Implementing the Concepts of William Farr: the Contributions of Alexander D. Langmuir to Public Health Surveillance and Communications

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Among Alexander Langmuir's many accomplishments in public health and epidemiology, his contributions to public health surveillance were pivotal. Langmuir credited William Farr with founding the modern concepts of surveillance in the nineteenth century (1). However, it was Langmuir who built on his own introduction to public health practice in the Westchester County (New York) Health Department to orchestrate a paradigm shift in the application of these concepts to populations and to appropriate action in public health. In the 1950s, while he was serving as chief epidemiologist at the Communicable Disease Center (now known as the Centers for Disease Control and Prevention (CDC)) in Atlanta, Georgia, Langmuir applied the term “disease surveillance” to the careful monitoring of disease in a population (2). The basic elements of data collection, analysis, and dissemination were fundamental to Langmuir's concept of surveillance, as was the responsibility to use the data for public health practice—information for action. In the early 1950s, the first applications of these elements in disease surveillance were initiated to chart the decline of malaria, smallpox, yellow fever, and other diseases in local geographic areas for the purpose of monitoring prevention and control programs.

In this paper, we describe chronologically Langmuir's contributions to the development of disease surveillance, with special emphasis on the use of the Morbidity and Mortality Weekly Report (MMWR) to communicate these data to those who need to know. We then describe the evolution of his concepts during the two decades following his retirement from CDC in 1970. Finally, we forecast how his ideas will be applied into the next century as part of effective public health practice throughout the world.

BACKGROUND

Langmuir clearly distinguished surveillance practice from disease control. The wider application of the term “disease surveillance” in public health practice and epidemiologic research was a frequent source of confusion and one that Langmuir carefully clarified. Further confusion resulted from the World Health Organization's decision to use the modifier “epidemiologic” to describe surveillance (3). This lack of clarity subsequently led to the recommendation that the modifier “public health” be used with “surveillance,” which more accurately describes Langmuir's original distinction between surveillance practice and epidemiologic research (4).

Langmuir's concepts of surveillance are best illustrated by their application to the control of poliomyelitis. In 1955, cases of polio were detected among inoculated individuals and their contacts within 2 weeks after announcement of the success of the Francis Field Trial. As a result, daily surveillance reports based on reports from state health departments were developed at CDC and disseminated to the states (5, 6). These surveillance data were then used for action. Careful and rapid analysis of these data led to an investigation that found that killed-virus vaccine was contaminated with live poliovirus and that, as a result, both primary and secondary cases had developed. Two lots of vaccine were identified as the source of the outbreak; the remainder of these lots were destroyed and the vaccination program was resumed. This timely use of data formed the conceptual basis for further applications of disease surveillance at CDC, throughout the United States, and eventually in other countries. Indeed, the institution of routine national poliomyelitis surveillance was directly responsible for the detection of unexpected vaccine-associated disease that occurred soon after the live-virus vaccine was licensed in 1961 (7), and for the subsequent change in vaccine recommendations for this disease.
Another important area of application for surveillance enhanced under Langmuir was that of influenza. With the appearance of an Asian influenza strain in 1957, US Surgeon General Leroy Burnley asked Langmuir to implement a surveillance system for this disease comparable with that developed for polio (2). Building on analytic studies of mortality data by Collins (8) and Serfling (9), Langmuir made the weekly reporting of death certificate data to CDC from 108 (later 122, now 121) US cities—data collection—the core of national surveillance efforts. Early in the influenza season, the pneumonia and influenza mortality graph appeared in surveillance reports—analysis—and was published weekly—dissemination—during the influenza season. Langmuir’s careful and easily understood presentation of these data made this information readily accessible to the news media and subsequently to the public (10). That availability of information heightened public awareness about influenza and its often devastating effects on communities. The careful use of these mortality data in the early 1960s led the Surgeon General’s advisory committee on influenza control to recommend administration of the influenza vaccine to high-risk groups, including the elderly and persons with chronic diseases—action. Morbidity data from CDC’s National Health Interview Survey and laboratory data from state health departments and World Health Organization collaborating centers complemented the mortality data and resulted in a comprehensive influenza surveillance system. During Langmuir’s tenure at CDC, other surveillance systems were established for infectious diseases (e.g., hepatitis and salmonellosis) and noninfectious conditions (e.g., abortion and congenital malformations).

