

# PART A

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## Public Health Surveillance: Questions and Answers

*Good surveillance does not necessarily ensure the making of right decisions, but it reduces the chances of making the wrong ones.*

Alexander D. Langmuir (Langmuir 1963).<sup>1</sup>

### What is public health surveillance?

*Surveillance* is defined as the “ongoing systematic collection, collation, analysis, and interpretation of data; and the dissemination of information to those who need to know in order that action be taken” ([www.who.int/emc/surveill/index.html](http://www.who.int/emc/surveill/index.html)).

*A more complete definition of surveillance* is: The ongoing systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know. The final link in the surveillance chain is the application of these data to prevention and control. A surveillance system includes a functional capacity for data collection, analysis, and dissemination linked to public health programs (CDC 1988).

There have been three developments in the conception and definition of surveillance. The original concept development was the watching and confinement of individual cases of highly communicable diseases responsible for devastating epidemics, in particular smallpox and yellow fever.

The object of watchfulness was moved from the individual to the surveillance of epidemic diseases in populations during the mid-20th century, largely due to the work of Alexander Langmuir (Langmuir 1976; Fowler 1993; Fowler 1994; Chorba and others 1989).

Finally, the concept of public health action was clearly attached to surveillance. *Action is what distinguishes surveillance from the task of simply monitoring events.* Donald Henderson, who was instrumental in the eradication of smallpox in the 1970s, once described surveillance as the “neurologic system of public health.” Surveillance, the eyes and ears of public health, provides information through which public health programs can act effectively and efficiently. Controlling and preventing diseases based on information collected through surveillance requires action. In some cases actions must be immediate—within hours—in order to prevent large-

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<sup>1</sup> Dr. Langmuir (1910–1993) was a surveillance expert and chief epidemiologist at CDC for more than 20 years. He was also founder of the U.S. epidemic intelligence service.

**Box 1.****SURVEILLANCE IS NOT RESEARCH**

Public health *surveillance* is essentially descriptive in nature. It describes the occurrence of injury or disease and its determinants in the population. It also leads to public health action.

*Research*, in contrast, is experimental in design, aimed at testing a hypothesis by comparing and contrasting groups. Surveillance data are usually limited in detail and price (that is, in the cost of obtaining the data), but may eventually be used to develop research hypotheses. Research data are often quite complex and detailed and are usually expensive to produce. If we confuse surveillance with research, we may be motivated to collect large amounts of detailed data on each case. The burden of this approach is too great for the resources available for surveillance systems and usually leads to failure.

scale epidemics and deaths (from, for instance, cholera, meningitis, Ebola, or food contamination). In others, control and prevention activities are long-term responses to information about diseases (such as tuberculosis [TB], acquired immune deficiency syndrome [AIDS], malaria, and noncommunicable diseases such as diabetes and hypertension), and action may be taken within days, weeks, or years.

**What are the goals of public health surveillance?**

The goals of surveillance often differ at the various administrative levels of the public health system (Table 1; WHO 1999a). Surveillance data are used to allocate resources and evaluate the impact of control and prevention strategies and programs at all levels. However, at the local level<sup>2</sup> the use of surveillance to trigger basic public health investigations and implement specific control activities predominates for infectious diseases and environmental hazards. In contrast, monitoring for trends, measuring the effectiveness of specific interventions, and conducting more complicated analysis to elucidate risk factors predominate at the national level. At the local level analytic capacity is usually much more limited than at the national level. At the state level<sup>3</sup> public health agencies typically share both perspectives.

There are many types of surveillance systems, which vary from very simple to complex. In general, in developing countries the use of less complex, more easily established, and sustainable systems are pre-

**Table 1.**  
**Levels Where Surveillance Activities Are Performed**

Activities	National level	State level	Local level
Detection and notification of cases	—	—	Yes
Collection and consolidation of case data	Yes	Yes	Yes
Analysis and interpretation	Yes	Yes	Yes
Investigation of cases and confirmation of diagnosis:			
• Epidemiologist	—	Yes	—
• Clinician	—	—	Yes
• Laboratory	Yes	Yes	—
Feedback	Yes	Yes	Yes
Dissemination	Yes	Yes	Yes
Action			

— = not usually

Source: Adapted from WHO 1999b.

<sup>2</sup> This toolkit will use the term “local level,” which is also referred to as the municipal, district, county, or jurisdictional level, among others.

<sup>3</sup> This toolkit will use the term state level to refer to the intermediate level between national and local, which is also referred to as provincial, departmental, or regional, among others.

ferred. Examples of key elements of surveillance systems are provided in box 2.

**Box 2.**

### KEY ELEMENTS OF SURVEILLANCE SYSTEMS

All surveillance systems involve six key elements:

1. Detection and notification of health event
2. Investigation and confirmation (epidemiological, clinical, laboratory)
3. Collection of data
4. Analysis and interpretation of data
5. Feedback and dissemination of results
6. Response—a link to public health programs, specifically *actions* for prevention and control.

Source: Adapted from WHO 1999a.

Central to the concept of surveillance is that any system implemented serves as a stimulus to some action. Collection of data without an accompanying plan for using these data to address health problems is a waste of resources. (Box 3)

**Box 3.**

### USES FOR SURVEILLANCE

Surveillance may be used to:

- Recognize cases or clusters of cases to trigger interventions to prevent transmission or reduce morbidity and mortality (includes the special case in which surveillance at the national level is required to recognize multi-state clusters);
- Assess the public health impact of health events or determine and measure trends;
- Demonstrate the need for public health intervention programs and resources, and allocate resources during public health planning;
- Monitor effectiveness of prevention and control measures and intervention strategies;
- Identify high-risk population groups or geographic areas to target interventions and guide analytic studies; and
- Develop hypotheses that lead to analytic studies about risk factors for disease causation, propagation, or progression.

