

CHAPTER 2

Fundamental Concepts

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Preface

In Chapter 2, we review fundamentals concepts related to healthcare and public health surveillance as well as trends in outbreak detection and response. As healthcare-associated infection and antimicrobial resistance (HAI/AR) surveillance improves and outbreaks are recognized earlier, the public health and healthcare communities are better positioned to reduce patient harm from HAIs, AR pathogens, and healthcare outbreaks. The ultimate goals of the healthcare outbreak response are to rapidly detect and respond to potential outbreaks, ensuring that any unsafe practices are discovered and corrected before further harm can occur.

2.0 Introduction

Healthcare-associated infections (HAIs) are infections acquired within a healthcare setting or related to the receipt of medical care. They are a leading cause of unnecessary death and are a serious threat to public health. Each year, millions of patients are affected by HAIs worldwide. Although significant progress has been made in preventing HAIs, data published by the Centers for Disease Control and Prevention (CDC) indicate there is much more work to be done.¹

The term “healthcare-associated infection” reflects that the infection had its onset in a specific healthcare setting or following a healthcare exposure; it does not necessarily reflect with certainty where a pathogen was *acquired*. This uncertainty is due to the fact that patients may become colonized (i.e., microorganisms may appear on the skin of or inside a person without causing a disease)

following exposure to a pathogen within the community or at a different healthcare facility.² Identifying HAIs and attributing them to a specific healthcare setting can be complicated, as some HAIs may not become apparent until after discharge from a healthcare facility.³

Antimicrobial resistance occurs when pathogens develop the ability to defeat antimicrobial agents designed to kill them. Infections caused by antimicrobial resistant (AR) pathogens can be difficult and sometimes impossible to treat. Both patients who are colonized and those who are infected with an AR pathogen can serve as a source of transmission. In many cases, AR infections result in extended hospital stays and may require use of more costly and more toxic alternative treatments. More than 2.8 million AR infections occur in the US each year, and at least 35,000 people die as a result.⁴ As novel AR pathogens emerge, new and innovative detection and response strategies will be needed.

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Protecting patients from acquiring an HAI or AR pathogen is a critical aspect of patient safety. Patients seek healthcare as a means of maintaining or improving their health. When, as an unintended consequence of healthcare, an infection occurs or colonization with an AR organism results, it can be a significant event for the patient—one shaped by the patient’s health status, understanding, emotions, and social context.⁵

HAI/AR pathogen outbreaks in healthcare settings usually stem from breakdowns in practices designed to prevent transmission of disease. Often, these outbreaks are the result of a failure to follow basic (“core”) infection control practices. Outbreaks also result from exposure of patients to contaminated medical products.

The evolving landscape of healthcare outbreak response has been shaped by changes in healthcare delivery, advances in laboratory techniques, and emerging pathogen resistance to antimicrobial agents. Health department expertise and capacity have grown dramatically. Increasingly, public health agencies, healthcare providers, and partner organizations are working together to identify and respond to potential HAI/AR outbreaks.

2.1 Trends in Healthcare

2.1.1 Healthcare Settings

The term “healthcare setting” represents a broad array of services and places where healthcare occurs, including

but not limited to acute care hospitals, urgent care centers, rehabilitation centers, nursing homes and other long-term care facilities, outpatient clinics, specialized outpatient services (e.g., hemodialysis, dentistry, podiatry, chemotherapy, endoscopy, and pain management clinics), outpatient surgery centers, pharmacies, and any other location where medical care is provided. In addition, some healthcare services are provided in private offices or homes.

Within each type of setting, specific locations or services may be the focal point of an epidemiologic investigation. Acute care hospitals are complex organizations that can have multiple specialized areas for triage and emergency care, inpatient and outpatient surgical procedures, management of immunosuppressed populations (e.g., oncology or transplant recipients), rehabilitation services, and intensive care units. The type of healthcare delivered within a healthcare setting can vary widely depending on the community. For example, rural areas may have different services and expertise available than urban areas.

An understanding of the types of patients and clinical services provided helps investigators recognize infectious disease transmission risks. Selected healthcare settings, definitions, and characteristics, as well as the staff with whom public health agencies will typically interact, can be found in Table 2.1.

Table 2.1 | Selected Healthcare Settings Where Public Health May Conduct HAI/AR Outbreak Response Activities: Definitions, Characteristics, and Key Staff

SETTING	NATIONAL QUALITY FORUM (NQF) AND CENTERS FOR MEDICARE AND MEDICAID SERVICES (CMS) DEFINITIONS ^{6,7,8}	ADDITIONAL CHARACTERISTICS	KEY STAFF CONTACTS
Ambulatory Care Settings	NQF: Healthcare services that do not require hospital admission. These may be provided in an ambulatory surgery center, clinician’s office, or clinic/urgent care setting.	This broad designation includes any outpatient medical care setting where a patient is not admitted.	For clinics, public health often interacts with an office manager or clinical staff. For outpatient procedure centers, public health may interact with clinical staff, with a manager, or in some cases with an infection preventionist.



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Ambulatory Surgery Centers (ASCs)	<p>NQF: Setting in which outpatient surgical services are provided.</p> <p>CMS: A facility where certain surgeries may be performed for patients who are not expected to need care for longer than 24 hours.</p>	A type of ambulatory care site where surgical services are provided. Some centers are located within a hospital or hospital complex but are licensed separately. Others are stand-alone centers. Public health authorities usually reserve the term “ambulatory surgery center” for Medicare-certified facilities. The term “office-based surgical practice” is usually applied to less-regulated entities such as oral or plastic surgery practices.	Public health may interact with an infection preventionist when one is on staff; sometimes this person is a hospital-based or other infection preventionist affiliated with the center. Public health may also interact with center administration personnel (manager or executive level) or with clinical staff.
Critical Access Hospitals (CAHs)	<p>CMS: A small facility located in a rural area more than 35 miles from another hospital or critical access hospital (15 miles away if the area has mountainous terrain or only secondary roads). This facility provides 24/7 emergency care, has 25 or fewer inpatient beds, and maintains an average length of stay of 96 hours or less for acute care patients.</p>	Critical access hospitals are acute care hospitals that meet specific criteria defined by CMS.	Typically, public health interacts with a clinical staff member who fulfills several duties, including that of an infection preventionist. Other staff members may include those found in an acute care hospital (see Acute Care Hospital).
Urgent Care Centers	<p>NQF: Setting in which urgent care services are provided. Urgent care services are medically necessary services required for illnesses/injuries that will not result in further disability or death if not treated immediately, but require professional attention and have the potential to develop such a threat if treatment is delayed longer than 24 hours.</p>	Urgent care centers are a type of ambulatory care.	Often public health interacts with an office manager or clinical staff.

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End-Stage Renal Dialysis Facilities/ Dialysis Centers	<p>NQF: Setting in which dialysis services are provided to patients.</p>	Dialysis facilities may be stand-alone centers or associated with a hospital complex. Often dialysis facilities are part of large corporations.	Public health may interact with an infection preventionist (who may have other duties), clinical staff or managers, office managers, administrators, or corporate representatives.
Home Health Agencies	<p>NQF: Limited part-time or intermittent skilled nursing care and home health aide services; physical therapy, occupational therapy, speech-language therapy, and medical social services organizations; and providers of durable medical equipment (such as wheelchairs, hospital beds, oxygen, and walkers), medical supplies, and other services that are provided to patients in their home or place of residence.</p> <p>CMS: An organization that provides home health care, defined as healthcare services and supplies that patients receive in their homes under a plan of care established by a provider.</p>	Many but not all home health agencies are designated Medicare-certified by CMS.	Public health typically has fewer interactions with home health agencies than other healthcare settings. When public health does interact, it will typically be with a clinical manager.
Hospice	<p>NQF: Palliative services provided to terminally ill patients and their families/ caregivers in the patient's place of residence or in an inpatient facility.</p> <p>CMS: An organization that is primarily engaged in caring for people who are terminally ill. Hospice care involves a team-oriented approach that addresses the medical, physical, social, emotional, and spiritual needs of the patient.</p>	Many but not all hospice practices are designated Medicare-certified by CMS.	Public health typically has fewer interactions with hospice than other healthcare settings. When public health does interact, it is typically with a clinical or facility manager.

