from regional, State, or Federal authorities. Even if activation is triggered at higher levels of government, however, DVC deployment and operation will remain under local control.

The "how" is centered on incident command and management.

Section Two: Fundamentals of DVC Design

This section is directed to public health and emergency management planners, who will be responsible for determining how many DVCs will be necessary for their community and how any personnel will be needed to staff those Centers. The section explains the concept of DVC operations, discusses patient flow through the DVC, and presents an overview of a method for estimating clinic and staff numbers.

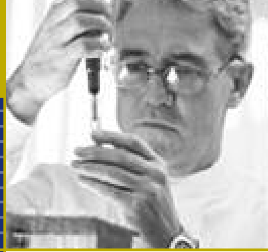
DVC Operations. DVCs are intended to dispense large volumes of medications or vaccines to protect people before they become infected and to identify those who are symptomatic and in need of hospitalization. The concept of DVC operations is explained in terms of core functions and support functions. Core functions (called "operations" in incident management terminology), with a few exceptions, directly facilitate the dispensing of drugs and vaccines. Core functions include:

- Greeting
- Form distribution
- Triage
- Medical evaluation
- Transportation assistance
- Mental health evaluation
- Briefing
- Drug triage (pharmacotherapeutic evaluation)
- Dispensing or vaccination
- Form collection and exit

The number of functions that are actually performed depends upon patient flow requirements.

Support functions (called "logistics" in incident management terminology) include:

- Drug/vaccine inventory, preparation, and/or resupply



- Patient traffic directors
- Data entry
- Translation services
- Communications/information technology support
- Food service
- Facilities maintenance
- Security
- Managers

Again, the number of functions that are actually performed will depend on the situation.

DVC Design. The *Guide* recommends that planners develop a single generic DVC design, including floor plan and patient flow plan, for use throughout their communities. The design will depend on local needs, including population size, staff resources, and response time. Six patient flow plans are discussed, from basic to complex. Figure 2 shows the basic high-flow model with entry screening. This floor plan was used in Operation TriPOD, a high-flow antibiotic dispensing exercise in New York City in May 2002, and attained patient flow rates of more than 1,000 per hour. The *Guide* also discusses potential bottlenecks in patient flow and provides recommendations on both how to prevent them and how to respond to them.

Number of DVCs and Staff. Planners can determine the number of DVCs they will use for a mass prophylaxis campaign in one of three ways:

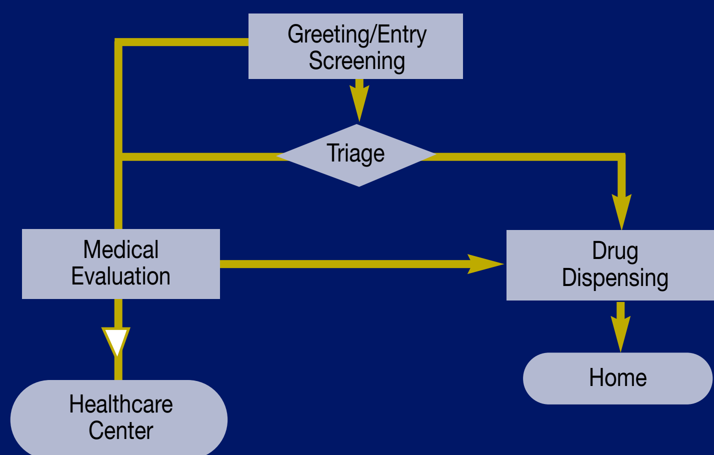
- Based on the total number of sites available in the community.
- Deciding on the number of staff needed to operate a center.
- Estimating the maximum patient flow rate at a standard DVC.

Each has advantages and disadvantages. The *Guide* provides formulas and explains calculations for estimates of patient flow rates per DVC and community-wide.

To determine the number of personnel needed to staff a DVC, planners are referred to the *Bioterrorism and Epidemic Outbreak Response Model (BERM)*, the automated spreadsheet that is the companion piece to the *Planning Guide*. (See p. 5)

Figure 2

High-Flow with Entry Screening



Section Three: From Principles to Practice: Examples of Antibiotic Dispensing and Vaccination Clinic Plans

Section three explains the procedures to be followed for antibiotic dispensing and vaccination. Procedures are explained in the context of what needs to be accomplished (the objectives of mass prophylaxis) and are accompanied by model flow charts.

Mass antibiotic prophylaxis would be needed for outbreaks of disease caused by any of the three bacterial pathogens on the CDC list of Category A agents: anthrax, plague, or tularemia. The most important goal in antibiotic dispensing is to get the correct antibiotic to the correct patient in the shortest amount of time.

