Part **Three**

Strengthening Health Systems

- Strengthening Public Health Services
- Strengthening Personal Health Services
- Capacity Strengthening and Management Reform

Chapter **53**

Public Health Surveillance: A Tool for Targeting and Monitoring Interventions

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What gets measured gets done.
—Anonymous

Public health surveillance is the ongoing systematic collection, analysis, and interpretation of data, closely integrated with the timely dissemination of these data to those responsible for preventing and controlling disease and injury (Thacker and Berkelman 1988). Public health surveillance is a tool to estimate the health status and behavior of the populations served by ministries of health, ministries of finance, and donors. Because surveillance can directly measure what is going on in the population, it is useful both for measuring the need for interventions and for directly measuring the effects of interventions. The purpose of surveillance is to empower decision makers to lead and manage more effectively by providing timely, useful evidence.

Increasingly, top managers in ministries of health and finance in developing countries and donor agencies are recognizing that data from effective surveillance systems are useful for targeting resources and evaluating programs. The HIV and severe acute respiratory syndrome (SARS) epidemics underscored the critical role of surveillance in protecting individual nations and the global community. For example, in 2005, China rapidly began to expand its surveillance and response capacity through its Field Epidemiology Training Program (FETP); Brazil and Argentina chose to use World Bank loans to develop surveillance capacity; and the U.S. Agency for International Development (USAID) redesigned its surveillance strategy to focus on the use of data to improve public health interventions (USAID 2005). Additionally, the guidelines for implementing the 2004 draft revised International Health Regulations require World Health Organization (WHO) member states to have key persons and core capacities in surveillance (http://www.who.int/csr/ihr/howtheywork/faq/en/#draft).

Just as decision makers require competent, motivated economists to provide quality technical analyses, they also need competent staff members to provide scientifically valid surveillance information and communicate the results as information for action. Competent epidemiologists and surveillance staff members are not a luxury in developing countries; they are a necessity for rational planning, implementation, and intervention (Narasimhan and others 2004).

DEFINITIONS AND BASIC CONCEPTS

In this chapter, we use the following definitions:

- *Indicator:* a measurable factor that allows decision makers to estimate objectively the size of a health problem and monitor the processes, the products, or the effects of an intervention on the population (for example, the number of new cases of diarrhea, the proportion of children fully immunized in a district, or the percentage of high school students who report that they smoke at least one cigarette a day).

- *Active surveillance:* a system employing staff members to regularly contact heath care providers or the population to seek information about health conditions. Active surveillance provides the most accurate and timely information, but it is also expensive.
- *Passive surveillance:* a system by which a health jurisdiction receives reports submitted from hospitals, clinics, public health units, or other sources. Passive surveillance is a relatively inexpensive strategy to cover large areas, and it provides critical information for monitoring a community's health. However, because passive surveillance depends on people in different institutions to provide data, data quality and timeliness are difficult to control.
- *Routine health information system:* a passive system in which regular reports about diseases and programs are completed by public health staff members, hospitals, and clinics.
- *Health information and management system:* a passive system by which routine reports about financial, logistic, and other processes involved in the administration of the public health and clinical systems can be used for surveillance.
- *Categorical surveillance:* an active or passive system that focuses on one or more diseases or behaviors of interest to an intervention program. These systems are useful for program managers. However, they may be inefficient at the district or local level, at which staff may need to fill out multiple forms on the same patient (that is, the HIV program, the tuberculosis program, the sexually transmitted infections program, and the Routine Health Information System). At higher levels, allocating the few competent surveillance experts to one program may leave other programs underserved, and reconciling the results of different systems to establish the nation's official estimates may be difficult.
- *Integrated surveillance:* a combination of active and passive systems using a single infrastructure that gathers information about multiple diseases or behaviors of interest to several intervention programs (for example, a health facility–based system may gather information on multiple infectious diseases and injuries). Managers of disease-specific programs may be evaluated on the results of the integrated system and should be stakeholders. Even when an integrated system is functioning well, program managers may continue to maintain categorical systems to collect additional disease-specific data and control the quality of the information on which they are evaluated. This practice may lead to duplication and inefficiency.
- *Syndromic surveillance:* an active or passive system that uses case definitions that are based entirely on clinical features without any clinical or laboratory diagnosis (for example, collecting the number of cases of diarrhea rather than cases of cholera, or "rash illness" rather than measles). Because syndromic surveillance is inexpensive and is faster than systems that require laboratory confirmation, it is often the first kind of surveillance begun in a developing country. However, because of the lack of specificity (for example, a "rash illness" could be anything from the relatively minor rubella to devastating hemorrhagic fevers), reports require more investigation from higher levels. Also an increase in one disease causing a syndrome may mask an epidemic of another (for example, rotavirus diarrhea decreases at the same time cholera increases).

  In the specialized area of surveillance for biologic terrorism, syndromic surveillance refers to active surveillance of syndromes that may be caused by potential agents used by biologic terrorists and sometimes refers to alternative measures such as increases in the use of over-the-counter drugs or increases in calls to emergency departments.
- *Behavioral risk factor surveillance system (BRFSS):* an active system of repeated surveys that measure behaviors that are known to cause disease or injury (for example, tobacco or alcohol use, unprotected sex, or lack of physical exercise). Because the aim of many intervention program strategies is to prevent disease by preventing unhealthy behavior, these surveys provide a direct measure of their effect in the population, often long before the anticipated health effects are expected. These surveys are useful for providing timely measures of program effectiveness for both communicable and noncommunicable disease interventions.

OBJECTIVES OF SURVEILLANCE SYSTEMS

Public health surveillance provides the scientific and factual database essential to informed decision making and appropriate public health action. The key objective of surveillance is to provide information to guide interventions. The public health objectives and actions needed to make successful interventions determine the design and implementation of surveillance systems. For example, if the objective is to prevent the spread of epidemics of acute infectious diseases, such as SARS, managers need to intervene quickly to stop the spread of disease. Therefore, they need a surveillance system that provides rapid early warning information from clinics and laboratories. In contrast, chronic diseases and health-related behaviors change slowly. Managers typically monitor the effect of programs to change risky behaviors such as tobacco smoking or chronic diseases once a year or even less often. A surveillance system to measure the population effects of a tuberculosis control program might provide information only every one to five years—for example, through a series of demographic and health surveys. The principle is that different public health objectives and the actions required to reach them require different information

Box 53.1

Different Objectives, Different Data, Different Systems

Objective	*Action*	*Data*	*System*
Detect epidemics	Epidemic response	Early warning information	Active surveillance
Monitor intervention programs	Program monitoring	Program indicators	Health information
Monitor impact of policy change	Health policy	Health indicators	Health information
Monitor health system	Resource allocation	Administrative data	Health information and management

Source: Nsubuga, Eseko, and others 2002.

systems. The type of action that can be taken, when or how often that action needs to be taken, what information is needed to take or monitor the action, and when or how frequently the information is needed should determine the type of surveillance or health information system (box 53.1).

PRINCIPLES AND USES OF SURVEILLANCE

Foege, Hogan, and Newton (1976) state that "the reason for collecting, analyzing, and disseminating information on a disease is to control that disease. Collection and analysis should not be allowed to consume resources if action does not follow." The fundamental principle of public health surveillance is that the surveillance should be designed and implemented to provide valid (true) information to decision makers in a timely manner at the lowest possible cost. Because managers are unlikely to need to make interventions to address small differences between areas, sacrificing precision makes sense to improve timeliness and save resources that can be used for public health interventions. The utility of surveillance data can be viewed as immediate, annual, and archival, on the basis of the public health actions that can be taken (table 53.1; Thacker and Stroup 1998b).

