Developing National Epidemiologic Capacity to Meet the Challenges of Emerging Infections in Germany

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In January 1996, the Robert Koch Institute, Germany's national public health institute, began strengthening its epidemiologic capacity to respond to emerging and other infectious diseases. Six integrated strategies were initiated: developing employee training, outbreak investigation, and epidemiologic research programs; strengthening surveillance systems; improving communications to program partners and constituents; and building international collaborations. By December 1999, five employees had completed a 2-year applied epidemiology training program, 186 health department personnel had completed a 2-week training course, 27 outbreak investigations had been completed, eight short-term research projects had been initiated, major surveillance and epidemiologic research efforts for foodborne and nosocomial infections had begun, and 16 scientific manuscripts had been published or were in press. The German experience indicates that, with a concerted effort, considerable progress in building a national applied infectious disease program can be achieved in a short time frame.

National and international strategies for detecting and preventing emerging infectious diseases have been created in both the civilian and military sectors (1-5). However, epidemiologic capacity at national, regional or state, and local levels is necessary to successfully implement many of these strategies. Health officials are conducting increasingly complex outbreak investigations, implementing and analyzing new surveillance systems, and conducting sophisticated applied epidemiologic research. However, the ability to carry out these tasks varies among countries and remains largely unevaluated. In 1996, Germany began strengthening its epidemiologic capacity to respond to emerging and other infectious diseases (6). We report the strategies used and their outcome through 1999.

Background

Germany is a highly industrialized country with 82 million inhabitants. It has 16 federal states, including five from the former German Democratic Republic. The principal responsibility for public health resides with the 16 state health ministries and approximately 420 local health departments. Although Robert Koch and his contemporaries built a strong tradition for infectious disease epidemiology in Germany in the late 19th and early 20th centuries, this tradition all but disappeared in the 1930s and 1940s. In the former West Germany, the national infectious disease institute (Robert Koch Institute [RKI]) was mainly focused on basic science research until the AIDS epidemic demanded a national public health response. In 1987, an independent AIDS Center was formed at the Federal Health Ministry. Reunification with the former East Germany and subsequent integration of the East German institutes for hygiene and microbiology gave additional incentives to improve infectious disease epidemiology. In 1994, a combined AIDS Center and Infectious Disease Epidemiology Division was created at RKI.

Substantial barriers hindered the further development of applied infectious disease

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epidemiology in Germany. Nearly all outbreak investigations were conducted at the local level; however, local health officials had little or no training in applied infectious disease epidemiology. No federal infrastructure existed to investigate outbreaks, nor was epidemiology recognized as a discipline distinct from microbiology.

In 1995, representatives of RKI, the Federal Ministry of Health and the Federal Ministry for Education and Research developed a concept for a network of collaborators whose goal would be intensifying epidemiologic research and improving infectious disease surveillance (7). As part of this concept, RKI was to develop a weekly epidemiologic bulletin, redefine national reference laboratories, form an infectious disease epidemiology commission, train epidemiologists in a 2-year applied training program similar to the Epidemic Intelligence Service at the Centers for Disease Control and Prevention (CDC) (8), and create networks of investigators capable of gathering existing public health data, identifying deficits, and collecting additional data as needed. A senior epidemiologist was seconded from CDC to help initiate this program, which began on January 1, 1996.

Program Goals, Strategies, and Outcomes

General Approach

The initial goal was to build sustainable national epidemiologic capacity over a 4- to 5-year period. Initial priorities were to develop capacity to identify and respond to epidemiologic emergencies, conduct applied epidemiologic research, and support state and local health departments in conducting these activities and in developing their own epidemiologic programs. Six integrated strategies were undertaken by RKI: developing employee training, outbreak investigation, and epidemiologic research programs; strengthening surveillance systems; improving communications between RKI and its partners and constituents; and building international collaborations (Figure 1).

Training and Manpower Development

The lack of personnel trained in applied infectious disease epidemiology made long- and short-term training programs a critical priority. The long-term program was to develop a cadre of epidemiologists (capable of performing outbreak investigations, epidemiologic research, and surveillance) who would later serve as trainers themselves. The short-term training program focused on providing health department personnel with practical skills and understanding to conduct and report on simple epidemiologic investigations and to conduct more complex epidemiologic research and surveillance activities in collaboration with national or state epidemiologists.

