

WATERBORNE

Disease Outbreak Investigation Toolkit



**U.S. Department of
Health and Human Services**
Centers for Disease
Control and Prevention



Contents

About Waterborne Disease Outbreaks	1
Water Systems	2
Drinking Water Systems	2
Figure 1: Drinking water system.	2
Recreational Water Systems	4
Other Water Systems	6
Preparation for a Waterborne Disease Outbreak Investigation	7
1. Organization	7
2. Partners	7
3. Training and Resources	8
4. Communication	9
Internal Communication	9
Communications with Partners	9
Public Communication	9
Communication Plan	9
Media Relations	10
Press Releases, Social Media, and Internal Talking Points	10
Waterborne Disease Outbreak Investigation Response	11
1. Detect a Possible Outbreak	11
Collecting Data to Detect Outbreaks	11
<i>Epidemiologic Data</i>	11
<i>Clinical/Laboratory Data</i>	12
<i>Environmental Monitoring Programs</i>	12
<i>Other Data Sources</i>	12
Investigation Tools	12
2. Define and Find Cases	13
Developing a Case Definition	13
Find Additional Cases	14
3. Generate Hypotheses	14
4. Test Hypotheses using Epidemiologic and Environmental Investigation	15
Epidemiologic Investigation	15
Environmental Investigation	15
5. Identify Source of Outbreak	15
Epidemiologic Investigation	16
Environmental Investigation	16
6. Control Outbreak Through Remediation and Outreach	16
Table 1 – Three primary public health strategies to control waterborne disease outbreaks	17
Figure 2: The cycle of the three primary public health strategies to control waterborne disease outbreaks.	17
7. Decide Outbreak is Over	18
8. Prevent Future Outbreaks Through Summarizing, Interpreting, and Reporting Findings	18
Reporting outbreaks	18
Learning from Outbreaks	18
Prevention and Education Materials	19
Appendices	20
Interpretation of an Epidemic Curve	20
Figure 3: Example of an epidemic (epi) curve from an outbreak investigation of cryptosporidiosis in Milwaukee, 1993.	20
Confirming Diagnosis	21





Overview

The purpose of this toolkit is to assist state and local health departments in conducting waterborne disease outbreak investigations.

Disease outbreaks that involve transmission through water can present unique challenges due to the numerous ways that individuals interact with water. To address these unique challenges, this toolkit describes similarities among many types of waterborne disease outbreak investigations based on best practices and experiences of epidemiologists at state and local health departments. This toolkit lays out a framework for a waterborne disease investigation and consolidates resources that may be useful to direct investigation activities.

Additional sections are available for specific situations that may require additional techniques, resources, or investigation activities.

About Waterborne Disease Outbreaks

Waterborne Disease & Outbreak Surveillance Reporting

- Water contaminated with pathogens, chemicals, or toxins can lead to waterborne illness if you ingest it, inhale aerosols or gases from it, or it contacts your skin, eyes, ears, or other mucous membranes.
- A waterborne disease outbreak is defined as two¹ or more people that are linked epidemiologically by time, location of exposure to water, and type of illness.
 - ▷ Epidemiologic evidence implicates water as the probable source of illness.
 - ▷ Environmental evidence can be important for implicating water as the source of infection (for example, water samples testing positive for pathogens).
- Once a waterborne disease outbreak is detected, public health and regulatory officials work to collect data to identify a source of contamination and take action to prevent additional illnesses. Timely detection, response, and control of waterborne disease outbreaks is crucial for protecting public health.
 - ▷ Outbreak investigations can provide important data that may highlight safety gaps in water systems or identify strategies to reduce waterborne illness. The CDC is available to assist local, state, territorial, and tribal health departments and other countries' ministries of health with investigating and controlling outbreaks.
- Depending on the type of exposure and contaminant, waterborne pathogens can cause a variety of health problems, including gastrointestinal, respiratory, dermatological, and neurological illnesses.

[Emergencies related to water](#) (e.g., floods, droughts) can cause community-wide disruption and illness.
Visit [this page](#) for more information on resources for the field before and after a WASH-related emergency.

¹Case definitions vary between different pathogens or different contaminants. In some cases investigating an outbreak only requires 1 case

Water Systems

Understanding the fundamental properties, treatment processes, and regulations for water systems can help public health departments effectively detect, investigate, and control waterborne disease outbreaks. Most outbreaks follow a general pattern of detection, investigation, and control but each outbreak can be unique and present its own challenges. The following descriptions of selected water systems contain information that may assist in outbreaks with unique conditions.

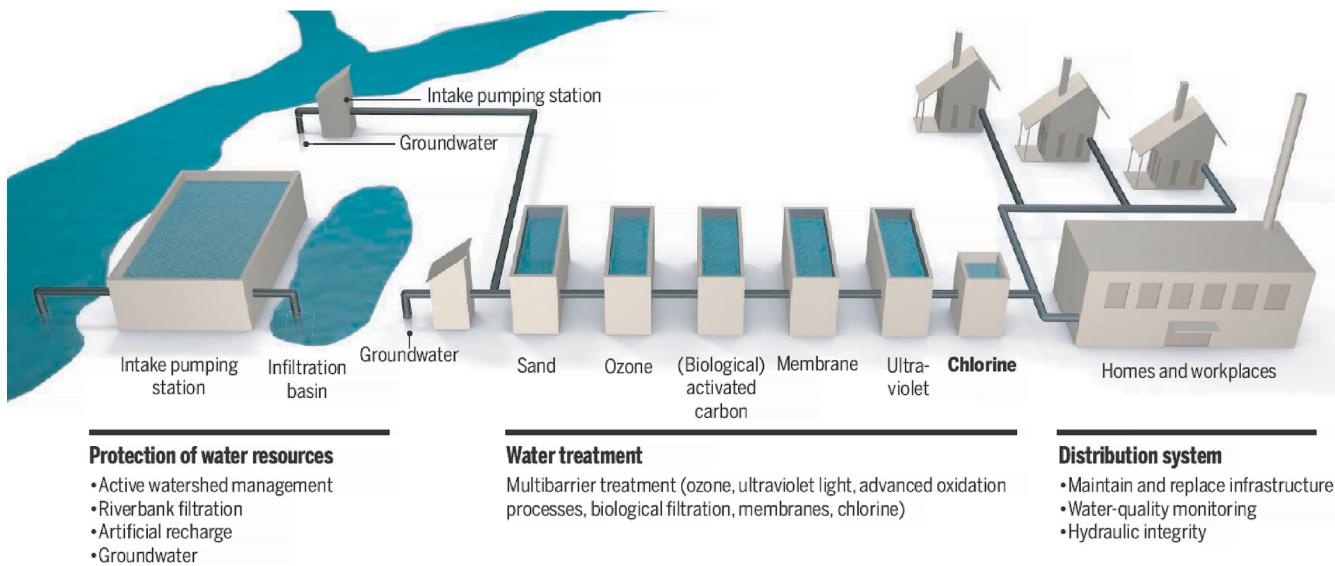


Figure 1: Drinking water system.

This figure illustrates the path water takes from water source, to water treatment, to water distribution system.

