CHAPTER 4

Outbreak Detection & Reporting

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The Council for Outbreak Response: Healthcare-Associated
Infections and Antimicrobial-Resistant Pathogens

Outbreak Detection & Reporting

Preface

Detection and reporting provide the foundation for healthcare outbreak response. Potential outbreaks may be detected and reported by healthcare facilities and astute clinicians, and occasionally from other partners and the public. Routine surveillance provides another important avenue to identify sentinel cases, clusters, and outbreaks of healthcare-associated infections (HAIs) and antimicrobial resistant (AR) pathogens.

4.0   Introduction

Detection represents the first and most essential step in the response pathway, triggering activities aimed at assessing the situation, implementing control measures, and halting disease transmission. In this chapter, we describe methods to detect outbreaks and ways in which HAI/AR outbreak identification can be improved. Section 4.1 provides an overview of healthcare outbreak detection and reporting; section 4.2 offers a description of communication pathways and systems to support direct reporting of potential outbreaks; and section 4.3 focuses on the use of routine surveillance systems for outbreak detection. The chapter concludes with section 4.4, which provides some considerations for detecting and reporting multifacility and multijurisdictional outbreaks.

4.1   Overview

Outbreaks can be detected by a variety of entities, including public health agencies, healthcare facilities,

healthcare providers, laboratories, and other partners. Public health agencies and healthcare facilities share responsibility for outbreak detection and investigation, and, as described earlier in Chapter 3, relationships and communication among partners that detect and respond to outbreaks are essential to protecting the health of patients as well as that of the public. In this section, we review the definitions of the terms "cluster" and "outbreak" that will be used throughout the chapter and describe methods to detect outbreaks.

4.1.1   Outbreak Detection Pathways

Outbreaks can be detected by public health agencies and healthcare facilities via direct reporting (section 4.2), using routine surveillance data (section 4.3), or other means (Table 4.1). Reporting of potential outbreaks should occur internally within healthcare facilities as well as externally to public health agencies; in general, outbreak reporting is required by law (see Chapter 3 for more information).

Table 4.1	Potential Methods of Outbreak Detection by Healthcare Facilities and Public Health Agencies		
ENTITY	**SOURCES OF OUTBREAK REPORTING**	**DATA SOURCES FOR OUTBREAK DETECTION**	**ADDITIONAL ACTIVITIES THAT MAY RESULT IN OUTBREAK DETECTION**
Healthcare Facility	• Healthcare providers • Infection preventionist • Other healthcare facilities • Clinical laboratory • Hospital epidemiologist • Public health agencies • Patients • Members of the public • Media and social media	• Facility tracking systems (e.g., electronic medical records) • Admission, readmission, and transfer reports • Automated cluster detection systems • Clinical laboratory data	• Infection prevention rounds • Microbiology rounds
Public Health Agency	• Healthcare facilities • Healthcare providers • Clinical laboratories • Public health laboratories • Other public health agencies • Members of the public • Other agencies (e.g., state survey agency, Centers for Medicare & Medicaid Services [CMS], and accrediting organizations) • Media and social media	• Reportable conditions (including pathogens and HAIs) as well as general outbreak reporting requirements • Public health laboratory data • Other public health surveillance systems (e.g., sentinel surveillance systems and disease registries) • Other data sources (e.g., hospital discharge data)	• Infection control assessments • Prevention collaboratives • Other public health initiatives and stakeholder engagement

Outbreak reports may be directed to local, state, territorial, or tribal public health agencies. Public health agencies typically have protocols for communicating these reports to partner agencies (e.g., local health departments may report to a state public health department and vice versa).

One of the primary reasons for systematic collection of selected HAI and AR pathogen data via surveillance is to identify outbreak activity. Surveillance data can be used by healthcare facilities and public health agencies to detect sentinel cases and recognize patterns indicative of clusters or outbreaks. Identification of clusters or outbreaks may be accomplished by identifying similar cases within a facility, across multiple facilities, within the community, or across a region.

Understanding the endemic rates of a disease via surveillance, which can vary across institutions and jurisdictions, is often a key component of determining if an outbreak is occurring. In general, outbreak detection efforts benefit from a regular and systematic approach to reviewing surveillance data; the use of software programs can help automate this process.

Public health agencies may also learn about potential outbreaks as a result of infection control assessments and surveys or audits. For example, serious infection control breaches are now more likely to be reported to public health agencies when detected by state survey agencies or by accreditation partners, due to a requirement from the Centers for Medicare & Medicaid Services (CMS) to do so.[1]

4.1.2 Definitions

The term "cluster" can be defined as an unusual grouping of two or more instances of a disease or similar pathogen that occur together in time and space or share some other unique characteristic. A cluster is often the initial signal of possible transmission of disease and serves as a threshold to trigger further investigations to determine if the cluster represents an outbreak.

When initial epidemiologic or laboratory evidence indicates possible transmission, we consider this a "potential" or "suspected" outbreak. This is the threshold for additional investigation and reporting to public health. The Centers for Disease Control and Prevention (CDC) *Field Epidemiology Manual* defines the terms "outbreak" and "epidemic" as follows:

> An outbreak is defined as "the occurrence of more cases of disease than expected in a given area or among a specific group of people over a particular period of time." When there are clearly many more cases than usual that are distributed across a larger geographic area, the term epidemic can be used.[2]

In healthcare settings in which certain types of infections are common and may even be the reason for a patient's admission, it can be challenging to recognize an increase in the number of cases above what is considered endemic or above the baseline of disease.[3] First, baselines vary from facility to facility, among various healthcare settings, and among regions of a state or country. Second, baseline levels within a particular healthcare setting may reflect inadequate control of ongoing transmission of pathogens.