Different goals require different approaches to data collection. Tradeoffs are necessary between timeliness and detail, and between achieving representativeness and getting case reports for control of transmission or exposure or other individualized interventions (Meriwether 1996). For example, at the local level a case of measles in a day-care center requires an immediate public health response to prevent spread based on clinical findings prior to laboratory confirmation. In contrast, only laboratory-confirmed cases and those cases that are epidemiologically linked to confirmed cases are used at the state and national levels to monitor progress toward measles elimination.

In a similar way local public health authorities may review individual cases of infant mortality to assess gaps in the health-care delivery system and obstacles to the implementation of community-based prevention strategies. At the state level infant mortality may be mapped using sophisticated geographic information systems (GISs) not available locally to identify areas where further interventions should be targeted. At the national level cause-specific infant mortality rates (IMRs) may be used to judge the effectiveness of nationwide strategies that promote infant survival (such as oral rehydration solution (ORS), or Integrated Management of Childhood Illnesses (IMCI), vaccination, breast-feeding, and clean deliveries). Cause-specific mortality rates are also used to modify recommendations as efforts to reduce infant mortality succeed and the causes of infant mortality change.

Surveillance often results in more targeted and focused prevention activities. Such activities can be described as primary, secondary, or tertiary (see box 4).

Surveillance systems play an important role at each of the three prevention levels. An example at the primary protection level would be surveys of im-

**Box 4.****PRIMARY, SECONDARY, AND TERTIARY PREVENTION IN PUBLIC HEALTH**

- Primary:** Prevention of the development of disease or injury in a susceptible or potentially susceptible population through specific measures, such as immunization
- Secondary:** Efforts to decrease the duration and severity of disease/injury through early diagnosis and prompt intervention
- Tertiary:** Efforts to limit mortality and the degree of disability and promote rehabilitation and restoration of function after disease/injury

munization coverage among school-age children that form the basis of a surveillance system of vaccination programs. Surveillance of reports from health-care providers on cases of measles to assess whether appropriate treatment has been rendered would be an example of surveillance at the secondary prevention level. Finally, routine assessment of hospital-based records for utilization of rehabilitative services for those cases with severe measles would be an example of surveillance at the tertiary prevention level.

**Why invest in surveillance?**

*With relatively small investments, public health programs are very effective in reducing death, disease, and disability.* By investing in public health surveillance the public health system is made more effective and efficient. For example, surveillance can lead to early detection of a local epidemic when its control is more effective and less costly in dollars expended and lives claimed. Apart from the health sector, epidemics can be costly because of their impact on productivity as well as on other aspects of the economy. For instance, the economic impact of the plague epidemic in India in 1994 was a loss of \$1.7

billion (which was especially due to losses in the tourism and exports industries). The 1991 cholera epidemic in Peru involved a total loss of \$770 million, which was primarily from losses in the tourism and seafood industries (Rodier 1998).

Intra-national and international borders are ineffective for containing diseases, so investment in surveillance and public health is a wise investment for the country in which the epidemic is or might be currently occurring, as well as the countries to which it might spread. The cholera epidemic in Peru mentioned above eventually spread throughout much of Latin America. Smallpox is another example of a disease that spreads quickly. The cost of the surveillance and public health programs to eradicate smallpox was relatively small in comparison to the increasing dividends to all countries for being able to eliminate mass immunization programs for this disease.<sup>4</sup> The economic devastation from the AIDS epidemic can serve as a warning of the potential consequences of a more rapidly lethal epidemic of hemorrhagic fever (including, for instance, the Ebola virus), plague, or cholera should we fail to control epidemics of any of these entities at the local level and should they become national, regional, or international epidemics. Antibiotic resistance is an emerging cross-border issue that requires surveillance for effective control and prevention ([http://www.who.int/emc/amr\\_interventions.htm](http://www.who.int/emc/amr_interventions.htm)). While it necessitates an investment in laboratory systems, in the long term such an investment may be minimal compared with the costs of treating antibiotic-resistance diseases on a large scale or from years of productive life lost (YPLL).

Beyond its role in controlling devastating epidemics surveillance is important for the control and prevention of endemic diseases that reduce produc-

<sup>4</sup> This is also true of the cost in terms of disability-adjusted life years (DALYs).

tivity and can be costly to manage. Good surveillance systems permit early identification of diseases such as TB and syphilis that can easily be cured with low-cost treatments, combined with other public health actions. Early detection of these communicable diseases decreases the amount of time an infected person is able to transmit the disease to others thus preventing, and potentially eliminating, new cases. Treatment of chronic noncommunicable diseases (NCDs) such as heart disease and diabetes and their sequelae is expensive, so their prevention is far more cost-effective. Prevention and control of these diseases requires surveillance of the behavioral risk factors (BRFs—such as smoking, physical inactivity, and obesity) that lead to their development, as well as actions to promote the desired changes and risk reductions.

While there are human and fiscal costs of epidemic and endemic disease, there are also opportunity costs associated with investing in public health programs. It is essential that interventions be evaluated and resources targeted so that their contribution, compared with other possible interventions, is optimized. Surveillance can provide useful information to identify populations at greatest risk where intervention may make the most contribution and to gauge the effectiveness of intervention programs. For example, surveillance of behavioral risk factors for diseases such as human immunodeficiency virus/acquired immune deficiency (HIV/AIDS) may identify growing high-risk sexual behavior in targeted populations. It may also provide information on whether programs such as public education are leading to an increase in preventive behaviors over time. In the case of HIV/AIDS, this would include increased condom use or decreased needle sharing.

### **What is the spectrum of outcomes amenable to surveillance?**

*Most countries have promulgated by law or regulation a list of public health conditions for which there*

*is mandatory reporting by health providers or health-care facilities. The list of conditions is determined by each country and primarily includes communicable diseases. Communicable diseases commonly subject to mandatory reporting are: childhood vaccine-preventable diseases such as polio, measles, tetanus, and diphtheria; TB; hepatitis; meningitis; and leprosy. However, reporting of noncommunicable conditions—such as infant and maternal deaths, injuries—and occupational and environmental diseases—such as pesticide poisoning—are often required, as well. International regulations currently require reporting the occurrence of three diseases to the WHO: plague, yellow fever, and cholera (WHO 2001b).*

Surveillance may be performed on any element of the chain of causation that leads to a communicable or NCD. For example, elements of measles surveillance could involve routinely assessing how many members of a community are vaccinated, how many cases of measles occur, how many cases occur among vaccinated individuals (called vaccine failure), and costs associated with vaccination programs and treatment of cases, among many others.