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Acute Care Hospitals (ACHs)	NQF: Setting in which healthcare services (including but not limited to diagnostic, therapeutic, medical, surgical, obstetric, and nursing) are provided by or under the supervision of physicians to patients admitted for a variety of health conditions.	A variety of hospital types including specialty hospitals (e.g., cancer hospitals, orthopedic hospitals, and pediatric hospitals, academic hospitals, community hospitals). Two hospital types are specifically described in this table: critical access hospitals and long-term acute care hospitals.	Typically, public health initially interacts with an infection preventionist or healthcare epidemiologist. Other staff may include quality and risk management, clinical staff (e.g., nurses, physicians, pharmacists, or therapists), executive administrative staff (e.g., chief medical or nursing officer), laboratory staff, administrative staff (e.g., medical records staff), facilities management (e.g., environmental services), and other specialty staff depending on the type of outbreak.
Inpatient Rehabilitation Facilities (IRFs)	CMS: A hospital or part of a hospital that provides an intensive rehabilitation program to inpatients.		Public health often interacts with the infection preventionist initially but may also interact with other staff members, similar to acute care hospitals.
Long-Term Acute Care Hospitals (LTACHs)	CMS: Acute care hospitals that provide treatment for patients who stay, on average, more than 25 days. Most patients are transferred from an intensive or a critical care unit. Services provided include comprehensive rehabilitation, respiratory therapy, head trauma treatment, and pain management.		Public health often interacts with the infection preventionist initially but may also interact with other staff members, similar to other acute care hospitals.

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SETTING	NATIONAL QUALITY FORUM (NQF) AND CENTERS FOR MEDICARE AND MEDICAID SERVICES (CMS) DEFINITIONS ^{6,7,8}	ADDITIONAL CHARACTERISTICS	KEY STAFF CONTACTS
Nursing Homes (NHs)/ Skilled Nursing Facilities (SNFs)	<p>NQF: Setting in which healthcare services are provided under medical supervision and continuous nursing care for patients who do not require the degree of care and treatment that a hospital provides and who, because of their physical or mental condition, require continuous nursing care and services above the level of room and board.</p> <p>CMS: A nursing facility with the staff and equipment to provide skilled nursing care and, in most cases, skilled rehabilitative services and other related health services.</p>	Although there are technical differences between the terms “nursing home” and “skilled nursing facility,” these terms are sometimes used interchangeably. Some skilled nursing facilities can provide additional highly specialized skilled care, such as ventilator or central line care. Skilled nursing facilities that provide ventilator care are sometimes referred to as vSNFs.	Public health typically interacts with the infection preventionist or a staff member who fulfills some duties of an infection preventionist. Public health may also interact with nursing home facilities management (e.g., environmental services), administrators, nursing managers, and other specialty staff, depending on the type of outbreak.
Residential Care Facilities	<p>Not applicable.</p> <p>While some healthcare services may be delivered on-site, residential care facilities are typically licensed under a social services model.</p>	Residential care is an umbrella term that encompasses board and care homes, assisted living facilities (ALFs), and continuing care retirement communities. Medical care delivery in ALFs is highly variable and entails models that include on-site staffing, home health agencies, and individual resident arrangements with community-based clinics and providers. Group homes are another example in the residential care spectrum, where persons, many with chronic medical needs, live in a congregate setting.	Depends on facility type, but public health typically interacts with the facility manager.

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Outpatient Clinics		Outpatient clinics (such as a medical practice) are not typically licensed as a facility. A rural health clinic is a type of outpatient clinic that is licensed through CMS and/or state regulatory bodies.	Often public health interacts with an office manager or clinical staff.
Dental Settings		Dental settings encompass outpatient locations where oral and dental care is provided. Typically, dental settings are not licensed, but the providers are licensed through the appropriate state agency.	Public health most often interacts with an office manager or clinical staff.

2.1.2 Healthcare Delivery

Healthcare delivery has changed dramatically in recent decades. Hospital stays have decreased,⁹ and healthcare is moving more toward outpatient settings. Between 2000 and 2016, the number of traditional institutional providers, such as hospitals and skilled nursing facilities, decreased or remained flat despite a growing and aging US population. Meanwhile, there was substantial growth and increased specialization among outpatient providers and certain forms of residential care such as assisted living facilities.¹⁰

Many types of surgeries have shifted from inpatient settings to ambulatory surgery centers, hospital outpatient departments, or office-based surgical practices.¹¹ Also, as healthcare improves and people needing critical care live

longer, the number of long-term acute care facilities and skilled nursing facilities specifically offering ventilator care services has grown. Additionally, cost and access issues have led some patients to seek care outside the US (e.g., medical tourism); care provided in these settings may result in exposures to pathogens not commonly found in patients' local communities.¹²

The changing healthcare delivery landscape requires public health agencies to be nimble when responding to outbreaks; each healthcare setting has unique characteristics, and its patient population carries unique risks that can result in a wide variety of outbreaks. Infection prevention needs for healthcare settings have similarly changed over time, and infection prevention resources available for healthcare facilities can vary widely.^{13,14}



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2.1.3 Regulation and Oversight

With growth and changes in healthcare delivery, regulations related to the prevention of healthcare-related infections have also expanded. Federal agencies, such as the Centers for Medicare and Medicaid Services (CMS), Food and Drug Administration (FDA), and Occupational Safety and Health Administration (OSHA), play significant roles from a regulatory point of view. Other agencies, such as the Centers for Disease Control and Prevention (CDC), generate recommendations and standards that heavily influence healthcare regulation. Of note, core infection control practices are established by CDC's Healthcare Infection Control Practices Advisory Committee (HICPAC) and can be found on the following web page: <https://www.cdc.gov/infection-control/hcp/core-practices/index.html>.

State-level agencies license many types of healthcare facilities and take an active role in enforcement. Accrediting organizations provide participating healthcare facilities with a structure for achieving regulatory requirements and other quality standards. Although regulations and requirements for infection prevention are established for some healthcare settings, not all settings have clear requirements or active oversight. Likewise, some facilities that are generally subject to federal and state regulations may lack clear standards governing the organization or staffing of their infection prevention and control programs, and some facilities with clear standards may still be working toward meeting newly established requirements (e.g., CMS implemented requirements for infection prevention and antibiotic stewardship in nursing homes in November 2016 with a rolling 3-year set of requirements¹⁵). Regulations affecting infection prevention, HAIs, antimicrobial resistance, and antimicrobial stewardship can be found on the following web page: <https://apic.org/policy-priorities/regulations/>.

Increasing calls for transparency and expansion of reporting requirements and regulatory oversight have resulted in additional resources being directed toward HAI detection and prevention in healthcare facilities and public health agencies. For example, HAI rates by specific hospital and nursing home are now publicly available

and can be found on the following web pages: <https://www.medicare.gov/hospitalcompare/> and <https://www.medicare.gov/nursinghomecompare/>, respectively.

