and other regulations. Laboratories face a rising demand for services from an aging population at increasing risk for infectious diseases.

Clinical laboratories are receiving diminished revenues and facing increased productivity demands that result from downsizing, consolidation, and mergers. There is a shortage of qualified personnel, resulting from loss of senior staff because of retirement and difficulties in recruiting and retaining younger microbiologists. A solution to this crisis will require higher starting salaries, better tuition reimbursement, increased provision of distance learning for current staff, and increased test automation.

Bioscience laboratories are potential sources of threatening pathogens and toxins. Control of these materials is essential, but how this is achieved must be carefully considered and implemented. Potential threat agents can often be acquired from nonbioscience sources. Moreover, the nature of these materials makes their diversion difficult to prevent, and because many biological materials and technologies have dual uses, illegitimate activities can be very difficult to detect. Although many security experts believe that the most credible threat comes from persons with legitimate access to bioscience facilities, security at such facilities has largely been focused on protection against outside adversaries. Such facilities cannot be protected unless their staff understand and accept the need for security measures.

To adequately protect collections of virulent biologic agents, those responsible for the design of biosecurity systems must understand biologic materials and research and have the active involvement of laboratory scientists. Since risk will always exist and every asset cannot be protected against every threat, distinguishing between acceptable and unacceptable risks is imperative. Facilities should conduct an agent-based, security-risk assessment to ensure that protection of their assets is proportional to the risk for theft or sabotage of those assets.

The list of potential human health, animal, and agricultural threat agents is extensive. Areas at risk include not only public health and well-being, but economic well-being, public trust, consumer confidence, and the national infrastructure.

Forensic science involves applying scientific procedures to the investigation of both criminal and civil legal matters. The principal questions that microbial forensics sets out to answer are the following: What is the agent? Was the event intentional? Was the pathogen engineered? Where did the pathogen come from? and Who committed the crime? The manner in which forensic evidence is generated is critical if it is to be admissible in court. To assist law enforcement, the Scientific Working Group for Microbial Genetics and Forensics has been established. This group has identified research needs for methods to identify and type threat agents. It has established quality management guidelines for laboratories, with the goal of promoting development of forensic methods that are rigorous and scientifically valid.

Recent reports from the Institute of Medicine (1) and others recognize that the public health laboratory system has many components. The challenge presented by emerging and reemerging infectious diseases, whether these be old microbes with new scenarios (e.g., *Bacillus anthracis*), new microbes (e.g., severe acute respiratory syndrome), or old microbes with new resistance patterns (e.g., multidrug-resistant *Mycobacterium tuberculosis*), requires greater coordination between public health, clinical, and commercial microbiology laboratories. Each segment produces unique, yet overlapping, data essential to the nation's health. Essential to good coordination is communication, which can be enhanced by joint participation in meetings, collaborative studies, training opportunities, cross-cutting committees, and service on regional or national advisory boards.

Patricia Somsel* and David Warnock†

*Michigan Department of Community Health, Lansing, Michigan, USA; and †Centers for Disease Control and Prevention, Atlanta, Georgia, USA

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Address for correspondence: Patrician A. Somsel, Division of Infectious Diseases, Bureau of Laboratories, Michigan Department of Community Health, 3350 N. Martin Luther King, Jr. Blvd, P. O. Box 30035, Lansing, MI 48909, USA; fax: 517-335-9631; email: SomselP@michigan.gov

Mathematical Modeling and Public Policy: Responding to Health Crises[1]

Mathematical models have long been used to study complex biologic processes, such as the spread of infectious diseases through populations, but health policymakers have only recently begun using models to design optimal strategies for controlling outbreaks or to evaluate and possibly improve programs for preventing them. In this session, three examples of such models were examined.

[1]Presenters: Marc Bonten, Utrecht University Medical Center; Mark Woolhouse, University of Edinburgh; and Ellis McKenzie, National Institutes of Health.