Behavioral risk factors are also a reasonable target for surveillance. Prevention of deaths due to heart disease, lung cancer, and stroke includes the promotion of abstinence from smoking, while sexually transmitted infections (STI) and AIDS prevention involves the promotion of condom use. The prevention and early detection of some cancers also involves changes in behavior (such as regular Pap smears and mammograms, use of sun block, or smoking cessation).

The expanding scope of conditions and determinants of conditions amenable to surveillance is, however, a cause for concern. *The number of conditions and determinants designated for surveillance must be restricted to the human and financial resources available*

to adequately sustain the surveillance system, and to conditions in which surveillance can effectively lead to prevention. There is no “magic number” of conditions that should be included. Rather, the resources available to manage the system effectively and to collect data of reasonable quality should determine the number of conditions and determinants that are included. Priorities must be established (discussed below under Setting Priorities). Notifiable diseases (such as botulism and anthrax) often occur at very low frequency, but because of their public health implications it is essential any cases be reported.

Although there is no “magic number,” table 2 presents a possible scheme for developing a surveillance system. The first column designates a minimal list of diseases for surveillance. (Note that all countries of the world now have at least some sort of rudimentary system of surveillance for at least polio and TB.) Diseases should be added as the system evolves and resources become available. A suggested second

line of diseases is presented in the second column of table 2. However, the expansion of the list of notifiable diseases will depend on a country’s public health priorities. In some countries (for example, countries in Eastern Europe and Central Asia) NCDs may be a greater priority, and therefore BRF surveillance may be more important to include in the second line. Once the system is developed other diseases may be added. High-income countries have dozens of conditions under surveillance. It is preferable to achieve a reasonable level of accuracy, connection to control programs, and sustainability before adding diseases.

Overambitious designation of conditions for surveillance stems from at least two sources. On the one hand the resources for doing surveillance well are underestimated. On the other hand even if a condition, however grievous, is not preventable, mounting a surveillance system is a way for governments to respond, albeit ineffectually, to societal pressures for action.

**Table 2.**  
**Scheme For Developing And Expanding A List For Mandatory Disease Reporting**

Minimal list	Second line	Third line
<i>Vaccine preventable:</i> Polio <sup>a</sup> Measles Tetanus	<i>Vaccine preventable:</i> Diphtheria Pertussis	<i>Vaccine preventable:</i> Rubella Chickenpox Mumps
<i>Communicable:</i> TB	<i>Communicable:</i> Meningitis Syphilis HIV/AIDS	<i>Communicable:</i> Hepatitis Nosocomial infections Gonorrhea/Urethritis Foodborne pathogens
<i>Internationally required:</i> Cholera Yellow fever Plague	<i>Non-communicable:</i> Infant death	<i>Non-communicable:</i> Behavioral risk factors Maternal death Pesticide poisoning
<i>In endemic areas:</i> Malaria Leprosy Onchocerciasis <sup>a</sup> (river blindness) Dracunculiasis <sup>a</sup> (guinea worm)	<i>In endemic areas:</i> Dengue-especially hemorrhagic Ebola/hemorrhagic fevers Rabies	<i>In endemic areas:</i> Encephalitis

<sup>a</sup>Targeted for eradication

**Table 3.**  
**Major surveillance methods**

Surveillance methods	Comments
Mandatory disease notification <sup>a</sup> by health-care providers or facilities	<ul style="list-style-type: none"> <li>• Require immediate public health response; or</li> <li>• Recognizable solely by providers</li> </ul>
Reports by laboratories (reporting source)	<ul style="list-style-type: none"> <li>• Immediate public health response may or may not be needed</li> <li>• Laboratory test needed for recognition or to meet case definition</li> <li>• Laboratory test adds relevant information (such as Salmonella serotypes, antibiotic susceptibilities for TB and pneumococcus, cell type for cancer)</li> <li>• Back-up to clinician's reporting</li> </ul>
Sentinel surveillance	<ul style="list-style-type: none"> <li>• Useful for collecting detailed information on a subset of cases</li> <li>• Designed so findings can be generalized to a specified population</li> <li>• Collect limited information to recognize the onset, termination and characteristics of a particular public health problem of limited duration (such as influenza)</li> <li>• Used when incidence of a condition is high (such as diarrheal diseases, acute respiratory infection [ARI])</li> </ul>
Periodic or ongoing prevalence surveys	<ul style="list-style-type: none"> <li>• To assess prevalence trends over time (such as HIV seroprevalence surveys, BRF surveys)</li> <li>• Optimal if designed to be useful to state and local public health agencies</li> <li>• Generate hypotheses regarding risk factors</li> <li>• Evaluate the effectiveness of a public health or clinical intervention</li> </ul>
Vital records	<ul style="list-style-type: none"> <li>• Surveillance of births and deaths; trends in causes of death</li> <li>• Key for infant and maternal mortality surveillance</li> <li>• May be used alone for some analyses</li> </ul>
Secondary analysis of datasets collected for other purposes	<ul style="list-style-type: none"> <li>• Places no additional burden on public health surveillance systems</li> <li>• Care must be taken in analysis and interpretation</li> <li>• Immediate public health response are not needed</li> <li>• Assess the public health impact or monitor trends</li> <li>• Measure morbidity costs due to chronic or recurrent health events</li> <li>• Potential data sources include hospital discharges, billing, insurance, emergency room, school/work attendance, immunization registries, work-site injury and law enforcement records</li> </ul>

<sup>a</sup>These diseases vary from country to country, and even from state to state.  
Source: Adapted from WHO 1999<sup>a</sup>.