Table 53.1 Utility of Surveillance Data

Immediate detection of	Epidemics
	Newly emerging health problems
	Changes in health practices
	Changes in antibiotic resistance
	Changes in distribution of population at risk for disease
Periodic dissemination for	Estimating magnitude of a health problem, including cost
	Assessing control activities
	Setting research priorities
	Determining risk factors for disease
	Facilitating planning
	Monitoring risk factors
	Monitoring changes in health practices
	Documenting distribution and spread of disease and injury
Stored information for	Describing natural history of diseases
	Facilitating epidemiologic and laboratory research
	Validating use of preliminary data
	Setting research priorities
	Documenting distribution and spread of disease and injury

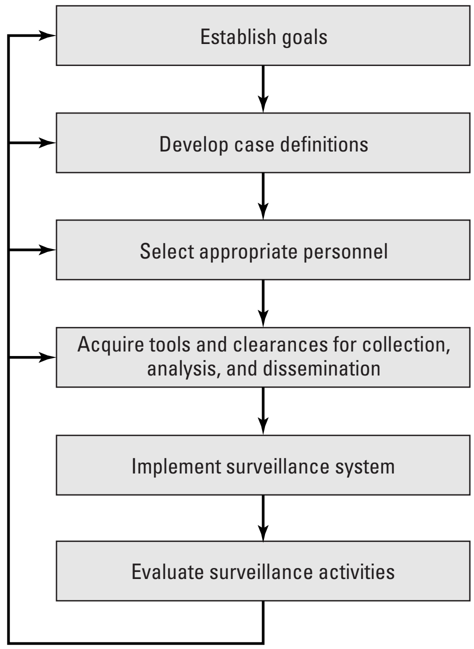
Source: Adapted from Thacker and Stroup 1998b, 65.

ESTABLISHING AND MAINTAINING A SURVEILLANCE SYSTEM

What is worth doing is worth doing right. Managers who decide to use public health surveillance as a management tool must recognize that they will need to commit political support and human and financial resources. As with every health system, competent, motivated health workers need to be found or trained and provided with career paths and supervision. After a manager decides to create a surveillance system, there are six steps to establishing the system. Because the system must adapt constantly to changes in the population and the physical and social environment, these steps are linked continuously (figure 53.1; Thacker and Stroup 1998a).

ANALYSIS AND DISSEMINATION OF SURVEILLANCE DATA

Surveillance information is analyzed by time, place, and person. Knowledgeable technical personnel should review data regularly to ensure their validity and to identify information



Source: Adapted from Thacker and Stroup 1998a, 119.

Figure 53.1 Elements in Establishing and Maintaining a Surveillance System

of use to top managers. Simple tables and graphs are most useful for summarizing and presenting data. Timely dissemination of data to those who make policy and implement intervention programs is critical to the usefulness of surveillance data.

The rapidly evolving field of public health informatics, which deals with collection, classification, storage, retrieval, analysis, and presentation of large amounts of health data, offers the potential for truly integrated public health surveillance based on data standardization, a communications infrastructure, and policies on data access and sharing. Surveillance will benefit by incorporating a systematic approach to standards for data content. For example, the U.S. Centers for Disease Control and Prevention (CDC) has used standards-based systems to support automatic electronic reporting of diagnostic laboratory results of notifiable diseases, thereby both increasing the number of cases reported and receiving results more rapidly (Effler and others 1999). Use of data standards facilitates comparability of surveillance information over time (for example, measurement of effect of program interventions), across different surveillance approaches (for example, facility-based reporting compared with sample surveys), and across countries and regions. To be credible, a standard should be developed through an open, participatory process, by an internationally recognized accredited standards-development organization that is also capable of long-term maintenance and evolution of the standard. Public health data needs extend into multiple areas beyond clinical medicine (for example, environmental toxins, unintentional injury, and food safety).

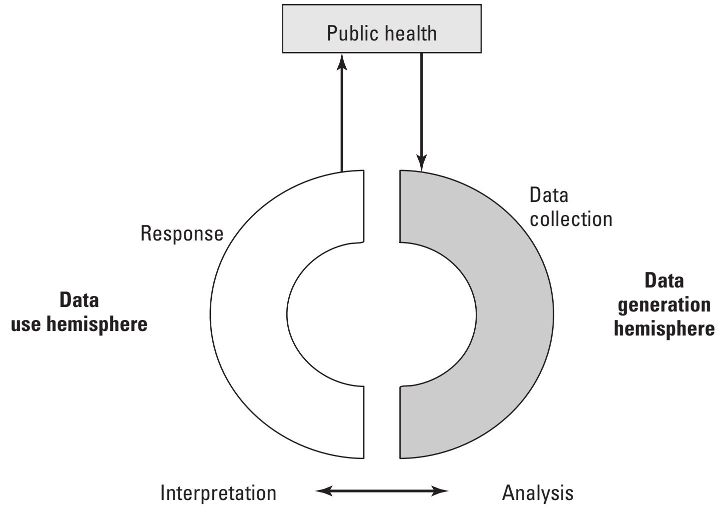
One international standard computer program used in many countries' information systems is Epi Info, an epidemiology surveillance and biostatistics program widely used around the world for the analysis of surveillance data (http://www.cdc.gov/epiinfo). CDC created, maintains, and distributes Epi Info at no cost to users.

SURVEILLANCE AS A COMPONENT OF NATIONAL PUBLIC HEALTH SYSTEMS

WHO and the World Bank cite public health surveillance as an essential function of a public health system (World Bank 2001). When linked to policy and program units, surveillance information improves the efficiency and effectiveness of health services by targeting interventions and documenting their effect on the population.

A critical challenge in the health sector in developing countries is to ensure quality and effectiveness of surveillance and public health response in an environment of decentralization. National-level program and surveillance system managers may lose control of the quality and timeliness of locally collected data. This situation can be avoided by training local decision makers in how to use information to meet their needs and negotiating with them over the core information collected by each district local unit. National-level managers or donors can also improve information quality by sponsoring national surveillance scientific and quality assurance networks, linking funding to provision of adequate data, and performing periodic surveys to confirm the results of local reporting. If the responsibility for implementing programs is devolved to local managers, then national-level managers need only a few summary indicators, rather than the detailed information they may be used to. District or local managers tend to prefer integrated systems to minimize filling out redundant forms.

Donors need surveillance data to target and evaluate their investments. If they perceive weakness in the national system, they may create parallel nongovernmental surveillance systems to gather data directly to meet their needs. These systems invariably pay workers more than government jobs do, so the most competent people in the government system may leave to work for the parallel system. Although this system meets donors' short-term needs, it invariably weakens government systems. Parallel systems may weaken the very ministries that they are meant to help and may not be sustainable after external funding ends. Therefore, parallel systems are inherently inequitable and should be used only as a last resort.



Source: Authors.

Figure 53.2 Surveillance and Response Conceptual Framework

SURVEILLANCE AS A TOOL TO IMPROVE PUBLIC HEALTH

Managers need focused, timely, scientifically sound information that provides evidence to make decisions on interventions for improving the health of the population in their jurisdiction. Simply collecting data and presenting them are not enough.

Using Surveillance Information for Evidence-Based Decisions

A major gap in promoting effective surveillance lies between the production of data and the ability to convert those data into usable information and then initiate the appropriate public health action. Surveillance and response can be described in terms of a *data generation hemisphere* and a *data use hemisphere* (USAID 2005). The data generation hemisphere is the traditional view of surveillance, whereas the data use hemisphere is the public health response that begins with interpretation of the data from the surveillance system (figure 53.2).

Substantial attention and the accompanying resources in surveillance have been devoted to the prompt and complete production of surveillance data. Although developing countries experience weaknesses in both hemispheres, more attention is needed to creating and strengthening the local capacity within developing countries to identify and manage effective responses to disease outbreaks and public health conditions of national and international concern. In some disease-specific programs, this capacity has to be imported through short-term expatriate assistance. Even when local capacity is developed, it is often specific to the disease program, making transfer of skills to other areas problematic. The failure to develop this indigenous capacity has limited the ability of developing countries to build national surveillance systems that respond to both international public health threats and local health concerns. This capability is essential to the sustained development of countries.

Role of Field Epidemiologists in Providing Evidence

Developed countries have constructed their public health and disease control strategies by using the principles of field epidemiology. Developing countries need to build and sustain human capacity in field epidemiology. Strengthened field epidemiologic capacity can serve a country in the following specific areas:

- providing a response to acute problems
- providing the scientific basis for program and policy decisions
- implementing disease surveillance systems
- supporting national health planning
- making resource allocation decisions
- allocating the human capacity base for national health priorities.

Specific competencies that should be developed include, but are not limited to, the ability to accomplish the following:

- design, implement, and evaluate surveillance for a health event
- identify and assess an actual public health problem
- design and conduct a scientific investigation
- analyze and interpret data from an investigation
- recommend logical and practical public health actions after the analysis and interpretation of data

- be proficient in all aspects of diseases of public health importance (for example, HIV and AIDS, sexually transmitted diseases, malaria, tuberculosis, and zoonoses).