Baselines may not be available for all pathogens and infection types; in some instances, the occurrence of even a solitary case can reflect a departure from baseline or expected levels. These may serve as sentinels (i.e., unexpected occurrences that require immediate attention) and are referred to in the *CORHA Principles & Practices* as "sentinel cases." For example, a solitary case of a bloodborne pathogen infection, such as the hepatitis C virus or human immunodeficiency virus (HIV), occurring as a result of a healthcare exposure exceeds the expected level; this is often sufficient to prompt an investigation.

Reports of unusual pathogens, unexpected infection types, or unusual combinations of pathogens and infections can all be useful in revealing a larger issue or outbreak. Examples of unusual situations that were reported to public health agencies and were the initial signals of larger outbreaks include nontuberculous mycobacteria (NTM) infections following cardiothoracic surgeries using heater-cooler devices,[4] a cluster of *Elizabethkingia anophelis* infections,[5] and fungal meningitis primarily due to *Exserohilum rostratum* among patients following injections of a compounded medication.[6]

Determining a single definition for "outbreak" that fits all HAI/AR situations can be challenging. Often it is beneficial to have established pathogen-specific reporting thresholds and outbreak definitions. A number of CORHA's pathogen- and condition-specific materials (available on the CORHA website) have been structured to include categories covering the threshold for facilities to begin an investigation, the threshold for facilities to report the situation to public health, and the definition of an outbreak. Note that confirmation of the presence of an outbreak, as part of an investigation, is discussed in Chapter 5.

Thresholds for investigation and reporting are critical for triggering a rapid response. For pathogens or conditions that do not have specific thresholds for reporting to public health, consideration should be given to the following general principles:
- There is a reasonable suspicion that pathogen transmission occurred between two or more individuals, based on preliminary epidemiologic and laboratory evidence.
- There is a reasonable suspicion that two or more cases of disease were acquired from a common source, based on preliminary epidemiologic and laboratory evidence.
- Single cases of unusual pathogens, unexpected infection types, and novel or rare conditions should be treated as sentinel cases so that they may be investigated as potential outbreaks. A similar rationale applies to suspected medical product contamination and serious infection control breaches (e.g., syringe reuse). The aforementioned criteria may also be applicable to illnesses due to noninfectious conditions (such as toxins or chemicals).

4.2 Reporting Sentinel Cases, Clusters, and Outbreaks

4.2.1 Purpose

Nearly every type of outbreak that can occur in the community can also occur within healthcare settings. On the other hand, healthcare settings are unique and complex settings that lend themselves to types of outbreaks that can only occur within healthcare venues. Many types of HAI/AR outbreaks can occur, and many of these are not routinely detected via public health surveillance because surveillance is usually limited in scope (e.g., specific infections or pathogens). The types of hazards addressed by healthcare outbreak response include overt outbreaks, clusters of infections, sentinel cases (e.g., an uncommon HAI or emerging AR threat), or serious breaches in infection control practice. Therefore, direct reporting of outbreaks, clusters, sentinel cases and serious breaches is a critical pathway for public health to become aware of potential outbreaks within healthcare settings.

4.2.2 Background

Reporting internally within a healthcare facility and externally to the public health agency as soon as a potential outbreak is detected is critical to ensuring an effective and timely outbreak response. See Table 4.1 for a list of possible reporting sources for each organization type. Although this chapter focuses primarily on public health outbreak detection, understanding the components of outbreak detection within healthcare facilities is also discussed to some extent for context.

4.2.2.1 Reporting within a Healthcare Facility
Healthcare facilities of all types should strive to have systems in place for staff to notify a designated person or team when a potential outbreak is recognized. Outbreaks are usually reported to an infection control team. In some facilities this may be a large team composed of infection preventionists, healthcare epidemiologists, and other experts. In other facilities it may be one person with multiple duties, including infection prevention. Within a healthcare facility, clinicians, staff, and laboratories are typically the most common sources of outbreak reports.

The culture of the healthcare facility should be such that internal reporting is an open process, wherein staff feel empowered to make a report and be supported when a notification is made. Public health agencies may detect an outbreak within a facility that the facility is not aware of, either by using surveillance data or based on a report from outside the facility. When this situation occurs, public health should contact administrators at the healthcare facility as soon as possible, to ensure that the facility can immediately respond to the situation and gather additional information.

4.2.2.2 Reporting to Public Health
Entities that report to public health are described in the next section and in Table 4.1. Processes should be established to receive, triage, and respond to reports of potential outbreaks.[7] These processes should be clearly communicated to outside partners that report as well as internally to staff members who respond to outbreaks. The easier it is for entities to report, the more likely they are to do so.

In general, all outbreaks are reportable to public health, including potential outbreaks, outbreaks occurring within a healthcare setting, and any situation that may indicate illness from a common exposure, including within healthcare. Increasingly, this includes requirements for reporting single cases of novel or rare conditions that may be sentinel events.[7] Healthcare facilities and other reporting entities should report potential outbreaks and should not wait until an outbreak is confirmed before doing so. However, not all outbreak reports will require an active response or extensive investigation; passive monitoring may be sufficient in some instances and is itself a form of surveillance (this topic is covered in additional detail in Chapter 5).

Public health agencies should collaborate with healthcare facilities and other reporting entities to improve outbreak reporting.[7] Some strategies that public health agencies can use to increase reporting include the following:
- Encouraging healthcare facilities to report anything that they believe is unusual, and maintaining open communication between the public health agency and the facility to allow for discussion of unusual situations

- Implementing an effective triage and prioritization process that allows for reporting of potential outbreaks with a full public health investigation only when indicated
- Striving for increased visibility among healthcare facilities and partners, such as through educational outreach on HAI/AR topics and reporting requirements and pathways
- Establishing and maintaining relationships among public health agencies and reporting entities

Perceived barriers to reporting potential outbreaks can include the following:
- Concern on the part of the facility that reporting may trigger additional work or regulatory action
- Uncertainty regarding reporting requirements or procedures
- Uncertainty about the thresholds for reporting
- Previous negative experiences with reporting

Public health agencies should be familiar with reporting barriers in their jurisdiction and collaborate with facilities to overcome these reporting barriers.