## What are the major surveillance methods?

### ***Mandatory reports of certain diseases by clinicians or health-care providers or facilities***

This is the traditional source of surveillance data. Compliance with reporting requirements varies greatly and is dependent on the health-care provider's perception of whether the public health agency is

really using the information for action rather than merely collecting and mothballing data. Generally, the more severe the illness (such as meningitis) the more likely it is to be reported. Reports from providers are routinely based on clinical diagnoses, which are not usually based on the most sophisticated diagnostic testing. Hence, cases are more likely to be reported as hemorrhagic fevers (rather than a

specific type of virus), or as suspected diagnoses, such as suspected rabies in the case of fatal encephalitis following an animal bite. Nevertheless, such reporting alerts the public health authorities to potential problems.

### **Reports by laboratories**

Laboratories are usually more compliant in reporting disease than are health-care providers. Surveillance systems based on laboratory reporting must balance the greater accuracy of the diagnosis with the sensitivity of the system for detecting a meaningful proportion of cases in the community. In more developed countries and those with stronger systems clear lines of communication between regional referral and reference laboratories and those responsible for surveillance should be nurtured, since the number of samples submitted (such as for suspected encephalitis) to the laboratory, as well as the number of confirmed cases are a dependable source of information. Due to high costs, the volume of laboratory testing in low-income countries is low and therefore the usefulness of lab-based systems is limited. Diagnostic accuracy in developing-country laboratories is also a frequent problem.

### **Sentinel surveillance**

In sentinel surveillance a sample of reporters (such as clinicians, hospitals, and local laboratories) are designated as the reporting sources. Sentinel surveillance is effective where the goal is to estimate the magnitude and trends of a disease, rather than to detect the earliest or all cases, which may not be within the domain of the sentinel reporter. By focusing on a specific sample of reporters the surveillance system has a better chance of obtaining accurate and high quality information. Sentinel reporting is sufficiently sensitive to detect common diseases such as influenza or diarrheal diseases, but is generally ineffective for epidemics that are localized and that must be identified as early as possible, such as any of the hemorrhagic fevers, cholera, or vaccine-preventable diseases.

### **Periodic or ongoing prevalence surveys**

A periodic survey of a representative sample of the population can provide useful information on prevalence of behavioral risk factors, utilization of preventive measures, occurrence of exposures, injuries, self-reported disease, and so on. The benefit of sampling is that information from a relatively small group of respondents provides accurate estimates of the general population. A repeated survey can qualify as surveillance, as in the case of phone surveys of seatbelt use, or school-based surveys of tobacco use or other behaviors among students. Continuous surveys require greater resources, but provide time-linked information that is very useful in assessing the impact of events or particular interventions.

### **Vital records**

Vital records of births and deaths are generally underutilized as a surveillance source. These records can be used to estimate the magnitude of certain diseases and injuries, describe distribution (such as by age or geography), track trends, set priorities, and fulfill many other useful public health needs. However, collection of information without analysis and dissemination for use in prevention does not qualify as public health surveillance. The reduction of IMR and MMR are two millennium development goals (MDGs)—whose surveillance is carried out using vital records, primarily. Effective surveillance of IMR and MMR at the local level can lead to more appropriate interventions for preventing such deaths. Electronic systems for reporting vital records data are making this type of surveillance more timely and effective. (See box 13, in appendix B.4, for more information.)

### **Secondary analysis of datasets collected for other purposes**

Data are collected by nonpublic health agencies for a myriad of reasons. For example, local industries will collect data on absenteeism and even on the causes for absenteeism. Departments of transporta-

tion may collect information on motor vehicle accidents and injuries. This information may then contribute to the overall surveillance system.

### What is the difference between surveillance and health information systems?

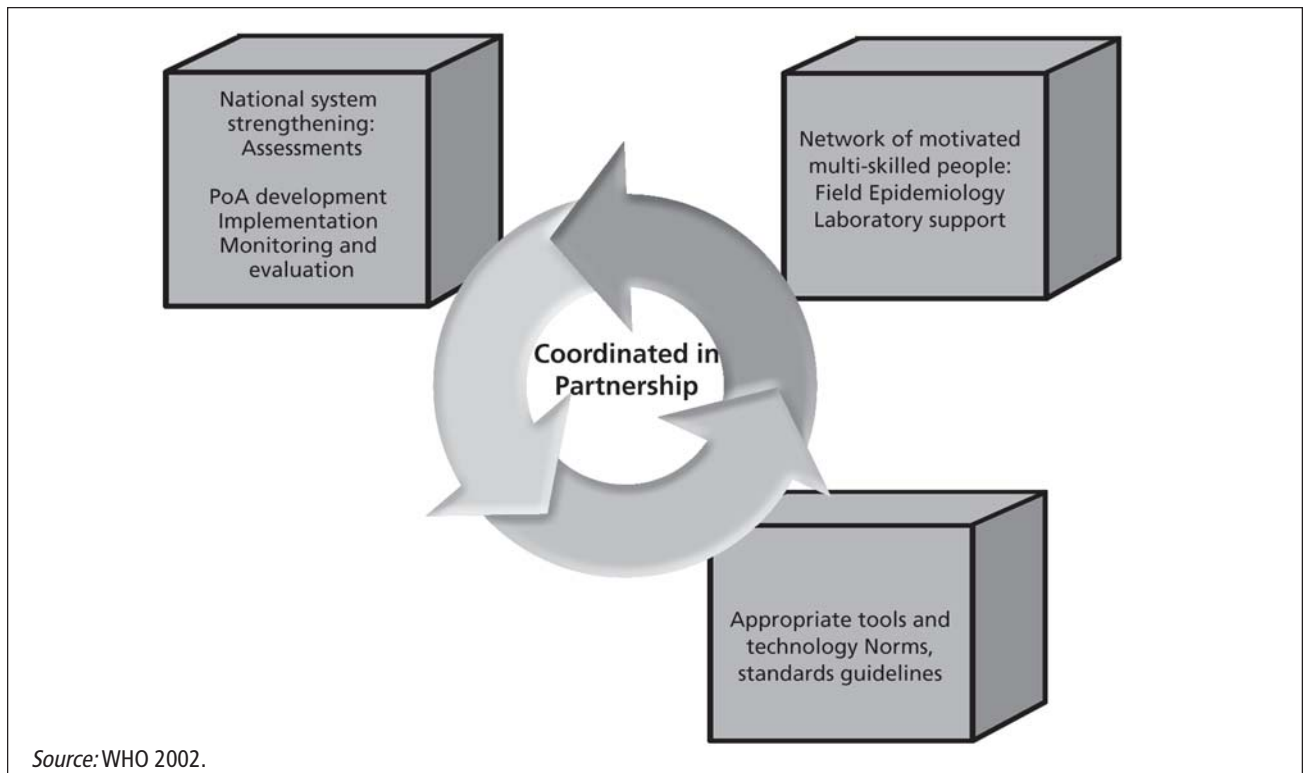
Health information systems encompass all the different data collection systems available to a ministry of health (MoH), including information from hospitals, clinics, and providers (such as the numbers of patients, diagnoses, procedures, and outcomes; personnel, and pharmaceutical and other procurement systems; program-specific data such as vaccinations, prenatal care, disease treatment outcomes; and so on). Public health surveillance is one component of the health information system. Health information systems everywhere, but particularly in low-income countries, should avoid collecting too much infor-