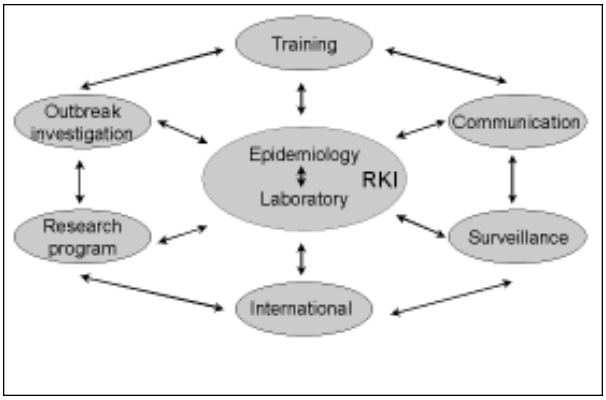

Figure 1. Integrated strategies used by the Robert Koch Institute (RKI) for the development of applied infectious disease epidemiologic capacity in Germany.

The 2-year training program, known as the German Field Epidemiology Training Program (FETP), began with two trainees in January 1996. Two additional cohorts of three trainees each began their training in 1998 and 1999, respectively. Seven of these eight trainees were physicians, and one was a veterinarian. Two of the physicians also had masters of public health degrees. All trainees were stationed at RKI. All were required to complete at least one outbreak investigation, surveillance project, and research project, as well as present their work at a scientific conference, participate as trainers in epidemiologic courses, and write at least one article each in a peer-reviewed scientific journal and in the national epidemiologic bulletin. Beginning with the second cohort, trainees also rotated for 2 weeks through RKI laboratories. This helped them understand the laboratory aspects of their epidemiologic investigations and further solidified the working relationships between the epidemiologists and laboratorians.

The German FETP started nearly simultaneously with the European Program for Intervention Epidemiology Training (EPIET), a Europe-wide, 2-year training program, also developed on an Epidemic Intelligence Service

model, in which a trainee from one European country trains in another. Four EPIET trainees from other countries have trained or are being trained at RKI, and three Germans have trained or are training in other countries as part of EPIET. The European program also provided a crucial training function for the German FETP by allowing each German FETP trainee to participate in EPIET's 3-week introductory training course and four 1-week training modules.

All five FETP graduates and three German EPIET graduates are employed. Two FETP graduates are now RKI epidemiologists, another is in charge of infectious diseases for the city and state of Hamburg, one works at a local health department with a focus on epidemiology, and one is a World Health Organization consultant. Of the three German EPIET graduates, one works in the EPIET program office, one is an RKI epidemiologist, and the third is an epidemiologist for the Health Ministry of North Rhine-Westphalia, the most populous German federal state.

The annual short-term training program consists of a 2-week applied epidemiology course for public health officials designed to impart practical skills. The first week involves lectures on basic epidemiologic study design, outbreak investigation methods, basic statistics, and three case studies. During the second week, students learn an epidemiologic data management and analysis computer program (EPI-Info) (9), collect data for a survey, enter the data in a computer, analyze data, and prepare a 10-minute scientific presentation, press release, and epidemiologic bulletin article based on the survey results. To date, 186 students from health departments have been trained, and the enrollment has increased from 29 in 1996 to 64 in 1999. Two short-term trainees later joined the German FETP. Seven outbreak investigations have been conducted jointly with RKI and the course graduates.

Outbreak Investigation

Benefits of developing the capacity to investigate outbreaks included filling a public health gap in the capacity to respond to epidemiologic emergencies; developing relationships between RKI and its partners, such as public health and research laboratories and health departments; forming hypotheses and bases for future research; providing training opportunities; and bringing recognition to public health, epidemiology, and RKI.