4.2.3 Reporting Entities

Reporting to public health can come from a variety of sources, including from the healthcare facility (from the infection prevention team, directly from staff, or from a clinical laboratory), from laboratories (public health laboratory, reference laboratory, or community laboratory), or from community sources (the public, the media, other government agencies, or other organizations). The public health agency receiving the report could be situated at the local, state, territorial, tribal, or federal level, and public health agencies that receive these reports should notify other impacted agencies as appropriate. If healthcare facility personnel contact CDC directly, CDC staff members will advise them of the need to coordinate with a state or local public health agency. Entities reporting outbreaks and those required to report may vary across jurisdictions.

4.2.3.1 Healthcare Facilities and Providers
In general, most HAI/AR outbreak reports are made to public health agencies by healthcare facilities and providers, who are on the front line for identifying reportable conditions, pathogens, and potential outbreaks. See Table 4.1 for information on how outbreaks come to the attention of facilities and public health.

4.2.3.2 Laboratories
Clinical laboratories and public health laboratories may detect potential outbreaks when, for example, similar test results indicate commonalities and possible linkages between specimens or patients. Laboratories may detect sentinel cases or identify clusters using automated processes and laboratory information systems, or astute laboratorians may identify these during specimen testing or record reviews. Laboratories that identify potential outbreaks should notify appropriate healthcare facility contacts (e.g., the infection prevention department), if applicable, and the public health agency. See sections 4.2.5 and 4.3.5 for more details.

4.2.3.3 Public, Patients, and Media
Less often, members of the public, including patients within a healthcare facility, may experience and report a sentinel case. Members of the public may call the health department directly, and public health agencies may also identify outbreaks based on information gleaned from social media. Initial reports may come to public health via the media, including posts on social media. In these situations, public health should initiate a brief investigation to see if there is a potential outbreak that has not yet been reported.

4.2.3.4 Other Government Agencies
Various other government agencies at the local, state and territorial, and federal levels may become aware of and report outbreaks to public health agencies.[7] For example, state facility licensing agencies may learn about an outbreak during a routine survey of a healthcare facility or an investigation of a complaint. Likewise, serious infection control breaches also may be identified by state facility and provider licensing agencies or other regulatory partners.[1,7] State healthcare facility and professional licensing agencies should report potential outbreaks to the public health agency. In turn, public health agencies should have protocols and the appropriate authority to receive and share information on potential outbreaks, including infection control breaches, with these entities.

4.2.3.5 Other Partners

Other partners working with healthcare settings may also be positioned to identify outbreaks.

- Accrediting organizations may identify and report a significant infection control breach or outbreak to public health authorities.
- Law enforcement personnel may identify concerns that they report to public health during criminal investigations.
- Other organizations with roles in HAI/AR prevention, such as hospital and long-term care associations, member organizations, and quality improvement organizations, may be the first to learn about an outbreak.

These partners may not have specific requirements to report; however, public health agencies should develop relationships with these entities, opening the door to communication when partners identify concerns.[7]

4.2.4 Epidemiology Process

When an initial report of an outbreak is received, there should be a pre-established process for intake as well as for assigning an appropriate staff member to the initial assessment. Information should be gathered from easily available sources to make a preliminary assessment and triage an appropriate level of response; see Chapter 5 for a detailed discussion of information to be gathered and how to determine the level of a response.

For each report received, consideration should be given to the possibility that the report may be linked to other reports or surveillance data. Linking clusters, outbreaks, and single cases of public health interest that have been detected can be done within the jurisdiction and is aided by having an outbreak investigation tracking system (see section 4.2.8.5) in place along with regular communications between surveillance and response staff. This can also be accomplished nationally via communication through CDC's Epi-X, listservs such as the Infectious Diseases Society of America's (IDSA's) Emerging Infection Network (https://ein.idsociety.org), or direct communication with CDC. These sources can be utilized to help ensure that the outbreak is not larger or broader than anticipated (e.g., due to distribution of a contaminated medical product).

4.2.5 Laboratory Process

When epidemiology staff members first receive a report of a potential outbreak, they should communicate with their public health laboratory colleagues to share initial information and allow them to prepare for upcoming laboratory activities appropriate for the investigation. In some instances, the public health laboratory will receive the first communication regarding a potential outbreak. For example, a hospital may contact the laboratory for assistance with specialized testing to assess the relatedness among isolates or samples as part of the hospital's internal investigation of a cluster of infections. At other times, a public health laboratory may detect a possible healthcare outbreak as part of its regular testing activities. In either case, laboratory staff should relay this information to their epidemiology colleagues. The key is to ensure clear communication and coordination between epidemiology and laboratory staff.

4.2.6 Strengths and Limitations of Outbreak Reporting Systems

4.2.6.1 Strengths

Strengths of outbreak reporting systems include the following:

- A healthcare outbreak reporting system provides the surest and fastest method for public health to learn about potential outbreaks.
- All types of outbreaks and infection control breaches can be reported, including outbreaks in which the pathogen is unknown or in which the pathogen or condition was not included in surveillance.
- During the reporting process, additional communication can occur between the reporter and public health staff.
  - Public health gains information quickly about the outbreak scope and infection control measures already in place.
  - Initial recommendations for prevention measures can be communicated during the initial report when appropriate, allowing for rapid intervention to prevent new cases. See Chapter 5 for additional details.
  - Healthcare facilities and providers have overlapping expertise with public health professionals, leading to a widespread system of experts who can identify clusters and outbreaks across the continuum of care.