mation that is never used, often because the goals are not clearly articulated or are focused on more specific needs.

### What is the difference between vertical and integrated surveillance systems?

*Vertical surveillance systems focus on one disease or injury.* Information is then fed back into the specific disease control program. The information collected may be drawn from one or more elements in the chain of causation and prevention of that disease or injury. For example, because of the current global effort to eradicate polio, information from surveillance systems is fed directly back to the Expanded Program on Immunization (EPI) polio program, which mounts a rapid response when a case of acute flaccid paralysis (AFP) is detected. Such surveillance systems tend to be costly but very effective. In the

**FIGURE 1**  
**INTEGRATED APPROACH TO COMMUNICABLE DISEASE SURVEILLANCE**



case of polio the costs are often borne by international donors who are supporting the global campaign to eradicate the disease.

In contrast, *an integrated approach envisages a common system for multiple diseases using similar structure, processes, and personnel.* (Figure 1) This requires coordination but is more efficient and less costly, because it allows building on existing resources and capacity. It also promotes the most effective use of health resources. The WHO is currently recommending the creation of units at the national level to coordinate various surveillance activities in communicable diseases. Coordination implies providing individual programs (such as programs for TB, vaccines, and injury prevention) with the needed information. An integrated surveillance system collects information on behaviors related to both NCDs and communicable diseases (condom use for HIV, hand-washing practices for diarrheal diseases, and hepatitis, for instance) and—ideally—requires an integrated approach (WHO 2000). At the local level, integrated systems are often the norm and make particular sense since the numbers of cases for any particular disease may be small and would not warrant separate vertical systems. At the local level, the same personnel usually report and investigate all notifiable diseases.

### **What is active versus passive surveillance?**

*Passive surveillance* depends on voluntary data reports from health-care providers, laboratories, and others. This is fundamental to any surveillance system. *Active surveillance* takes surveillance another step and involves searching for cases by a surveillance authority. House-to-house searches in outbreaks, such as an outbreak of Ebola, is an example of active surveillance. STI surveillance (gonorrhea or syphilis, among others) is often active surveillance, with follow-up of cases confirmed by the laboratory to ensure all cases have been adequately treated. STI surveillance usually involves

an active search for persons who have had sexual contact with infected persons to ensure their treatment. Little surveillance takes place in low- and middle-income countries because it is resource-intensive; exceptions may include case finding in outbreaks and contact investigation for STIs or TB.

### **What are important issues when considering sources for surveillance data?**

There are three major issues in considering alternative sources of surveillance data. One issue is *cost*. Surveillance systems that are based on, or that piggyback on, existing systems are less costly. Such systems are also more likely to survive through the worst of times, since the rationale for maintaining the program on which surveillance is based may be more compelling to decisionmakers than supporting a surveillance system that stands alone. For example, reporting of communicable diseases by health-care workers is a low cost surveillance system.

A second issue in selection of source of surveillance data is *sustainability*. Whether a surveillance system can be sustained and maintain its effectiveness over time depends on many factors, including the complexity of the system, its burden on reporters, the reporters' perception of the system's value to them, the cost of the system, and program funders' assessments of the system's contributions to prevention.

The third major factor is *whether the system meets its goals*. There are numerous goals for surveillance, including the detection of epidemics, responding to health problems with appropriate public health actions, and estimating the magnitude of a health problem over time. The goals of each surveillance system should be well specified. While not every surveillance system meets all the goals of surveillance, a surveillance system that does not meet its specified goals should be corrected or abandoned.

## **What are the considerations in planning public health surveillance?**

### ***Setting priorities***

Priorities must be set among the long list of diseases and injuries that affect humankind. A common problem is an over-ambitious approach in establishing the list of notifiable diseases and injuries. The list of associated risk and preventive factors is also long. Priorities should be based on public health importance, including the measure of the disease's seriousness for the individual, its current burden on society, the potential burden on society (which involves the issue of communicability and the potential for epidemic spread), and preventability. Priorities are also determined by the country's capacity to respond with the necessary public health actions for disease prevention and control. Middle-income countries will be able to address an expanded list of health priorities compared with low-income countries.

Parameters for measuring the importance of a health event—and therefore the need for a surveillance system with which to monitor it—include:

- Total number of cases, incidence, and prevalence
- Indices of severity, such as the case-fatality ratio
- Mortality rate
- An index of lost productivity: such as bed-disability days
- An index of premature mortality: such as YPLL
- Cost-effectiveness of interventions
- Preventability
- Epidemic potential

### ***Setting goals and objectives***

There are many goals for surveillance programs. These goals include estimating incidence, measuring trends, identifying cases for intervention,

developing effective prevention and control programs, and evaluating interventions. Not every surveillance project can meet each goal, but a given system must meet the goals for which it was designed. Data must be collected for a purpose, not just routinely, or the system will ossify, and participants—especially reporters—will lose interest.