These competencies need to be tailored to the various levels of the health care system.

Since 1975, CDC and WHO have collaborated with more than 30 countries to strengthen health systems and address training needs for disease detection and response in a country-specific, flexible, and sustainable manner. More than half of the world's population now lives in a country where surveillance, investigation, and response are carried out by staff members and trainees of FETPs and allied programs, which include the Epidemic Intelligence Service in the United States, the European Program for Intervention Epidemiology Training, and Public Health Schools without Walls (PHSWOWs). These programs generally function within central ministries of health and may not be visible outside the public health system. It can be argued that these programs provide most of the surveillance of and response to emerging infections in the world, in addition to training most of the public health workers who manage surveillance systems at the top level. FETPs are two-year courses designed to provide a ministry with a motivated, professional group of field epidemiologists with the expertise to respond to managers' needs for evidence, perform surveillance, respond to outbreaks, and train and supervise technical personnel at other levels (White and others 2001).

Other models have evolved. Guatemala's marriage of its FETP (part of a larger, Central American FETP) with the Data for Decision Making program (Pappaioanou and others 2003) exemplifies this successful local adaptation. Data for Decision Making recruits health workers from the community and subdistrict levels to receive training in surveillance and outbreak investigation in the context of their daily work. This training is delivered as a series of linked workshops with practical field-based projects, providing short-term service at the local levels. The most promising graduates of the course are selected for further training in an FETP. India, with its decentralized system, complex cultural and population dynamics, and wide variance in the sophistication of public health institutions, provides another model for strengthening national surveillance. The World Bank initiated the Integrated Disease Surveillance Project, which develops the capacity of local and midlevel surveillance workers in India. Additionally, FETP graduates are recruited as the project's surveillance officers at the state level to coordinate the surveillance activities of the hundreds of local health workers throughout the states.

SELECTED SURVEILLANCE STRATEGIES

Surveillance systems need to be designed and implemented to meet top management's needs for focused, reliable, timely evidence gathered efficiently and presented effectively. Because these needs differ, depending on management's needs, a number of different strategies have been developed. Here are some of the most useful.

Sentinel Surveillance

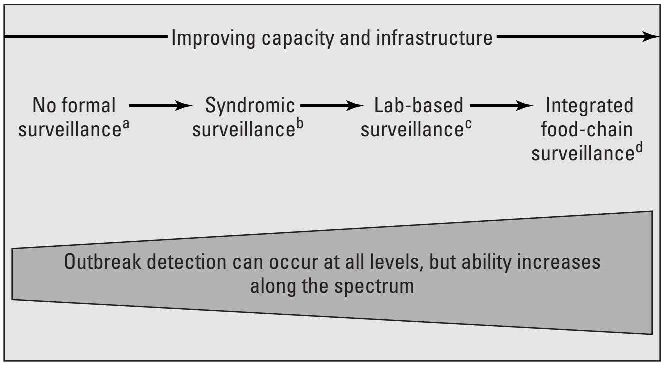
In a sentinel surveillance system, a prearranged sample of reporting sources agrees to report all cases of defined conditions, which might indicate trends in the entire target population (Birkhead and Maylahn 2000). When properly implemented, these systems offer an effective method of using limited resources and enable prompt and flexible monitoring and investigation of suspected public health problems. Examples of sentinel surveillance are networks of private practitioners reporting cases of influenza or a laboratory-based sentinel system reporting cases of certain bacterial infections among children. Sentinel surveillance is excellent for detecting large public health problems, but it may be insensitive to rare events, such as the early emergence of a new disease, because these infections may emerge anywhere in the population.

Periodic Population-Based Surveys

Population-based surveys can be used for surveillance if they are repeated on a regular basis (Thacker and Berkelman 1988). Examples of population-based surveys in surveillance include the BRFSS in the United States, HIV-prevalence surveys, household surveys, and the demographic and health surveys that many developing countries conduct every five years (http://www.orcmacro.com). Population-based surveys require careful attention to the methodology, particularly the use of standard protocols, supervision of interviewers, comparable sampling strategy, and standard questionnaires. These surveys require a clear definition of the target population to which the results can be generalized, and they need careful attention to the sample size, based on efficiency and the epidemiologic characteristics of the health condition under surveillance (for example, rare conditions require substantial samples). Supervising interviewers and maintaining high response rates are critical to avoid bias. Because the surveys are repetitive, population changes (caused, for example, by mortality or mobility) might bias results.

Laboratory-Based Surveillance

The methods used for infectious disease surveillance form a spectrum that evolves with the economic development of a country. Foodborne disease (FBD) surveillance, for example, is divided into four distinct levels of surveillance. Each level is more complex and has greater capacity for controlling and detecting disease, but it also depends on more resources and infrastructure (figure 53.3).



Source: Authors.

a. Without a formal surveillance, only large or unusual outbreaks can be detected.
b. Syndromic surveillance is based on groups of signs or symptoms indicative of a common diagnosis, such as acute gastroenteritis.
c. Laboratory-based surveillance relies on laboratory-confirmed pathogens, such as *Salmonella* or *Shigella*.
d. Integrated food-chain surveillance uses data from across the food chain.

Figure 53.3 Spectrum of Case-Based Foodborne Disease Surveillance

For FBD, surveillance for clinical syndromes is the most common method of surveillance in the developing world. Surveillance of FBD outbreaks that are investigated by public health authorities is often a useful means of monitoring both the safety of the food supply and the activities of the public health system. Although both surveillance for clinical syndromes and outbreak surveillance will remain important, the future in FBD is in laboratory-based surveillance. If microbiologic diagnosis is sought routinely for a sample of patients with acute gastroenteritis, then surveillance based on those diagnoses is possible. For enteric bacterial pathogens such as *Salmonella* or *Shigella,* determining the serotype of the strains in central reference laboratories allows more rapid and complete identification of epidemics, which may otherwise lead to preventable death and disability.

Laboratory-based surveillance systems require resources, facilities, and training. A central public health reference laboratory is essential for quality assurance and quality control and support. Such a laboratory-based system might begin with systematic referral of a sample of strains isolated at a sample of sentinel clinics, plus those strains that are part of outbreaks. A systematic sampling scheme provides better data than a more haphazard attempt at universal reporting. Regular sharing of information between the public health microbiology laboratory and epidemiologists is critical for the information to be used successfully.

The utility of serotyping as an international language for *Salmonella* subtypes has led to its widespread adoption. In a recent survey, 61 countries reported that they used *Salmonella* serotyping for public health surveillance (Herikstad, Motarjemi, and Tauxe 2002). A collaborative WHO program called Global Salm-Surv promotes the use of *Salmonella* serotyping internationally among countries that wish to upgrade their national capacity for FBD surveillance (http://www.who.int/salmsurv/en).

Molecular subtyping is now expanding the power of laboratory-based surveillance to detect outbreaks in the background of sporadic cases by distinguishing the molecular "fingerprint" of an outbreak strain. CDC maintains PulseNet, an Internet-based network of all U.S. public health laboratories that uses a standardized genotyping method called pulsed-field-gel-electrophoresis (PFGE) as the basis for a national database of PFGE subtypes (Swaminathan and others 2001). Standardized subtyping protocols have now been developed for seven pathogens, and next-generation, gene-based technologies are under development for the future. Similar networks are developing around the world, with PulseNet Europe and PulseNet Canada already active and discussions rapidly advancing for PulseNet Asia Pacific and PulseNet Latin America. As with *Salmonella* serotyping itself, the global use of standard genotyping will facilitate the detection of multicontinent clusters.

Integrated Disease Surveillance and Response

The Integrated Disease Surveillance and Response (IDSR) strategy, first developed in Africa, links epidemiologic and laboratory data in communicable disease surveillance systems at all levels of the health system, with emphasis on integrating surveillance with response (WHO 1993, 1998). Districts were identified as a focus for strengthening efforts in collecting timely data, analyzing the collected data, and using the generated information for public health responses. The IDSR strategy is based on core activities, including case-patient detection, registration, and confirmation; reporting, analysis, use, and feedback of data; and epidemic preparedness and response (for example, outbreak investigations, contact tracing, and public health interventions). Support functions include coordination, supervision or performance evaluation, training, and resource provision for infrastructure, including communication (Nsubuga, Eseko, and others 2002).