Twenty-seven outbreak investigations requiring travel to the field have been completed, with the number increasing from four in 1996 to nine in 1999 (Table). Each investigation was at the request and approval of the state health ministries, with the local health department or state ministry retaining overall control and responsibility. Eight of these outbreaks were foodborne or waterborne: Four were traditional common-source, foodborne outbreaks arising from single kitchens (Table 1, outbreaks 7,14,15,22), and four were from widely distributed commercial products (outbreaks 1,4,17,19). The other outbreaks were due to a diverse group of agents and modes of transmission and covered areas as large as Europe (Table).

Among the findings of these investigations were the recognition of *Escherichia coli* as a potentially common foodborne pathogen (outbreak 1), the recognition of Q fever as an emerging pathogen in Germany (partially due to urbanization in close proximity to sheep farms or grazing areas; outbreaks 2,18,23), and the role of Norwalk-like viruses in producing outbreaks in Germany (outbreaks 4,10,21). Germany's new epidemiologic capacity enabled it to participate in two multinational outbreaks among returnees from overseas travel (outbreaks 11,26) as well as in a World Health Organization investigation in Romania (outbreak 25).

Epidemiologic Research

The aim is to create a self-sustaining program of applied epidemiologic research at RKI focusing on foodborne and diarrheal diseases; AIDS and other sexually transmitted diseases, including hepatitis; vaccine-preventable diseases; respiratory diseases; travel-associated, vector-borne, and parasitic diseases; and nosocomial infections. The program has four developmental stages: outbreak investigation, initial targeted investigations, comprehensive line of research, and a fully realized research program.

Outbreak investigations provided an initial concrete focus of activity between RKI and collaboration partners in the field, such as health departments and laboratory scientists. In addition, outbreak investigations revealed health problems in need of further planned epidemiologic study. An example was the discovery from an outbreak investigation of the emergence of a sorbitol-fermenting enterohemorrhagic *E. coli*

Table. Outbreaks investigated by the Robert Koch Institute, 1996-1999

No.	Year	Setting	Syndrome	Pathogen	Cases (no.)	Comment (references)
1	1996	statewide	hemolytic-uremic syndrome	*Escherichia coli* O157	28	raw, spreadable sausage, new sorbitol-fermenting *E. coli* O157 strain (10)
2	1996	community	Q fever	*Coxiella burnetii*	45	community downwind from sheep farm. Climatic factors promoted airborne transmission (11-13)
3	1996	4 day-care centers	meningitis	echovirus 30	71	clinical illness increased risk of transmission to family members, high attack rate (14)
4	1996	vacation center for veterans	gastro-enteritis	Norwalk-like virus	86	bottled mineral water; national diagnostic capability for Norwalk-like viruses established as a result of outbreak
5	1997	ski group	upper respiratory syndrome, toxic shock syndrome	influenza A virus *Staphylococcus aureus*	38	followed foreign travel (15)
6	1997	ski group	upper respiratory syndrome	influenza A virus	39	followed foreign travel
7	1997	6 day-care centers	gastroenteritis	*Campylobacter jejuni*	186	common source from one kitchen
8	1997	community	meningitis	echovirus 30	353	high attack rate, person-to-person transmission (16)
9	1997	case investigation	hepatic failure, rhabdo-myalysis, bleeding	unknown	1	false-positive test for Lassa fever virus, 3 other persons of same ethnic origin identified with similar clinical syndrome (17)
10	1998	residence for elderly	gastroenteritis	Norwalk-like virus	189	person-to-person transmission
11	1998	nationwide	gastroenteritis	*Salmonella* livingstone	119	Europe-wide outbreak following foreign travel
12	1998	community	fever, sudden death	unknown	3	infants, no common risk factors identified
13	1998	community	meningitis, death	*Neisseria meningitidis*	9	associated with discotheque attendance in carnival season (18)
14	1998	company employees	gastroenteritis	*Salmonella* enteritidis	531	common source from a single kitchen
15	1998	community	gastroenteritis	*S.* enteritidis	103	common source from a single kitchen, alcohol protective
16	1998	hospital employees	myocarditis	unknown	40	pseudo-outbreak
17	1998	multiple states	gastroenteritis	*S.* blockley	12	imported eel smoked at multiple smokeries (19)
18	1998	community	Q fever	*Coxiella burnetii*	101	urban area in close proximity to sheep grazing and shearing
19	1999	10 commun-ities	trichinosis	*Trichinella spiralis*	52	investigation revealed two simultaneous outbreaks from different sources (20)
20	1999	hospital patients	sepsis, death	methicillin-resistant *S. aureus*	26	cardiac surgery intensive-care unit
21	1999	home for elderly	gastroenteritis	Norwalk-like virus	71	person-to-person transmission
22	1999	nationwide	gastroenteritis	*S.* enteritidis	48	national convention attendees, common source from one kitchen
23	1999	community	Q fever	*C. burnetii*	81	urban area in close proximity to sheep farm; uninvestigated outbreak from same sheep farm occurred 6 yrs. earlier
24	1999	case investigation	yellow fever	yellow fever virus	1	originally thought to be hemorrhagic fever (21)
25	1999	Romania	meningitis	echovirus	>5000	widespread outbreak involving multiple serotypes
26	1999	nationwide	gastroenteritis	*S.* paratyphi	43	Europe-wide outbreak from foreign travel
27	1999	hospital patients	sepsis, death	methicillin-resis-tant *S. aureus*	18	cardiac surgery intensive-care unit