4.2.6.2 Limitations

Outbreak reporting systems also have limitations.

- Defining and communicating clearly what should be reported can be challenging.
- Reporting systems depend on a wide variety of reporters with inconsistent understanding, interpretation, and practice related to surveillance and reporting.
- Signal fatigue can occur.
- Recognition of multifacility outbreaks can be delayed or missed if not all facilities involved make reports.

4.2.7 Key Determinants of Successful Outbreak Reporting Systems

A successful outbreak reporting system is one in which the reporting criteria are defined as clearly as possible, the entities reporting are clear about when and what to report, reporting is systematic and complete, processes for handling reports have been pre-established, and, when indicated, rapid investigation is initiated as a result.

4.2.7.1 Sensitivity of Detection

The sensitivity to detect outbreaks using an outbreak reporting system is highly dependent on the reporter's ability to recognize the significance of a sentinel case or to identify a cluster or other evidence of a potential outbreak, as well as awareness of and ease of using outbreak reporting mechanisms and procedures. Sensitivity of detection may also be dependent on the availability of resources at the public health agency, including staff with HAI/AR experience. Multifacility and product-related outbreaks can prove more difficult to detect than other types of outbreaks, because several individual reports may need to be linked together by the public health agency or agencies.

4.2.7.2 Prevalence of Disease

The prevalence of a pathogen or infection (or a pathogen-infection combination) impacts the ability of a healthcare facility, provider, or public health agency to identify a cluster. When the background prevalence of a disease is low, it is generally much easier for a sentinel case or cluster to stand out and be recognized. Conversely, when the background prevalence of a disease, infection, or pathogen is high (e.g., methicillin-susceptible

Staphylococcus aureus), it can be challenging to discern a potential outbreak from background rates of sporadic disease occurrence. This can lead to delayed recognition and underreporting, along with missed opportunities for intervention and outbreak control. It can also lead to overreporting (due to decreased specificity), additional work for healthcare facilities and public health, and depletion of resources. Similarly, during an investigation involving a pathogen with a higher background prevalence, inclusion of cases that are not actually part of the outbreak (i.e., misclassification) can lead to challenges in finding the cause of the outbreak.

4.2.7.3 Relationships

The quality of relationships between the reporting entity and the public health agency can impact the willingness of the entity to report. If there is trust, mutual respect, and an understanding of the expertise and importance of each entity, the partners are much more likely to actively engage in reporting and joint investigations. It is critical to develop relationships prior to an outbreak, as discussed in detail in Chapter 3. Each outbreak response experience can have an impact on future reporting. Public health agencies can improve reporting by demonstrating sensitivity to the burden experienced by healthcare facilities and providers during a public health response to an outbreak; however, this should not be at the expense of a complete investigation when warranted.

4.2.8 Model Practices for Outbreak Reporting Systems

4.2.8.1 Required Reporting

Public health agencies benefit from establishing and communicating clear outbreak reporting requirements. Ideally, these will encompass HAI/AR response needs broadly, including confirmed outbreaks, clusters, sentinel cases (e.g., a novel or rare HAI or an emerging AR threat), and serious infection control breaches.[7] The method for setting forth requirements for reporting varies among states and territories. In addition, public health agencies should also have clear authority to initiate an outbreak investigation, including those occurring in healthcare settings, as well as authority to conduct all activities needed to stop the outbreak (as outlined in Chapter 3).

4.2.8.2 Ensuring Timeliness

Potential outbreaks should be reported to public health upon initial identification. Reporting entities should not wait until an outbreak is "confirmed" or an internal investigation has been completed before reporting to public health. Public health agencies should have a clear and easy reporting process (described below) and develop relationships with reporting entities to maintain open lines of communication.

4.2.8.3 Clear Reporting Process

Public health agencies should work toward ensuring that reporting entities understand reporting requirements in their jurisdiction;[7] toward this end, reporting requirements should frequently be communicated to reporting entities. Thresholds for reporting can be challenging to define and challenging for public health agencies to clearly communicate.

Public health agencies can remove barriers to reporting by helping interpret guidance, communicating expectations, and making the reporting process as simple as possible. When possible, the processes for reporting potential outbreaks should be clearly written and easily available, and include the following:

- Clear guidance on timing of reporting
- Description of what information is needed when making a report
- Clear, easy-to-locate information on the reporting method, which could be via phone (with numbers that are easy to locate, including a 24/7 after-hours number) and/or via systems for electronic reporting such as a web- or text message–based system
- Guidance on what to expect during and after the reporting process

Public health staff should have a clear understanding of the reporting process for entities that report, and there should be a clear, written internal process for standardized intake and triage of reports. Ideally, the reporting intake process should be centralized, so that one or only a few people conduct the intake or one person reviews reports to identify commonalities.

4.2.8.4 Useful Tools

Useful tools for an effective outbreak reporting system include clear written processes for intake, recording, and reviewing outbreak reports to guide the systematic collection of reports. An intake form can be helpful to ensure that information is collected systematically each time. Alternatively, an electronic system with required fields for filing outbreak reports can make it easy for the entity charged with reporting, as outlined in the following section.

Depending on the type of outbreak, reports of outbreaks can be checked against data collected in other systems, including state survey reports on the facilities involved; CDC's Epi-X, the IDSA Emerging Infection Network listserv (https://ein.idsociety.org), and other reports of ongoing national outbreaks; and public health surveillance systems that may identify additional cases.

Knowledge of healthcare facility systems and patient transfer patterns can be a useful tool to detect multifacility outbreaks and understand the potential scope of an outbreak. If public health agencies have the expertise and resources, a model practice is to create and maintain a network analysis of facility transfer patterns to apply to detected outbreaks.