Key steps in implementing the IDSR strategy include sensitizing key health authorities and stakeholders; conducting situational analysis; preparing a strategic IDSR plan; identifying and training a motivated, competent workforce; developing national IDSR technical guidelines; implementing the plan; and monitoring and evaluating implementation to improve performance (WHO 2000b). Assessment of the existing national surveillance and response activities provides baseline data to measure progress; to identify and build consensus on the national priority communicable diseases; to identify surveillance gaps of the selected priority diseases; to document

Table 53.2 Steps in the Development of the Philippine National Epidemic Sentinel Surveillance System

Steps	Data side	Human capacity side
1.	Identify the health problems thought to cause burden disease.	Consult top managers, donors, international agencies, and experts.
2.	Determine who will make interventions.	Involve users in design.
3.	Determine information users' need to make interventions.	Involve users in design.
4.	Decide how often decision makers need reports.	Involve users in design.
5.	Identify who collects, tabulates, and analyzes reports and who disseminates information.	Identify manager and staff to analyze, report, and enter data.
6.	Design report.	Involve users and staff in design.
7.	Make table shells.	Involve staff in design.
8.	Design questionnaire.	Involve staff in design.
9.	Pilot questionnaire.	Involve staff in implementation and evaluation.
10.	Pilot data flow and analysis.	Involve staff in implementation and evaluation.
11.	Pilot system.	Train staff in system and involve them in evaluation.
12.	Run system.	Involve staff in ongoing training and quality assurance monitoring.
13.	Evaluate system: Was information used? Are data and analysis of good quality?	Involve staff and users in design of external evaluation and in review of evaluator's report.

Source: Adapted from White and McDonnell 2000, 311.

the strengths, weaknesses, and opportunities of the existing systems; and to make appropriate recommendations. The WHO Regional Office for Africa, collaborating with its partners, has prepared tools and guidelines for implementation of IDSR at the country level. Indicators to monitor the performance of the surveillance and response systems have been prepared and field tested and are now in use in Africa.

Example: The Philippine National Epidemic Surveillance System

In the late 1980s, the Philippine Department of Health (PDOH), relying on its integrated management information system, detected less than one outbreak per year in a population of more than 60 million people. In 1989, the PDOH designed the National Epidemic Sentinel Surveillance System, a hospital-based sentinel surveillance system that encompasses both the flow of data and the personnel requirements needed to make the surveillance system work effectively (table 53.2). After the pilot study demonstrated promising results, the PDOH created personnel positions and a supervisory structure for sentinel physicians, nurses, and clerks in regional epidemiology and surveillance units (RESUs) integrated into the public health system. In 1995 alone, the system detected and formally investigated about 80 outbreaks, including 25 bacteriologically confirmed outbreaks of typhoid and 5 of cholera. As the Philippines developed HIV serological and behavioral risk surveillance, the RESU staff conducted surveys in their communities. By integrating surveillance functions that were based on the skills of the workforce, PDOH was able to avoid the duplications, inefficiencies, and sustainability problems of multiple vertical systems (White and McDonnell 2000).

Informal Networks as Critical Elements of Surveillance Systems

WHO and other agencies frequently receive telephone calls or informal reports about urgent health events. WHO publishes an informal list of these "rumors," which allows public health workers to respond to health risks promptly rather than waiting for formal reports (http://www.who.int/csr/don/en/). The graduates of FETPs, PHSWOWs, and similar programs that provide competency-based on-the-job training in ministries of health make up one of the most important informal networks.

FETPs and allied programs both train epidemiologists and provide service to their ministries of health. For example, a student in the Brazilian FETP was assigned to review routine data on patients with leishmaniasis. She noted that some patients had symptoms of heavy metal poisoning, and further study indicated that a drug being used to treat leishmaniasis was contaminated with heavy metals. The drug was reformulated, and the problem was resolved. When this study was presented at a regional meeting of the Training Programs in Public Health Interventions Network (a network of FETPs and allied training programs), other countries banned the drug until it was reformulated (CDC 2004a).

Large categorical surveillance systems are expensive, and staff members might become complacent, especially if the disease under surveillance is rare. For example, the polio surveillance system for acute flaccid paralysis in the Western Hemisphere detected no cases in July 2000. A trainee from the FETP of the Dominican Republic, while investigating a case of suspected poisoning in a child, documented the first outbreak of circulating vaccine-type poliovirus in the Western Hemisphere since 1991. There were 13 confirmed cases in the Dominican Republic and 8 cases in Haiti. Her investigation led to national immunization days in both countries, which raised immunization levels and stopped the outbreak (Kew and others 2002).

THE ROLE OF SURVEILLANCE IN MAJOR OUTBREAKS

It seems incredible that a disease as devastating as AIDS could have spread silently to many countries over many years before it was detected and before effective control measures were implemented in the 1980s. In recent years, surveillance and response systems at all levels have been more effective at identifying and preventing spread of infectious diseases.

Example: Surveillance and Global Response to SARS

An epidemic of severe pneumonia of unknown etiology was detected in Guangdong province, China, in November 2002, and control measures were instituted on the basis of the way the disease spread from person to person. In February and March 2003, the disease spread to Hong Kong (China) and then to Vietnam, Singapore, Canada, and elsewhere (WHO 2003b). This new disease was named *severe acute respiratory syndrome*, and a preliminary case definition was established on the basis of initial epidemiologic investigations. A novel coronavirus (SARS-CoV) was identified as the causative agent in March, and mapping of the full genome was completed in April. This global pandemic ended in July 2003, as transmission was interrupted in Taiwan (China), after more than 8,000 patients in 26 countries and five continents were affected and 774 deaths were confirmed (Peiris and others 2003).

WHO spearheaded the global effort to control this pandemic, working with national and subnational health workers. In China, the FETP, which was initiated in October 2001 in the China Center for Disease Control, mobilized all 20 of its trainees, and they contributed substantially to the surveillance, investigation, and control of the SARS outbreak, working with local health officials (CDC 2003a). In Canada, which had the most cases of SARS outside Asia, 8 of the 10 FETP residents were involved in the SARS outbreak. They instituted surveillance, conducted epidemiologic investigations, designed prevention and control guidelines, responded to inquiries from the media and the public, and planned and implemented epidemiologic studies (http://www.phac-aspc.gc.ca/cfep-pcet/outbreaks_e.html).

The success of this global effort to control the first new epidemic disease of the 21st century depended on a combination of open collaboration among scientists and politicians of many countries and the rapid and accurate communication of surveillance data within and among countries. Rapid global spread was recognized, and a global surveillance network was established on the basis of an agreed-upon case definition that was sufficiently specific to ensure effective reporting.

Public health surveillance is critical to recognizing new cases of SARS and differentiating this disease from other causes of severe respiratory illness, especially influenza (Heymann and Rodier 2004). Ongoing research into sources in the environment as well as clinical, laboratory, and epidemiologic concerns will improve surveillance for this critical public health problem. Notably, this highly contagious disease—for which there is neither a vaccine nor a cure—was controlled by competent, dedicated health workers with access to excellent communications. SARS presented a greater challenge than smallpox, for which long incubation periods and vaccine facilitate control (Mack 2005). Although it is reassuring that national, regional, and global systems were effective in controlling SARS, there is no reason to rest on our laurels. The only certainty is that there will be more new challenges, very possibly including further outbreaks of SARS.

Example: Avian Influenza in Thailand

The disastrous pandemic (worldwide epidemic) of influenza in 1918 is thought to have originated from epidemics in birds, as were the influenza pandemics of 1957 and 1968 (Ungchusak and others 2005). In early 2004, large epidemics of avian influenza were recognized in birds in eight Asian countries; by November, the disease had spread from birds to 44 humans, 73 percent of whom died (Ungchusak and others 2005). This contagion sparked fears that the highly lethal avian virus might be adapting to spread from person to person, which could cause extensive health and economic damage around the world. In Thailand, avian influenza was investigated by FETP graduates and others in the Thai Ministry of Health in partnership with CDC. By applying field epidemiologic techniques supported by laboratory studies, they detected that the virus was being spread from human to human in a family. It is likely that person-to-person transmission may have occurred in other countries, where field epidemiology was not used.