2.2 Trends in Surveillance

2.2.1 Overview

In 1963, Alexander Langmuir defined disease surveillance as “the continued watchfulness over the distribution and trends of incidence through the systematic collection, consolidation and evaluation of morbidity and mortality reports and other relevant data”; dissemination of data should involve “all who need to know”.¹⁶

The World Health Organization (WHO) definition of public health surveillance is “the continuous and systematic collection, orderly consolidation and evaluation of pertinent data with prompt dissemination of results to those who need to know, particularly those who are in a position to take action.”¹⁷

Public health agencies, healthcare facilities, and many other partner organizations conduct disease surveillance for the purposes described by Langmuir and the WHO. Here we describe trends in HAI/AR surveillance for public health agencies and healthcare settings that have influenced outbreak detection and response.

2.2.1.1 Public Health Surveillance, Healthcare-Associated Infections, and Antimicrobial Resistance Program Development

Widespread public health surveillance of HAIs and healthcare-associated pathogens, including AR organisms, is a relatively new endeavor. Historically, healthcare facilities performed their own surveillance and responded to outbreaks within their walls. In recent years, public health has taken a greater interest in the surveillance of infections that occur within healthcare settings. Technologic advancements in medical care have introduced new types of infection-related healthcare risks.

Dramatic improvements in HAI/AR surveillance and outbreak response have been made within the last decade, including increased health experience and expertise.¹⁸ In addition, state public health reporting laws



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have expanded to include additional HAI/AR reportable conditions over the last decade.

Support for state and local public health HAI and AR pathogen activities grew substantially beginning in 2009. Funds from the American Recovery and Reinvestment Act were used to establish HAI programs as part of CDC's Epidemiology and Laboratory Capacity for Prevention and Control of Emerging Infections Diseases Cooperative Agreement (ELC). This initial funding, which also established HAI surveillance activities as part of CDC's Emerging Infections Program (EIP), resulted in a foundation for health departments to support and coordinate efforts with healthcare partners, engage in HAI prevention efforts, and expand HAI surveillance (as described in the following section).

Greater levels of funding for HAI/AR program activities have been added to ELC in recent years. For example, approximately \$85 million for healthcare Infection Control Assessment and Response (ICAR) was added as part of the Domestic Ebola Supplement in 2015¹⁸ and further investments were made because of the AR Solutions Initiative beginning in 2016. During the SARS-CoV-2 pandemic, HAI/AR programs received several substantial funding supplements, further enhancing their capacities for surveillance, prevention, and outbreak response.

2.2.1.1.1 Reportable and Notifiable Diseases and Conditions

State, territorial, tribal, and local public health agencies establish lists of diseases and conditions for public health surveillance that are reportable by healthcare providers, healthcare facilities, and/or laboratories, including HAI and AR pathogens. Reporting is mandatory, involves use of personal identifiers, and enables states to identify cases in which immediate disease control and prevention are needed.

Each state has its own laws and regulations defining what diseases and conditions are reportable. Reporting criteria include how to report, to whom to report, and the time frame within which reporting should occur. Reports may be pathogen-specific or based on infection type or other criteria. Most public health agencies also include a broad requirement for reporting suspected outbreaks (which

covers all pathogens and is not limited to those pathogens already required to be reported as individual cases).

Reporting to public health agencies ideally takes place via a web-based reporting system and/or automatic generation from electronic medical records or laboratory information systems. Systems that rely on phone calls, mail, or fax are still used in some circumstances (e.g., a phone call may be required for urgently reporting a condition in redundancy with web-based or electronic reporting) but can be slower and more labor-intensive. Isolates or clinical material are often required to be submitted in conjunction with the report; required samples are sent to public health laboratories for storage and/or additional testing.

Lists of reportable diseases and conditions vary among states and over time; public health agencies typically evaluate these lists periodically for needed changes to be responsive to emerging pathogens and shifting priorities. Note that reporting requirements by state can be found on the following web page: www.cste.org/group/SRCAQueryRes.

Public health agencies share de-identified data with CDC based on the nationally notifiable disease list found on the following web page: <https://ndc.services.cdc.gov/>. Data are reported voluntarily via CDC's National Notifiable Diseases Surveillance System (NNDSS). Lists of notifiable diseases vary among states and over time. The list of national notifiable diseases is reviewed and modified annually by the Council of State and Territorial Epidemiologists (CSTE) and CDC. Every national notifiable disease is not necessarily reportable in every state. In addition, not every state's designated reportable disease or condition is nationally notifiable. While NNDSS has limited utility for healthcare outbreak detection, it generally supports monitoring of trends and developing public health policies and prevention strategies for select conditions and diseases.

Most HAI conditions and some pathogen-specific data are reported separately from the NNDSS into a long-standing CDC-developed surveillance system, the National Healthcare Safety Network (NHSN). Reporting requirements and definitions for the NHSN have been



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established by CMS and CDC, respectively. Additional state requirements vary among states; some states require reporting and others do not. Definitions for reportable conditions may differ from those of the NHSN. See section 2.2.2.2 for more information regarding NHSN.

2.2.1.2 Surveillance within Healthcare Facilities

Many healthcare facilities perform their own facility-specific surveillance in addition to performing surveillance activities to meet reporting requirements (e.g., CMS requirements for NHSN reporting¹⁹). How surveillance is performed within a facility varies widely. In hospitals this is typically performed by infection preventionists or infection prevention teams, whereas in other types of facilities surveillance may be performed by healthcare personnel with multiple duties.

In recent years, many healthcare facilities have moved toward using data mining within electronic health records to identify conditions of interest to infection prevention. Modules within electronic health record systems designed to monitor possible infections are available; these can show useful aggregate information on dashboards, save time, and assist with flagging infections for staff to review. However, these systems are not always feasible for all healthcare systems and facility types, and in some situations manual reviews may be more effective or necessary. Some healthcare facilities rely heavily on notification of outbreaks by clinicians.

Public health agencies should be aware of surveillance systems used within healthcare facilities in their jurisdiction, including barriers that facilities may experience in implementing surveillance systems as well as the systems' various limitations. As public health surveillance has improved, the burden on healthcare facilities for reporting to public health has increased. It is critical that infection prevention programs have adequate resources to complete necessary infection prevention tasks, including surveillance, outbreak detection and response, and active prevention of infections.

2.2.2 Public Health Systems

Public health surveillance systems rely on surveillance case definitions to identify cases systematically and

consistently. Surveillance case definitions may differ from case definitions developed during an outbreak, which can be more specific for the purposes of counting outbreak cases. (Outbreak case definitions are described in Chapter 5.) A surveillance case definition is a set of uniform criteria used to define a disease for public health surveillance; it enables public health officials to classify and count cases consistently across reporting jurisdictions. Surveillance case definitions are not intended to be used by healthcare providers for making a clinical diagnosis or determining how to meet an individual patient's health needs.²⁰

Reporting of conditions associated with healthcare settings can be population-based or facility-based. Reporting of HAIs is usually facility-based; reporting of AR pathogens may be population- or facility-based. Other surveillance systems not described here may be used in limited jurisdictions. Employees involved with HAI/AR programs should understand the capabilities and limitations of surveillance systems used within their agency and explore ways to partner or capitalize on opportunities to use other surveillance and monitoring systems.