4.2.8.5 Outbreak Tracking

As described in Chapter 3, each agency should strive to track all forms of outbreak reports and response activities, inclusive of clusters, sentinel events, and infection control breaches.[7] CORHA developed an HAI/AR Outbreak Investigation and Response Tracking System and associated data dictionary for this purpose; they are available on the CORHA website (www.corha.org/resources-and-products/?filter_cat=data-management). Health department HAI/AR programs also receive specific guidance on response tracking from CDC.

4.3 Detecting Sentinel Cases, Clusters, and Outbreaks through Surveillance

4.3.1 Purpose

By using surveillance data, public health agencies can systematically detect sentinel cases, clusters, and outbreaks of pathogens and conditions that are currently under public health surveillance. This is an essential public health activity that complements the direct outbreak reporting pathways reviewed in section 4.2. Patterns suspicious for an outbreak can be recognized not only within a single facility but across multiple facilities and throughout the community. Pattern recognition can occur via manual review of surveillance or laboratory data or automatically using specific software for data mining and cluster detection.

Public health agencies that rely on the detection of outbreaks using both surveillance data and outbreak reporting systems will detect more outbreaks than agencies relying on either system alone. Of note, while this section primarily takes the point of view of public health surveillance, many of the activities and principles reviewed here can also apply to healthcare facilities, especially larger hospital-based systems.

4.3.2 Background

Disease surveillance is an established practice in public health (as detailed in Chapter 2). By receiving reports of every case of a specific condition or pathogen, surveillance can be comprehensive, and by using various techniques, patterns in data can be recognized. In some situations, a review of case information in an electronic health record or health information exchange can be helpful to identifying characteristics indicative of a cluster or sentinel case. Public health agencies may adjust their approaches to performing surveillance and analyzing the data based on local epidemiology and priorities.

Two techniques that can assist with detecting patterns within surveillance data are routine laboratory typing and the use of automated systems to detect clusters.

For example, when all *Salmonella* isolates undergo whole genome sequencing (WGS), a technique now used routinely in foodborne surveillance, clusters are identified based on the similarity of the isolates, which is determined by examining single nucleotide polymorphism (SNP) differences. A cluster of three *Salmonella* isolates with no SNP differences may lead to an investigation to find a link between cases.

HAI/AR programs within the U.S. have begun to implement similar laboratory testing approaches for pathogens related to healthcare settings, particularly those that represent emerging AR threats (see section 4.3.5). When available, innovative laboratory technologies provide powerful methods for enhancing outbreak detection. The use of automated systems, such as cluster detection software tools, applied to surveillance data is another method by which clusters and outbreaks may be detected. This method is described in greater detail in section 4.3.4.

4.3.2.1 Detection within a Healthcare Facility

Public health agencies should be aware of surveillance systems in place in healthcare facilities in their jurisdiction, including barriers that facilities may experience in implementing surveillance systems. Surveillance systems may vary widely across facilities and healthcare settings, and can include electronic health records, infection prevention systems, laboratory systems, or even basic line lists in small or low-resource facilities. Facility surveillance systems cross paths with public health when such systems are used to collect and report conditions under public health surveillance and when a system results in the detection of a cluster or outbreak that triggers public health reporting requirements.

Healthcare facilities should have surveillance systems in place for selected pathogens, conditions, and syndromes; an essential function of facility surveillance systems is to detect situations that indicate disease transmission within the facility. There is no single approach to surveillance that fits all healthcare facilities, and facilities should design surveillance procedures and systems based on their populations, priorities, and objectives, as well as on any applicable regulatory requirements.[8]

Recommendations for surveillance within healthcare facilities are outside the scope of this chapter, but other resources are available for this purpose.[7]

4.3.2.2 Detection by Public Health

HAIs and healthcare-associated pathogens, including AR pathogens, are reported to public health agencies according to state or territorial, tribal, and local regulations. Public health agencies establish lists of conditions for public health surveillance that are reportable by healthcare providers, healthcare facilities, and/or laboratories. Conditions to report may be pathogen-specific or based on infection type (described later in this chapter), or based on some other criteria. Isolates or clinical material are often required to be submitted in conjunction with the report. Additional information on surveillance practices can be found in Chapter 2. Reporting requirements by state are available at www.cste.org/group/SRCAQueryRes. Conditions that are notifiable to CDC on a national level can be accessed at https://www.cdc.gov/nchs/hus/sources-definitions/nndss.htm.

4.3.3   Types of Surveillance Data

It is important to understand the distinct types of HAI/AR surveillance data collected by public health agencies as well as their advantages and limitations. The two types of surveillance used extensively by health department HAI/AR programs are population-based surveillance and healthcare facility–based surveillance. Population-based surveillance involves identifying cases that meet a specific surveillance definition within a defined population, typically residents of a certain jurisdiction such as a state or a county.

For some conditions, surveillance occurs at the healthcare facility level rather than the population level; each healthcare facility may be expected to report conditions for their facility either to a local or state public health agency or to a national system such as CDC's National Healthcare Safety Network (NHSN), which in turn may transmit back to or be accessed by a local or state public health agency. See Chapter 2 for additional information on these surveillance practices.

When a cluster is detected using a specific data source, understanding the strengths and limitations of the surveillance system will lead to a more accurate interpretation of the significance of the cluster. An outbreak may be detected using population-based surveillance, healthcare facility–based surveillance, or other surveillance systems in use. One example of the latter may be a review of local or regional antibiogram data, when available, to understand the resistance pattern for organisms that are not selected for routine surveillance and to monitor for increasing levels of a particular pathogen or resistance pattern.