Drinking Water Systems

Municipal Water Systems

- **Description** – Drinking water that is supplied through municipal systems comes from surface water (e.g., streams, rivers, lakes, reservoirs) and/or ground water. Drinking water distribution systems are made up of treatment facilities, storage tanks, and pipes that deliver safe water to the community. Municipal water systems are regulated by the Environmental Protection Agency (EPA), which requires testing for over 90 contaminants, including microorganisms, inorganic and organic chemicals, radionuclides, and disinfectants. Contamination of drinking water can occur through source water, water treatment failures, physical deficiencies (e.g. broken distribution system pipes), or changes in water quality due to building-specific factors. Municipal water systems use various methods of water treatment to provide safe drinking water for their communities. The most common steps in water treatment used by community water systems (mainly surface water treatment) include: coagulation and flocculation, sedimentation, filtration, and disinfection. (e.g., chlorine or chloramine).
- **Detection** – The EPA monitors water quality in different components of the system up to the meter. A challenge to consider would be the lack of public health detection abilities in these systems because there is no standard surveillance for low pressure events (e.g., main breaks, maintenance activities). Additionally, people in homes and buildings use water in different ways (i.e., some communities choose to not drink tap water). These factors make it difficult to detect an outbreak.
- **Investigation** – Public health departments should partner with the water engineers and operators of these municipal systems as well as their state drinking water administrators (who could be within the health department or within separate agencies such as departments of environmental protection, etc.) to adequately investigate.
- **Control** – Common control methods include boil water advisories, do not drink advisories, do not use advisories, fire hydrant flushing, recommendations for homes/buildings to flush, and chlorine burns. Other solutions include maintenance, replacing, or repairing the water distribution system.

Outbreak Example: *Giardia duodenalis*, Utah 2012

Twenty-eight individuals who lived on the same street in the same neighborhood reported gastrointestinal illness within a 7-week period. Stool samples from five individuals were positive for *G. duodenalis*. In the month prior to the first case illness onset, the neighborhood's municipal water distribution system transitioned from one municipal water system to another, which likely caused low pressure in the neighborhood's section of the municipal water distribution system. The change in water pressure temporarily allowed non-potable water to flow into the water distribution system. The source of non-potable water was a previously unknown cross-connection between the neighborhood's section of the municipal water system and a secondary irrigation water system. The cross-connection was fixed, and no additional illnesses were reported.

Private Wells

- **Description** – Private wells use ground water as their water source. Groundwater can become contaminated through naturally occurring chemicals and minerals (e.g. arsenic, radon), local land use practices (e.g. pesticides, chemicals, animal feeding operations), malfunctioning wastewater treatment systems (e.g. septic tanks), and other sources. Contamination of a private well can impact not only the household served by the well, but also nearby households using the same aquifer.
- **Detection** – The private well owner is responsible for the water safety and should regularly (e.g., annually) have well water tested for contaminants. The state health department may assist with testing the private well or direct the well owner to testing resources.
- **Investigation** – A well assessment and septic assessment conducted by certified professionals would be necessary to investigate or confirm the source of a private well outbreak.
- **Control** – If the source of the contamination is known, remediation of the current well and/or septic system is necessary to prevent ongoing contamination BEFORE initiating temporary water disinfection of the well. Alternative sources of water (e.g., new well, bulk water delivery) and/or wastewater removal/treatment (e.g., new septic system, portable toilets) may be necessary. Additionally, household water treatment systems can be considered. (<https://www.cdc.gov/healthywater/drinking/home-water-treatment/water-filters.html> and https://www.cdc.gov/healthywater/drinking/home-water-treatment/household_water_treatment.html)

Additional Resources

- [EPA. Drinking Water Distribution Systems](#)
- [CDC. Public Water Systems](#)
- [EPA. Private Drinking Wells](#)
- [CDC. Private Wells](#)
- [EPA. Drinking Water Requirements for States and Public Water Systems](#)
- [EPA. Drinking Water Regulations](#)
- [CDC. Water Treatment](#)





Recreational Water Systems

Pathogens and chemicals found in various recreational waters that we swim in can cause recreational water-associated illnesses (RWIs). Chemicals used for treating recreational water can cause illness or injury through direct contact or by inhalation. RWIs can be gastrointestinal, respiratory, neurologic, skin (i.e., wound infection), ear, and eye illness. The most frequently reported illness for RWI outbreaks is diarrhea, which is most commonly caused by *Cryptosporidium*, followed by *Giardia*, *Shigella*, and *norovirus*.

Treated Recreational Water (Swimming Pools, Waterparks, Water Playgrounds, Hot tubs/Spas)

- **Description** – Outbreaks associated with exposure to treated recreational water can be caused by pathogens or chemicals in venues such as pools, hot tubs/spas, and water playgrounds. The most frequently reported illness for treated recreational water-associated outbreak is diarrhea. Swallowing even a small amount of water contaminated with enteric pathogens can make swimmers sick.
- **Detection** – An outbreak associated with recreational water is the occurrence of similar illnesses in two or more persons, epidemiologically linked by location and time of exposure to recreational water or to pathogens or chemicals aerosolized or volatilized from recreational water into the surrounding air. Public health officials might be alerted to an outbreak when they see an increase in the number of case reports. Typically, these reports come from diagnostic laboratories or healthcare providers. Additionally, public health officials might receive inquiries from healthcare providers or the public regarding illness in a specific group of people.
- **Investigation** – Working with an environmental health practitioner can aide in identifying what issues related to the operation and management of public treated recreational water venues contributed to the outbreak. Outbreaks caused by chlorine-susceptible pathogens signal the need to ensure that the water is adequately halogenated (chlorinated or brominated). Outbreaks caused by the extremely chlorine tolerant pathogen *Cryptosporidium* do not necessarily signal issues in operations.
- **Control** – [Chlorine \(or bromine\) concentration and pH](#) should be tested and recorded to ensure that most pathogens are properly inactivated. Chlorine will inactivate most pathogens that cause RWIs within minutes. However, *Cryptosporidium* can survive for more than 7 days in adequately treated recreational water.

Hot Tubs/Spas

- **Description** – “Hot tub rash”, a skin infection caused by *Pseudomonas*, is a common RWI spread through [improperly operated](#) hot tubs/spas. *Legionella* can cause Legionnaires’ disease, a severe type of pneumonia, and Pontiac fever, a milder illness than Legionnaires’ disease without pneumonia, are also commonly associated with improperly operated hot tubs/spas. High water temperatures and aerosolization of water pose a challenge for maintaining the disinfectant concentration. When disinfection concentration decreases, bacteria can amplify in hot tub/spa water.
- **Detection** – An outbreak associated with recreational water is the occurrence of similar illnesses in two or more persons, epidemiologically linked by location and time of exposure to recreational water or to pathogens or chemicals aerosolized or volatilized from recreational water into the surrounding air. Public health officials might be alerted to an outbreak when they see

an increase in the number of case reports. Typically, these reports come from diagnostic laboratories or healthcare providers. Additionally, public health officials might receive inquiries from healthcare providers or the public regarding illness in a specific group of people.

- **Investigation** – Working with an environmental health practitioner can aide in identifying what issues related to the operation and management of public treated recreational water venues contributed to the outbreak. Outbreaks caused by [chlorine-susceptible pathogens](#) signal the need to ensure that water is adequately halogenated (chlorinated or brominated). Outbreaks caused by the extremely chlorine tolerant pathogen *Cryptosporidium* do not necessarily signal issues in operations.
- **Control** – Drain all water from the hot tub/spa. Vigorously scrub all hot tub/spa surfaces, skimming devices, and circulation components. Replace filters (for cartridge or diatomaceous earth filters) or filter media (for sand filters).