(Table, outbreak 1). This investigation forged alliances between the RKI laboratories, a university laboratory, federal veterinarians, and a state health department. A working group was formed that developed a future research and surveillance program for enteric diseases.

The second stage of the program was to initiate targeted investigations involving single research projects to answer specific health problems. Eight short-term research projects were begun. These included a study of hepatitis B and C in Berlin dentists (22), risk factors for emergence of quinolone-resistant *E. coli* in a hospital, prevalence and risk factors for methicillin-resistant *Staphylococcus aureus* in Berlin nursing homes, three studies of influenza vaccine coverage (23,24), incidence and risk factors of borreliosis in an area where Lyme disease was highly endemic, and risk factors for echinococcus in Germany.

The third stage—a more comprehensive line of applied epidemiologic research conducted over a period of years in each of the six above-named fields—is being developed sequentially since it requires considerable personnel resources, financial commitment, and experience. In 1999, the Ministry for Education and Research began to fund the development of applied infectious disease research and surveillance networks. The selection criteria and proposal review panel were chosen to ensure that funded projects had an appropriate mixture of epidemiologic and laboratory science. RKI will receive DM 1,684,000 (approximately US $842,000) to develop a foodborne infections research network, which will include a German version of PulseNet (25) for the molecular characterization of Shiga toxin-producing *E. coli*, a national case-control study of sporadic enterohemorrhagic *E. coli* infections, and a national nosocomial infections network with integrated surveillance, research, and outbreak investigation components.

The last stage—a fully realized epidemiologic research program with field epidemiologists specialized in each of the six research areas and with integrated surveillance, laboratory, and prevention components—is a long-range goal. The program would have a steady research-funding stream for short- and long-term projects, whose priority would be determined by RKI and its collaboration partners based on immediate and long-term public health needs.

Strengthening Surveillance Systems

Federal law governs nationally notifiable disease surveillance. Reporting by local health departments to state and federal authorities is by aggregate number of cases only. The current law does not use case definitions, and many newly identified pathogens, such as hepatitis C, are not reported separately. There is no provision for laboratory-based reporting. Beginning in 1996, data obtained by the system have been published weekly in the newly formed epidemiology bulletin.

A new infectious disease law was passed by the German parliament and becomes effective in January 2001. In addition to allowing for single case reports using case definitions and specifying both laboratory- and health-care-provider-based reporting, the new law also gives a clear mandate for RKI to be the central federal authority for organizing and conducting surveillance and applied infectious disease epidemiologic research on a federal level and provides 30 additional staff.

The time it took to draft and gain passage of the new infectious disease law allowed RKI and new state epidemiologic programs to develop. As a result, 186 health department personnel have already been through short-term training, which will ease implementation of the new surveillance system in the field. A pilot study using components of a new computerized surveillance system is being set up in selected health departments. In addition, German FETP trainees have started six studies to evaluate existing surveillance systems or initiate sentinel surveillance. These studies include developing a national surveillance system for enterohemorrhagic *E. coli* and hemolytic uremic syndrome, evaluating a laboratory-based sentinel system for monitoring viral infections, and evaluating a system for monitoring foodborne outbreaks.

