

PUBLIC HEALTH SURVEILLANCE

Laura R. Johnson

Emory University School of Medicine, Atlanta, Georgia, USA

David L. Heymann, MD, MPH

World Health Organization, Geneva, Switzerland

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Contents

1. Introduction
 2. History of Surveillance
 3. Background on the Modern Concept of Surveillance
 - 3.1 The Case Definition
 - 3.2 Data Collection
 - 3.3 Data Management and Analysis
 - 3.4 Data Dissemination
 - 3.5 Evaluation of Surveillance Systems
 4. Sources of Surveillance Information
 - 3.1 The Case Definition
 - 3.2 Data Collection
 - 3.3 Data Management and Analysis
 - 3.4 Data Dissemination
 - 3.5 Evaluation of Surveillance Systems
 5. Conclusion
- Glossary
Bibliography
Biographical Sketches

Summary

The modern concept of surveillance has evolved over the centuries. Disease surveillance is the systematic collection, analysis, and dissemination of morbidity and mortality data for the purpose of taking action to improve health outcomes. After a brief history of surveillance, this chapter delves into the evolution of its current definition, then discusses several common elements of surveillance systems: the case definition, data collection, data management and analysis, data dissemination, and evaluation of the system. It then focuses on three different sources of surveillance information, the patient record, the population survey, and outbreak detection and reporting networks. Tuberculosis is used to illustrate how the medical record of an individual patient seeking care becomes an important source of surveillance information. Population surveys of people at-risk for, or living with, HIV/AIDS exemplify how this second source of surveillance information can target preventive interventions. Finally, the case of Severe Acute Respiratory Syndrome (SARS)

illustrates how detection and reporting networks can provide the surveillance data necessary to control the spread of a deadly pandemic.

1. Introduction

The protection of public health relies on the ability of health systems to identify health threats and implement measures to respond to these threats, whether endemic or epidemic, and thus ensure the safety of individuals and populations. This chapter will discuss surveillance of disease.

2. History of Surveillance

The concept of surveillance has evolved over the centuries, and as the literature traces its long history in detail, a summary will be presented here. The story begins with Hippocrates, who, in his writings on disease, made a distinction among the steady state, the endemic state, and the abrupt change in incidence--the epidemic (Berkelman, Stroup, and Buehler 759, citing Eylembosch and Noah). However, the "first public health action that can be attributed to surveillance" occurred during a 1348 bubonic plague epidemic, in which three guardians of public health for the Republic of Venice prohibited ships with infected passengers from docking at the port (Declich and Carter 285).

The Renaissance of the fifteenth century brought the emergence of scientific thought, and in the sixteenth century (1532), the first London Bills of Mortality were prepared. However, these documents were not used for surveillance purposes until the 1600s, when the clerks of London reported the number of burials and causes of death to the Hall of the Parish Clerks' Company, which compiled the statistics, interpreted them, and disseminated them in a weekly Bill of Mortality. John Graunt analyzed these weekly bills in the late 1600s and is cited as the first to "conceptualize and quantify the patterns of disease and to understand that numerical data on a population could be used to study the cause of disease," (Declich and Carter 286, citing Eylembosch and Noah). In the Americas, the colony of Rhode Island was seeing the development of a fledgling surveillance system, which in 1743 required by law that tavern-keepers report contagious disease among their patrons, including smallpox, yellow fever, and cholera (Declich and Carter 286). At about the same time, 1766, Johann Peter Frank encouraged more extensive surveillance of health in his native Germany, especially in the areas of health of schoolchildren, injury prevention, maternal and child health, and public water and sewage disposal (Berkelman et al. 279). He formulated policy that had far-reaching effects on Hungary, Italy, Denmark, and Russia (Declich and Carter 286, citing Anonymous). In addition, leaders of the French revolution (1788-1799) declared that the health of the people was the responsibility of the state.