Oceans, Lakes, and Rivers (Untreated Water)

- **Description** – Oceans, lakes, and rivers can be contaminated with pathogens from sewage spills, animal waste, water runoff following heavy rain, fecal incidents, and naturally occurring organisms. Illnesses associated with ocean, lake, and river exposure can vary based on the type of pathogen and can affect the gastrointestinal tract (diarrhea, vomiting), ears, eyes, skin, or central nervous system.

[Harmful algal blooms](#) (HABs) are visible colonies of cyanobacteria and microalgae. Contributors to the formation of HABs include nutrient pollution and warm water. Some HABs can create toxins that cause illness in people or animals through direct contact, ingestion, or inhalation. Cyanobacteria are usually found in fresh water but have occasionally caused coastal blooms—sometimes severe.

- **Detection** – An outbreak associated with recreational water is the occurrence of similar illnesses in two or more persons, epidemiologically linked by location and time of exposure to recreational water or to pathogens or chemicals aerosolized or volatilized from recreational water into the surrounding air.
- **Investigation** – Investigations of outbreaks associated with untreated recreational water can be supported environmental investigations (including but not limited to beach monitoring data and sanitary surveys) to provide information about potential sources of contamination (e.g., sewage spills, nutrient pollution). Pathogens introduced by environmental contamination or ill swimmers might not be killed or removed as readily as in treated venues due to the lack of disinfection and filtration.
- **Control** – Control measures might consider water quality from beach monitoring activities. Beach closures or other restrictions on use (e.g., no swimming, no fishing) may be implemented by water body managers until water quality concerns are eliminated. Control measures may also consider factors that would improve water quality (e.g., by reducing the influx of environmental contaminants, improving the circulation of stagnant water). Monitoring requirements for untreated recreational water venues vary by jurisdiction.

Additional Resources

[Swimming Pools, Waterparks, Water Play Areas](#)

Healthy Swimming

[CDC. Model Aquatic Health Code](#)

Hot Tubs/Spas

[CDC. Pool/Spa Inspector Training](#)

[Oceans, Lakes, and Rivers](#)

[CDC. Harmful Algal Blooms Associated Illness](#)

[CDC. Oceans, Lakes, and Rivers](#)

[NOAA. Harmful Algal Blooms](#)

[EPA. Harmful Algal Blooms](#)

[EPA. Beaches](#)



Other Water Systems

In addition to drinking and recreational water systems, water has many other uses, including agriculture, industry, decoration, and healthcare. Each of these uses provides unique opportunities for exposure to unsafe water.

Agriculture/Irrigation

- **Description** – Agricultural water is used to grow fresh produce and sustain livestock. Examples of water use in agriculture include irrigation, pesticide and fertilizer applications, crop cooling, frost control, and hydrating livestock. Agricultural water comes from a variety of sources, including surface water, ground water from wells, rainwater, and municipal water systems. Contaminated water can affect the quality of crops, causing illness in employees and workers who handle these affected food crops or in people who consume these crops. For example, irrigating fresh produce with contaminated water can contaminate ready-to-eat food products, which can lead to illness when consumed.
- **Detection** – detecting illness related to food consumption (e.g., fresh produce)
- **Investigation** – product traceback leads to farms with contaminated water. Environmental investigation detects the contamination on the farm.
- **Control** – Common control solutions include treatment or excluding the use of surface water. Other sources of infection, like wildlife, can be controlled or monitored to prevent future outbreaks. Use of non-contaminated water for growing and processing food can also be used as a control measure.

Industrial Uses of Water

- **Description** – Manufacturing and other industries use water during the production process, either for creating products or for cooling the equipment. Notably, large amounts of water are used to produce food, beverages, paper, and chemicals. Heavy metals, solvents, and other accumulated wastes from this industrial production can contaminate local water sources and can be hazardous to human health. Poor water quality can also affect employees/workers. For example, workers may be exposed to various chemicals or *Legionella* through mists or water used for cooling industrial equipment.
- **Detection** – Detection of cases in industrial settings can vary greatly depending on the contaminant. Collection of large-volume water samples might be required to identify pathogens that require special protocols for their recovery.
- **Investigation** – At the beginning of an outbreak it's important to identify as many confirmed cases as possible to help find the source of the outbreak. This can be done through mass mailings, press conferences, the Internet, and other types of public outreach.
- **Control** – Due to the wide variety of contaminants, control of industrial waterborne outbreaks will vary greatly by etiology. More information can be found at: <https://www.cdc.gov/healthywater/emergency/index.html>

Outbreak Example: *Legionella pneumophila*, Florida 2014

Three residents of a federal long-term care facility were diagnosed with legionellosis over a 2-month period; all cases were in one of eight living units. Environmental water sample analysis conducted by the facility from multiple locations including sink, ice machine, shower, fountain, and refrigerator water tested positive for *Legionella pneumophila* (0.1-2.6 cfus/mL; median 1.4 cfus/mL). Chlorine levels ranged from 0.0 to 0.1 (median=0.01 ppm); hot water temperatures ranged from 105-140°F (median=128°F); cold water temperatures ranged from 65-91°F (median=86°F) during the sampling time frame. The investigation determined that automatic biocide sensing equipment malfunctioned in conjunction with stagnant water conditions that existed in dead legs prior to occupancy likely were factors contributing to the outbreak. Following remediation, the premise plumbing system was continually monitored and point of use filters along with other short-term measures were utilized until the water system was cleared of *Legionella*. The facility operators continued to develop, improve and implement their water management program.

Additional Resources

- [CDC. *Legionella*](#)
- [CDC. Industrial Water](#)
- [USGS. Industrial Water](#)
- [CDC. Agricultural Water](#)
- [USDA. Agricultural Water](#)
- [CDC. Medical Water](#)



Preparation for a Waterborne Disease Outbreak Investigation

1. Organization

- Develop general outbreak [plans, procedures, and templates](#) prior to an outbreak.
- List available resources and asset types, including people (e.g., environmental health, engineers, laboratorians, nurses, epidemiologists, public information officers), laboratory equipment and supplies, and response equipment. If your health department does not have the resources to adequately respond to large or complex waterborne disease outbreaks, plan for requesting needed resources from other local, state, or federal partners.
- Consult with your departmental legal team to ensure compliance with applicable legal requirements.

2. Partners

Building relationships prior to an outbreak can strengthen partnerships during interagency responses. Individuals, agency participation, and responsibilities will vary based on the cause of the outbreak. Organizations and agencies that could provide assistance during outbreaks include:

- Other local or state health departments
- Other local or state agencies with jurisdiction involving water (e.g., departments of environmental quality/protection)
- Healthcare facilities
- Clinical and environmental laboratories
- Municipal water systems and recreational water facilities
- Local media
- Emergency management agencies
- Child care centers and elder care facilities
- Community based organizations which could provide support to vulnerable populations (e.g., persons experiencing homelessness, HIV positive individuals)
- During an outbreak, it can be important to identify and work with state and federal regulatory agencies and public health legal authorities.
- Establish operational memorandums of understanding or interagency agreements, as appropriate.