2.2.2.1 Population-Based Surveillance

Population-based surveillance involves identifying cases that meet a specific surveillance definition within a defined population. Typically, in public health the population under surveillance is the population of residents of a certain jurisdiction such as a state or county. Often in public health HAI/AR programs, population-based surveillance is often laboratory-based (e.g., presence of carbapenem-resistant Enterobacteriales [CRE] or *Clostridioides difficile*). Reporting of these conditions within a population is typically performed by clinical laboratories when the pathogen of interest is identified during testing of clinical specimens, either by submitting each individual case or lists of cases, often via electronic laboratory reporting. In some jurisdictions, providers and healthcare facilities may also report cases.

Routine public health surveillance of HAI/AR conditions is relatively new. With respect to foodborne surveillance, AR surveillance has been in place since 1996, following the establishment of the National Antimicrobial Resistance Monitoring System for Enteric Bacteria (NARMS), which



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tracks changes in the antimicrobial susceptibility of selected enteric bacteria found in ill people (CDC), retail meats (FDA), and food animals (US Department of Agriculture [USDA]) in the US.²¹ Tracking of healthcare-related AR pathogens was established much more recently.

Pathogen-specific surveillance may be performed as facility-specific surveillance (i.e., reported only by specific healthcare facility types, as described in the next section) or at a population level. Increasing the capacity of public health laboratories to receive isolates and clinical material, and to perform additional specialized testing (e.g., polymerase chain reaction [PCR] to identify mechanisms of resistance or whole genome sequencing) has allowed public health agencies to focus surveillance and prevention efforts on specific subsets of AR organisms such as carbapenemase-producing (CP)-CRE.

In 2016, CDC established the Antibiotic Resistance Laboratory Network (AR Lab Network), which includes laboratories in 50 states, four cities, and Puerto Rico, including seven regional labs and the National Tuberculosis Molecular Surveillance Center. The AR Lab Network is integrated with ELC-supported HAI/AR Program activities and supports a nationwide lab capacity to rapidly detect antimicrobial resistance.²²

With increases in funding, as described above, state and local public health agencies have drastically increased their capacities to perform pathogen-specific surveillance of AR pathogens and other organisms associated with healthcare, such as carbapenem-resistant organisms (CRE, carbapenem-resistant *Pseudomonas aeruginosa* [CRPA], and *Acinetobacter baumannii* [CRAB]), methicillin-resistant *Staphylococcus aureus* (MRSA), *Candida auris*, and *Clostridioides difficile*.

Surveillance of other organisms that are of interest to HAI/AR programs but do not fall into the category of AR organisms are often tracked using population-based surveillance practices (e.g., using NNDSS). Such organisms may include nontuberculous mycobacteria (NTM), *Legionella* spp., hepatitis B and C viruses, and group A *Streptococcus*. These organisms often lie within the purview of HAI/AR programs when they intersect with healthcare (i.e., manifest as HAIs). As a result, HAI/

AR programs may coordinate with other public health communicable disease programs for surveillance and outbreak response within healthcare facilities. Note that these surveillance activities may identify cases or outbreaks in need of investigation in settings other than healthcare, such as nail salons, tattoo parlors, and other community sites.

2.2.2.2 Healthcare Facility–Based Surveillance

For some conditions, surveillance occurs at the healthcare facility level rather than the population level. HAIs are typically reported using healthcare facility–based surveillance practices, which means that individual healthcare facilities will report conditions specific to their facility. Pathogens may be reported using healthcare facility–based surveillance or population-based surveillance, as described above. The system most often used for reporting healthcare facility–based surveillance is the CDC-developed NHSN.

In 1970, CDC launched the National Nosocomial Infections Surveillance System (NNIS), a collaborative surveillance system connecting CDC and hospitals that voluntarily reported “nosocomial” infections (now termed HAIs) into the system.²³ In 2005, NHSN was established, combining NNIS with the Dialysis Surveillance Network and the National Surveillance System for Healthcare Workers (NaSH).²⁴ NHSN facilities report HAI surveillance data for aggregation into a single national database.

NHSN now encompasses data from tens of thousands of medical facilities including acute care hospitals, long-term acute care hospitals, outpatient dialysis centers, ambulatory surgery centers, and nursing homes. Infections can be risk-stratified based on facility type, including specific hospital types such as pediatric, cancer, teaching, or others. Facilities report HAIs based on state mandates, CMS requirements, or voluntarily, and usually use NHSN for reporting; 34 states and the District of Columbia, as well as CMS, mandate reporting to NHSN.^{19,25} See Box 2.1 for conditions that can be reported to NHSN.

Some jurisdictions may choose to implement both healthcare facility–based and population-based surveillance for some conditions; for example, acute care hospitals

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may be required to report CRE via NHSN and clinical laboratories may report all cases of CRE throughout a jurisdiction on a population level. Population-based surveillance will capture all cases; facility-based surveillance will capture only cases within that facility type and will miss community cases. However, the benefit of facility-based surveillance is that analyses can focus on a particular facility type or a specific facility, allowing for the development of more directed infection prevention efforts. Both surveillance methods have their advantages, and use of both methods can provide a clearer picture of the HAIs and pathogens associated with healthcare within a jurisdiction and facility.

State and local health departments can access NHSN data based on local authority for regional, state, and local surveillance purposes, including identifying facilities in need of prevention assistance. Information on NHSN can be found on the following web page: <https://www.cdc.gov/nhsn/>.

NHSN data are used for national-, state-, and local-level analyses, as well as for targeted prevention initiatives by healthcare facilities, states, regions, quality groups, and national public health agencies.^{26,27} Nationally, CDC has used NHSN-reported HAIs to develop the AR dataset of the Patient Safety Atlas, which allows the user to quickly customize maps and tables by filtering datasets to show AR data by geographic area, facility type, phenotype, HAI type, and time period.²⁸ Position statements from CSTE established *C. auris* and carbapenemase-producing carbapenem-resistant Enterobacterales (CP-CR: *Escherichia coli*, *Klebsiella* spp., and *Enterobacter* spp.) as nationally notifiable conditions in 2017 and 2018, respectively; CSTE position statements can be found on the following web page: <https://www.cste.org/page/PositionStatements>.

Box 2.1 | Reporting to the National Healthcare Safety Network (NHSN): Conditions and Healthcare Settings

Examples of conditions that can be reported to NHSN

Healthcare-associated infections

- Central line–associated bloodstream infections
- Surgical site infections
- Catheter-associated urinary tract infections
- Ventilator-associated events
- Dialysis events
(e.g., bloodstream infection, antibiotic starts)

Pathogens

- *Clostridioides difficile*
- Carbapenem-resistant Enterobacterales
- Methicillin-resistant *Staphylococcus aureus* (bloodstream infections)
- SARS-CoV-2

Antimicrobial use and resistance

Blood safety errors

Healthcare process measures

- Healthcare personnel influenza vaccine status

Infection control adherence rate

Healthcare settings that can submit reports to NHSN

Acute care hospitals

Critical access hospitals

Inpatient rehabilitation facilities

Long-term acute care hospitals

Nursing homes

Outpatient dialysis facilities

Ambulatory surgery centers

Inpatient psychiatric facilities



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2.2.2.3 Other Surveillance Systems and Forms of Surveillance

Although the two main types of surveillance systems for HAI and healthcare-associated pathogen reporting are population-based and healthcare facility–based, there are other systems that can support monitoring and outbreak detection. Each system or form of surveillance has advantages and limitations, may be employed in some jurisdictions but not others, and is not a replacement for population-based and healthcare facility–based surveillance systems.