The Thai example is important for achieving the following: (a) raising global awareness of the potential of a global catastrophe early enough that plans can be made to avert or decrease harm and (b) demonstrating that, as with SARS, the disease could be controlled with proven field epidemiologic methods supplemented by good communications, without vaccines, drugs, or a high-technology laboratory or surveillance system (Mack 2005).

Example: Ebola in Uganda, the Role of the PHSWOW

On October 8, 2000, a second-year student in the Ugandan PHSWOW returned to Gulu district in northern Uganda for his field project. He found a hospital jammed with patients with high fevers, diarrhea, and bleeding. He diagnosed viral hemorrhagic fever. He called the Ministry of Health in Kampala, where that weekend a graduate of the PHSWOW was in charge of taking calls about epidemics. She agreed with his diagnosis and arranged for samples to be rushed to the National Institute for Virology in South Africa, the nearest WHO reference center for viral hemorrhagic fevers. When the minister of health arrived at his office the next day, the graduate briefed him. Recognizing the gravity of the situation, the minister sent the graduate to head the public health team surveillance and control team in Gulu, and the student headed the clinical team that established infection control in hospitals and treated patients.

Laboratory tests quickly confirmed that the illness was Ebola hemorrhagic fever, which usually kills more than 50 percent of those infected (Heymann 2004). Public health surveillance was difficult for several reasons. Because the disease was severe and rapidly fatal, rural villagers feared that they might be stigmatized if the government knew about cases in their area. Some sought out traditional healers; others fled as soon as they realized they had been exposed, which prompted outbreaks in two other districts. Gulu was a politically unstable area, and some villages were difficult to reach because of rebel or bandit activity. The Ugandan government mobilized its military to help with case finding and invited WHO, CDC, and other international teams to assist. Patients with Ebola infection require intense nursing and medical attention to control bleeding, diarrhea, and fevers. Some patients bleed easily, and all their secretions can be highly infectious. Hospitals in Gulu were desperately short of supplies to control the spread of infection from so many patients simultaneously. In spite of this situation, Ugandan health workers selflessly cared for the sick. By January 23, 2001, a total of 425 cases had occurred, the largest Ebola outbreak recorded. Only 53 percent of the patients had died, a proportion far less than the 88 percent reported in the 1976 Ebola outbreak in the Democratic Republic of Congo (formerly Zaire) and other previous epidemics (WHO Report of an International Commission 1978). Sadly, 22 health care workers were infected. Because the team from the Ugandan Ministry of Health set up active surveillance nationwide, the other two outbreaks, started when infected Gulu residents fled to distant villages, were quickly detected and controlled. International observers commented, “National notification and surveillance efforts led to the rapid identification of these foci and to effective containment” (CDC 2001).

The Ugandan Ministry of Health invested in developing competent, motivated health workers through the PHSWOW, an active partnership with Makerere University, the Rockefeller Foundation, CDC, and WHO. Both students and graduates contributed to the ministry’s ability to rapidly identify and control this dangerous epidemic. Because the minister had timely evidence, he was able to notify other countries quickly and to bring in international teams before the disease spread further. Partially because of the lessons learned from this epidemic, Uganda has become one of the leading countries in implementing the IDSR program.

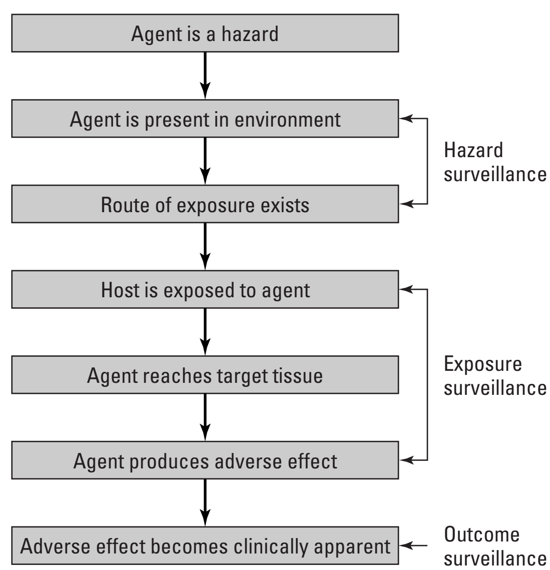
SURVEILLANCE FOR SPECIFIC CONDITIONS

Surveillance systems are important tools for targeting, monitoring, and evaluating many health risks and interventions. Because managers need a wide variety of information for specific interventions, systems have been developed and tested to meet those needs.

Environmental Public Health Surveillance

Surveillance for environmental public health practice requires the collection, analysis, and dissemination of data on hazards, exposures, and health outcomes (figure 53.4; Thacker and others 1996).

Health outcomes of relevance include death, disease, injury, and disability. However, relating those outcomes to specific environmental hazards and exposures is critical to



Source: Thacker and others 1996.

Figure 53.4 The Process of Adverse Effects and the Corresponding Surveillance environmental public health surveillance. Hazards include toxic chemical agents, physical agents, biomechanical stressors, and biologic agents that are located in air, water, soil, food, and other environmental media. Exposure surveillance is the monitoring of members of the population for the presence of an environmental agent, its metabolites, or its clinically inapparent (for example, subclinical or preclinical) effects.

Four challenges complicate environmental public health surveillance. First, the ability to link specific environmental causes to adverse outcomes is limited by our poor understanding of disease processes, long lead times, inadequate measures of exposure, and multiple potential causes of disease. Second, data collected for other purposes rarely include sufficient information to meet a case definition for a condition caused by an environmental agent. Third, public alarm is often out of proportion to the hazard of concern, and sentiment will often influence public policy disproportionately to scientific information. Fourth, biologic markers will become increasingly critical elements of environmental exposure surveillance.

Obtaining data on exposure, which can include estimates derived from hazard data through sophisticated modeling or direct measurements of individual exposure obtained from use of personal monitors (for example, passive air samplers), is generally impractical in developing countries. Childhood blood lead levels are the only biomonitoring data that are collected routinely in several countries, either in national surveys or from screening programs for children at high risk.

Health outcome surveillance as applied to environmental public health is similar to traditional surveillance efforts. In the United States, the focus is on surveillance for birth defects; developmental disabilities (for example, cerebral palsy, autism, and mental retardation); asthma and other chronic respiratory diseases (for example, bronchitis and emphysema); cancer; and neurological diseases (for example, Parkinson's disease, multiple sclerosis, and Alzheimer's disease) (McGeehin, Qualters, and Niskar 2004). Other nations have different sets of priority conditions for surveillance. Disease registries, vital statistics data, annual health surveys, and administrative data systems (for example, hospital discharge data) are sources that have been used for monitoring health conditions. The challenges mentioned previously have constrained our ability in all nations, regardless of level of development, to establish and maintain effective and comprehensive environmental public health surveillance systems. As we invest in understanding the enlarging threats in the global environment, we must overcome these challenges and establish improved surveillance systems. The health of the global community depends on this investment.

Injury Surveillance

Injuries are a major public health problem and are among the 10 leading causes of death worldwide, killing an estimated 5 million persons each year and causing high rates of disability. People from all economic groups are at risk for injuries, but death rates caused by injury tend to be higher in developing countries (Peden, McGee, and Sharma 2002). Injury surveillance includes monitoring the incidence, causes, and circumstances of fatal and nonfatal injuries. Injuries are classified by the intention of the act into two groups: unintentional injuries and violence-related injuries. WHO (Holder, Peden, and Krug 2001) and the Pan American Health Organization (Concha-Eastman and Villveces 2001) have developed guidelines for establishing injury surveillance systems in developing countries.

If the range of fatal and nonfatal injuries, as well as the risk factors that can lead to injury, are to be fully captured, surveillance systems need to be established in multiple settings. Fatal injuries can be captured by using forensic or death certificate data. A far greater number of injuries are nonfatal and can be tracked through hospital- or primary care–based systems. Systematic information on nonfatal injuries, including prevalence, incidence, and related risk behaviors can also be obtained through ongoing population-based surveys.

Critical points should be addressed when planning an injury surveillance system in a developing country. First, data sources need to be clarified. In some developing countries, routine data on injuries are not always captured in health information systems. It is therefore necessary to consider other sources of data—for example, law enforcement agencies, coroners, or medical examiners. Next, the events and variables in an injury surveillance system should be defined according to the objectives of the system. Criteria such as the intentionality (violence-related injuries versus unintentional injuries); the outcome (fatal injuries versus nonfatal injuries); and the nature of violence-related injuries (physical, sexual, psychological, deprivation, or neglect) should be considered when establishing the system. Finally, case definitions and coding procedures should be defined before implementing the system.