In the 1960s, Langmuir assigned members of his staff, notably Ida Sherman, to organize and energize the notifiable disease system that had been maintained by the US Public Health Service since the early 1900s. Expanding beyond an archival function, the notifiable disease surveillance system became the core of national disease surveillance. Despite limitations of specificity and incomplete reporting, these data became a valuable source for monitoring disease and assessing the effectiveness of intervention programs at local, state, and national levels.

In 1961, the routine reports for notifiable diseases were an integral part of MMWR when responsibility for its publication was moved from the National Office of Vital Statistics (now the National Center for Health Statistics, which became part of CDC in 1987) to CDC. The MMWR became the critical communication mechanism for CDC under Langmuir’s leadership.

**Morbidity and Mortality Weekly Report**

An essential element of Langmuir’s practice of surveillance included the ready, regular, and even preliminary use of morbidity data from the state health departments, CDC’s primary constituents. Except for the unique reporting systems provoked by the polio and influenza epidemics of the mid-1950s, however, CDC and Langmuir did not regularly receive communicable disease morbidity data. Nothing better exemplifies Langmuir’s vision of surveillance and his ability to seize an opportunity than the transfer in 1961 of MMWR to CDC. The historical development of MMWR provides a context for surveillance at the time Langmuir began to make his mark in public health.

In 1878, the US Congress mandated that a system of national reporting of important health events be implemented by the Surgeon General of the Maritime Hospitals (the antecedent of the Public Health Service) (11). “Bulletins, No. 1” was the first in a series of weekly publications that served as a record of communicable disease occurrences; these occurrences were usually epidemics. State health departments found these reports extremely useful and, in 1897, the Public Health Service began to publish this information in its weekly journal, *Public Health Reports*. By 1925, all states reported regularly to the Public Health Service the occurrence of pellagra and 23 communicable diseases (12).

Until 1942, the Public Health Service’s Division of Sanitary Reports and Statistics collected, compiled, and published these morbidity statistics. These functions were then transferred to the Public Health Service’s Division of Public Health Methods. In 1949, another transfer placed these functions in the National Office of Vital Statistics. In 1950, *Public Health Reports* relinquished its control of the morbidity reporting system, and the *Morbidity Weekly Report* was created in the National Office of Vital Statistics. This weekly publication was renamed the *Morbidity and Mortality Weekly Report* in 1952.

Early in his career at CDC, Langmuir recognized the intrinsic worth of a reporting system such as that housed at National Office of Vital Statistics. He clearly saw the opportunity to enhance relations with state and local health departments, to have morbidity data available immediately for possible intervention, and to strengthen the practice of public health surveillance nationally. Moreover, he sadly noted that those who received these data in Washington, DC, were not trained in epidemiology and public health practice and had no obligation—or, apparently, inclination—to analyze data rapidly and act on the implications of such information (David J. Sencer, CDC, retired, personal communication, 1994).
Therefore, it is not surprising that after the remarkable successes of his impromptu and unconventional surveillance systems of polio and influenza, Langmuir focused on a possible transfer of MMWR to CDC's Epidemiology Branch. Although some persons at CDC did not support the proposal, Langmuir convinced the Director of the agency of the worth of MMWR to CDC and its mission of prevention and control of disease (E. Russell Alexander, Seattle-King County Department of Health, Seattle, Washington, personal communication, 1994).

Langmuir also had to convince higher-level Public Health Service administrators such as Carl Dauer, the Director of the National Office of Vital Statistics, David J. Sencer, then Assistant Director of CDC, and E. Russell Alexander, Chief of Langmuir's Surveillance Section, helped negotiate and smooth the way for the move. With Langmuir as editor, CDC published its first MMWR in January 1961.

During the first 9 years under Langmuir's direction, the character and import of MMWR began to emerge. He encouraged his staff, other CDC staff, and health officials at many levels to write articles for MMWR and to generate material for publication. He gave MMWR his highest priority and labored over the text and its implications and sparingly used an editorial note for explanation, interpretation, and discussion of the report's significance.