Example of Key Partners: Colorado Statewide cryptosporidiosis outbreak, 2007

On August 20, 2007, the Colorado Department of Public Health and Environment (CDPHE) identified an increase in the number of reported cases of cryptosporidiosis. *Cryptosporidium* species are chlorine-resistant, protozoan parasites that causes prolonged watery diarrhea. By August 31, 2007, CDPHE had received 56 reports of cryptosporidiosis for the month of August. The expected number of reported cases of cryptosporidiosis in Colorado for August is 12.

Key Partners of the Colorado Department of Public Health and Environment (CDPHE)

- 7 + County Health Departments
- Colorado State Laboratory
- Division of Parasitic Diseases, CDC

The CDPHE worked with local county health departments, state laboratory, CDC laboratory, and CDC partners to develop and administer a laboratory survey, stool specimen investigation, and a case-control study to determine sources of the outbreak and develop recommendations for outbreak control.

3. Training and Resources

- Several trainings and resources are available to prepare for waterborne disease outbreak investigations. These trainings provide knowledge on water sources and outbreak investigation methods.
- Environmental Health Resources and Trainings
 - ▷ [Potable Water – Environmental Public Health Online Course](#)
 - ▷ [Wastewater – Environmental Public Health Online Course](#)
 - ▷ [Environmental Health Online: Water Supply and Waste Water](#)
 - ▷ [Sampling guidance for unknown contaminants \(EPA\)](#)
 - ▷ [Preventing Legionnaires' Disease: A training on Legionella Water Management Programs \(PreventLD Training\)](#)
 - ▷ [Building field capabilities to respond to drinking water contamination \(EPA\)](#)
 - ▷ [e-Learning on Environmental Assessment of Foodborne Illness Outbreaks \(CDC\)](#)
 - ▷ [Legionella Environmental Investigation Videos](#)
 - ▷ [Certified Pool Operators Course](#)
 - <https://www.cdc.gov/mahc/editions/current.html>
 - <https://www.cdc.gov/mahc/networks-tools-forms.html>
 - www.cdc.gov/nceh/ehs/eLearn/EPHOC.htm
 - <https://www.cdc.gov/nceh/ehs/elearn/pool-inspection.html>
- Epidemiologic Case Studies
 - ▷ [Cryptosporidiosis in Georgia](#)
 - ▷ [Norovirus in Vermont](#)
 - ▷ [Molecular Epidemiology and Sequencing Approaches in Public Health Modules](#)

4. Communication

Internal Communication

Identify all key partners within your organization and designate a shared space to store outbreak materials, develop a communication distribution list, and establish the most efficient ways to communicate outbreak updates. Depending on the magnitude of the outbreak and the degree of involvement with other agencies, the department may decide to follow the [Incident Command System](#) (ICS) to assist in command, control, and coordination of the emergency response.

Communications with Partners

Regular communication with key partners through pre-established channels (i.e. conference call, email, etc.) is essential to keep partners informed, plan next steps, and share information on the status of the outbreak.

Decide on a mechanism for sharing information, such as e-mail, state communication systems, or national communication systems, such as EPI-X.

Plan for daily situational reports (SitReps). These regular summaries should be updated with important case information, including clinical information, non-identifying demographic information (sex, age), and updates and progress on the investigation. SitReps should not include protected health information (PHI), such as patient names, patient addresses, medical record numbers, or dates of birth.

Public Communication

Providing information regularly to help people make the best possible decisions for their health and well-being during waterborne disease outbreaks is a crucial outbreak response activity. Emergency risk communication must be done in rapid timeframes and without knowing everything about the outbreak. Because water systems are essential to multiple community systems, it is important for the public to understand the potential risk to their health and what actions they can take to reduce their risk. Even if the health department is not responsible for regulating the water system, the public will look to the health department for credible health information and updates on water safety.

Planning ahead for outbreak communication can help disseminate timely, consistent, and reliable information to the public. While it is impossible to predict the type of contamination or illness prior to an outbreak, it may be possible to plan for the types of questions that will be asked and how they can be addressed in ways that control the outbreak and provide guidance for people to protect their health.

The following communication guidance may be helpful for communication planning:

- [CDC's Crisis and Emergency Risk Communication Manual](#)
- [Developing Risk Communication Plans for Drinking Water Contamination Incidents, EPA, 2013](#)
- [Drinking Water Advisory Communication Toolbox, CDC, 2016](#)
- [CDC's Crisis and Emergency Risk Communication](#)

Communication Plan

Creating a Communication Plan will allow you to deliver consistent and effective messaging to the right audience at the right time.

To develop an effective communication plan, answer these questions within the strategy:

- **Goal**—What do you want people to know or do?
- **Audience(s)**—Who are you communicating with?
- **Message**—What information do you want to communicate?
- **Strategies**—How are you going to achieve your communication goal?
- **Timeline**—When are you going to do it?
- **Staffing and/or partnerships**—Who is going to do it?
- **Budget**—How much will it cost?

Media Relations

- Identify and establish a working relationship with your Public Information Officer (PIO). Plan for coordination with other response PIOs (e.g., water utility, emergency management agency).
- Identify a primary spokesperson for media interviews. The primary spokesperson should have detailed knowledge of the situation and preferably have previous experience with media interviews. Identify a secondary spokesperson for back-up in the event the primary is not available. Share this information with your PIO.
- Work with your PIO to develop and maintain a distribution list of local news agencies and reporters with current contact information.
 - ▷ Use this list to send news and updates about outbreaks, recent events, and other information.
- Discuss and agree upon a schedule for sending updates to the media during an outbreak or event.
 - ▷ This should be done on a case-by-case basis; every outbreak or event will have different communication needs.

Press Releases, Social Media, and Internal Talking Points

- Develop internal talking points with your PIO. Consider including pre-determined answers to questions that may be asked by reporters, the public, or other agencies once a press release is issued.
 - ▷ Share internal talking points with established key contacts and partners for message consistency.
- Determine the best channels for communicating with the affected community. These could include press releases, press conferences, website updates, social media messages, or emergency alerts.
- When appropriate, press releases should include information regarding:
 - ▷ **Who** is affected by the outbreak or event
 - ▷ **What** is the contamination (e.g., pathogen, toxin, chemical)
 - ▷ **Where** the outbreak or event is occurring
 - ▷ **When** it happened
 - ▷ **What** is being done to resolve the issue(s) and steps people can take to protect themselves
- Keep press releases brief and use clear and simple language. Post on website and social media.
 - ▷ Be responsive to reporters' questions.
 - Provide transparent answers for what information is known and unknown.
 - Share what steps are being taken to move the investigation forward to address current gaps in information.
- Determine what the case definition is and the number of cases for release in a public case count.
 - ▷ In uncertain circumstances, it is acceptable to leave room for changing case counts, as ongoing tests are verified or case definitions change. For example, consider using language such as "greater than" or "less than (x) cases," rather than giving exact numbers.
- Identify a clearance chain for reviewing all public information before release.
 - ▷ Share a draft of the press release with established key contacts and partners before release.
- Include pathogen-specific information in communication. Consider adding this information to press releases or your department website.
 - ▷ [Information on pathogens related to water](#)
- Consider communication channels to reach special populations (e.g., non-English speakers).
- Determine how and when to inform the public that the outbreak event is over and that the health risk has subsided.
- For drinking water outbreaks, use the tools and templates in the [Drinking Water Advisory Communication Toolbox](#).