4.3.4   Epidemiology Process

Once reports of cases of a condition under surveillance are received by the public health agency, individual cases may be reviewed to gather additional epidemiologic data, depending on the priorities of the public health agency and local epidemiology as well as on the characteristics of the condition. Gathering additional epidemiologic information may be accomplished via discussions with the healthcare facility, medical record reviews, and/or interviews with patients. The level of additional data gathered for each case and the methodology employed is highly variable among jurisdictions and among specific pathogens or conditions; broadly speaking, it covers the epidemiologic "who, what, where, and when" and sometimes also includes aspects of the "why and how."

Resource limitations typically do not allow for complete data collection on every case for every pathogen and condition for which reports are collected. Public health agencies prioritize individual case investigations based on local epidemiology and priorities. Routine collection of selected information should occur as soon as possible after public health receives a case report to maximize the possibility of cluster detection. For more information on descriptive epidemiology, see Chapter 5 and *CDC's Principles of Epidemiology in Public Health Practice, 3rd Edition*.[3]

As epidemiologic information accrues, these data can be reviewed for possible linkages among cases in etiology, person, time, and place. Manual review of cases is one method to identify clusters in need of additional

investigation. Reviews may identify clusters associated with a particular facility or facility network among patients with similar healthcare conditions or exposures to procedures, or among patients with similar community exposures or other unique exposures. This works well if the condition under surveillance has a fairly low prevalence and the reviewer has a solid understanding of the data. If the prevalence of the condition is high, manual review of cases may be too labor-intensive and subjective to perform routinely.

More automated methods can be used to detect clusters using surveillance data, particularly when a high prevalence of disease is too cumbersome for manual review. Some public health agencies and hospital systems use automated methods, such as application of data mining and cluster detection software, to identify clusters among surveillance data. Automated technologies can speed up the process of detecting clusters and can combine data across data sources. Advantages of using automated cluster detection include speed, efficiency, accuracy, reduction of staff time, and the potential to detect more clusters and prevent more disease.[9,10] Additional resources are needed to implement such processes, such as information technology support, staff training, and software acquisition.

Use of automated systems by public health agencies to detect clusters currently varies greatly by jurisdiction; in a 2017 survey, 36% of respondents indicated that their agency did not use automated methods for cluster detection.[11] The most commonly reported barriers to automated methods for cluster detection include lack of resources, perceived lack of timeliness, lack of access to data, and lack of expertise.[11] It can be challenging to set parameters that provide enough sensitivity to detect every cluster that truly represents an outbreak without being so sensitive that more clusters are identified than can be investigated practically (including many that are not true outbreaks, representing a poor signal-to-noise ratio); a recent review found that the sensitivity of detection algorithms can vary between 17% and 100%.[12]

4.3.5 Laboratory Process

Electronic laboratory reporting for conditions under public health surveillance supports complete and accurate reporting. When unusual pathogens, testing results, and pathogen-specimen combinations are detected, astute laboratory staff are in a prime position to detect clusters and report potential outbreaks to clinical and public health partners. Laboratory information systems and other laboratory databases also can be sources of data to detect sentinel cases, clusters, and potential outbreaks.

Clinical laboratories forward isolates or clinical specimens to the public health laboratory according to local regulations as part of the surveillance process. For AR pathogens, as well as for other healthcare-associated pathogens (such as group A *Streptococcus*), it is important to receive isolates for confirmation (e.g., by identifying an organism's genus and species as well as its antimicrobial susceptibility) and additional testing to further characterize the isolate (e.g., by molecular testing).

For example, identification of mobile genetic elements of interest to public health, such as carbapenemase and *mcr-1* genes,[13] may be important to identify potential outbreaks; this additional characterization helps focus epidemiologic investigations on selected cases that truly may be related and avoid case misclassification. Additionally, some jurisdictions may prioritize AR pathogens with specific characteristics such as carbapenemase-producing carbapenem-resistant Enterobacterales (CP-CRE).

Epidemiologists should be aware of what testing is performed routinely on isolates submitted to the public health laboratory, what is the turn-around time, and how results are communicated to healthcare facilities. Communication of results to epidemiology and the healthcare facility should be timely and part of an established process. Laboratory processes that support surveillance also support the detection of clusters; epidemiology should be able to act quickly on single cases and clusters that have been detected.

In 2016 CDC established the Antibiotic Resistance Laboratory Network (AR Lab Network), which led to the expansion of capabilities of facilities and public health agencies to detect emerging AR threats and support coordinated local responses to prevent their spread. It also functions as a surveillance entity with the capacity to provide information on national trends and detect outbreaks. More information on the AR Lab Network can be found in Chapter 2 and at this website: https://www. cdc.gov/antimicrobial-resistance-laboratory-networks/php/ about/index.html.

4.3.6   Strengths and Limitations of Surveillance for Outbreak Detection

4.3.6.1 Strengths
Using surveillance data to detect sentinel cases, clusters, and outbreaks has several strengths, namely
- Use of surveillance data has the potential to be thorough and systematic.
- When epidemiologic information is available on cases, the signal-to-noise ratio and sensitivity can be high.
- Surveillance data collection supports complementary processes—both manual and automated. The manual process of outbreak detection relies on personnel to review surveillance data and make connections among cases. With experienced personnel and less common conditions, this methodology should identify most outbreaks of diseases and conditions under surveillance. Using data mining and cluster detection software can supplement and automate this process.

4.3.6.2 Limitations
Limitations of outbreak detection using surveillance data include the following:
- Reliance on surveillance data to detect outbreaks only works for conditions under surveillance.
- Outbreak detection based on using surveillance data is typically slower than that based on direct outbreak reporting to public health. It is dependent on the timing and completeness of individual case reports, reports on results of additional testing, and the time it takes for staff or automated processes to flag a cluster (see section 4.3.7).