2.2.2.3.1 Emerging Infections Program: Healthcare-Associated Infections Community Interface

The Healthcare-Associated Infections Community Interface (HAIC) component of CDC’s Emerging Infections Program (EIP) engages a network of 10 state health departments and their academic medical center partners to help answer critical questions about emerging HAI threats, advanced infection tracking methods, and antibiotic resistance in the US. Data gathered through the HAIC play a key role in better understanding the epidemiology of targeted HAIs and pathogens.

HAIC differs from NHSN in that it tracks infections both inside and outside healthcare settings; typically, case ascertainment utilizes data from a variety of laboratories serving the population within surveillance catchment areas. Activities include surveillance of invasive *Staphylococcus aureus* infections, AR Gram-negative organisms (Multi-Site Gram-Negative Surveillance Initiative [MuGSI]), *Candida* bloodstream infections, and *C. difficile*, as well as HAI and antibiotic use prevalence surveys across healthcare settings. For more information on HAIC activities within the EIP, please visit the following web page: www.cdc.gov/hai/eip/index.html.

2.2.2.3.2 Antibiotic Resistance Laboratory Network (AR Lab Network)

As described previously, lab capacity in both clinical and public health laboratories is critical for the detection of AR organisms. The AR Lab Network includes public health laboratories in all 50 states, several cities, and Puerto Rico, as well as seven more comprehensive regional laboratories and the National Tuberculosis Molecular Surveillance Center.

This network infrastructure provides the capacity to detect emerging AR threats, respond at state and local levels to slow transmission, and increase understanding of AR trends and emerging threats.²¹ Regional laboratories provide additional testing when state or local laboratories have limited capacity. At the time of this writing, this includes advanced testing for *Acinetobacter*, *Candida*, *C. difficile*, CRE, colistin resistance among extended-spectrum beta-lactamase (ESBL)–producing organisms, *Mycobacterium tuberculosis*, *Neisseria gonorrhoeae*, *Aspergillus fumigatus*, and *Streptococcus pneumoniae*.

The AR Lab Network assists each local jurisdiction with AR surveillance, and the network functions as a surveillance entity with the ability to provide information on several important pathogens. Regional laboratories that detect organisms and mechanisms of public health interest alert laboratories and epidemiologists who can implement public health actions to address transmission. More information on the AR Lab Network can be found on the following web page: <https://www.cdc.gov/drugresistance/solutions-initiative/ar-lab-network.html>.

2.2.2.3.3 Sentinel Surveillance

Sentinel surveillance is a form of surveillance that occurs among a group of healthcare facilities or settings (or other reporting entities) that have been selected to report cases of a specific disease. This contrasts with population-based surveillance, in which data are collected across an entire population. In sentinel surveillance, reporting occurs from only a carefully selected group of healthcare facilities. It is typically used when population-based surveillance is not feasible or practical.

Healthcare facilities selected for this purpose should have a high probability of encountering cases of the disease under surveillance as well as the clinical expertise and laboratory capability needed to detect the disease. Data collected can be used to monitor trends and disease burden, and, if the facilities selected are most likely to encounter the disease, can also be used to detect emerging diseases. Emerging diseases can be missed if they occur outside the sentinel system.²⁹ Sentinel surveillance has been used for AR pathogens in limited circumstances, such as AR pneumococcal disease,³⁰ and has the potential to be applied in other situations as well.





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2.2.2.3.4 Syndromic Surveillance

Syndromic surveillance is a form of surveillance that was developed in the context of a need for early detection of a large-scale release of a biologic agent. It has also found application in situations of seasonal respiratory illnesses such as influenza. Increasingly, syndromic surveillance has been used for a variety of other surveillance activities—often short-term event-based surveillance, although it is also used for sustained surveillance activities.³¹

Syndromic surveillance definitions rely on a constellation of symptoms (hence the modifier “syndromic”) for reporting. For this reason, syndromic surveillance is often a sensitive but not specific surveillance system. Since HAI/AR surveillance relies heavily on a laboratory component, syndromic surveillance is not often used in HAI or AR pathogen surveillance. Jurisdictions that perform syndromic surveillance can consider how such systems may complement or enhance their standard approaches to healthcare-related outbreak detection.

2.2.2.3.5 Regulatory Monitoring Systems

Public health communicable disease staff should consider collaborating with regulatory partners to understand their unique surveillance systems and reporting requirements. Regulatory partners, including state licensing agencies and CMS and FDA at the federal level, typically have systems in place to receive reports of adverse events; information gathered through these systems can help identify risks for communicable diseases in healthcare settings. For example, agencies and professional boards that receive reports of drug diversion events record these events in systems that ideally could be used by public health communicable disease staff to identify situations needing investigation to assess patient infection risks. Starting in 2014, CMS issued expanded guidance requiring accrediting organizations and state survey agencies to report serious infection control breaches to state health departments.³² In addition, FDA monitors medical product safety, operating a variety of post-marketing surveillance and adverse event reporting programs, many of which help support outbreak detection and response (as described in subsequent chapters).

2.2.2.3.6 Administrative Databases

Some jurisdictions have access to administrative databases, such as hospital discharge databases, which can be used for surveillance purposes including case finding. These types of databases may be used to supplement other surveillance systems, such as comparisons with population-based or facility-based systems, to ensure complete case finding.

2.2.3 Impact of Advances in Laboratory Methods on HAI/AR Surveillance

The progress of microbiological and molecular testing technology over recent decades has dramatically impacted HAI/AR surveillance. Advances in testing have led to increased detection of specific organisms of interest to public health as well as to implementation by healthcare facilities of specific infection control measures to prevent transmission. Over the years, the expansion and refinement of DNA-based molecular techniques such as pulsed-field gel electrophoresis (PFGE), PCR typing, and multilocus sequence typing (MLST) have been applied to the surveillance of healthcare-associated pathogens, enhancing the detection of cases as well as the detection and investigation of outbreaks.

The use of nucleic acid amplification testing (NAAT) to identify resistance mechanisms and resistant organisms has impacted public health activities. Surveillance of carbapenem-resistant organisms relies on the detection of carbapenemases to identify cases of the highest public health import; with the advent of the AR Lab Network, the capacity to detect CP-CRE has expanded. In some jurisdictions, carbapenemase-producing organisms that rely on advanced laboratory testing for detection may be the only reportable carbapenem-resistant organisms.

Screening of patients for AR organisms as part of antibiotic resistance prevention efforts also relies on NAAT. Whole genome sequencing and related technological advances (referred to collectively as next generation sequencing [NGS]) can detect differences between organisms down to a single nucleotide. The application of NGS to timely surveillance data can identify related organisms and outbreaks and, when coupled



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with epidemiologic data, pinpoint the spread of specific strains through healthcare and community settings. See Chapter 6 for more details.

Another area of laboratory advancement is the increasing use of culture-independent diagnostic testing (CIDT) in healthcare settings, often as part of a panel of tests. CIDT is performed directly on clinical material, leading to rapid and sensitive identification of organisms and mechanisms without generating an isolate. However, positive CIDT results (e.g., those for *Klebsiella pneumoniae* carbapenemase [KPC], MRSA, vancomycin-resistant *Enterococcus* [VRE], or *C. difficile*) may compromise efforts to perform additional identification, characterization, and typing for case linkage.

CDC laboratory protocols for the detection of antimicrobial-resistant and healthcare-associated pathogens can be found on the following web page: https://www.cdc.gov/hai/settings/lab/lab_settings.html.