### ***Case definition***

The definition of what constitutes a “case” in terms of surveillance can depend on clinical diagnosis, laboratory results, demographic information, or any other agreed on attribute. Cases can be defined with different degrees of certainty. For example, measles may be defined by clinical presentation, or by sophisticated laboratory procedures. Case definitions for surveillance must be standardized. They may be more or less restrictive than criteria used for clinical diagnosis (CDC 2001). Case definitions vary from country to country depending on what resources (particularly laboratory resources) are available (CDC 1997). (See appendix A.8 for examples of WHO case definitions.)

### ***Suspected versus confirmed cases***

It is important to maintain a high degree of suspicion and cast a wide net initially, in order not to miss cases. Thus a definition for a suspected case is established and the case is then confirmed through laboratory testing or clinical follow-up. Most suspected cases are reported with minimal information; this is followed up with a more thorough investigation to confirm the disease, and assess potential sources and possible contacts so that they, too, may receive treatment, as needed.

## **What conditions lend themselves to successful surveillance programs?**

As stated earlier, an important component of a national surveillance plan is a list of priority diseases for surveillance. This list, as short as possible, should be established with the close participation of national

health authorities. These questions should be addressed not only from the national perspective but also from a regional, and possibly international, viewpoint because diseases may spread rapidly, without regard for national boundaries. The questions in box 5 can be used to guide disease selection.

In addition to specific diseases, specific syndromes (including hemorrhagic fever syndrome) as well as some specific public health issues (such as antibiotic susceptibility of some infectious agents) should be considered for surveillance. Following, or possibly preceding, the list of priority diseases, an inventory of existing surveillance activities should be carried out. This should be based on thorough on-site visits and a review of all key components of the health system, including public and private sectors where appropriate, as well as a review of any nongovernmental organizations (NGOs) involved in long-term health activities in the country.

#### Box 5.

#### CRITERIA FOR DISEASE SELECTION

- Does the disease have a high disease impact (morbidity, disability, or mortality)?
- Does it have a significant epidemic potential (including cholera, meningitis, or measles)?
- Is it a specific target of a national, regional, or international control program (by, for example, the WHO, or other international or regional control programs)?
- Will the information collected lead to significant public health action (such as an immunization campaign, other specific control measures, or international reporting)?

Source: WHO 1999a.

#### What data should be collected?

*Data sources and surveillance methods must be carefully selected to match the specified goals of surveillance and to maximize the attributes* (such as timeliness, sensitivity, positive predictive value, simplicity, or flexibility<sup>5</sup>—see also appendix A.6) of greatest importance at each level of the public health system for each health event or determinant (Romaguera, German, and Klaucke 2001; CDC 2001). Data that are not needed should not be collected, unless it is more efficient to collect a standard set of easily available data for a group of health events. For example, it may be more convenient to collect a copy of a hospital admission sheet and abstract the desired information later, rather than collect only the information needed for surveillance while at the hospital.

Surveillance systems vary in their need for personally identified information. Where there is a need to refer to the individual case or to identify the community of the case, or perhaps the eating establishment frequented by the case, there is a need for personal identifiers. At the national level, where attention is more focused on magnitude and trends of conditions, personal identifiers are rarely needed.

For some illnesses (such as meningitis, rabies, or gonorrhoea) it is necessary to collect the name of the patient, and the time and place of infection. In each instance direct individual actions are taken in response to the case—whether the action is antibiotic prophylaxis, vaccination, or treatment of recent sexual contacts. However, for conditions such as dengue fever there are no such direct, individual interventions, but rather community level interventions. Therefore simply counting case numbers is generally sufficient and does not overburden the system.

<sup>5</sup> *Timeliness*: delay between steps in the surveillance process. *Sensitivity*: identification of all cases of a disease or condition in question. *Predictive value positive*: the probability that a person with a positive test result actually has the disease. *Simplicity*: system structure and ease of operation. *Flexibility*: the ability of the system to adapt to changing needs, such as the addition of new conditions or data-collection elements.

Data should be collected in the least labor-intensive manner possible consistent with the quality, scope, and detail needed. An efficient surveillance system is one in which the minimum necessary local or state public health resources (personnel and fiscal) are expended to collect information.

### Are there stages of development in a public health surveillance system?

Public health surveillance systems range in complexity from the very basic (using pins in maps to track cases) to the very complex (using digital GISs to link data and geography). Some involve very simple laboratory techniques (blood smears for malaria), while others are exceedingly sophisticated (HIV sequencing, which requires DNA testing). Data management can range from a box of index cards to enormous datasets maintained on computers.

*For all systems, however, there is a need to first identify the goal or goals of the surveillance system—what*

*data are being sought and to what end—and to select the simplest system that allows for collection of these data.* As the complexity of the surveillance system increases, so does the cost of the system, as well as the infrastructure required (much more overhead is involved in HIV sequencing in the laboratory than is involved in doing blood smears for malaria in the field).

Nearly all countries now have some type of surveillance for polio and TB, albeit with varying degrees of success. Many countries have also developed surveillance systems for measles, malaria, and cholera. These systems may then form the basis for functioning public health surveillance systems.