For example, the Nicaraguan Ministry of Health, in collaboration with CDC and the Pan American Health Organization, began developing and implementing an injury surveillance system in 2001 (Clavel-Arcas, Chacon, and Concha-Eastman 2004). The system, based on the medical facility emergency department (ED), collects data on injuries in keeping with the *Injury Surveillance Guidelines* established by WHO (Holder, Peden, and Krug 2001). Under the system, a reportable case is defined as a patient who died from or was treated for an injury in the ED. Cases include patients with unintentional and violence-related injuries.

ED staff members identify cases and collect data in five hospitals in Nicaragua. Information used to complete the instrument is collected directly from the patients or their representatives. An ED admission clerk collects basic demographic data on the patient's arrival. ED medical staff members (physicians and nurses) collect the remaining information (for example, location, mechanism of injury, nature, severity, and circumstances surrounding the injury) during triage and assessment.

The hospital epidemiologist collects data collection forms daily from the ED, reviews the quality of data, and requests data from the ED staff if the forms are incomplete. The statistician reviews data daily. The country project coordinator also monitors the quality of the data periodically. Using Epi Info 2002 programs developed specifically for this project, the project coordinators analyze trends and identify potential risk factors (Noe and others 2004). The information is used to produce monthly reports for dissemination. Information is reported at both the regional and the country levels.

Injury prevention programs in Nicaragua use surveillance data to assess the need for new policies or programs and to evaluate the effectiveness of existing policies and programs. For example, the municipality of León is using the information from the hospital to monitor the increase in suicide attempts among youths abusing pesticides and to evaluate an intersectoral campaign to promote life that includes primary through tertiary prevention strategies.

Surveillance for Biologic Terrorism

Surveillance for biologic terrorism is conducted primarily for outbreak detection and management. Surveillance must support early detection of an incident of biologic terrorism and its characterization in the same manner as for the detection and control of naturally occurring outbreaks of infectious diseases. Early detection of outbreaks can be achieved by the following (Buehler and others 2004):

- timely and complete receipt, review, and investigation of disease case reports, including the prompt recognition and reporting to or consultation with health departments by physicians, health care facilities, and laboratories
- improvement of the ability to recognize patterns indicative of a possible outbreak early in its course (for example, by using analytic tools that improve the predictive value of data at an early stage of an outbreak or by lowering the threshold for investigating possible outbreaks)
- receipt of new types of data (such as purchases of health care products, absences from work or school, symptoms presented to a health care provider, or orders for laboratory tests) that can signify an outbreak earlier in its course.

Environmental detection systems for microbial pathogens and toxins of concern for biologic terrorism might also be categorized as new types of data early in the course of an outbreak, before infection (Meehan and others 2004). The primary surveillance tools for event detection and management are the traditional disease-reporting systems for notifiable diseases discussed elsewhere in this chapter. These core surveillance tools should be robust before new data types can be considered for supplementing public health surveillance.

Syndromic surveillance is an investigational approach by which health department staff members, assisted by automated data acquisition and generation of statistical signals (computerized algorithms), monitor disease indicators continually to detect outbreaks of disease earlier and more completely than might otherwise be possible with traditional reportable disease methods (Buehler and others 2004).

CDC's list of biologic terrorism agents and diseases can be found at http://www.bt.cdc.gov and an updated list of references dealing with syndromic surveillance is at http://www.cdc.gov/epo/dphsi/syndromic/.

Complex Emergency Surveillance

The key elements in planning a disaster surveillance system are establishing objectives, developing case definitions, determining data sources, developing simple data collection instruments, field testing the methods, developing and testing the analysis strategy, developing a dissemination plan for the report or results, and assessing the usefulness of the system. The surveillance needs are different in the preimpact, impact, and postimpact phases (Binder and Sanderson 1987).

The role of surveillance in disaster situations has included the following broad framework of activities:

- predisaster activities (for example, hazard mapping, provision of guidelines, and training for medical and rescue teams)
- continuous monitoring and surveillance for priority health problems in affected populations (for example, in the post-tsunami surveillance in Tamil Nadu, India, a one-page instrument was used for 10 priority health conditions for daily active surveillance in displaced populations at camps)
- prospective surveillance of affected populations focusing on the natural history of exposure and health effects and long-term effects of stress disorders among survivors.

Surveillance in Refugee Populations

Support of relief efforts following national and global disasters has been a relatively new application of epidemiologic practice for the public health professionals. Nevertheless, since the initial CDC involvement with the United Nations in a large-scale relief effort concerning approximately 20 million displaced people affected by the 1967–70 civil war in Nigeria, CDC staff members have participated in several assessments of the health needs, damage, and nutrition in refugee populations resulting from man-made and natural disasters. The more notable and extended actions were conducted in the 1979–82 Khmer

Thailand-Cambodia refugee-relief action, followed by long-term public health surveillance of Somalian refugees (1980–83), periodic but comprehensive health and nutritional assessments of Afghan refugees in Pakistan (1980–2002), and growth and nutritional assessments of internally displaced populations—especially children—in the Democratic People's Republic of Korea (1990s) and southern Sudan. Although these relief efforts occurred many years and many thousands of miles apart, they shared several important characteristics:

- Large numbers of people were in fixed camps or on the move searching for food and shelter. These needs were usually addressed by external aid agencies and many times caused local environmental degradation (fuel, temporary housing, water pollution, and so on).
- Refugees, after the initial phase, competed with indigenous populations for scarce jobs, leading to social strife and stress. Refugees were also exploited and suffered violence—additional factors leading to stress and social maladjustment.
- No administrative structure to provide and coordinate assistance of the necessary magnitude existed before the crisis, and thus, it had to be created after the fact.
- Assistance was complicated by the uncertainty associated with military activity, crime, and hostile governments.
- Data that were relatively simple to gather and analyze provided health workers and administrators information needed to plan and monitor assistance and its impact.
- Close collaboration with other local and international relief organizations (such as the United Nations High Commissioner for Refugees, the International Red Cross, the United Nations Children's Fund, WHO, and USAID) was essential to instituting and sustaining a meaningful surveillance system for refugees that led to interventions.

The major goal of these activities is to identify and eliminate preventable causes of morbidity and mortality. Planning requires effective use of existing knowledge about characteristic or predictable demographic patterns, easily applied health indicators, and avoidable errors of omission or commission. As in disasters, the principles of surveillance (data collection, data analysis, response to data, and assessment of response) and other public health techniques should be an integral part of relief efforts. Retrospective evaluation of these efforts has also proved useful (CDC 1983).

Chronic Disease Surveillance Systems

Development and evaluation of policies for health improvement require a reliable assessment of the burden of disease and injury, an inventory of the disposition of resources for health, assessment of the policy environment, and information on the cost effectiveness of interventions and strategies. In all these areas, consideration of noncommunicable (mostly chronic) conditions becomes critical. In 1999, noncommunicable diseases were estimated to cause approximately 60 percent of the deaths in the world and 43 percent of the global burden of disease (WHO 2000a). WHO forecasts that by 2020 the burden of disease from noncommunicable diseases for developing and newly industrialized countries will have increased more than 60 percent (Murray and Lopez 1996).

Some developing countries have found it difficult to acquire and analyze accurate mortality statistics regularly, let alone morbidity and quality-of-life information. Ensuring development, implementation, and widespread use of noncommunicable disease data for better decisions on resource allocation is critical to improving the quality of lives and promoting a more equitable future for health within and between countries.

Hypertension, elevated blood cholesterol, tobacco use, excessive alcohol consumption, obesity, and the multiple diseases linked to these risk factors are a global public health problem. In one study, smoking, high blood pressure, and high cholesterol alone explained approximately two-thirds to three-fourths of heart attacks and strokes (Vartiainen and others 1995). Until recently, surveillance for risk factors was an activity commonly associated with developed countries (Holtzman 2003). However, recently WHO has increased attention to noncommunicable disease surveillance by developing tools and working to achieve data comparability between countries (WHO 2003c). Data on key health behaviors, obesity, hypertension, lipids, and diabetes are collected inconsistently in developing countries, especially in Africa. Data on tobacco use are available through the Global Youth Tobacco Survey (http://www.cdc.gov/tobacco/global).