Waterborne Disease Outbreak Investigation Response

A waterborne disease outbreak investigation will go through several steps—or response activities—with the goal of identifying the outbreak source and stopping additional illness. The steps will be described in order, but in reality, investigations are dynamic and multiple steps may happen at the same time. Investigations can also be cyclic, requiring certain steps to be repeated if cases continue after control measures have been implemented. It is important to remember that no two waterborne disease outbreaks are the same. The following steps were developed as a guideline to follow during an investigation, but all steps may not necessarily apply to all outbreak investigations or occur in chronological order.

1. Detect a Possible Outbreak

A waterborne disease outbreak occurs when two or more people become ill after exposure to a common contaminated water source. Multiple data sources can aid in detecting waterborne disease outbreaks. Types of data used to identify an outbreak include epidemiologic data, clinical/laboratory data, and environmental monitoring data.

Collecting Data to Detect Outbreaks

Epidemiologic Data

- **Interviews** with patients who are ill with potential waterborne diseases provide important clues regarding the source of infection. Thorough interviews, utilizing both standardized risk factor questionnaires (e.g. [CDC's National Hypothesis Generating Questionnaire](#)) and unstructured questions about exposures, can give clues to develop hypotheses regarding the outbreak source.
- **Regular reviews of the data** identify patterns in the geographic distribution of illnesses and the time periods when people became ill, facilitating identification of outbreaks. States mandate that diagnostic laboratories and healthcare providers [report certain diseases, including many illnesses caused by pathogens that cause waterborne disease \(e.g., Cryptosporidium, E. coli\)](#).
 - ▷ Sources of data to consider
 - Active/passive surveillance data
 - Available epidemiologic data
- **Illness complaint systems** provide a means for reporting and triaging public health concerns from providers or citizens. These can be used to report illnesses associated with water exposures or food consumption, assisting states in quickly identifying clusters of illness among people with exposure to a particular water source and initiating an investigation.
- **Syndromic Surveillance systems** at Emergency Departments, hospitals, or clinics can provide early warning of illness (e.g., Biosense, [ESSENCE](#)). Predefined statistical algorithms may alert the health department when there is an unusual increase in reports of illness in space and time. Review of the data can identify a pattern of illness suggestive of an outbreak.
- **Increased sales of anti-diarrheal medications** can indicate a community-wide outbreak. Some states regularly monitor their over-the-counter medication sales as part of surveillance.
- **Increased absentee reports** from schools and major employers can point to development of an outbreak. For example, some states mandate that schools report absentee rates above a certain threshold.

- **Increased calls to Poison Control Centers** can also be suggestive of an outbreak. Poison Control Centers have been instrumental in identifying potential public health threats via real-time public health surveillance through their National Poison Data System (NPDS). These data can be accessible through their data-request process, [AAPCC data request process](#).
- **Healthcare providers** can notify local and state health departments regarding unusual or increased cases of illnesses within their hospitals or clinics; these reports might include additional clues from patient histories.

Clinical/Laboratory Data

- Patient illness information can determine if a patient is potentially associated with an outbreak.
 - ▷ Medical record abstraction can identify additional cases who meet the specified case definition for follow-up. Medical records are helpful if a patient is identified as part of an outbreak investigation, as they often contain a brief exposure history.
- Clinical laboratory data are used to determine if there are additional cases pending confirmation in the area. Helpful information from clinical labs includes baseline information (e.g., the average number of specimens they receive to test for a specific disease and how often that disease is positively identified) to understand if there is an elevation in confirmed cases.
- Public Health labs can identify an increase in clinical specimens of the same molecular pattern by using techniques such as pulse-field gel electrophoresis (PFGE) pattern or whole genome sequence (WGS) and indicate that they might have a common exposure source.

Environmental Monitoring Programs

- Environmental testing of water systems can identify risks to water quality and potential sources of contamination that can cause infections. Many states mandate public reporting (i.e., drinking water advisories) of decreased water quality in drinking water systems.
- Beach monitoring programs can identify decreased water quality (i.e., fecal contamination) or the presence of harmful algal toxins at swimming beaches.
- Events that increase risk for waterborne disease, including floods, sewer system overflows, and water system outages, are also important to monitor.
- National data on water quality includes:
 - ▷ [United States Geological Survey \(USGS\)](#) provides data on water including water levels, streamflow, temperatures, and more.
 - ▷ [National Oceanic and Atmospheric Administration \(NOAA\)](#) provides data on rainfall.
 - ▷ [National Weather Service](#) provides weather data including information on rivers, lakes, and rainfall.
 - ▷ [EPA Beach program](#) provides information on beach water quality.

Other Data Sources

- Situational awareness is an important component for outbreak detection. Investigators should be conscious of events or large conventions happening in the area that can be potential sites of outbreaks. News or media alerts can assist public health in identifying additional ill persons for follow-up.
 - ▷ Monitor traditional and social media alerts and complaint hotlines to track illness complaints, follow up with the complaints to determine if they meet a case definition, or spread prevention messages to the affected community.

Investigation Tools

- Line List
 - ▷ Line lists are utilized to summarize information provided during case investigation. Line lists should include demographic information and clinical information such as signs and symptoms (type, duration), onset dates and times, case status, and exposure information.
 - ▷ [CDC Line List template](#)
- Epidemic Curve
 - ▷ To help keep track of the number of illnesses over time, create an epidemic (epi) curve. The pattern of the epi curve can help to determine if the exposure is a point course or if exposure occurred over a longer time period.
 - ▷ [CDC Quick-Learn Lesson, Create an Epi Curve](#)
- Maps and spatial analysis tools
 - ▷ Maps and spatial analysis can be useful investigation tools for visualizing the location of cases, facilitating recognition of any spatial relationships, giving clues to outbreak source, and tracking geographic spread over time. Some tools include ArcGIS, or R studio to build data visualization maps and SatScan for spatial analysis.

2. Define and Find Cases

Developing a Case Definition

Health officials develop a case definition to identify which ill persons will be classified as part of the outbreak. Case definitions should be sensitive enough to include all cases, and specific enough to only identify the cases involved in the outbreak. Case definitions may include details about:

- Features of the illness
- The pathogen or toxin, if known
- Certain symptoms typical for that pathogen or toxin
- Time range for when the illnesses occurred
- Geographic range, such as residency in a state or region
- Other criteria, such as patterns of molecular characterization of pathogens

There might be several case definitions during an outbreak investigation, each with a different purpose. For example, one case definition might be for confirmed illnesses and another for probable illnesses. The number of illnesses that meet the case definition is called the case count. As the investigation proceeds with more information about the illnesses and outbreak, the case definition will be further refined to include compatible symptoms, laboratory confirmation, and onset dates. It is important to document the case definition development throughout the investigation. The Council of State and Territorial Epidemiologists (CSTE) has developed case definitions for many waterborne pathogens based on uniform criteria used to define a disease for public health surveillance that can be reviewed on the [National Notifiable Disease Surveillance System \(NNDSS\) website](#). These case definitions may be helpful in determining if a case is confirmed, probable, or suspected in an outbreak.

Cryptosporidiosis (*Cryptosporidium* spp.)