Improving Communications

Because the impact of emerging and reemerging infectious diseases on public health in Germany was grossly underestimated, a deliberate communications strategy was necessary to heighten public awareness. Also important was involving health department personnel in implementing new surveillance initiatives and conducting outbreak investigations by using analytic epidemiology. Finally, the collaboration of other scientific authorities, such as university research departments and professional associations, was needed.

Five communication strategies were used, and principal target groups were identified (Figure 2). Outbreak investigation was initially a high priority, in part to bring public recognition of infectious disease threats and the role of RKI and local public health authorities in responding to these threats. Subsequently developed public health guidelines also highlighted RKI's and health departments' roles in promoting science-based public health. Guidelines about diagnosing Shiga toxin-producing *E. coli* and investigating foodborne and nosocomial outbreaks are in preparation.

The new epidemiology bulletin reaches a wide audience, including the media, public health departments, and other researchers. It provides a weekly source of epidemiologic findings and surveillance data, giving RKI and participating health departments a regular, visible central role in infectious disease epidemiology. In addition, the bulletin publishes public health guidelines for one transmissible infectious disease per month. As of December 1999, guidelines for 11 infectious diseases (influenza, meningococcus, early summer tick-borne meningoencephalitis, Lyme borreliosis, hepatitis A, enterohemorrhagic *E. coli*, Q fever, campylobacter, rabies, measles, and Legionnaire's disease) have been published. The guidelines provide public health practitioners with an accessible resource for decision-making and guidance for obtaining national reference laboratory and epidemiologic assistance.

To gain credibility and support for the national epidemiologic program, 65 scientific presentations were given at conferences, and 19 scientific manuscripts based on original epidemiologic data were written; 16 of these are in press or have already been published in refereed journals or international bulletins (10-22, 26-28). The German FETP trainees and the EPIET trainees who have trained in Germany were first authors on 14 of these articles and wrote 18 articles in the German epidemiologic bulletin. Although publication in international medical journals was emphasized, publication in the epidemiology bulletin was vital because it was more widely read among public health practitioners.

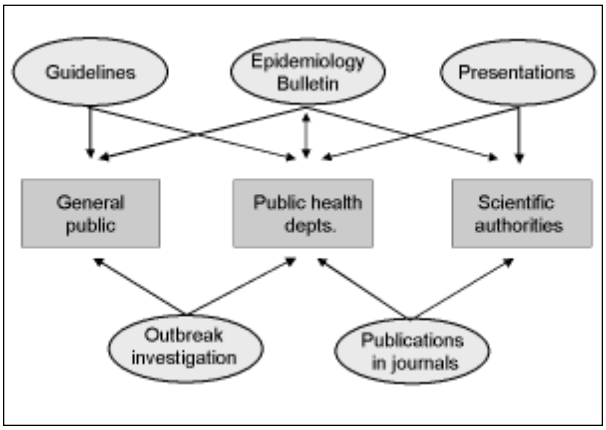

Figure 2. Program communication activities and principal target groups for the development of applied infectious disease epidemiology at the Robert Koch Institute.

Building International Collaborations

Although the principal focus of the national infectious disease epidemiology program was domestic, the integration of Germany into the European Union required the program to have an international presence. RKI's collaboration in training with EPIET and in investigating international outbreaks within Europe are two examples. The initial decision not to build a Europe-wide epidemiology center, but to approach Europe-wide surveillance through networks (29), requires many member states to take an active role in initiating and running one or more multinational surveillance systems. RKI has received funding for an exploratory study to determine the feasibility of a European campylobacter surveillance system.

Outside Europe, Germany has been extremely underrepresented in providing epidemiologic technical assistance for health projects or international assessment missions, largely because trained personnel were lacking. To help build this capacity, German FETP trainees have participated in 3-month assignments in Chad (28), Burkina Faso, and India as part of the World Health Organization's global polio eradication effort. In addition, RKI sent a team as part of a World Health Organization mission to support an outbreak investigation in Eastern Europe.