Antibiotic Resistance in Hospital Settings

Patient dependency characterizes the epidemiology of disease transmission within multiple small wards with rapid patient turnover. Other variables affecting the epidemiology of resistance are the use of antimicrobial agents, introduction of colonized patients, and efficacy of infection-control measures. A Markov chain model originally made for vector-borne diseases was used to elucidate the relative importance of different routes within intensive care units.

Managing Foot-and-Mouth Disease Epidemics

State-of-the-art modeling approaches were used in Britain during the outbreak of 2001 to address such questions as: Were planned control policies sufficient to bring the epidemic under control? What was the optimal intensity of preemptive culling? Would a logistically feasible vaccination program be a more effective control option? This "real-time" use of models, although of help in devising an effective control strategy, also proved controversial.

Developing Smallpox Models as Policy Tools

Although models of infectious diseases have influenced public policy, that process and its results could be improved by regular, direct contact and communication between modelers, policy advisors, and other infectious-disease experts. At the U.S. Department of Health and Human Services, the Secretary's Council on Public Health Preparedness is sponsoring initiatives using various modeling approaches to assess biodefense strategies.

Common themes in this session were: 1) involving substantive experts, thereby ensuring that conceptual frameworks underlying the mathematics are faithful to current understanding of complex natural phenomena, 2) including all possible interventions, which could then be evaluated alone or in various combinations, and 3) identifying inadequacies in available information, for augmentation through further research.

John Glasser,* Martin Meltzer,* and Bruce Levin†

*Centers for Disease Control and Prevention, Atlanta, Georgia, USA; and †Emory University, Atlanta, Georgia, USA

Address for correspondence: John Glasser, Centers for Disease Control and Prevention, 1600 Clifton Rd., NE, Mailstop E61, Atlanta, GA 30333, USA; fax: 404-639-8616; email: jglasser@cdc.gov

Public Health Workforce Development[1]

Until the early 1990s, most of Uganda's public health workforce obtained master's degrees from abroad. The responsibility for health training institutions has been shifting between the Ministry of Health and the Ministry of Education, although it is currently under the Ministry of Health, also the main employer of public health workers. The Ugandan Public Health School Without Walls is an innovative and sustainable model of worker development, conceived in 1994 in partnership with Makerere University, which houses the program; the Ministry of Health; and the development partners, notably, the Rockefeller Foundation, the Centers for Disease Control and Prevention (CDC), and the World Health Organization (WHO). Up to 145 professionals from medical, biologic, and social sciences have been trained in a 10-year period. The curriculum is flexible and is constantly reviewed and adapted to the local situation. The program is 75% field-based, during which trainees are placed in 15 district training sites under professional working conditions and they also rotate through various Ministry of Health programs, where they get hands-on training. The program emphasizes operational research, dissemination of findings to policymakers, and evidence-based management decisions, features that have translated into marked improvements in the quality of the delivery of health systems in the country. Students participate in both national and international outbreak investigations. Challenges include increasing the numbers of students to match the high demand and increasing the number of learning facilities. Ensuring effective mentorship, appropriate recruitment, career paths for graduates, and sustainability of the program with reduced donor funding are also problems.

Other examples of international public health worker development initiated by WHO and its Communicable Disease Surveillance Response unit for development of training materials in partnership with CDC are the Lyon 2-year training program for laboratory specialists and epidemiologists, Global Outbreak Alert and Response Network, and various internships.

The Council of State and Territorial Epidemiologists (CSTE) conducted an Epidemiology Capacity Assessment survey of all states and territories. As of November 2001, a total of 1,366 persons were employed as epidemiologists in the 44 responding state and territorial health departments; almost half (47.7%) of these epidemiologists were working in infectious disease. The survey found that 42%

[1]Presenters: Margaret Lamunu, World Health Organization; Matt Boulton, Michigan Department of Community Health; and Lou Turner, North Carolina Public Health Laboratory.