Case Definition Example

Setting: Time: Onset between Jan 2012-Dec 2012 **Geographic Range:** Residents of State A or State B

Clinical Description:

A gastrointestinal illness characterized by diarrhea and one or more of the following: diarrhea duration of 72 hours or more, abdominal cramping, vomiting, or anorexia.

Laboratory Criteria for Diagnosis

Confirmed: Evidence of *Cryptosporidium* organisms or DNA in stool, intestinal fluid, tissue samples, biopsy specimens, or other biological sample by certain laboratory methods with a high positive predictive value (PPV), e.g.,

- Direct fluorescent antibody [DFA] test,
- Polymerase chain reaction [PCR],
- Enzyme immunoassay [EIA], **OR**
- Light microscopy of stained specimen.

Probable: The detection of *Cryptosporidium* antigen by a screening test method, such as immunochromatographic card/rapid card test; or a laboratory test of unknown method.

Case Classification

Probable: A case with supportive laboratory test results for *Cryptosporidium* spp. infection using a method listed in the probable laboratory criteria. When the diagnostic test method on a laboratory test result for cryptosporidiosis cannot be determined, the case can only be classified as probable, **OR**

A case that meets the clinical criteria and is epidemiologically linked to a confirmed case.

Confirmed: A case that is diagnosed with *Cryptosporidium* spp. infection based on laboratory testing using a method listed in the confirmed criteria.

Comments

Persons who have a diarrheal illness and are epidemiologically linked to a probable case because that individual was only diagnosed with cryptosporidiosis by an immunocard/rapid test/or unknown test method cannot be classified as probable cases. These epi-links can be considered suspect cases only.

Find Additional Cases

At the beginning of an outbreak investigation, it is important to identify as many potential cases as defined by the case definition as possible to guide determination of a common source or sources. The first illnesses that are recognized can be only a small part of the total outbreak. Identifying more persons who are ill is integral to understanding the magnitude, timing, severity, and possible sources of the outbreak for public health officials.

Using the case definition, investigators search for more illnesses related to the outbreak by:

- Reviewing public health reportable condition surveillance reports
- Reviewing state and national molecular typing databases
- Asking local healthcare providers to order diagnostic testing of persons ill with the specific clinical profile, as well as to report cases as soon as they suspect the diagnosis
- Reviewing emergency room records for similar illnesses
- Surveying groups that may have been exposed
- Asking health officials in surrounding jurisdictions to watch for illnesses that might be related
- Alerting the affected community to the outbreak and asking any ill persons with similar exposures to notify the health department



3. Generate Hypotheses

Developing a hypothesis regarding the cause of the outbreak is often challenging and is a crucial step in the outbreak investigation.

Many pathogens that cause waterborne diseases can also be transmitted by contaminated food or by contact with an infected person or animal. When looking for the source of the illness, investigators first need to decide on the likely mode(s) of transmission. The identified pathogen, where ill persons live, or the age of the patients may suggest a particular mode of transmission and could help identify a specific source. Hypothesis generation should be considered an iterative process in which possible explanations are continually refined or refuted.

When exposure to water is suspected as the source of contamination, public health officials interview ill cases to determine water exposures in the days or weeks prior to onset of illness. These interviews are called “hypothesis-generating interviews.” Interviews can either use a standardized questionnaire (e.g., “shotgun” questionnaire), or they can be open-ended. [Standardized interviews](#) include a set of questions used by public health officials to interview ill people during outbreak investigations. Open-ended interviews are not standardized and do not provide concrete exposures for analysis. Interviews will focus on activities and experiences that occurred during the pathogen’s incubation period—the time it takes to get sick after exposure to the contaminated water. A table of common waterborne pathogens and their incubation period is listed in APPENDIX

Based on all the information gathered, the investigators make a hypothesis about the likely source of the outbreak. If they are not able to develop a hypothesis, investigators can return to intensive, open-ended interviews or utilize a different set of standardized questions to develop clues to the outbreak source. Clues to the outbreak source might come from ill persons with few exposure opportunities or from interviewing cohorts (e.g., family groups or sports teams) within the larger outbreak population.

4. Test Hypotheses using Epidemiologic and Environmental Investigation

Once a hypothesis is generated, it should be tested to determine if the source has been correctly identified. Investigators use several methods to test their hypotheses.

Epidemiologic Investigation

Case-control studies and cohort studies are the most common type of analytic studies conducted to assist investigators in determining statistical association of exposures to ill persons. These types of studies compare information collected from ill persons with comparable well persons.

Cohort studies use well-defined groups and compare the risk of developing illness among people who were exposed to a source with the risk of developing illness among the unexposed. In a cohort study, you are determining the risk of developing illness among the exposed.

Case-control studies compare the exposures between ill persons with exposures among well persons (called controls). Controls for a case-control study should have the same risk of exposure as the cases. In a case-control study, the comparison is the odds of illness among those exposed with those not exposed.

Using statistical tests, the investigators can determine the strength of the association to the implicated water source instead of how likely it is to have occurred by chance alone. Investigators look at many factors when interpreting results from these studies:

- Frequencies of exposure
- Strength of the statistical association
- Dose-response relationships
- Biologic /toxicological plausibility

For more information and examples on designing and conducting analytic studies in the field, please see [The CDC Field Epidemiology Manual](#).

Information on the clinical course of illness and results of clinical laboratory testing are very important for outbreak investigations. Evaluating symptoms and sequelae across patients can guide formulation of a clinical diagnosis. Results of advance molecular diagnostics can be evaluated to compare isolates from patient and the outbreak sources (e.g., water).

Environmental Investigation

Investigating an implicated water source with an onsite environmental investigation is often important for determining the outbreak's cause and for pinpointing which factors at the water source were responsible. This requires understanding the implicated water system, potential contamination sources, the environmental controls in effect (e.g., water disinfection), and the ways that people interact with the water source. The factors considered in this investigation will differ depending on the type of implicated water source (e.g., drinking water system, swimming pool). Environmental investigation tools for different settings and venues are available.

The investigation might include collecting water samples. Sampling strategy should include the goal of water testing and what information will be gained by evaluating water quality parameters including measurement of disinfection residuals, and/or possible detection of particular contaminants. The epidemiology of each situation will typically inform the sampling effort.

5. Identify Source of Outbreak

After forming and testing the hypothesis, the investigators should use evidence from epidemiologic and environmental investigation to identify the source of the outbreak. Results from the hypothesis testing can assist in focusing an investigation and should be integrated with other information gathered in the investigation to understand the exposure associated with illness. This involves understanding the epidemiology, environmental factors, microbiology, and transmission dynamics of the particular situation. For example:

- If the outbreak is small, there might not be enough statistical power to use epidemiology alone to link the illnesses to a specific exposure.
- If it is a large outbreak, several risk factors might be statistically significant. This might require a more complex analytic approach (e.g., regression modeling) to account for confounders.
- For acute illnesses (e.g., chemical exposure at a pool), time between exposure and illness is so short that an epidemiological study might not be necessary.



Epidemiologic Investigation

Investigators review the collected and analyzed epidemiologic data to determine whether it implicates a particular water source or exposure.