Funding

The Federal Ministry for Education and Research provided DM 1,144,000 (US $572,000) for the CDC consultant's salary, travel, and other costs related to outbreak investigations from 1996 through 1999, as well as short-term training courses for public health officials in 1997. The Federal Ministry of Health funded trainees' salaries (DM 752,000 [US $376,000]) and travel

to outbreak investigations, EPIET training modules, and scientific meetings (DM 98,000 [US $49,000]). The total cost of the program from 1996 through 1999 was approximately US $997,000. Additional funding was provided to enhance the nosocomial infections network and develop the foodborne disease network.

Future Plans

After the first 2 years of operation, the demands placed on the program greatly exceeded the available trained staff. A new nationwide surveillance system in 2001 will further tax the personnel resources. Although the new infectious disease law will provide 30 new federal positions for RKI, many of the new employees will need training. For this reason, FETP training will continue to be a high priority. States will likely continue to build up their epidemiologic capacity, further increasing demand for trained epidemiologists. The current demands on the program's resources do not permit expansion into other areas than infectious diseases. Another high priority will be building up the epidemiologic research program, financed in part through changes in funding for Germany's national reference laboratories. Laboratories participating in collaborative epidemiologic and surveillance projects will be eligible for discretionary funds beginning in 2000.

Conclusions

Several factors have contributed to the success of the new applied epidemiology program at RKI. The first was achieving a broad consensus about the program's scope and objectives among the program's future participants and customers. In Germany, this included the Federal Ministry of Health, the Ministry for Education and Research, the state health departments, and RKI. The second ingredient in the program's success was the initial emphasis on training, particularly for building a national epidemiologic program. The short-term training program quickly produced a growing network of collaborators in health departments. The long-term training programs (German and Europe-wide) produced technically competent investigators, who are now assuming key positions in infectious disease epidemiology. Because experiences in many countries have shown that at least 2 years is needed to train a field epidemiologist (8), achieving a critical mass of field epidemiologists at federal and state levels will take many years. Thus, the full effects of the long-term training program are not likely to be seen in the near future. This delay challenged the program: Many persons called for more rapid and less expensive alternatives (e.g., traditional classroom teaching or shortening the training period to 1 year) that would have severely compromised quality.

Because epidemiology is an applied science, the quality of the epidemiologic training and research depends on the experience of the program managers. Thus, an international consultant with considerable experience vastly improved the quality of training and research programs. Our experience suggests that an external consultant should remain in a country for 4 to 5 years for the program to become self-sustaining. A final key to the program's success was a stepwise and deliberate plan for developing a network of partners in the field and in the laboratory and for selling the program to consumers of the information. The simultaneous buildup of a Europe-wide epidemiology training program was crucial to developing the German one. The German trainees' participation in the EPIET training modules allowed them to be part of a larger regional network of trainees, thus simultaneously developing German and European networks of epidemiologists. The number and quality of EPIET's training modules could not have been achieved in Germany with the resources then available. Furthermore, EPIET provided a crucial external evaluation of the German FETP through periodic site visits. For example, one evaluation pointed out the need for better integration of the epidemiology and surveillance programs at RKI. As a result, the trainees' involvement with the analysis and interpretation of routine surveillance data was increased.

Our experiences in the program's first 4 years have shown that an organized applied epidemiology program with a high degree of technical expertise at the national level is necessary to effectively respond to emerging infections. For example, of the 27 outbreaks investigated to date, 4 were the traditional common-source, foodborne outbreaks from a single kitchen. Most of the others involved multinational or multi-state outbreaks, threats of imported exotic diseases, or community outbreaks of uncommon agents or bacterial or viral strains that were new, difficult to detect, or resistant to multiple drugs. The

traditional outbreak investigation approach that emphasizes a single health department's collection of samples from cases for microbiologic analysis would not have been adequate to determine the scope of nearly all of these outbreaks nor to identify their modes or vehicles of transmission.

RKI's activities thus far have formed the foundation for the continuing development of a national epidemiology program with integrated surveillance, research, and prevention components for most transmissible pathogens. Further development is critical, as the experiences to date suggest that epidemiologists, public health officials, and laboratory scientists are likely to become involved in increasingly complex scientific endeavors as they respond to emerging infections in Germany.

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