Table 4 offers considerations for implementing or strengthening surveillance systems in countries with weak institutional capacity and financial resources (which would include many African countries), and for countries with moderate institutional capacity

**TABLE 4**  
**FEASIBLE SURVEILLANCE SYSTEM CHARACTERISTICS RELATIVE TO DIFFERENT RESOURCE LEVELS**

Consideration	Low resources	Moderate resources
Goals of surveillance	Information for action but limited to highest priority diseases and outbreaks of most serious communicable diseases. Strive to use surveillance data for planning.	Same but extended scope of conditions and routine use for health planning and evaluation.
Scope of surveillance	Vital registration; core communicable diseases; detection of outbreaks and preventive interventions (seat belt use).	Same plus expanded list of communicable and NCDs; surveillance for BRFs (smoking)
Training needs	Basic concepts of surveillance applied to routine disease control and outbreak investigation.	Application of more complex methodology for surveillance of NCDs, injuries, and so on.
Information transfer	Reliance on routine means of communication: mail, phone, or fax.	Use of e-mail, Internet sites, and so on if available in-country (usually a mix of old and new).
Laboratory	Emphasis on accurate basic capability; reliance on reference laboratories for sample analysis.	More capability in-country with reference laboratories used more for quality control than for sample analysis.
Communication	Focus on direct communication with disease reporters to insure transmittal of information to those who must know and on whom the surveillance system relies for routine information.	Expanded range of communication of information to broader audience with goal of raising societal public health competency.
Major problems	Ineffective surveillance (too many conditions, too much useless information, too little connection to action) leading to decreased interest in surveillance and public health.	Enthusiasm based on series of successes leading to increasing expectations that are not matched by new resources; greater emphasis on chronic diseases where success of public health intervention is less demonstrable in the short term.

and financial resources (including most Latin American or Eastern European countries).

Development of surveillance builds on success. Demonstration of the effectiveness of an initial surveillance system builds support among reporters and those who must provide resources. It can create public awareness of the importance of information for managing epidemics, tracking diseases, and better health in general. Once the potential benefits of surveillance is better understood it may be difficult to initiate a surveillance system for a small, limited array of conditions. However, being too ambitious initially may lead to loss of enthusiasm for any continued effort and be more destructive than starting slowly.

While advances in computer and information technology present many opportunities for improved surveillance, they also present new threats to the development of effective surveillance. It is easier to buy equipment (provided funding is available) than to train and develop adequate staff and to build partnerships with disease reporters and others, without whom surveillance would not function. Effective surveillance can be accomplished with rudimentary technology; *technology will not replace conceptual understanding, management skills, and development of essential partnerships.*

### **What systems are used for data transmittal?**

The data transmission system should be the result of design choices that are practical and feasible for the situation. There is an array of potential reporters to be considered, including providers, clinics, hospitals, and community health workers. In addition, many potential communications media may be employed, including postcards, telegraph, telephones, faxes, e-mail, and the Internet. Similarly, databases may be based on paper files, may be computerized, or may be Internet-based. The methods of data transmittal must be technologically appro-

priate for the country. Historically, effective surveillance systems have used very basic means of communications, such as postcards.

In designing the surveillance system consideration should first be given to development of the analysis plan. What data should be analyzed for the intended audience? Analysis can have different levels of complexity, depending on technical capacity and needs for decisionmaking. Decisions must be made concerning the frequency of tabulation and the level of analysis (for instance local as opposed to state, or state as opposed to national). Very basic tabulation of data is often quite useful for disease-prevention activities. More complex analyses sometimes reveal opportunities for prevention that are lost in the simplest data analyses. The degree of effectiveness of data analysis is more dependent on an analysis that is logical in thinking and committed to prevention, and less based on an automated or regimented approach.

### **What are the common issues in communication of surveillance results?**

#### ***Communication to whom?***

The communication style and format will depend on the intended audience. It may be directed to the governmental hierarchy, including local, state, and national authorities, or communication may flow across parallel levels of government, such as village-to-village or state-to-state. There may be a need to communicate internationally among governments. Obviously, information to individuals who must make personal decisions (concerning condom use, for instance) must be clearly articulated. Another frequently used avenue of communication is to nonhealth organizations or NGOs that may play a role in prevention (this category includes schools, industry, and the media).

#### ***Means of communication?***

Among the many potential vehicles for communicating to the parties identified above are:

- Yearly bulletins (yearly reports of vital statistics)
- Periodic reports of notifiable diseases (such as weekly reports of numbers of notifiable cases, reports of epidemics, and other events)
- Periodic reports of epidemics of local, regional, national, or international importance
- Newsletters and mailings to professional groups
- Press and media releases
- Interviews with the press
- Posting to Web sites

#### ***Problems in communication?***

Public health practitioners often run into attitudinal problems among potential data users and collectors. Among the more important problems are:

- Incredulity that communication can lead to change
- Potential inconsistency of public health and political messages
- Overly hierarchical, top-down communication
- Secretive attitudes

#### ***Problems in preparation?***

Potential pitfalls in successfully preparing information include the following:

- Communication of data rather than communication of a public health message
- Undisciplined or impromptu policy developed ad hoc during communication itself
- Lack of timeliness
- Poor framing of message
- Inconsistent messages that are not integrated into overall public health strategy
- Over-dependence on only one of many effective communication strategies

#### **What is the relationship between laboratories and surveillance?**

Laboratories play many critical roles in prevention and are essential partners in surveillance. Clinical diagnosis often requires laboratory confirmation, such as in the diagnosis of malaria or TB. Laboratory work also determines, through drug susceptibility testing, how best to treat a patient for TB or dysentery. Beyond clinical diagnosis for the individual, specialized laboratory testing may demonstrate that a common organism is the cause of multiple outbreaks that are separated in space and time. Research laboratories may identify the cause for a heretofore-unknown condition, such as was the case with Legionnaire's disease and mad cow disease soon after their clinical recognition.

A complete health-care system will have a continuum of laboratories at the local, state, national, and international levels that work together in a cohesive network. The laboratory continuum is characterized by its diagnostic and research capability, and by its capability for containment of infection. A system of grading laboratories for biosafety has been developed: gradations range from P1 to P4, with P1 requiring the least and P4 requiring the most biosafety measures (CDC/NIH 1999). The P4 laboratories, however, are exceedingly costly to build and maintain and, to date, exist only in a small number of countries.

It is important for each system to consist of a continuum of laboratories providing the most basic to the most sophisticated services, but it is implausible that resources are sufficient everywhere to provide the entire continuum. Some smaller, low-income countries may need to consider cross-border collaboration and regional reference laboratories to resolve some of their laboratory needs. However, such collaboration still requires an organized system of transporting specimens and communicating results in order to be successful. While sophisticated equip-

ment must be reserved for the most sophisticated referral laboratories, good laboratory practices—such as the use of gloves and avoidance of procedures that aerosolize specimens—should be practiced universally. Good laboratory practices are the first line of defense against inadvertent infection of laboratory workers and the community.