It was not until the nineteenth century however, that surveillance came into its own under the leadership of the Englishman, Sir Edwin Chadwick (1800-1890). Chadwick's work as Secretary of the Poor Law Commission clearly demonstrated the link between poverty and disease, using surveillance data, and his contemporary in the United States, Lemuel Shattuck, reported similar findings in his "Report of the Massachusetts Sanitary Commission" (1850). In particular, Shattuck recommended a decennial census, the standardization of nomenclature for disease and causes of death, and the collection of

health data by age, sex, occupation, socioeconomic level and locality (Declich and Carter 286, citing Eylenbosch and Noah). Another Englishman, William Farr, was appointed in 1838 as the first Compiler of Abstract (i.e. medical statistician), and during his forty-one years at the General Register Office, created a surveillance system that has earned him recognition as the founder of the modern concept of surveillance (Berkelman et al. 759). Another British contemporary, John Snow, an anaesthesiologist, is widely regarded as the father of modern epidemiology for his work in 1854 in tracing a deadly cholera outbreak in London to a contaminated water pump on Broad Street.

Finally, the twentieth century brought the expansion and diversification of surveillance systems. In 1955, the newly-established United States Centers for Disease Control (CDC) intensified its active surveillance of acute poliomyelitis cases in order to prove that an epidemic of the disease could be traced to a single vaccine manufacturer. At one point, the CDC was issuing daily reports of the disease (Berkelman et al. 760). A decade later, in 1965, the Epidemic Surveillance Unit was established in Geneva as part of the World Health Organization's (WHO) Division of Communicable Diseases. This unit published its first Communicable Disease Surveillance Reports in 1966. The advent of microcomputers in the 1980s revolutionized the way data were collected, analyzed, and shared throughout global surveillance networks, and in recent years, surveillance has proven critical during the smallpox eradication campaign (1967-1980), during the early years of the AIDS epidemic, for the current campaigns to eradicate poliomyelitis and guinea worm, and for the control of emergent and re-emergent infectious diseases.

3. Background on the Modern Concept of Surveillance

In 1963, Dr. Alexander D. Langmuir defined surveillance, when applied to disease, as "the continued watchfulness over the distribution and trends of incidence through the systematic collection, consolidation and evaluation of morbidity and mortality reports and other relevant data." He explained that the data and their interpretations must then be disseminated "to all who have contributed and to all others who need to know." Five years later, WHO expanded Dr. Langmuir's definition to include the assumption that surveillance information is collected in order to take appropriate action to improve health outcomes. While it is often associated with outbreaks of dangerous diseases, in a broad sense, surveillance can be applied to all areas of public health, including injuries, social problems such as drug addiction, mental illness, chronic conditions, and cancer (Declich and Carter 288).

Declich and Carter differentiate between personal surveillance, which follows potentially exposed individuals for detection of early symptoms of disease, and population surveillance, which describes health events in populations as a whole. WHO's report of the Technical Discussions of the 21st World Health Assembly (1968) further defined population surveillance as the systematic collection, consolidation, and analysis of data, and "the dissemination of information by means of narrative epidemiological reports," (Declich and Carter 287).

The public health literature discusses in detail various *types* of surveillance, including routine, immediate/case-based for suspected epidemics, laboratory-based, community-based, and sentinel (a limited number of sites collect data that represent the entire

population, which is only useful for early warnings and when every event need not be reported individually). Characteristics of surveillance include the importance of developing a clear case definition for the disease under surveillance, defining a target population, identifying constituents and key players, managing and analyzing the data appropriately, and evaluating the system. After examining these common characteristics, this chapter will address three sources of surveillance data: a) patient treatment registers, b) health-related surveys that target communities or populations at risk, and c) global outbreak detection networks. Finally, examples of diseases will be used to illustrate each type of surveillance information.

3.1 The Case Definition

The case definition is a "fundamental" piece of a surveillance system because "it the formal answer to the question of what manifestations of a disease or condition are under surveillance," (Berkelman et al. 763, citing CDC 1997). The initial definition often encompasses a group of clinical signs and symptoms, which is then followed by laboratory confirmation. The herpes virus is an illustrative example: a non-specific, symptom-based clinical definition is the observation of small, fluid-filled lesions on the genitals, buttocks, anus, and adjacent areas. This clinical finding strongly suggests a herpes virus infection, but only microscopic analysis of a specimen can distinguish the virus from other microorganisms such as syphilis, while a blood test can differentiate between herpes simplex virus types 1 and 2.

To be useful, the case definition must be sufficiently sensitive (inclusive) to avoid missing cases of disease (prevent false negatives), yet sufficiently specific (exclusive) to include only "true" cases (prevent false positives). Furthermore, it must be usable by all constituents. Depending on the disease, the case definition may be divided into symptomatic and asymptomatic cases, or described as a spectrum, ranging from possible cases through presumptive cases to confirmed cases.