Incidence data (the number and proportion of new cases in a population) are limited in developing countries. However, India's National Cancer Registry program may serve as a notable exception (http://icmr.nic.in/ncrp/cancer_regoverview.htm). In 1981, the Indian Council of Medical Research, recognizing that there was a lack of information on follow-up of cancer patients to assess quality of care, instituted a cancer registry network. The network provides data on the magnitude and patterns of cancer in eight areas of India to enable studies of the histologic features correlating with prognosis and association studies (for example, whether a history of vasectomy is associated with cancer of the prostate). Another important example relates to the widespread use of folic acid in China and the resultant reduction in incidence of birth defects (Kelly and others 1996; Wald 2004).

Surveillance data have been critical in establishing the importance of obesity as a public health priority in the United States. Data for individual states provided by CDC's BRFSS have enabled individual health departments to document their obesity epidemic (Sturm 2003). These data provide a measure of the effectiveness of interventions to meet the control objectives. The BRFSS is a practical tool for developing and middle-income countries, as Jordan demonstrated when it implemented a BRFSS in 2002; the first survey documented substantial levels of obesity, especially among women, combined with low levels of physical activity (CDC 2003b).

ECONOMICS OF PUBLIC HEALTH SURVEILLANCE SYSTEMS

The outbreak of SARS in 2003 demonstrates the far-reaching economic impact of not having an effective global public health surveillance system in place, with an estimated reduction in real gross domestic product of more than US$1.0 billion in Canada (Darby 2003) and estimated income losses in the range of US$12.3 billion to US$28.4 billion for East and Southeast Asia as a whole (Fan 2003).

Public health surveillance is considered a global public good (Zacher 1999), particularly when it is used for eradication of such diseases as poliomyelitis. As eradication campaigns decrease the number of cases, maintaining systems to find the last few cases becomes more expensive. Often, the majority of the costs for these systems fall on hard-pressed developing countries. This factor raises questions of fairness and equity. For example, as poliomyelitis becomes rare, it ceases to be a significant risk to national populations, whereas other diseases, such as malaria and diarrhea, typically are major causes of morbidity and mortality. In such countries, it seems most fair and efficient for the global community to finance eradication campaigns, leaving national systems free to address the diseases that most affect their populations. The negative impact of globally mandated eradication surveillance systems can be mediated or reversed by leveraging on the eradication program's infrastructure to gather surveillance data for diseases of concern to local governments (Nsubuga, McDonnell, and others 2002). A similar case can be made for influenza early warning systems in countries that gather information that will be used to create vaccines that will benefit other populations but not their own. Equity demands that the countries that benefit from such systems finance them.

Public health surveillance systems serve an essential function in preventing and controlling disease spread within and across national borders. Although the private sector benefits, it lacks the incentive to invest in public health surveillance systems, and sovereign states depend on the contribution of others (WHO 2002); this situation has important implications for the financing of public health surveillance systems. Even within national borders, the difficulty of quantifying the benefits of surveillance systems for individual communities leads to neglect by local authorities, providing the economic rationale for funding by the national government. Developing countries are reportedly the weak link in the global surveillance framework, although they bear the greatest burden of disease, emerging and reemerging old pathogens, and drug-resistant pathogens (U.S. GAO 2001). The greatest need for surveillance systems is in these countries, but most lack both the resources and the political will to build human capacity and finance the systems (table 53.3). Resource constraints and intense pressure to provide care and treatment services lead public health authorities in the poorest countries to spend resources on surveillance (U.S. GAO 2001). Because the costs and benefits derive from surveillance systems spilling across national borders, donors should assist with capacity building in countries that have been unable to invest the human and material resources required.

Table 53.3 Health Expenditures by National Income Level of Countries, 2001

Income group[a]	Government expenditures on health as a percentage of gross domestic product	Total expenditures on health as a percentage of gross domestic product
High income	6.30	10.74
Upper-middle income	3.68	6.41
Lower-middle income	2.58	5.63
Low income	1.22	4.78

Source: World Bank 2004.

a. All World Bank member economies with populations of more than 30,000 are classified into income groups, divided according to 2003 gross national income per capita, calculated using the World Bank Atlas method. The groups are low income, US$765 or less; lower-middle income, US$766 to US$3,035; upper-middle income, US$3,036 to US$9,385; and high income, US$9,386 or more.

An interesting and unresolved feature of these global public goods—the solution to their adequate provision and supply rests at local, national, and sometimes regional levels—has prompted the international health community to advocate for capacity building in developing countries rather than for consolidation of the fragmented systems at the global level (WHO 2002).

Standard tools of economic evaluation (Meltzer 2001) have been used to compare the benefits and costs of several public health interventions. The public good characteristics of surveillance systems, with benefits that are not easy to quantify, make the use of such tools difficult to implement in practice. However, economic evaluation of laboratory surveillance systems to detect specific disease-causing organisms have been undertaken in the developed world by comparing benefits and costs now and in the future (Elbasha, Fitzsimmons, and Meltzer 2000). These evaluations have not been done in developing countries and are needed. At best, an analysis of the benefits and costs of existing or proposed surveillance systems is feasible. This analysis requires an estimate of the cost of illness and answers the question of how many cases of a particular disease need to be prevented by the surveillance system to be exactly equal to the expenditure on the system.

Given expenditures on specific health interventions or programs, one can, by using traditional econometric tools, apply the data on health outcomes from the surveillance systems as inputs to economic analysis. Surveillance also clearly leads to a cost saving if it prevents the need for expenditure on treating patients.

FUTURE OF SURVEILLANCE

Public health agencies, ministries of finance, and international donors and organizations need to transform surveillance from dusty archives of laboriously collected after-the-fact statistics to meaningful measures that provide accountability for local health status or that deliver real-time early warnings for devastating outbreaks. This future depends in part on developing consensus on critical surveillance content and developing commitment on the part of countries, funding partners, and multilateral organizations to invest in surveillance system infrastructure and to use surveillance data as the basis for decision making. This vision of the future assumes a coherent, integrated approach to surveillance systems that is based on matching the surveillance objective with the right data source and modality and on paying attention to country-specific circumstances while maintaining global attention to data content needs.

Information technology and informatics can help in attaining this vision. Specifically, technology can facilitate the collection, analysis, and use of surveillance data, if data standards are developed and compatible systems are established. Data collection for surveillance would be an automatic by-product of any electronic systems used to support clinical care. Under this scenario, an automatic electronic message would be sent to the responsible public health jurisdiction with information about a health event (for example, death, disease, or injury), including all relevant information from the electronic health record about the patient, provider's name, patient's home address, risk factors, previous immunizations, and treatments. Even before this ideal capacity becomes widespread, technology such as cell phone–based systems could accelerate collection of key data (for example, occurrence of a viral hemorrhagic fever outbreak). The rapid penetration of cell phones in developing countries might obviate the need for prohibitively expensive landline-based systems. An accelerated system of wireless Internet access might also transform the capacities to which a local health post or a district health official might have access. These systems should also be considered as means for collecting information beyond traditional data. For example, telemedicine access can permit views of a rash illness to be shared with national or international medical specialists.

Analysis of surveillance data can also be transformed by using available technology. Software that is Web-enabled, together with the advances in geographic information system software and global positioning devices, means that anyone with Internet access can potentially apply the latest version of software running on a distant server in the national capital to local data to generate up-to-date maps and graphs describing health status in that jurisdiction.

Use of surveillance data can also be transformed. Sophisticated algorithms can be applied to data as it is collected to determine when (and how) an alert should be sent to local, national, or even international health officials to indicate a need for immediate investigation. Increasingly sophisticated visual display techniques and creation of custom channels with data of particular relevance to groups of data users are just some of the tools already being used to put public health content on the desktop of anyone with broadband, secure Internet access.