### **How do you evaluate the surveillance system?**

Evaluation of an existing surveillance system can be broken down into the following essential steps. Complete details of the process may be found in appendixes A.6 and B.1.

- What are the goals and objectives of the surveillance system, and is it meeting them?
- What is the public health importance of the diseases or health events under surveillance?
- How does the system operate?
- What resources are required?
- What are the system's attributes (see appendix A.6)? Is the system communicating with data sources?
- Is there communication and feedback between the different administrative levels?
- Does the system provide useful information? Is it leading to public health action?
- Are the findings provided to, and used by, policymakers?

There must be support from all those on whom the surveillance system depends. These groups who initiate and sustain the system includes government officials, health-care providers, community health workers, NGOs, and advocacy groups. Starting surveillance for a disease or BRF that is not sustainable due to a lack of resources is counter-productive in the long run.

### **What are the components of an effective surveillance program?**

Surveillance systems can either show their public health merit (and become more effective), or they can spiral downward. Malison has described this downward spiral and presents a model for understanding how ineffective surveillance systems evolve (Malison 1992). Poor quality data is not useful, so it is not in demand by those who would effectively improve the public health. Other demands for data continue from "archivists," who are interested more in process and completeness of data than in their utility (see table 5). Lack of demand reduces incentives to improve quality, so the system deteriorates. The cycle continues until the supply of data—which continue to worsen in quality—equals demand that comes less from public health decisionmakers interested in improving outcomes and more from "archivists" interested in bean counting.

### **What are the issues of data privacy and accessibility for use?**

*Surveillance systems and the information systems that support them should be designed in such a manner that personal identifying information is accessible only to public health professionals who need to collect additional information of importance required to intervene to prevent adverse public health outcomes (such as transmission of communicable diseases, preventable workplace injuries, or progression from mild to advanced chronic disease), or for bona fide research. Indiscriminant data access can be minimized by providing training on confidentiality and privacy to surveillance staff, providing privacy on work phones, locking cabinets for hard copy data storage, secure computer storage for electronic data, and limiting transmission of data over public communication lines. It should be emphasized that confidentiality is both a matter of hardening data storage from intrusion, as well as limiting gossip and inadvertent disclosure of personal information.*

**TABLE 5  
FACTORS LEADING TO USEFULNESS OR INEFFECTIVENESS OF SURVEILLANCE SYSTEMS**

Factor or element	Effective system	Ineffective system
Number of conditions	Fewer	Too many
Amount of information per case	Lean	Too much
Burden on reporter ( reporting forms)	Lean	Too complex and burdensome
Decisionmakers' interest in surveillance data	High	Low
Goals for surveillance	Clear and supported	May never have been clear
Reporting strategy for serious but common conditions	Enough information to meet goals and make decisions	Complete reporting
Usefulness of data to local collectors	High	Low
Limited to analysis of data and archiving	Low	High
Usefulness to decisionmakers for prevention action	High	Low

Inadvertent disclosure of personal information may occur for various technical reasons, such as occur when mapping cases with geographic information systems (GIS) to the point where an individual is identifiable.

In many cases personal identifiers (such as names, addresses, and social security numbers) are not needed to conduct effective surveillance. For example, there is generally no need for personally identifiable data at the national level, where public health issues mainly involve magnitude and trends.

**Is a legal basis for public health surveillance necessary?**

Medical information obtained by physicians and other health-care providers is usually considered confidential. However, mandatory reporting of some diseases includes personal identifiers such as name and address of the person affected. This permits the case investigation needed to control communicable diseases or the identification of interventions to prevent further cases from occurring as in infant and maternal mortality surveillance. In part due to this conflict between individual rights and societal needs, a legal basis is required in most countries for effective

mandatory notification to be implemented. Surveillance and disease-control activities are authorized in state statutes as part of the "police powers" of states. These laws usually include restrictions on the use and accessibility of the information thus trying to balance the needs of society to protect the public's health, with protection of the individual's right to privacy (Matthews, Neslun, and Churchill 2000).

**How are outbreaks recognized?**

Epidemics come in various sizes, from smaller, localized outbreaks (such as plague, food-poisoning, typhoid, diphtheria, Ebola), to widespread pandemics (cholera in South America in 1992–94, influenza worldwide in 1918, and the current almost-worldwide pandemic of HIV). Recognition of outbreaks occurs in various ways.

*Localized outbreaks* are usually identified and reported by an astute observer: by a victim, health department, or health practitioner. This is an informal system that works well when public health officials are flexible, curious, receptive to phone calls, and responsive. It is likely that some reports will be false positives. Nonetheless, officials should remain responsive to each of these reports.

In contrast, formal systems for detection of epidemics, such as those in place for pneumonia and influenza surveillance, depend on systematic collection and analysis of data and comparison with the expected number of cases. Many local and state health departments in the Americas maintain "endemic channels" for diseases (such as malaria and dengue fever) that are based on observations from the previous five years. A range for the maximum number of cases expected over the period of a year is developed. When the number of cases exceeds the maximum expected—the epidemic threshold—an epidemic is considered to be occurring, and public health actions beyond the routine should be initiated.

Recent advances in laboratory techniques have improved public health practitioners' abilities to recognize and track epidemics. Among these techniques is genetic fingerprinting of disease organisms,

which allows linkage of otherwise independent outbreaks. A recent example of the utility of this technique was the recognition of transmission of multidrug-resistant TB among the inmates of New York state prison facilities (CDC 1991).

### **How do I complete the surveillance process?**

The surveillance process is completed when action is taken. Possible actions range from disease control measures to policy and planning or resource allocation activities.

#### **THE #1 TAKE-HOME MESSAGE**

There is no value to a surveillance system unless the information is used for actions that prevent or control diseases.