- Investigators review clinical data and clinical laboratory reports to assess whether illnesses and identified pathogens are consistent with contamination of the implicated water source and the suspected organism, chemical or toxin.
- Multiple people with similar signs or symptoms linked to a common water source.
- Multiple people diagnosed with the same illness linked to a common water source
- Attack rates from specific water exposures: Attack rates for water exposures that can account for most cases
- Odds Ratios from case-control studies or risk ratios from cohort studies: Epidemiologic data provided about exposed and unexposed persons, with relative risk or odds ratio ≥ 2 or p-value ≤ 0.05 , that links outbreak cases to the same water exposure.
- Molecular Epidemiology:
 - ▷ Molecular characterization of pathogens from clinical specimens matched for ≥ 2 cases who had the same water exposure
 - ▷ Molecular typing results matched to environmental sampling results

Environmental Investigation

Investigators review the results of the environmental investigation to assess supporting or confirmatory evidence of outbreak source.

- Disinfectant residual: measure the disinfectant residual (e.g., chlorine) for treated drinking water and recreational water systems to see if is adequate to inactivate the implicated pathogen
- Historical information about lapses in water treatment: review monitoring data on water systems to assess evidence for lack of effective treatment
- Indicators of fecal contamination: test for fecal bacteria to assess whether it exceeds levels for safe drinking or untreated recreational water
- Detection of contamination in a treated or untreated water source: test water for pathogen of interest

6. Control Outbreak Through Remediation and Outreach

Public health officials may decide on control measures on the basis of strong epidemiological evidence about the disease's origin, spread, and development. They do not always need to wait for definitive proof of contamination from the laboratory. This practice can result in earlier action to protect the public's health. As officials learn more during the investigation, they may change, focus, or expand control measures and advice to the public.

All control strategies require risk communication to inform the public about the outbreak, how investigators are working to understand it, and what they can do to reduce risk. Risk communication should be initiated early, even before the outbreak is solved. While there are many ways to control waterborne disease outbreaks, there are three practical strategies for public health recommendations—health promotion, processes and policies, and water treatment to reduce risk.

Table 1 – Three primary public health strategies to control waterborne disease outbreaks

Measure	Strategy	Examples
Health Promotion	Protect the person	<ul style="list-style-type: none"> ▪ Healthy swimming messages ▪ Boil water advisories
Processes and Policies	Change the way people interact with water systems	<ul style="list-style-type: none"> ▪ Bathroom breaks at pools ▪ Diarrhea exclusion policies ▪ Point-of-use water filters
Water Treatment to Reduce Risk	Isolate people from the hazard	<ul style="list-style-type: none"> ▪ Remediation ▪ Hyperchlorination ▪ Temporary closure of building wing ▪ Temporary closure of a beach

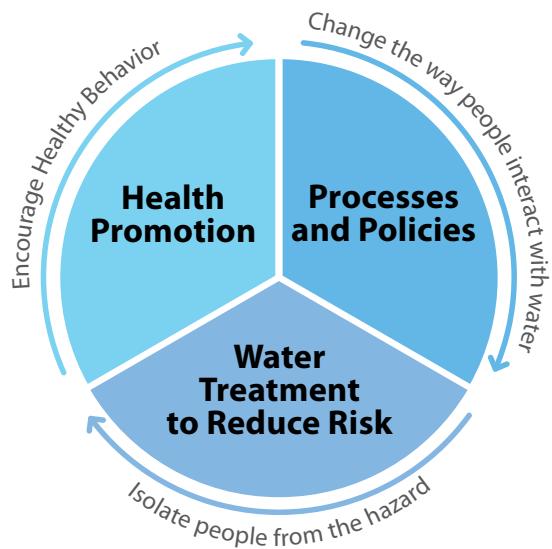


Figure 2: The cycle of the three primary public health strategies to control waterborne disease outbreaks.

As many water systems are often connected to other community systems, control measures such as elimination and substitution are often not practical or effective unless there are extreme circumstances. Considerations for using these approaches:

- Elimination—physically remove the hazard
 - ▷ Examples: shutting off tap water supplies and closing springs
 - ▷ Challenges: people need tap water for multiple household uses, ill swimmers will go to other facilities, people may continue to use unsafe water sources
- Substitution—replace the hazard
 - ▷ Examples: providing an alternative source of water
 - ▷ Challenges: providing supplemental water from a different source is challenging for extended periods of time

7. Decide Outbreak is Over

An outbreak ends when there is no evidence of ongoing transmission or chemical contamination, despite active efforts to identify cases. For example, water testing no longer detects contamination or the number of illnesses identified through surveillance drops back to pre-outbreak levels. An epidemic curve helps investigators visualize symptom onset and see that illnesses are declining. Even when illnesses from an outbreak appear to have stopped, public health officials can continue surveillance for a few weeks thereafter (e.g., two incubation periods beyond the last onset date) to ensure that case presentation does not again escalate. If an increase in case presentation is observed, public health officials continue or restart their investigation. Outbreak resurgence may occur if the source was not completely or effectively remediated by initial control efforts or if there is a second contamination event involving another water source linked to the first outbreak. When the outbreak is over, ensure the members of the community affected by the outbreak are informed that the risk has subsided.

8. Prevent Future Outbreaks Through Summarizing, Interpreting, and Reporting Findings

Outbreak investigations are important learning opportunities for recognizing threats to safe water, uncovering contributing factors to water contamination, and identifying ways to prevent future outbreaks. Data from waterborne disease outbreaks provide crucial information for understanding risk factors for waterborne disease and for identifying ongoing and emerging threats. Additionally, these data facilitate evaluation of any progress made in the improvement and in the provision of, as well as access to, safe water. Drinking water outbreak data have been used to inform the development and implementation of drinking water regulations. Recreational water outbreak data have been used to identify emerging threats and develop a model aquatic health code. Compiling and sharing outbreak reports supports public health efforts to protect the public from waterborne disease.

Reporting outbreaks

■ Local Health Departments

- ▷ Most states and territories require that local health departments report outbreaks of suspected foodborne and waterborne illness to their state or territorial health department.

■ State and Territorial Health Departments

- ▷ Public health agencies in all 50 states, the District of Columbia, U.S. territories, and Freely Associated States have the primary responsibility of identifying and investigating waterborne outbreaks, as well as using a standard form to report outbreaks voluntarily to the CDC. Waterborne disease outbreaks became nationally notifiable in the United States in 2009.
- ▷ State and territorial health departments can report all waterborne disease outbreaks to the [National Outbreak Reporting System \(NORS\)](#). Individual cases of harmful algal bloom (HAB)-associated human or animal illness and HAB events can be reported in the [One Health Harmful Algal Bloom System \(OHHABS\)](#).

Learning from Outbreaks

Following a public health investigation gathering and sharing information about the investigation, the steps taken, and the results can be used to aid in future investigations. This is why health departments voluntarily submit de-identified outbreak data to CDC. The reported information includes a summary of the number of outbreak-associated illnesses, hospitalizations and deaths, as well as the etiologic agent(s), implicated water venue or system, water settings, environmental data and contributing factor information.

CDC epidemiologists review the outbreak data and follow up with the health departments to verify the information and to gather additional information as needed. Periodically, CDC and EPA researchers analyze the outbreak data and report on outbreak characteristics and trends. Waterborne disease outbreak reports have been published since the 1970s. Outbreak data are available online through the NORS Dashboard, a publicly available data visualization tool that also has a dataset download feature. See CDC's Waterborne Disease and Outbreak Surveillance reporting website: <https://www.cdc.gov/healthywater/surveillance/index.html>

Public health agencies, policymakers, and the general public can access waterborne disease outbreak reports and data to inform development of prevention efforts, namely through evidence based health communication and policy efforts targeted to prevent future spread and occurrence of waterborne disease.