Within CDC, epidemiologists were given the opportunity to serve as writers, and sometimes editors, for the publication. This practice developed their communication skills and showed them the value of disseminating information to "those who need to know" as part of the practice of surveillance. Other CDC staff saw how their own interests could be served by using MMWR as a vehicle to inform the professional and lay public and also to increase program visibility, to develop constituencies, to apply pressure to public and private health professionals, and as a management tool for documenting events and handling the news media.

National disease surveillance is currently conducted in collaboration with state health departments, an association that Langmuir fostered through its organization in 1951 and subsequent development of the Conference (now Council) of State and Territorial Epidemiologists.

After 1961, state and local health departments began to use the MMWR. In addition to Langmuir's constant pressure on health departments to use MMWR for their own purposes, he insisted that health departments be given prime visibility by identifying them first at the end of each report, with names and titles of persons responsible for the report included in the citation. His policy ensured that health departments were properly credited for recognizing and reporting of the health events within their jurisdiction and for taking responsibility for such events—a procedure not always happily accepted by state health departments. Credits to CDC, if any, always appeared at the end and did not include names or titles of CDC staff.

By the 1960s, Langmuir was an internationally recognized figure in public health (13). His efforts in surveillance culminated in the 1968 World Health Assembly, which was devoted to the national and global surveillance of communicable diseases (14). In collaboration with colleagues throughout the world, especially Karel Raska of Czechoslovakia, Langmuir developed the agenda of this convocation. Representatives of more than 100 countries participated in the assembly and formulated, for the first time, an explicit global agenda for disease surveillance. This work formed the basis of international understanding of the concepts of disease surveillance and underlined the need for a permanent disease surveillance activity within the World Health Organization.

By the time Langmuir retired in 1970, CDC's role and influence in disease prevention and control had become more visible and recognized. MMWR was identified clearly as CDC's voice in the world of public health practice. The power and public health leverage gained from rapid analysis and distribution of epidemiologic data, as was seen decades earlier with polio and influenza, was reaffirmed on the pages of the MMWR.

PUBLIC HEALTH SURVEILLANCE AFTER 1970

After Langmuir retired from CDC and the Public Health Service in 1970, his efforts had firmly implanted a belief in his concepts of surveillance in both the CDC culture and the public health infrastructure. A special issue of the International Journal of Epidemiology in 1976 was devoted to surveillance and the concepts developed by Langmuir during his career (15). Three elements of Langmuir’s legacy in surveillance warrant consideration here: an appreciation of surveillance as a rigorous public health discipline, the application of surveillance principles to noninfectious diseases, and the evolution of communicating surveillance data through the MMWR and other publications.

Although Langmuir probably considered surveillance as a practice and not a scientific discipline, a high degree of rigor has been applied to this practice as envisioned by Langmuir (16). He readily recognized the limitations of surveillance but also understood the potential for public health action despite those limitations. Subsequent research has led to a clearer appreciation of both the limits of data and efforts to analyze the impact of these limitations on public health prac-
tice. Interest in surveillance can be measured by the increasing body of literature: three textbooks devoted to surveillance have been written (17–19), and CDC has more than 300 published articles on file that relate to the topic. In addition, CDC has developed and disseminated criteria for evaluating surveillance systems (20).

More sophisticated statistical techniques for surveillance, a concept first developed by Langmuir in collaboration with his CDC colleague Robert Serfling (9), have led to better use of surveillance data, both in infectious and noninfectious diseases. Application of time series analysis and sophisticated regression methods have extended our understanding of epidemic influenza (21–24). Computer software designed specifically for analyzing surveillance data is now available at CDC (25). Notifiable disease surveillance data are now transmitted electronically on a weekly basis from all state health departments, and some of these data will emanate from local health departments and possibly from physicians who use computers (26).

However, to students of Langmuir, such advances in computerization and statistics are worthwhile only when they enhance the use of surveillance data for public health action.

Expanding responsibilities have introduced different disciplines into public health practice. Still, high quality surveillance data are essential for public health, and investigators have successfully taken the basic principles of surveillance and applied them to chronic disease (27), injury (28), environmental health (29), occupational health (30), medical technology (31), and adverse drug reactions (32). Surveillance of evolving public health issues has led to a need for additional data sources and methods of reporting, different concepts of timeliness, and different statistical methodologies (e.g., time series analysis (21) and bootstrap techniques (33)). At the same time, broader concepts of public health surveillance continue to focus on the practical applications of surveillance that Langmuir championed.