2.2.4 Quality and Usefulness of Surveillance Data

2.2.4.1 Uses of Surveillance Data

HAI surveillance data help identify prevention priorities, including specific facilities that may need additional support to prevent infections, guide resource allocation, and be used to evaluate the effectiveness of prevention efforts over time. Surveillance data can be used to examine long-term patterns and trends for HAIs and AR organisms as well as to identify sudden changes in disease occurrence that may signal an outbreak that needs investigation. Public health and healthcare partners can act on surveillance data to rapidly respond to individual cases of high-consequence organisms, leading to immediate infection prevention interventions to prevent transmission. When additional epidemiologic information is collected on cases, data can be used to characterize groups at greatest risk for a disease, thus informing prevention efforts.

2.2.4.2 Completeness and Quality of Data

Although national, state, territorial, and local capacities for detection and surveillance of HAIs and AR organisms have improved throughout the past decades, surveillance

of every case is incomplete for a variety of reasons, including the following:

- Case definitions may not be 100% sensitive.
- Case definitions may not be applied uniformly or interpreted correctly.
- HAIs may not be identified post-discharge.
- HAIs identified post-discharge (regardless of whether they are identified by another facility or in the community) may not be reported.
- Patients and community residents may be colonized with an organism that is not detected, and therefore they are not recognized as case-patients.
- Not all types of pathogens can be diagnosed with routine laboratory testing.
- Laboratories and health-care providers may fail to report to a public health agency.

The scope of possible underreporting for population-based healthcare-associated pathogens is often unknown. Since the syndromes as well as the signs and symptoms of infections can be quite varied, even for a specific pathogen, and because asymptomatic colonization is often included in pathogen-based surveillance, it is challenging to determine what proportion of cases are missed. It can be helpful to validate complete reporting by conducting laboratory audits or requesting line lists of all cases periodically to compare with reported cases. Electronic laboratory reporting can also be used to help assess data quality and completeness.

HAIs reported to NHSN are validated in some jurisdictions to enhance data completeness and quality. Validation usually includes systematic identification of facilities and medical records for review, comparison to other data sources when available, and review of facility processes for reporting. CDC provides guidance to public health departments embarking on validation efforts, which is provided on the following web page: <https://www.cdc.gov/nhsn/validation/index.html>. Healthcare facilities can also perform their own validation efforts, and CDC guidance for facilities can also be found on this web page. Despite the resources and expertise required, correcting errors identified during validation (in particular, underreporting) can be critical for establishing and maintaining accurate HAI reporting.^{33,34}



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2.3 Trends in Outbreak Detection and Response

Improvements in HAI/AR surveillance and the expansion of public health HAI/AR programs have increased the detection of and capacity to respond to healthcare-related outbreaks. For example, \$85 million of increased funding to 55 state/local public health agencies, as part of domestic Ebola response activities in 2015, led to the expansion of state and local HAI/AR programs, including increased staffing for an outbreak response (96% of funded programs hired staff for this purpose), performance of on-site infection control assessments (83% of programs gained staff and expertise in this domain), development of investigative tools (78% of programs developed new tools), and increased outbreak-related laboratory capacity (91% of programs expanded the size of their laboratory space).¹⁸

As noted in section 2.2.3, healthcare outbreak detection and response have benefited from the increased capacity of public health and clinical laboratories to detect organisms of public health interest and provide laboratory testing which leverages advances in molecular testing methods. Healthcare outbreak detection and response have also benefitted from increased collaboration among public health, healthcare facilities, and partners, such as was necessary during the COVID-19 Public Health Emergency. As this field continues to evolve, collaboration between public health agencies and healthcare settings remains critical to the success of outbreak response.

Infection risks can vary widely across various healthcare facilities, reflecting the types of care the facilities deliver, differing patient characteristics, and pathogens most likely to be present in specific communities or settings. As described in section 2.1.1, healthcare settings range from acute care hospitals with broad variability among internal care locations (e.g., operating rooms, neonatal intensive care units, oncology wards, and burn units) to long-term care facilities as well as a diverse array of outpatient facilities covering everything from doctor's offices to ambulatory surgery centers.¹⁰

Outbreaks can be related to medical products, encompass multiple facilities and healthcare settings,

span healthcare and community settings, or result from drug diversion and other unique circumstances. A vast number of infectious agents have been implicated in HAI transmission scenarios; these include a constantly evolving list of bacteria, fungi, viruses, parasites, and prions. HAI outbreaks can be caused by pathogens that are common throughout the community or by pathogens that are rarely observed outside healthcare environments and specific patient populations.⁴

Health department tracking of healthcare outbreak response activities is relatively new and still evolving. One recent assessment found that ELC-funded state and local health departments reported conducting 6,665 response activities in calendar year 2016, with the majority (78%) of activities involving long-term care facilities.¹⁸ Much of this routine outbreak response pertained to the investigation and control of gastrointestinal and influenza-like illnesses in nursing homes. Superimposed on this baseline, we see a wide range of more complex and challenging healthcare outbreak response activities.³⁵⁻⁴⁰

2.3.1 Modes of Transmission

Classically, outbreaks have been characterized based on the mode of transmission and using terms such as “point-source” or “person-to-person.” Often the pathogen identified provides a clue to the most likely method of transmission. For example, a group A *Streptococcus* outbreak is more likely to be person-to-person, whereas an unusual pathogen identified as part of a cluster of bloodstream infections across multiple units in a hospital is more likely to be point source.

In healthcare-related outbreaks, person-to-person is often the most common mode of transmission and can occur directly from one patient to another patient, from a patient to a healthcare worker and vice versa (often resulting in patient-to-patient spread), or from one person to another person via contamination of the environment or shared equipment. Poor adherence to hand hygiene and environmental cleaning contribute to person-to-person spread within healthcare facilities.

Examples of point-source outbreaks include those caused by contaminated medical equipment or medical products, including situations in which contamination occurs at the



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point of manufacture, the point of distribution, or within the facility, and those caused by environmental point sources (such as *Legionella* contamination of a water feature).

The healthcare setting's physical environment is an important source for pathogen transmission that can result in infection or colonization among patients. The environment can be conducive to certain pathogen types (such as molds in water-damaged walls or ceilings), and human interactions with the environment can result in the transfer of pathogens between healthcare workers or patients and environmental surfaces.

In some cases, point-source and person-to-person transmissions can overlap—for example, when a healthcare worker with group A *Streptococcus* colonization spreads infection to patients during wound care or peripartum care or delivery. Likewise, a healthcare worker infected with a bloodborne pathogen (human immunodeficiency virus [HIV], hepatitis B, or hepatitis C) can spread the infection to patients when diverting medications (usually opioids) due to reuse or tampering with medications and injection equipment. A thorough epidemiologic investigation is needed to confirm a healthcare worker as a point source; this situation may need to be managed delicately, in close collaboration with the healthcare facility.

2.3.2 Outbreak Types Based on Etiology

Specific pathogen types, infection types, the involved body site, and relationships to procedures can all provide clues to investigators about possible modes of spread and sources of an outbreak. These clues can inform potential control measures that can be implemented even prior to completion of the investigation, as described in more detail in Chapter 5.

2.3.2.1 Outbreaks Based on Pathogen

Most HAI/AR outbreaks are identified based on a specific pathogen cluster. When an increase in a specific pathogen is identified, this can indicate the presence of an outbreak, and reporting and further investigation are usually warranted. One should suspect a possible outbreak when cases of a specific pathogen are clustered based on epidemiologic links between cases, such as when cases occur within the same medical unit, following the same procedure, or close in time.