It is important to bear in mind that no permanent "gold standard" exists to define cases of disease. Rather, case definitions are dynamic as knowledge about the illness changes. For example, in 1992, CDC expanded the Acquired Immunodeficiency Syndrome (AIDS) surveillance case definition to add pulmonary tuberculosis, recurrent pneumonia, and invasive cervical cancer to the list of twenty-three AIDS-defining diseases that were already included. CDC also decided to classify all HIV-positive adolescents with T-lymphocyte counts below 200/uL as having AIDS, even if they did not have any of the twenty-six AIDS defining diseases. This reclassification resulted in many more infected individuals meeting the AIDS case-definition. (Stewart 1992) Thus, high-quality surveillance relies upon a clear definition of what constitutes disease in a population.

3.2 Data Collection

In general, effective surveillance systems gather *all* of the data needed to respond appropriately, but *only* the data needed. Data collection tools are usually paper or electronic forms, and these tools must strike a balance between completeness and too labor-intensive. Abramson suggests that data collection efforts for disease surveillance focus on three types

of variables: universal variables (socio-demographic characteristics such as sex, age, parity, ethnic group, religion, place of birth and residence, etc.), measures of time (dates and times of specific events such as injury, disease onset, treatment, and/or death), and variables that distinguish the individuals or populations under study from the general population (Parrish and McDonnell 42). Unlike data collected for research studies, which is precise and thorough, information collected for surveillance purposes should be streamlined and easy to use (Buehler 436).

The timing of data collection (and reporting), depends on the nature of the disease under surveillance. To function as an early-warning system for outbreaks, the reporting, confirmation, decision-making, and response must be rapid. However, for more endemic disease, the goal may be to use data to track the progress of control or eradication initiatives. National surveillance systems should implement "two-speed reporting mechanisms" to accommodate both needs (WHO 9). For instance, during outbreaks of disease, it is crucial to conduct weekly or even daily reporting of the following data: cases and deaths; names, addresses, and demographic characteristics of each case; details of place and time of disease onset; name of health care provider and facility; and basis for diagnosis (clinical or laboratory). Then, the local, state, or national health department can conduct a timely epidemiological investigation of every confirmed case, with the goal of identifying the source and controlling the spread of disease. On the other end of the spectrum, disease registries for chronic illness or other conditions such as cancer can be updated and disseminated much less frequently, some even on an annual basis.

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Biographical Sketches

Laura R. Johnson is currently an MD/MPH candidate at Emory University School of Medicine in Atlanta, Georgia, USA. She received her BA in the History of Science from Princeton University (2004) and prior to medical school, she worked as a Clinical Research Coordinator at the University of California-San Francisco Breast Care Center. In 2006, Laura was a Global Health Fellow with the World Health Organization's Global Polio Eradication Initiative.

David L. Heymann, a citizen of the United States of America, is currently the executive director of the World Health Organization (WHO) Communicable Diseases Cluster. He was born in 1946 and is married with three children.

Dr. Heymann holds a B.A. from Pennsylvania State University, an M.D. from Wake Forest University, a master's in tropical medicine from the London School of Hygiene and Tropical Medicine, and has completed practical epidemiology training in the two-year Epidemic Intelligence Service (EIS) training programme of CDC. He has published over 100 scientific articles on infectious diseases in peer-reviewed medical and scientific journals.

From October 1995 to July 1998, he was director of the WHO Programme on Emerging and Other

Communicable Diseases Surveillance and Control. Before becoming director of this programme, he was the chief of research activities in the Global Programme on AIDS. From 1976 to 1989, before joining WHO, he spent 13 years working as a medical epidemiologist in sub-Saharan Africa (Cameroon, Côte d'Ivoire, Malawi, and the former Zaire) on assignment from the U.S. Centers for Disease Control and Prevention (CDC) in CDC-supported activities aimed at strengthening capacity in surveillance of infectious diseases and their control, with special emphasis on the childhood vaccine-preventable diseases, African hemorrhagic fevers, pox viruses, and malaria. While based in Africa, he participated in the investigation of the first outbreak of Ebola in Yambuku (former Zaire) in 1976, then again investigated the second outbreak of Ebola in 1977 in Tandala. In 1995, he directed the international response to the Ebola outbreak in Kikwit. Before 1976, he spent two years in India as a medical officer in the WHO Smallpox Eradication Programme.

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