In the 1970s, for example, Langmuir served on a committee consulting with the National Institute of Occupational Safety and Health (NIOSH) on the surveillance of occupational diseases and injuries that had two significant impacts (J. Donald Millar, CDC, retired, personal communication, 1995). First, the challenge of transposing traditional communicable disease surveillance to the occupational setting humbled Langmuir. Second, this difficulty strongly influenced the thinking of NIOSH staff about surveillance. These deliberations set the stage for later applications of the "Sentinel Health Event" approach pioneered by Rutstein et al. (34) and led ultimately to the implementation of the Sentinel Event Notification System for Occupational Risks (SENSOR) program, which moved occupational health surveillance into the traditional state health department system (35).

Finally, MMWR remains a critical tool to disseminate surveillance information, and its format has been copied in many other countries. The initial reports of Legionnaires disease, Guillain-Barré syndrome, toxic shock syndrome, acquired immunodeficiency syndrome, and eosinophilia myalgia syndrome represented milestones in rapid identification and control of new diseases. The visibility gained, the recognition achieved, and the public health practice improved by such a communication system became more apparent to many public health professionals. Consequently, many state, provincial, and national health departments have created or modified their own publications after the MMWR format, solidifying the need and worth of such a written exchange and ensuring the continuing extension of Langmuir's concepts of public health surveillance.

The vision that Langmuir had for MMWR continues to evolve, and more advanced statistical methods and visual applications have enhanced the data collected for notifiable diseases (33, 36). Furthermore, new tables, such as one for premature deaths and years of potential life lost, have been applied to other diseases (37). A publication in the MMWR series, the CDC Surveillance Summaries, has given special focus to surveillance activities at CDC and state and local health departments (37). In 1992, a special issue of MMWR was devoted to an international symposium on public health surveillance; this symposium was the first such international effort since the 1968 World Health Assembly (39).

FUTURE DIRECTIONS

Langmuir's contributions to the conceptualization, development, and implementation of public health surveillance were enormous. Langmuir successfully applied the concept of surveillance to populations, rather than individual patients. He defined surveillance as a practice distinct from disease control activities but linked to intervention. Third, Langmuir emphasized the importance of using provisional morbidity data for public health action. Fourth, he emphasized the important role of disseminating data, an activity embodied by MMWR. Fifth, he recognized and fostered the critical role of state health departments in national disease surveillance. Finally, he recognized the importance of applying surveillance concepts to noninfectious diseases and newly identified public health problems.

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Langmuir wrote in 1968,

The one essential requirement for a surveillance system is a reasonably sophisticated epidemiologist who is located in a central position in the health structure, who has access to information on the occurrence of communicable disease, who has power to inquire into and verify his [or her] facts, and who has the ear and confidence of his[her] chief medical officer of health (40, p. 683).

This requirement has remained essentially unchanged despite the evolution of surveillance practice since that time and the application of sophisticated tools of epidemiology, statistics, and computer science. The definition of public health surveillance as the ongoing systematic collection, analysis, and interpretation of outcome-specific data, closely integrated with the timely dissemination of these data to persons responsible for controlling and preventing disease or injury, has changed minimally since Langmuir’s early definitions. The need for timely and accurate data for action by epidemiologists and other public health officials also remains unchanged.

What has changed, however, has been the expansion of these concepts beyond communicable diseases, the evolution of the impact of all disease and injury problems on communities, the global scope of disease control activities and their impact in a shrinking world, and the access to new tools that have increased public expectations of public health. We can now reasonably conceive that each day epidemiologists will access real-time data from their computers for acute disease problems throughout their districts and regions, analyze these data using tools available with a touch of the computer mouse, and display these data on their computer monitors in a manner readily understandable to the general public (41). Indeed, in 1995, MMWR became available to users on the Internet (42).

The major barriers to successfully integrating national public health surveillance and information systems remain a lack of appreciation for the value of high-quality, provisional surveillance data and a weak societal commitment to public health (41). However, Langmuir’s vision and his resourcefulness have fostered public health practice, particularly public health surveillance, for almost five decades and will continue to do so. The responsibility of Langmuir’s successors in epidemiology and public health is to retain and extend his concepts while envisioning what the next paradigm should be in the practice of public health surveillance in the 21st century.

REFERENCES


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