Chapter 15: Surveillance Indicators

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I. Role of surveillance in disease elimination programs

Traditionally communicable disease surveillance programs have relied on passive reporting, with reports received from physicians and other providers. In recent years laboratory-based surveillance has been well established as a valuable adjunct to provider reporting. For diseases and conditions for which laboratory confirmation is routinely obtained, laboratory-based reporting has virtually replaced traditional provider-based reporting in many jurisdictions, because case ascertainment is far more complete.[1,2] However, even when supplemented by laboratory-based reports, reporting in traditional passive surveillance systems remains incomplete. Nonetheless, in spite of this limitation, these data remain useful because they are used primarily for monitoring trends in disease occurrence rather than for initiating public health action in response to each individual case.

In contrast, the role of surveillance in disease elimination programs is different. In order to achieve zero cases of a disease, aggressive efforts must be made to identify factors that allow cases to continue to occur in spite of a low incidence of disease. The occurrence of these cases may indicate the need for new strategies, but in the absence of surveillance, it is impossible to track progress. In addition, timely notification is essential so that public health action can be taken to limit spread of disease. For example, during the global smallpox eradication program, the continued occurrence of cases of smallpox in spite of high coverage led to the development of anew strategy for smallpox eradication; a wide circle of contacts around each case was identified and vaccinated, creating a wall of immunity around the remaining cases, and leading ultimately to the global eradication of smallpox.[3] This could not have been achieved without recognition of the need for an additional strategy, and that new strategy could not have been implemented without the ability to rapidly identify and respond to individual cases. As Andrews and Langmuir wrote in 1963, "to achieve and maintain the eradication status of a specific disease within an area, it is necessary 1) to obstruct transmission until endemicity ceases, and 2) to prevent of nullify the reestablishment of the disease from carriers, relapsing cases, or imported sources of infection. Accordingly, an adequate surveillance organization must be developed to identify and cope with these threats to the achievement of disease eradication."[4]

In routine disease control programs, routine disease surveillance systems are usually adequate to meet program demands, in spite of their limitations. In contrast, in disease elimination or eradication programs routine surveillance activities are inadequate, once the goal is near. In advanced disease elimination and eradication programs, such as current efforts to eliminate targeted vaccine-preventable diseases in the United States, ***every case counts***. Without

adequate surveillance, we will be unable to achieve and sustain elimination of vaccine-preventable diseases.

II. Use of surveillance indicators in surveillance

Because of the essential role of surveillance in disease elimination, methods to monitor its quality were developed in 1988 by the Pan American Health Organization (PAHO) as part of the polio eradication effort in the Western Hemisphere. Surveillance indicators included measures of surveillance infrastructure (e.g., the number of reporting units reporting on a weekly basis), timeliness of notification (e.g., the interval between case onset and notification), the adequacy of case investigation (e.g., the proportion of cases with appropriately timed laboratory specimens obtained), and the timeliness of laboratory testing.[5] Although not generally done outside of special evaluation projects in routine disease control programs, monitoring these attributes would undoubtedly provide useful information for any surveillance system; these attributes overlap with those recommended by CDC for evaluation of surveillance systems[6] (see **Appendix 22**).

III. Use of surveillance indicators in disease elimination programs

Because of the unique requirements of surveillance in disease elimination programs, PAHO also developed an indicator that allowed monitoring of the completeness of reporting. In disease elimination programs, it is critical to have some measure of the adequacy of case ascertainment. Indicators that only measure how well cases were investigated ***once they are reported as suspected cases*** will provide no information on the completeness of ascertainment of suspected cases in the first place. In a disease eradication program, it is insufficient to adequately investigate the reported cases, if most of the cases are never reported. More importantly, as disease incidence falls, it becomes increasingly difficult to interpret the absence of reported cases. How can you tell if zero means zero? Does it mean there were no cases, or does it mean no one looked?