- Manual review of surveillance cases can miss clusters, is subject to human error, can be limited to a set of prespecified organisms (e.g., multidrug-resistant organisms [MDROs]), and can be very time-intensive.
- Automated cluster detection minimizes risk of human error; however, adjusting thresholds to achieve an effective signal-to-noise ratio can be tricky when the condition is common. Signal fatigue could occur if the signal-to-noise ratio is low.
- Using software for automated detection requires information technology resources and staff expertise.

Incorporating both outbreak reporting systems and use of routine surveillance data to detect outbreaks capitalizes on their complementary strengths and minimizes the limitations of each system. Public health agencies should consider options for improving and optimizing their use of both types of systems to detect potential outbreaks.

4.3.7   Key Determinants of Successful Outbreak Detection via Surveillance Systems

Successful use of surveillance to detect outbreaks is dependent on rapid surveillance with complete data, targeted and specific information collected on cases that supports epidemiologic linkage and cluster detection, and rapid and systematic identification of clusters using the data collected. The key determinants are discussed in this section.

4.3.7.1 Completeness of Reporting
To use surveillance data to detect clusters, cases must be reported in a complete, accurate, and timely fashion. Public health agencies can support this by ensuring that requirements for reporting within their jurisdictions are clear, there are rapid time frames for reporting, and there is clear communication with entities reporting cases for surveillance. Electronic laboratory reporting is systematic; it ensures complete and timely reporting on the part of the entities using it and should be employed when possible.

Additional epidemiologic information gathered on each case should be limited to what is needed and specific to assisting the detection of outbreaks; superfluous

information should not be included because that may divert resources. Laboratory testing performed by the reporting entity should be communicated to public health. The capacity of the public health laboratory to perform additional laboratory testing (e.g., confirmation of clinical laboratory test results and advanced laboratory testing including molecular testing) may determine if cases can be linked based on laboratory data; any testing performed by the public health laboratory should be completed in a timely manner and shared with epidemiologic staff responsible for performing cluster detection.

4.3.7.2 Sensitivity of Detection

Depending on the pathogen or condition, surveillance may identify only a sampling of the true number of cases in the population, and the completeness of reporting the true number of cases directly impacts the ability of public health to detect a cluster. With some HAI conditions, underdiagnosis and underreporting can decrease the sensitivity of case detection. Pathogen-specific surveillance, particularly that for AR pathogens, may provide an incomplete picture because of the presence of colonized individuals in the population or because of differential approaches to testing. Similarly, if isolates and clinical material are not routinely submitted for confirmation and additional testing, the included cases may not represent the true scope of an outbreak. WGS and other forms of next generation sequencing are extremely promising to help define the scope of outbreaks, particularly as these techniques become applied more widely. See Chapter 6 for more information.

4.3.7.3 Prevalence of Disease

As described previously, the prevalence of a disease often has an inverse relationship to the ease with which an outbreak can be detected. When the prevalence of disease is high, determining additional characteristics of the pathogen (e.g., by resistance mechanism testing or molecular typing such as WGS) and collecting additional epidemiologic data can be helpful in distinguishing cases that may be part of a cluster. For example, if a healthcare facility identifies two cases of carbapenem-resistant Enterobacterales (CRE) in an intensive care unit, it may be difficult to determine if this is a likely outbreak. However, if additional testing is performed and both

isolates harbor a carbapenemase that has not yet been identified in the facility, it is much more likely that this will be identified as a cluster and possible outbreak.

4.3.7.4 Speed of Detection of Diseases and Conditions under Surveillance

It is advantageous to detect outbreaks as soon as possible so that, if warranted, an investigation can proceed and provide opportunities for swift implementation of control measures. Rapid outbreak detection and response depend on the speed of the reporting, which can be affected by local reporting requirements, time spent reviewing records and collecting information, and ease of use of reporting processes.

4.3.8 Model Practices for Detecting Outbreaks through Surveillance

4.3.8.1 Case Reporting

To support rapid detection of outbreaks, surveillance requirements and processes should reflect the need for timely case detection and reporting. Public health agencies can do the following:

- Create local timelines for reportable conditions that are commensurate with the urgency to detect outbreaks involving a specific disease or condition
- Put processes in place to make reporting easier for reporting entities (e.g., support electronic laboratory reporting) and support those entities by providing education, being available for questions, and communicating frequently and clearly the methods for reporting
- Ensure that case information that is collected is limited to what is needed for effective surveillance, outbreak detection, and other public health needs, ensuring judicious use of resources

4.3.8.2 Submission and Characterization of Isolates

Public health agencies often issue requirements for submission of isolates and clinical material in connection with case reports of communicable disease. This is especially useful when agency-directed testing for confirmation and characterization may assist with the identification of clusters and outbreaks. Clearly communicating the rationale and mechanisms for isolate submission helps ensure that this process happens

quickly and reliably. Providing additional guidance, as needed, to affected laboratories helps ensure that case reporting and isolate submission can occur simultaneously.

Awareness of local epidemiology, supported by communication between epidemiologists and public health laboratorians, allows laboratories to prioritize testing of pathogens as needed. Outbreak detection should be a strong consideration for prioritization of testing. Epidemiology staff should understand the testing practices and timelines of their laboratory partners.

When detecting clusters using surveillance data, establishment of etiology is a critical component. Laboratory testing frequently plays a key role in determining and confirming the diagnosis. For example, public health laboratories often will confirm test results performed at the clinical laboratory, especially when the etiology is in question. It is best practice to enlist the assistance of a reference laboratory with the capacity to perform advanced laboratory testing, such as the public health laboratory, when attempting to determine if isolates or specimens are related.