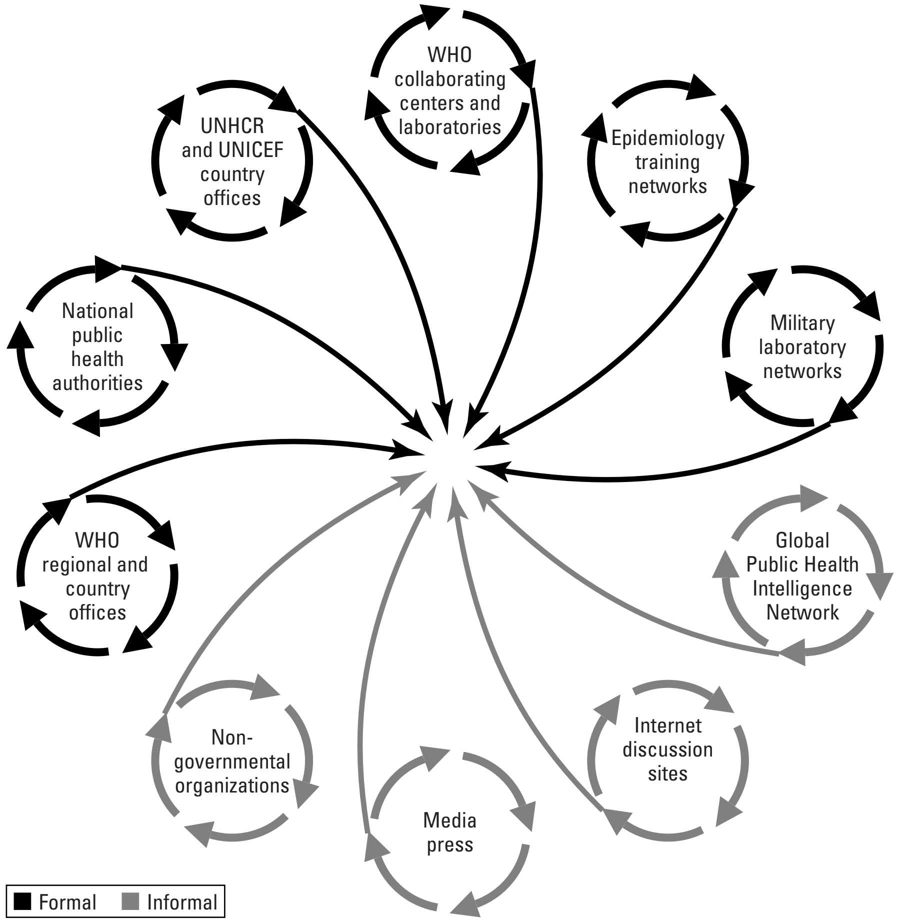
Realization of this future vision does not require technology beyond what is already feasible, but the following factors are needed:

- the organizational and political will to develop and coordinate the needed systems and standards that will enable those systems
- appropriate attention to individual privacy and system security
- removal of the financial and logistical barriers to broadband Internet access
- a strategic multisectoral approach to accelerating national infrastructure among the poorest developing nations.

GLOBAL SURVEILLANCE NETWORKS

Globally, infectious disease surveillance is implemented through a loose network that links parts of national health care systems with the media, health organizations, laboratories, and institutions focusing on particular disease conditions. WHO has described a "network of networks" (U.S. GAO 2001) that links existing regional, national, and international networks of laboratories and medical centers into a surveillance network (figure 53.5).

Government centers of excellence (for example, CDC, the French Pasteur Institutes, and FETPs) along with WHO country and regional offices also contribute to disease and health condition reporting. Military networks, such as the U.S. Department of Defense's Global Emerging Infectious Disease System, and Internet discussion sites, such as ProMed (http://www.promedmail.org) and Epi-X (http://www.cdc.gov/epix), also supplement the reporting networks. In 1997, WHO started the Global Outbreak Alert and Response Network, and



Source: U.S. GAO 2001.
a. UNHCR represents the United Nations High Commissioner for Refugees.
b. UNICEF represents the United Nations Children's Fund.

Figure 53.5 Global Infectious Disease Surveillance Frameworks

it was formally adopted by WHO member states in 2000. The network has more than 120 partners around the world and identifies and responds to more than 50 outbreaks in developing countries each year (Heymann and Rodier 2004).

The International Health Regulations are the only binding international agreements on disease control. The regulations provide a framework for preventing the international spread of disease through effective national surveillance coupled with the international coordination of response to public health emergencies of global concern by using the guiding principle of maximum protection, minimum restriction (WHO 2003a). The current regulations apply only to cholera, plague, and yellow fever; they require WHO member states to notify WHO of any cases of these diseases that occur in humans within their territories and then give further notification when the territory is free of infection. The regulations are being revised to include the development of national core capacities and national focal persons who have the competencies of graduates of FETPs and allied training programs. Programs established to improve the capacity of both epidemiologists and laboratorians to collect, use, and interpret surveillance and outbreak data (for example, the collaborative WHO program in foodborne diseases called the WHO Global Salm-Surv) are also important components in developing global surveillance networks.

RESEARCH AGENDA IN PUBLIC HEALTH SURVEILLANCE

Developing nations share surveillance needs with the rest of the world, yet they are challenged by economic limitations, weak public health infrastructure, and the overwhelming challenges of poverty and disease. As a result, countries in the developing world often depend on the research efforts of others, or they collaborate with others to conduct the research necessary for their surveillance needs. Within individual countries, surveillance systems are essential in measuring disease and injury burden as a first step in establishing public health priorities that lead to policies and programs.

The major research question for surveillance is how to develop and maintain a cadre of competent, motivated surveillance and response workers in developing countries. Other questions include how to design and maintain surveillance systems for these problems, especially morbidity systems for chronic diseases. Standard methods can be used to evaluate existing surveillance systems, which, in turn, will help define surveillance needs (Romaguera, German, and Klaucke 2000). Developing countries have used the IDSR strategy, which provides an efficient approach to data collection and analysis. Unfortunately, the majority of developing countries have limited surveillance systems for noninfectious diseases; instead, existing data systems (for example, vital records, motor vehicle crash records, or insurance claims data) are potential sources of surveillance data. In other settings, even these data sources are scarce, and approaches such as verbal autopsies and recurrent surveys might be alternatives (White and McDonnell 2000).

Surveillance for risk factors is another challenge, and BRFSSs need to be validated and applied more widely in developing countries. Surveillance for injuries, environmental hazards (such as traffic intersections that are associated with high rates of injuries), and exposures to chemical or biological agents is a key public health concern with few examples of effective application anywhere in the developed or less developed parts of the world. Rigorous research is required in this field (Thacker and others 1996).

The burgeoning use of electronic data systems and the almost universal availability of the Internet provide a tremendous opportunity for more timely and comprehensive surveillance in all parts of the world. Yet in this rapidly emerging field, critical needs exist, including the following:

- competent, motivated health workers
- data standards (Lober, Trigg, and Karras 2004)
- global policies and practices for international surveillance
- useful software (Dean 2000)
- evaluation of the effectiveness of all these applications.

New approaches that must be evaluated by using standard methods (Romaguera, German, and Klaucke 2000) include the following:

- IDSR for infectious diseases
- syndromic surveillance (CDC 2004b) for terrorism and emergency response
- laboratory-based surveillance methods to enhance diagnostic accuracy and increase timeliness of recognition of outbreaks and interventions (Swaminathan and others 2001).

Many research questions remain about surveillance methodology, including how to do the following:

- use data for forecasting or temporal and spatial analysis for aberration detection
- conduct surveillance for multiple competing risk factors that lead to a single condition (for example, smoking, cholesterol, hypertension, and overweight for heart disease)
- conduct surveillance for the adverse effects of drugs
- interpret ecologic data relative to data collected on individuals (Greenland 2004)
- measure cost-effectiveness of alternative approaches to surveillance (for example, integrated compared with categorical approaches)
- link data sources effectively (for example, hazard, exposure, and outcome data for environmental diseases)
- build and sustain human infrastructure in developing countries
- strengthen evidence-based decision-making cultures in ministries of health and finance.

CONCLUSION

Public health surveillance is an essential tool for ministries of finance, ministries of health, and donors to effectively and efficiently allocate resources and manage public health interventions. To be useful, public health surveillance must be approached as a scientific enterprise, applying rigorous methods to address critical concerns in this public health practice (Thacker, Berkelman, and Stroup 1989). Although the surveillance needs in the developing world appear to differ from those in the developed world, the basic problems are similar. In a time when we are confronted with SARS and avian influenza, the need to integrate global networks is undeniable, and research in how these concerns are addressed is essential. Collaboration among practitioners, researchers, nations, and international organizations is necessary to address the global needs of public health surveillance.

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