The procedures to be followed for vaccination are more complex than for antibiotic dispensing, so more stations and staff are required in each DVC.

The *Planning Guide* explains those complexities and provides detailed guidance on the procedures for smallpox vaccination.

Section Four: Clinic Management/Command Structure

A bioterrorism event or infectious disease outbreak could result in mass casualties that would require the use of local, State, and Federal medical stockpiles; coordination of multiple local, State, and Federal agencies, including law enforcement and public health; and outreach to the local community for prophylaxis and treatment. Thus, the response to such

an event epitomizes the type of complex, multi-jurisdictional operation for which NIMS has been designed. As the primary point of contact for prophylaxis and treatment, DVCs are a critical part of the larger response. DVC operations must, therefore, have a clearly defined command structure that integrates seamlessly into the broader command structure. The *Planning Guide* shows non-public health emergency response professionals how that can be done.

For public health planners, the *Planning Guide* explains how the DVC, command structure should be organized using the titles and terminology of incident command. The *Guide* describes the responsibilities of all command staff positions (which are separate from the core and support functions described in Section Two) and lays out the requirements for a DVC operational guide, or "site action plan."

The Importance of Modeling

The *Planning Guide* describes the component parts of a community mass prophylaxis plan and how those parts fit together and function. The subsequent three Weill/Cornell projects are computer models that generate concrete numbers to use in planning.

The value of modeling is to help planners question their common assumptions about what it would take to respond to a large mass casualty incident. Modeling permits analysis of the variables involved (time, numbers of patients, resources available, etc.) in quantitative terms so that planners can work with concrete numbers as they develop and modify their strategies.

The Bioterrorism and Epidemic Outbreak Response Model (BERM)

BERM is an interactive computer model that allows users to develop realistic plans for their local jurisdictions in response to a bioterrorism event or epidemic outbreak. Users enter their working assumptions on such variables as the size of the population to be treated, the duration of the campaign, and how quickly they can process patients. The model then generates data on how many dispensing stations will be needed and how many core staff and support staff will be needed in each station.

Section One: Inputs

Section one, allows the user to enter data based on specific local needs and resources. Basic data fields include the size of the population to be treated and the number of days the prophylaxis campaign will last, plus the number of hours per day the clinics will be open and how many shifts will be needed. More complicated data fields are as follows:

- **Patient flow**—The single most important number for the model is the patient flow rate. If the user knows the anticipated per-clinic flow rate, that number can be entered. Alternatively, the model can calculate the flow rate based on the number, size, and duration of mandatory briefings for all patients passing through the clinic. This calculation is based on the fact that the flow rate through the entire clinic cannot exceed the rate at which patients are briefed.
- **Clinic layout**—The model performs calculations for response to a communicable or non-communicable agent. If planning is for a communicable disease such as smallpox, the user can choose whether to include two possible optional stations: crisis/isolation counseling (which would require adding mental health staff) and testing (which would require additional staff to test for pregnancy, HIV, etc.)
- **Process times**—The user can select one of three predetermined sets of process time estimates: "Baseline" (representing averages based partly on data from live, large-scale dispensing exercises in the United States over the last two years), "slow" (slower than "baseline"), or "fast" (best-case scenarios). For example, the "baseline" time estimate for vaccination is 2 minutes, for "slow" it is 3 minutes, and for "fast," 1 minute.
- **Event characteristics**—After selecting for a communicable or noncommunicable agent, the user can select from one of three possible event scenarios:
  - Pre-event, in which the prophylaxis campaign would operate prior to the occurrence of any illness from the target biological agent;
  - Small-scale event, in which the campaign would operate in response to a small-scale bioterrorist event or outbreak (defined as 5-10 percent of the population who present to clinics having been exposed);
  - Large-scale event, in which the campaign would operate in response to a large-scale

bioterrorist event or outbreak (defined as 10-20 percent of the population who present to clinics having been exposed).

For example, the percentage of patients requesting crisis counseling at a vaccination clinic is estimated at 5 percent in a pre-event scenario, 10 percent in a small-scale event, and 15 percent in a large-scale event. These percentages have obvious staffing implications.

The final part of section one, "User Inputs," provides a summary of the values the user has entered. The user then returns to the "Table of Contents" page and proceeds section by section to see the results calculated by the model, enter additional information for more detailed calculations, and get a complete picture of requirements for the local prophylaxis response plan.

Section Two: Overall Model Outputs

Basic outputs include the number of clinics required, the number of core staff for each clinic, and the total number of core staff for all clinics.