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One very successful strategy to address this problem was developed by PAHO. In the polio eradication effort in Latin America, surveillance was performed not for paralytic poliomyelitis, but for a syndrome that includes both paralytic polio and other conditions, including Guillain-Barré Syndrome (GBS), among children < 15 years of age—that is, the surveillance system was organized to identify cases that were clinically consistent with polio (suspected cases), and then to track them as laboratory investigation was performed to either rule in or rule out a diagnosis of polio due to wild poliovirus. If adequate laboratory testing was not obtained to definitively rule in or rule out the diagnosis of polio, the case was classified as compatible, and considered a failure of case investigation and surveillance. In the absence of polio, GBS and other conditions causing acute flaccid paralysis (AFP) in children occur at a fairly constant rate over time. Thus, the adequacy of ascertainment of suspected cases of polio could be monitored by tracking the incidence of AFP among children < 15 years of age. In countries

or regions achieving reported rates of AFP of 1 per 100,000 children < 15 years of age and ***without confirmed or compatible cases of polio***, one could be reasonably confident that the absence of reported cases of polio in fact meant the absence of polio. In contrast, if AFP rates were less than 1 per 100,000 among children, the absence of cases might reflect inadequate surveillance, rather than the absence of polio. Monitoring the rate of AFP reporting in Latin America was a critical component of PAHO's effort to monitor the adequacy of polio surveillance. By tracking this closely at the regional and national level, areas with inadequate surveillance could be identified and assisted, and resulting improvements documented.

Unfortunately, there are few other examples of vaccine-preventable diseases for which indicators analogous to the AFP rate are known. No external standard for determining the completeness of measles surveillance exists that is equivalent to the rate of AFP in the surveillance of polio.[7]

While monitoring all cases of AFP is highly sensitive, it is not specific, and there is another essential part of the PAHO approach that is essential—that is, classifying incompletely evaluated cases as "compatible." In a disease elimination program we want to capture all the true cases by having a case definition that is very sensitive; nonetheless, it is also important to exclude non-cases by adequate case investigation and laboratory testing. The PAHO strategy captured both these elements, enhancing sensitivity and specificity of the surveillance system.

IV. Surveillance indicators in the United States

The National Immunization Program monitors the following indicators by state on a regular basis.

Indicators for measles surveillance

1. The proportion of confirmed cases reported to the National Notifiable Diseases Surveillance System (NNDSS) with complete information.

2. The median interval between rash onset and notification of a public health authority, for confirmed cases.

3. The proportion of confirmed cases that are laboratory-confirmed.

4. The number of cases that meet the clinical case definition, but are not confirmed.

5. The number of cases that meet the clinical case definition in which measles is ruled out by appropriate laboratory testing.

6. The number of chains of transmission that have an imported source.

7. The number of chains of transmission for which at least one clinical specimen for virus isolation was collected and submitted to CDC.

Other indicators are currently used for monitoring the quality of surveillance of rubella, *Haemophilus influenzae* type b invasive disease, and pertussis.

Indicators for rubella surveillance

1. The proportion of confirmed cases with complete information reported to the NNDSS.

2. The median interval between rash onset and notification of state or local public health authorities in confirmed cases.

3. The proportion of confirmed cases that is laboratory confirmed.

4. The proportion of confirmed cases among women of child-bearing age with known pregnancy status.

Indicators for Haemophilus influenzae type b invasive disease surveillance

1. The proportion of confirmed cases among children < 5 years of age with complete information, including vaccination status and serotype, reported to NNDSS.

2. The median interval between onset of clinical symptoms and notification of state and local public health authorities in confirmed areas.

Indicators for pertussis surveillance

1. The proportion of probable and confirmed cases with complete information, including detailed vaccination history (dates, vaccine type and manufacturer) and duration of cough, reported to NNDSS.

2. The proportion of cases meeting the clinical case definition that is laboratory confirmed.

Measles surveillance indicator reports are distributed quarterly, and surveillance indicator reports for the other diseases are distributed at least annually.

V. Additional approaches and future directions

Although these indicators have proven useful for identifying major problems with case investigation and reporting, given the small number of cases of most vaccine-preventable diseases now reported in the United States, a critical issue remaining is the sensitivity of the surveillance system—does the absence of cases from a particular jurisdiction indicate that there were in fact no cases?