When the pathogen is rare enough that it is unlikely to have caused multiple sporadic infections without a common source, an outbreak should also be considered. An outbreak may also be signaled by the presence of a single case when it involves a unique, unexpected pathogen. For example, in Colorado in 2012, investigation of a single case involving the first locally identified New Delhi metallo-beta-lactamase (NDM)–producing CRE revealed a much larger hospital outbreak.⁴¹

As laboratory techniques for assessing isolate relatedness have improved, outbreaks have been able to be identified based on specific pathogen characteristics, as illustrated in the previous paragraph. Whole genome sequencing has allowed for greater discrimination and more accuracy when confirming the relatedness of isolates of the same pathogen; this information can help confirm or refute the presence of an outbreak or determine if individual cases appear related to a larger outbreak. As NGS techniques become more available, they will likely play a larger role in the identification, investigation, and responses to outbreaks (See Chapter 6 for more details).

The regional and even global spread of specific pathogens forces public health and healthcare to consider outbreak responses not only on a local level but also on regional, national, and global scales. Understanding transmission of emerging pathogens provides context for local communities to determine outbreak investigation priorities. What is endemic in one region may be novel upon appearance in another region; public health agencies and healthcare facilities should understand their regional epidemiology as well as the wider epidemiology of emerging pathogens that could enter their region. For example, examination of clonal lineages of carbapenem-resistant *Klebsiella pneumoniae* in Europe identified four clonal lineages with high transmissibility within hospital environments and showed that spread among hospitals within a country was more frequent than between countries.⁴² Likewise, understanding the global spread of *Candida auris* provided context for the emergence of *C. auris* within the US, which informed recommendations and guidance for *C. auris* among US jurisdictions.⁴³



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2.3.2.2 Outbreaks Based on Infection Type

Outbreaks identified based on the type of infection, such as bloodstream infections or surgical site infections, when the pathogen is unknown or multiple pathogens are involved, are less common than outbreaks identified based on a specific pathogen. Although both etiology and infection type are clues to the reason for an outbreak, in some cases both clues may not be available. Examples of this type include outbreaks of an unknown respiratory infection or an undiagnosed gastrointestinal illness.

An outbreak based on infection type should be considered when the overall rates of specific infection types are higher than expected or when infection occurs within a defined patient population known to be susceptible to certain types of infections, such as patients receiving dialysis or patients undergoing a specific procedure. An example of this type of outbreak was identified in dialysis patients from three hemodialysis facilities during 2015–2016, when increases in bloodstream infections due to *Serratia marcescens* and *Pseudomonas aeruginosa* were noted. The cause was recorded as pooling and regurgitation of waste fluid at recessed wall boxes that housed connections for dialysate components and effluent drains located at dialysis treatment stations, along with infection control practices that allowed healthcare workers' hands to become contaminated at the wall boxes.⁴⁴

Another clue to identifying a mixed-pathogen outbreak can be the type of pathogen involved; in the example given, both pathogens frequently contaminate water and, therefore, investigation of possible water sources can help direct the course of the investigation.

2.3.2.3 Outbreaks Based on Other Etiologies

Noninfectious etiologies may also result in an outbreak within a healthcare setting and should be investigated with the same investigative steps described in the *CORHA Principles and Practices* for infectious disease outbreaks.

For example, toxic anterior segment syndrome (TASS) is an uncommon postoperative inflammatory reaction following eye surgeries involving the anterior segment, such as cataract extraction; the cause is a noninfectious

substance that enters the anterior segment of the eye causing inflammation and damage to intraocular tissues. Investigations of TASS outbreaks have resulted in the identification of poor infection control practices and endotoxin contamination of shared products as possible causes of some outbreaks.^{45,46}

Other examples of noninfectious outbreaks within healthcare settings include infant morbidity and mortality following intravenous administration of vitamin E,⁴⁷ aluminum toxicity following use of dialysis machines with electric pumps whose parts contain aluminum,⁴⁸ and carbon monoxide poisoning during surgery related to anesthesia circuits.⁴⁹

2.3.3 Outbreak Types Based on Setting

The specific healthcare or non-healthcare setting of the outbreak has a substantial impact on the investigation and response. Some healthcare settings are more prone to certain types of outbreaks than others. Additionally, the need for public health assistance among healthcare facilities and other settings can vary. For example, dialysis facilities are more likely to have bloodstream infection–related outbreaks than gastrointestinal outbreaks, due to the nature of the healthcare provided. The changing landscape of healthcare discussed earlier in this chapter impacts the trends of types of outbreaks that occur. Understanding these different settings when investigating HAI/AR outbreaks is crucial to understanding likely risk factors and etiologies.⁴ Examples of healthcare settings and types of outbreaks are shown in Table 2.2.

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Table 2.2 | Outbreak Examples Based on Healthcare Setting or Procedure Type*

SETTING OR PROCEDURE	EXPOSURE OR RISK FACTOR	PATHOGENS OR CONDITIONS	INVESTIGATION AND RESPONSE CONSIDERATIONS
General	Infected or colonized persons (healthcare personnel, patients, or visitors); contaminated environmental surfaces	Organisms spread by contact (e.g., <i>Staphylococcus aureus</i> , AR Gram-negative bacteria, <i>Clostridioides difficile</i> , and group A Streptococcus)	AR prevention strategies as per CDC guidance [†]
	Serious, high-risk infection control breaches	Bloodborne pathogens (HIV, hepatitis B, and hepatitis C)	Consideration of patient notification, including possible bloodborne pathogen testing and prophylaxis
	Contaminated water sources (e.g., sinks, ice machines, whirlpool bathtubs, and hydrotherapy locations), aqueous medication preparation areas, or any device that generates mist	Hydrophilic organisms (<i>Legionella</i> , <i>Pseudomonas</i> , <i>Acinetobacter</i> , <i>Serratia</i> , <i>Stenotrophomonas</i> , and nontuberculous mycobacteria)	Epidemiologic investigation and infection control assessment focusing on water sources
General/ injections	Contamination of medications at the point of production (manufacture or compounding)	Environmental organisms (Gram-negative bacteria and fungi)	Syndromes often reflect the mechanism of transmission (e.g., infections at an injection site)
	Contamination of medications at the point of delivery (healthcare facility)	Gram-negative bacteria, Gram-positive bacteria, fungi, and bloodborne pathogens (HIV, hepatitis B, and hepatitis C)	Assessment of injection safety practices
	Diversion of medications (narcotics and related medications) by healthcare personnel	Bloodborne pathogens (HIV, hepatitis B, and hepatitis C), environmental bacteria	Assessment of medication handling practices; epidemiologic investigation focusing on healthcare personnel
General/point-of-care (POC) testing involving capillary blood sampling	Reuse of single-patient lancing devices or contaminated monitoring devices	Bloodborne pathogens (HIV, hepatitis B, and hepatitis C)	Assessment of infection control practices focusing on blood glucose monitoring or other POC testing
General/ surgical procedures	Contamination of surgical wounds from the following sources: healthcare workers, environment, or inadequately sterilized instruments	Varied, includes environmental pathogens (Gram-negative bacteria, fungi, and mycobacteria), colonized healthcare workers (<i>Staphylococcus aureus</i> or group A <i>Streptococcus</i>), and antimicrobial-resistant pathogens	Assessment of infection control practices related to surgical procedure, sterilization, and perioperative practices

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Table 2.2 | Outbreak Examples Based on Healthcare Setting or Procedure Type*