Resources do not always allow for every isolate or specimen to undergo advanced laboratory testing. When resources do not allow for typing of all submitted isolates, it is important for epidemiologists and public health laboratories to coordinate on prioritization strategies. The ideal practice would be to perform molecular typing on all isolates that are submitted. Detection of clusters via assessments of relatedness (e.g., sequencing and isolate typing) and confirmation of relatedness of isolates when suspected transmission is occurring would add to the ability of public health to detect clusters, confirm outbreaks, and ensure that cases identified as part of an outbreak investigation are not misclassified. Routine typing of isolates that are submitted as part of surveillance is gaining ground and remains an important long-term goal for the HAI/AR field.

4.3.8.3 Standardized Processes for Cluster Detection

Processes to identify clusters using surveillance data should be as rapid as possible, regardless of whether they are conducted manually or using an automated method. Public health entities may choose to implement manual cluster identification or automated cluster detection, depending on the pathogen or condition and available resources. As often as possible, public health agencies should have processes in place, preferably written, that are standardized to ensure consistent identification of clusters and outbreaks.

4.3.8.4 Communication

Laboratory staff should understand local epidemiology and be kept informed of clusters and outbreaks; epidemiology staff should understand the testing practices, constraints, and timelines of the laboratory. It is critical that laboratory and epidemiology staff communicate regularly to accomplish this. Routine procedures for communicating general practice information (such as regular meetings) should be established, as should procedures for rapidly communicating the day-to-day work of surveillance data, test results, cluster and outbreak detection, and local epidemiology patterns.

4.3.8.5 Useful Tools

The use of software programs to automate cluster detection is increasing, particularly in conjunction with antimicrobial resistance surveillance. Free software is available. One such tool is SaTScan™, which can be used in combination with data sources to detect clusters of disease using space, time, and space-time data. WHONET was developed to manage microbiology data by focusing on antimicrobial susceptibility test results; it has the capability to develop descriptive statistics and graphs that can be reviewed to detect possible clusters. WHONET can be used in combination with SaTScan. For further information or use, click on whonet.org and www.satscan.org.

Knowledge of healthcare facility systems and patient transfer patterns can be a useful tool to detect multifacility outbreaks and understand the potential scope of an outbreak. Public health agencies can consider creating and maintaining network analyses of facility transfer patterns to apply to detected outbreaks. Surveillance data can be applied to facility network maps to understand patterns that may indicate clusters or to identify facilities that may be at risk.

4.3.8.6 Outbreak Tracking

As discussed in Chapter 3, each agency should strive to track all outbreak responses, including investigations related to confirmed outbreaks, clusters, sentinel events, and infection control breaches. 7 As mentioned earlier, CORHA has an HAI/AR Outbreak Investigation and Response Tracking System and associated data dictionary for this purpose: www.corha.org/resources-and-products/?filter_cat=data-management. In addition, health department HAI/AR programs receive specific guidance on response tracking from CDC.

4.4   Multifacility and Multijurisdictional Considerations

Multifacility and multijurisdictional outbreaks can result from contaminated medical devices or drugs, a common healthcare provider, or other shared infection source that is present in multiple facilities or jurisdictions. Recognizing this type of outbreak is challenging because initial signals can manifest as a collection of seemingly isolated case reports. Recognition also may depend on a high index of suspicion and benefits from the use of direct reporting mechanisms. In fact, major multifacility and multijurisdictional outbreaks with high incidences of morbidity and mortality have been detected due to reports of a nonreportable condition that originated from a single healthcare facility or provider.[6,14,15]

While healthcare facilities and healthcare providers play important roles in helping identify multifacility outbreaks, public health agencies have the advantage of being able to monitor and link reports across facilities and even across jurisdictions. Cluster detection using surveillance data can help identify multifacility and multijurisdictional outbreaks that would otherwise go undetected.

Public health agencies should employ methods to detect outbreaks via reporting and use of surveillance data, as described throughout this chapter, to detect multifacility outbreaks; these agencies should maintain a low threshold for sharing concerns regarding a potential multijurisdictional outbreak with other state public health agencies or relevant federal agencies including CDC and the US Food and Drug Administration (FDA). Detection and investigation of multifacility and multijurisdictional outbreaks will be covered in additional detail in Chapter 7.

CORHA Keys to Success

Maximizing Outbreak Detection

Receiving Reports

- Perform surveillance for HAIs and AR pathogens that includes mandatory reporting and submission of isolates and clinical material when applicable.
- Ensure mandatory reporting includes reporting of potential outbreaks and novel or rare conditions that may represent sentinel events.
- Establish processes for reporting that are clear to reporting entities, easy to follow, and allow for rapid reporting.
- Establish thresholds for reporting potential outbreaks that are clearly defined; make guidelines for reporting as clear as possible.
- Ensure that entities that do not report regularly can easily find methods for reporting when they do identify a potential outbreak; build relationships with a variety of partners that may report.

Detection of Clusters and Outbreaks

- Use multiple methods to detect HAI/AR outbreaks, including, at a minimum, receiving reports of clusters and outbreaks and using surveillance data to detect clusters.
- Ensure processes are in place to detect clusters and outbreaks by using surveillance data; this may include review of surveillance data by experienced personnel, data analysis to identify clusters and outbreaks, or automated processes involving data mining and cluster detection methods.

- Ensure public health laboratory testing practices support the detection of outbreaks, including prioritization of testing based on local epidemiology and the ability to perform advanced laboratory testing, with regular communication between epidemiology and laboratory staff.

Communication

- Ensure that reporting entities receive detailed communication on reporting requirements with a frequency that maximizes sharing of information without overload.
- Clearly communicate thresholds and guidelines for reporting potential outbreaks to reporting entities.
- Ensure clear and regularly scheduled communication on local epidemiology and laboratory testing practices between epidemiology and laboratory public health staff. Processes for rapid communication of test results should be in place.

Evaluations

- Use an outbreak tracking database to monitor reports and investigation activities in a comprehensive manner. Use this information to identify areas for improvement.
- Periodically evaluate processes for outbreak detection and refine and enhance them when needed.

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