One approach to improving the completeness of reporting is to implement active surveillance—that is, to make contact with all providers and institutions responsible for reporting on a regular basis to solicit reports. Active surveillance has been shown to increase reporting of measles, rubella, salmonellosis, and hepatitis in demonstration projects but is generally too expensive to perform routinely.[8,9]

In addition, there are other problems with active surveillance that are less well recognized. In response to a small measles outbreak, an urban health department recently approached pediatric infectious disease practitioners in the community and asked them to participate in active surveillance for a limited period of time. City public health officials were surprised and disappointed when the clinicians were unwilling to participate in active surveillance, a standard recommendation for public health response to outbreaks (see Chapter 6, "Measles"). Although there may have been many factors that contributed to the failure to recruit clinicians to participate in this effort, this episode highlighted the difficulty of improving completeness of reporting of rare diseases. The following assumptions underlie active surveillance:

- Cases are occurring in the community.
- Persons who are cases seek medical attention or otherwise come to the attention of institutions subject to reporting requirements.
- The condition is recognized by the provider or institution.
- Cases are not reported because filling out reporting forms or calling the health department is too much trouble.
- If the administrative reporting burden for providers is reduced, cases will be reported.

For rare diseases (such as most vaccine-preventable diseases in the United States) these conditions are rarely met. Indeed, previous demonstrations of the usefulness of active surveillance have focused on diseases that were relatively common or at least endemic in the population under surveillance. In many communities and states, no cases of measles or rubella have occurred in years, and in the absence of a large, ongoing outbreak, participating in active surveillance for these conditions is unlikely to be of much interest to providers.

As part of the polio eradication effort in the Western Hemisphere, PAHO instituted a system of weekly negative reporting that allowed them to monitor surveillance infrastructure (that is, the number of clinics and other facilities that participated in the surveillance system). Each reporting unit was to include in the weekly notifiable diseases report not only cases of disease identified, but for AFP only, a negative report, if no cases were identified that week (i.e., "no cases of acute flaccid paralysis"). It was implicitly assumed that any such cases would seek medical care and would be recognized; in short, it was an attempt to gain the benefits of active surveillance within a passive surveillance system without the investment of resources needed to conduct active surveillance. An evaluation in one country suggested that at the local level negative reporting was *not* accompanied by efforts at case finding, and substantial training was needed to make negative reporting meaningful at the local level.[10]

What approach *can* provide firm evidence that the absence of reported cases means the absence of disease in the population? Several methods may be useful: application of external standards; identification of imported cases;

monitoring the level of reporting for suspected cases that are ruled out as cases by epidemiologic and laboratory investigation; monitoring diagnostic effort; and monitoring circulation of the organism.

External standards

As discussed above, monitoring the rate of AFP among children < 15 years of age was found to be a powerful tool in assuring the adequacy of surveillance during the polio eradication program in the Western Hemisphere. Unfortunately, a similar external standard does not exist for measles or for most other vaccine-preventable diseases. However, an external standard may exist for invasive disease due to *Haemophilus influenzae* type b. Data from an active laboratory-based surveillance system suggests that among children < 5 years of age, non-type b invasive disease occurs at a rate of about 1.6 per 100,000.[11] If this rate is relatively stable over time in different geographic areas, it can serve as an external standard for monitoring the quality of reporting of type b invasive disease. In 1991 *Haemophilus influenzae* invasive disease became nationally notifiable; cases caused by type b and non-type b strains are included in the NNDSS. Because invasive disease due to non-type b *Haemophilus influenzae* strains are not prevented by vaccination in any age group and because type b cases continue to occur among adults, the absence of reported cases of invasive *Haemophilus influenzae* disease of any type in any age group in a jurisdiction strongly suggests that surveillance is inadequate.

Identification of imported cases

One indirect measure of the quality of case ascertainment at the national level is the demonstration that a surveillance system is sufficiently sensitive to detect imported cases; at the state level, no importations may occur, and the absence of reported cases may reflect either the absence of disease or the absence of effort to identify cases. Cases in persons who are not permanent residents of the United States are probably less likely to be reported and adequately investigated than cases in permanent residents due to a number of factors; for example, visitors may not have access to medical care, may be only briefly in an area (making it difficult to complete an adequate case investigation), and may avoid contact with authorities if in the U.S. without appropriate documentation. Single cases of measles—usually with no or very little indigenous spread—are often reported, investigated, and confirmed in the United States.[12] In jurisdictions in which no indigenously-acquired cases are reported, the demonstration of imported cases provides good evidence for a well-functioning surveillance system. This concept is reflected in measles surveillance indicator 6, the number of chains of transmission that have an imported source.