SETTING OR PROCEDURE	EXPOSURE OR RISK FACTOR	PATHOGENS OR CONDITIONS	INVESTIGATION AND RESPONSE CONSIDERATIONS
General/ endoscopy	Endoscope reprocessing errors or device design problems that prevent adequate cleaning and disinfection	Gram-negative bacteria (particularly with duodenoscopes); upper- and lower-respiratory tract infections (e.g., bronchoscopes); and pseudo-outbreaks of nontuberculous mycobacteria	Infection control assessment focusing on endoscope use and reprocessing
Transplant units	Dust exposure or air-handling problems for severely immunocompromised patient populations (e.g., during building construction or renovation)	Fungi including <i>Aspergillus</i> and mucormycetes	Review of air handling systems and construction processes; typical scenario is invasive mold infections in a bone-marrow transplant unit
Hemodialysis clinics	Lapses in injection safety, maintenance of dialysis machines, or vascular access care	Bloodborne pathogens and bloodstream infections with varied bacterial or other pathogens	Review all dialysis infection control processes
Dental clinics	Biofilm formation in inadequately maintained dental unit waterlines; inadequate cleaning and sterilization of dental surgical instruments	Nontuberculous mycobacteria infections; bloodborne pathogens	Review of dental clinic infection control processes, water sources, and sterilization practices
Laboratory	Specimen collection, handling, or testing-related activities that may put laboratory workers at risk	Brucellosis, tularemia, coccidioidomycosis, and bloodborne pathogens (HIV, hepatitis B, and hepatitis C)	Evaluation of unintentional laboratory staff and other healthcare personnel exposures to bloodborne pathogens through needlesticks and splashes to mucous membranes; evaluation of specimen handling practices
Laboratory	Contamination of microbiological specimens during collection, handling, or culture	Pathogens vary	Pseudo-outbreaks resulting in inappropriate invasive diagnostic procedures, antibiotic prescriptions, or extended hospitalizations

*Adapted from Christensen BE, Fagan RP. Healthcare settings. In: Rasmussen SA, Goodman RA, eds. *The CDC Field Epidemiology Manual*.⁴

†See <https://www.cdc.gov/healthcare-associated-infections/php/preventing-mdros/index.html>



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2.3.3.1 Single-Facility Outbreaks

Most healthcare outbreaks involve a single facility. This type of outbreak is easier to identify than a multifacility outbreak. Single-facility outbreaks may stem from infection control lapses that facilitate person-to-person transmission or contamination of shared equipment and supplies that function as point sources; environmental reservoirs can also play a role. In a review of outbreak investigations occurring in outpatient settings in Los Angeles County, it was found that 16 (57%) of 28 outbreaks were suspected to be due to lapses in infection control.⁵⁰ In an example of a point-source outbreak related to lapses in infection control, contamination of laundry with *Rhizopus microsporus* (a zygomycete) due to substandard washing, drying, and storage resulted in cases of pulmonary and cutaneous infections.⁵¹

2.3.3.2 Multifacility Outbreaks

Multifacility outbreaks can result from person-to-person transmission when patients are transferred between healthcare facilities or from a point source such as medical product contamination. Multifacility outbreaks can be challenging to identify unless there is timely and complete reporting to public health and recognition of the potential for patient sharing, common healthcare staff providing care across multiple facilities, or contamination of a medical product. This type of outbreak is typically identified when public health agencies receive similar outbreak reports from multiple facilities, when public health agencies identify an outbreak across facilities using surveillance or laboratory data, or when a healthcare facility performs its own outreach to other healthcare facilities.

2.3.3.2.1 Local Multifacility Outbreaks

Local multifacility outbreaks are more likely to be caused by person-to-person spread related to the transfer of patients between facilities within a jurisdiction. These types of outbreaks often result from the combination of infection control breaches and poor communication between transferring and receiving facilities. Less common scenarios may include local product contamination when a medical product is locally distributed, such as with a local compounding pharmacy; drug diversion by a healthcare worker who works at

multiple facilities; or medical equipment contaminated locally and shared across multiple facilities.

2.3.3.2.2 Widespread Multifacility Outbreaks

In some situations, multifacility outbreaks can spread across multiple jurisdictions, states, or countries. This may occur when a pathogen is transmitted across multiple facilities, often related to patients being transferred between facilities that have poor infection control practices and no facility-to-facility communication; when an outbreak source moves across jurisdictions, such as the case of a healthcare worker infected with hepatitis C virus (HCV), who abused narcotic drugs intended for patients and transmitted HCV to patients across multiple healthcare facilities and states⁵²; or when a contaminated medical product is distributed to facilities across a wide region.

As laboratory techniques, public health agency–healthcare facility relationships, and HAI/AR surveillance have improved over recent decades, the chance of finding an outbreak from product contamination has similarly improved. Reports of large-scale, high-profile outbreaks due to product contamination have increased in recent years, including outbreaks of fungal meningitis resulting in severe morbidity and mortality⁵³ and fungal endophthalmitis⁵⁴ leading to severe vision complications, both associated with widespread distribution of compounded medications, and an outbreak of invasive *Mycobacterium chimaera* associated with contaminated heater-cooler devices following cardiac surgeries.^{55,56}

2.3.3.3 Healthcare Facilities as Sentinels for Community Outbreaks

A healthcare facility, such as an acute care hospital, may identify a suspected outbreak in which the source lies outside the facility. Broadly speaking, healthcare facilities can serve as sentinel sites for detecting outbreaks occurring in the larger community. For example, an emergency room or urgent care center may detect multiple cases of gastrointestinal illness associated with a community setting (e.g., at a school or restaurant) or an event. A healthcare facility may detect an outbreak in an assisted living residence or independent living center that has limited capacity to recognize an outbreak on its



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own. A hospital may detect an outbreak associated with outpatient care, such as multiple infections following a procedure performed in a clinic setting. Healthcare facilities may also experience or be affected by outbreaks (e.g., hepatitis A or measles) that reflect unique circumstances in the communities they serve.

2.3.3.4 Outbreaks Related to Medical Tourism

The term “medical tourism” is commonly used to describe international travel for the purpose of receiving medical care.¹² Outbreaks related to medical tourism have been identified following reports from healthcare settings where patients have been evaluated and treated upon their return to the US. Detection of outbreaks related to medical tourism is challenging. This type of outbreak typically manifests with sporadic cases appearing across multiple states. Reporting such cases to CDC (email: medicaltourism@cdc.gov) can help facilitate outbreak recognition.¹²

An example of an outbreak associated with medical tourism involved Verona integron–encoded metallo-beta-lactamase (VIM)–producing carbapenem-resistant *Pseudomonas aeruginosa* infections; 11 cases of this infection were identified in medical tourists who traveled to a hospital in Mexico for bariatric surgery and subsequently presented for care in multiple facilities throughout the US.⁵⁷ Other examples include surgical site infections caused by nontuberculous mycobacteria in patients who underwent cosmetic surgery in the Dominican Republic and Q fever in patients who received fetal sheep cell injections in Germany.¹²

2.3.4 Investigation of Serious Infection Control Breaches

Conditions or practices that may lead to transmission of a pathogen are sometimes identified in the absence of identified infections. Following some types of infection control breaches, patients may develop an infection that could have long-term consequences but may not be immediately apparent. A prime example is the reuse of a syringe for multiple patients, which carries the risk for transmission of bloodborne pathogens with long incubations and symptoms that can be subtle, variable, or altogether absent.

Serious infection control breaches can be identified from internal audits and observations or from survey activities conducted by state survey agencies or accrediting organizations. CMS introduced a policy in 2014 that indicates that surveyors who identify serious infection control deficiencies should relay their concerns to public health agencies for evaluation, including considerations about the need for patient notification.³² Investigations of infection control breaches should involve taking action to halt further exposures and correct deficient practices, as well as consideration of patient notification. See Supplement B for additional information.

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URLs in this document are valid as of April 29, 2024.

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