Section Three: Station-Specific Staffing

Presents station-by-station estimates of the optimal number of core staff needed to operate each clinic. If there is a local limit on the total core staff size per clinic, the user can enter the maximum number of core staff that can be expected. *BERM* will then re-calculate the number of staff per station.

Section Four: Support Staff Calculations

The first part of this section lists critical support staff functions and the recommended number of staff for each function. Recommended numbers are presented as a range, based on a ratio of either core staff to support staff or patient flow to support staff. After the user selects the ratio appropriate for the local site, *BERM* calculates the number of support staff needed per site per shift, plus the total number of support staff per clinic per shift and for the entire campaign.

Section Five: Summary of Model Results

The model calculates a summary of estimated core and support staffing requirements per clinic and for the entire campaign.

Section Six: Campaign Modifications Due to Limited Staff

All calculations generated by the model produce optimum numbers. Section six allows the user to see how much of the optimum can be accomplished with the actual number of available staff. A limited number of core staff may force a decrease in the number of people who can be processed or an increase in the time required to process an entire population.

At any point in this process, the user can change values. The model will recalculate accordingly.

A final option for *BERM* users is to calculate estimates of recommended per-clinic and campaign-wide core staff and support staff based on user inputs.

However, instead of using the pre-set process times (baseline, slow, or fast) and the event scenarios (pre-event, small-scale, or large-scale) from Section One, the user can enter each process time and population proportion individually. *BERM* will perform these calculations based on the customized data that have been entered by the user. Thus, the "customizable staffing model" offers more flexibility but requires more inputs.

The Regional Hospital Caseload Calculator (RHCC) Model

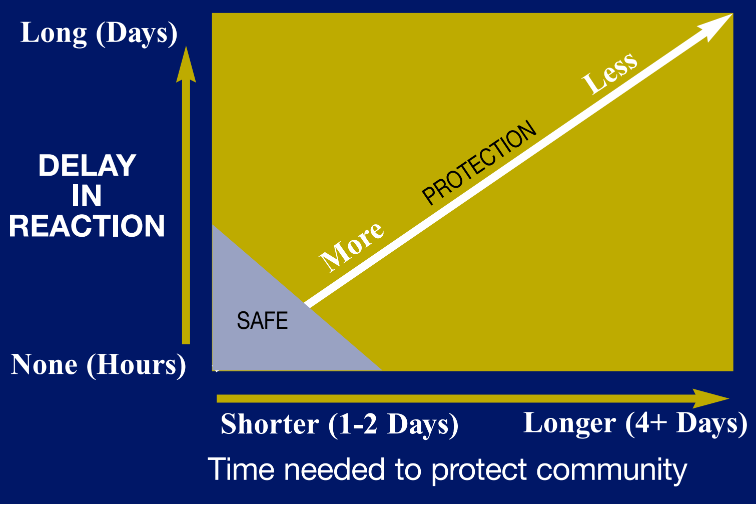
While *BERM* calculates staff resources that will be needed for a mass prophylaxis campaign, the *Regional Hospital Caseload Calculator (RHCC)* model calculates the proportion of the population that can be reached by that campaign and, consequently, the proportion that will need to be treated in the hospital system.

The basic concept of the *RHCC* model is presented in Figure 3. This illustration of pre-hospital capacity was developed by Dr. Nathaniel Hupert, the principal investigator for development of the Weill/Cornell models, and his colleagues. The figure shows that *degree of protection* is a function of how long it takes the community to respond to the attack or outbreak *(delay in reaction)* and the time required to administer medication to the affected population *(time needed to protect community)*.

Dr. Hupert and his colleagues have translated this concept into the *RHCC* model. The formulas in the model start with consensus estimates about the biological agent and incorporate a set of assumptions about detection, effectiveness of treatment, and patient compliance with medication. The type of agent, the speed with which a prophylaxis response is initiated once an outbreak has been identified, and the maximum population that the campaign can protect when operating at full capacity all have an impact on the number of people who become

Figure 3

Modeling Pre-Hospital Capacity



symptomatic and require hospital care. The model allows for daily changing probabilities of becoming symptomatic or receiving prophylaxis and calculates the changing proportion of the population that is symptomatic and requires hospital resources as each day of the epidemic passes. Thus, the model illustrates the importance of pre-hospital treatment in reducing hospital surge. Applied differently, the model also predicts when surge is most likely to occur.

The *RHCC* model is currently configured to calculate outcomes for anthrax, bubonic plague, tularemia, or pandemic flu. It requires only six inputs, which may be actual or hypothetical:

- Total population/community size.
- Number of people exposed to the pathogen.
- Percentage of exposed people who will develop symptoms if not treated.
- Number of days following the attack the prophylaxis campaign can begin (0-10).
- Number of days from start of campaign to reach maximum prophylaxis capacity.
- Maximum number of people to whom prophylactic antibiotics could be delivered per day.