Measles is now rare throughout the Western Hemisphere, but is endemic in many countries of Western Europe and Asia. Importation of measles by travelers from these countries occurs frequently. In countries with substantial numbers of international travelers, importation of measles is expected. The failure to detect such cases suggests that, at the national level, surveillance is not sensitive enough to detect individual cases.

Monitoring cases that are ruled out

Another approach to tracking the quality of case ascertainment is to track the number of cases of suspected disease that are reported, investigated, and ruled out as cases. This approach was employed by PAHO in the polio eradication program in the Western Hemisphere. Even though polio had become an extremely rare disease, suspected cases continued to be reported throughout the region and were aggressively evaluated, including obtaining appropriately timed laboratory specimens. In this way, thousands of cases were demonstrated **not** to be polio, providing a measurement of system performance. Likewise, cases of acute flaccid paralysis that were not adequately investigated were classified as compatible and indicated a failure of surveillance and case investigation.

Measles surveillance indicator 5, the number of cases that meet the clinical case definition in which measles is ruled out by appropriate laboratory testing, was designed to track the quality of measles surveillance and case investigation at the state level, but it has proven difficult in some areas to collect the information to monitor this indicator. The limitation of this approach is that it requires collecting a good deal of information on cases that ultimately are ruled out, which outside of special evaluation projects may be considered to be an inappropriate use of limited resources. Secondly, in the United States, there is great variation in the delegation of responsibility for case investigation. In many states, responsibility for case investigation is delegated to city and county health departments. Although it may be recognized at the state level that collecting this information is useful as a performance measure, the necessary information may be unavailable at the state level. When cases are diagnosed at the local level and measles is almost always ruled out, requiring that every suspected case of measles be reported to the state will be difficult. When such information is available, however, the simultaneous demonstration that (1) many cases were reported and (2) all were ruled out as measles by appropriate investigation provides some assurance that efforts are being made to identify cases of measles and that once reported, case investigation is adequate. Of course, in the absence of an external standard, we remain uncertain about how many cases of suspected measles should be reported and investigated in a population in the absence of introduction and circulation of measles virus.

Monitoring diagnostic effort

Given the difficulties in collecting data on reported cases that are ruled out as cases, another approach to measuring the same thing—does anyone even suspecting the diagnosis?—could be to measure diagnostic effort. This is already recommended for evaluation of pertussis surveillance; tracking the number of pertussis specimens submitted over time, even if none are positive, provides good evidence that the diagnosis is being considered, even if no cases are found. Similarly, diagnostic effort for other vaccine-preventable diseases could be monitored by tracking submission of laboratory requests for diagnostic testing (measles and rubella IgM antibody tests, for example). If no testing is being done, no one is looking.

Consolidation of laboratory functions and development of standards and systems for electronic reporting of laboratory data make this approach feasible without developing new data collection systems. If testing occurs, the diagnosis is being considered. Under these circumstances, the absence of reported cases is more

likely to reflect the absence of disease. In the absence of an external standard, how much testing is "enough" is still open to question, but this approach does capture suspected cases that are evaluated in the private sector and not reported as "suspected cases."

Monitoring circulation of the organism

One adjunct to case surveillance is surveillance for the agent (the virus or bacteria that causes the disease). Molecular typing methods exist for measles, rubella, diphtheria, pertussis, and polio and have been used in all of these diseases to supplement the information collected in disease surveillance. Monitoring the organism can provide information about its origin, evidence of repeated introduction from multiple sources, and evidence of endemic transmission. The recent demonstration of endemic transmission of multiple strains of toxigenic *Corynebacterium diphtheriae* in a Northern Plains Indian community provided evidence of an ongoing public health problem in the absence of reported cases.[13] Molecular epidemiology has been critical in the demonstration of the interruption of indigenous transmission of measles in the United States and the continuing importance of importation in this country.[14] Similar methods are now being applied to isolates of rubella virus from infants with congenital rubella syndrome and persons with rubella in the United States.[15] Ultimately, as diseases progress toward eradication, monitoring circulation of the organism becomes an essential component of surveillance activities.

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