The last three inputs are critical components of each jurisdiction's response strategy. Based on the six inputs, the RHCC calculates four results.

The first result is the proportion of exposed individuals in the target population who would be protected by post-exposure prophylaxis campaigns that differ by two functions: how quickly after exposure prophylaxis begins, and how long it takes to complete the prophylaxis campaign. The shorter the delay and the shorter the time to complete, the higher the proportion of people protected.

The second result is the number of casualties (people sick with the BT illness), by day. Results are displayed in three formats:

- Total number of people who become sick.
- Number of people who become sick on each succeeding day (0-30).
- Graph depicting number of exposed people developing sickness, by day.

The graph is especially valuable for illustrating the magnitude of the surge in demand on hospital treatment.

The third result is the number (rather than proportion) of people protected, by day. Results are displayed in the same format as the number of casualties.

- The total number of people protected by prophylaxis.
- The number protected from sickness on each succeeding day (0-30).
- Graph depicting number of people protected, by day.

The fourth result offers information on how outcomes would be different if the campaign strategy were modified. These include the additional number of people who would be protected if the prophylaxis campaign began one day earlier or were completed one day earlier. In the event the campaign could not be initiated immediately, the model would also calculate the additional number of people who would be protected if the campaign reached full capacity without any ramp-up.

Using the model, planners can take one exposure scenario, play it out in a number of different ways, and wind up with very different daily and total casualty loads depending on how the community has been organized and how successful the community is in responding to that event. The *RHCC* model demonstrates how critical it is for communities to develop the capability to respond immediately and to have the personnel resources and materiel available to complete prophylaxis as quickly as possible.

Modeling the U. S. Health System's

The RHCC model demonstrates how critical it is for communities to develop the capability to respond immediately and to have the personnel resources and materiel available to complete prophylaxis as quickly as possible.

Epidemic Response Capacity

The Weill/Cornell team currently is building upon and expanding the *RHCC* model. The *RHCC* can calculate outcomes for anthrax, bubonic plague, tularemia, or pandemic flu. The new project is developing models for all six Category A bioterrorist agents and SARS. The *RHCC* calculates the number of people who can be protected by prophylaxis and the number who will need hospitalization. The models being developed under the new project will project capacity for pre-hospital and hospital-based response and the need for assistance from outside the region.

With funding by AHRQ, Dr. Hupert and his colleagues have analyzed three determinants of **surge capacity**. The first is surge arrivals at the hospital, a function of (1) the number of people who have been exposed or involved in an event and (2) the possible treatment of patients outside the hospital, or "pre-hospital management." As the *RHCC* model shows, the number of surge arrivals will depend on how many patients can be accommodated by pre-hospital management. Once patients arrive at the hospital or network of health care facilities (eg, clinics, rehabilitation facilities, and long-term care facilities) the second determinant of surge capacity is the **availability of hospital resources**. The number of patients who can be treated during a surge event depends on factors such as number of staff, quantities of medical supplies, and circulation of beds. The circulation of beds, in turn, depends to some extent on the third determinant, which is surge discharge. The concept of **surge discharge** is that some patients who were already in the hospital at the time of the event may be transferred to other facilities, thus making space available for surge arrivals.

The *Modeling U.S. Health System's Epidemic Response Capacity* project has two components. The first, which has been completed, involved the evaluation of patterns of emergency health service utilization during an actual public health emergency. It was based on patient surges at eight New York City emergency departments during the 2001 anthrax attacks. Using administrative data from the New York Presbyterian Healthcare System, the study assessed neighborhood-by-neighborhood variability in patient arrivals. The response of the public to such an emergency has important implications for mass prophylaxis planning.

The second component will assess health system capacity by developing discrete event simulation models of hospital treatment for the six Category A bioterrorist agents and SARS. Models will balance hospital bed capacity in each of the 313 United States Hospital Referral Regions against simulated epidemic curves that reflect both disease and public health response variables. Given one of the scenarios and based on local capacity, the model will project pre-hospital response, hospital-based response, and need for assistance from outside the region.

For More Information

Community-Based Mass Prophylaxis: A Planning Guide for Public Health Preparedness and *BERM* are available on the AHRQ Web site (www.ahrq.gov/browse/bioterbr.htm). Dr. Hupert and his colleagues are developing a Web-based version of the *Regional Hospital Caseload Calculator*, which will be available soon on the AHRQ Web site. Tools developed under the *Modeling U.S. Health System's Epidemic Response Capacity* project will be posted on the AHRQ Web site as they become available.

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