Improving outbreak response:

To improve future outbreak responses, health departments should consider conducting an after-action review following an outbreak investigation. Inviting key partners from the outbreak to discuss the outbreak timeline, communication processes, control measures, and other outbreak outcomes can help determine if there were deficiencies within the organization processes that can be improved. Working with partners to document lessons learned and publish novel findings can further strengthen partnerships and improve future outbreak responses.

Prevention and Education Materials

1. CDC. [Community Drinking Water Systems](#). Guidance for how community drinking water systems can prepare for an emergency situation.
2. CDC. [Healthy Swimming](#). Information for healthy and safe swimming experiences and how to maximize health benefits of swimming while minimizing the risk of illness and injury.
3. Gelting RJ, Miller MD. [Linking Public Health and Water Utilities to Improve Emergency Response](#). [PDF - 5 pages] J Contemp Water Res Educ. 2004;(129):22-26.
4. Learn how to plan for and respond to (Water, Sanitation, & Hygiene) WASH-related emergencies. [View and download these free materials](#) intended for the public, public health professionals, first responders, and others who are interested in WASH-related emergency topics.
5. [Fact Sheets](#)
Printable fact sheets about what to do during an emergency or outbreak.
6. [Posters](#)
Printable posters about water, sanitation, and hygiene (WASH)-related emergencies and outbreaks.
7. [Podcasts](#)
Audio podcasts about water, sanitation, and hygiene (WASH)-related emergencies and outbreaks.

The links below provide information and resources for the general public with regard to WASH-related emergencies.

- [Emergency Planning, Training, and Response](#)
- [Emergency Water Supply Preparation](#)
- [Private Drinking Water Wells](#)
- [Cisterns and Other Rain Catchment Systems](#)
- [Septic & Onsite Wastewater Systems](#)
- [Hygiene, Handwashing, & Diapering](#)
- [Household Cleaning & Sanitizing](#)
- [Floods](#)
- [Drought](#)

Appendices

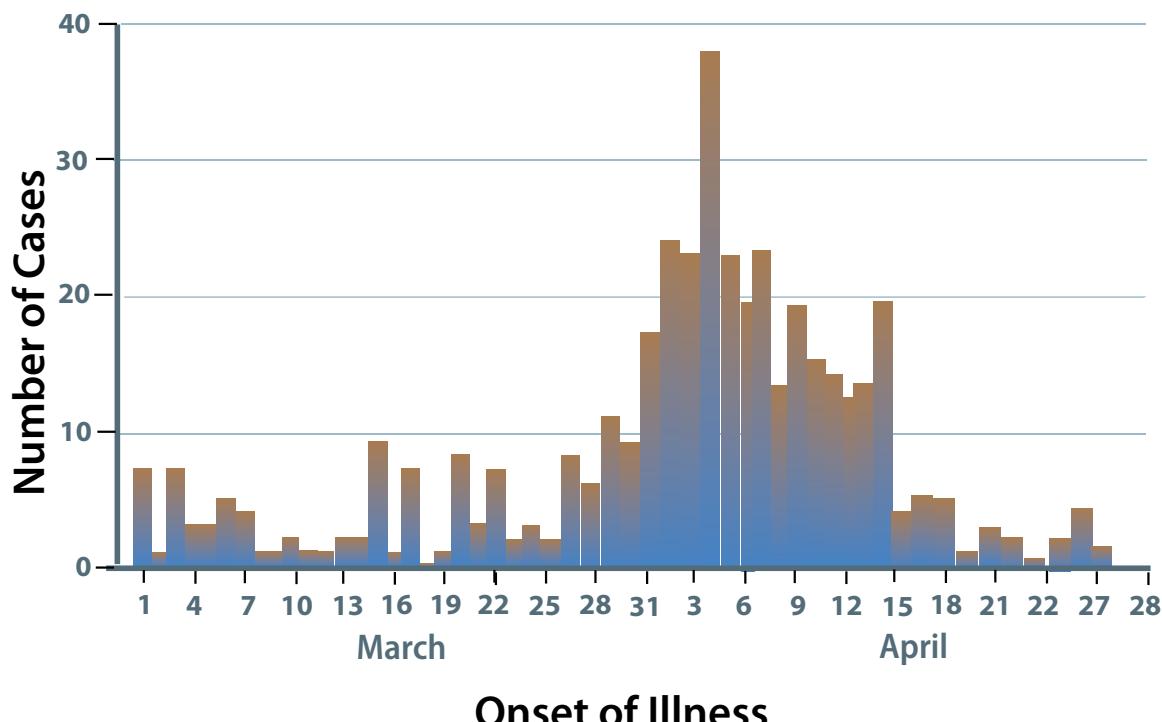
Interpretation of an Epidemic Curve

An epidemic curve (epi curve) shows progression of illnesses in an outbreak over time. Epi curves depict when people became ill by day, week, or month. This information is often shown by the week people became ill. The horizontal axis (x-axis) is the week when a person became ill, also called the week of illness onset. The vertical axis (y-axis) is the number of persons that meet the case definition each week. During ongoing outbreak investigations, the epi curve is updated as new data becomes available. There are several important issues in understanding and interpreting epi curves during ongoing outbreak investigations.

- **There is an inherent delay between the date that an illness starts and the date that the case is reported to public health authorities.** This delay can be several weeks; someone who became ill last week is very unlikely to have his or her infection reported to public health authorities by now, and someone who became ill 3 weeks ago may have just had it reported.
- **Some background cases of illness are likely to occur that would have happened even without an outbreak. This makes it difficult to say exactly which case is the first in an outbreak.** Epidemiologists typically focus on the first recognized cluster (group) of illnesses, rather than the very first case. Due to the inherent reporting delay described above, the cluster is sometimes not detected until several weeks after the persons initially became ill.
- **For some cases, the date of illness onset is not known because it takes time before someone from the health department can do an interview to ask for this information.** Sometimes, this interview never occurs. If investigators know the date that a specimen from an ill person arrived in the laboratory for testing, they may estimate the date of illness onset as 2 or 3 days before the specimen collection or submission date.
- **It can be difficult to determine when cases start to decline because of the reporting delay.** This information will become clearer as time passes.

It can be difficult to say when the outbreak is over because of the reporting delay. The delay means that the curve for the most recent 3 weeks always looks like the outbreak could be ending even during an active outbreak. The full shape of the curve is clear only after the outbreak is over.

Figure 3: Example of an epidemic (epi) curve from an outbreak investigation of cryptosporidiosis in Milwaukee, 1993.



Reported date of the onset of watery diarrhea during the period from March 1 through April 28, 1993, in 436 cases of infection identified by a random-digit telephone survey of the greater Milwaukee area.

Confirming Diagnosis

This table is intended to assist health departments with developing hypotheses about the possible cause of waterborne diseases and outbreaks during the outbreak investigation. If some of the clinical or exposure information is known, it might direct laboratory testing. Additionally, historical water exposure information might provide clues for developing investigation tools.

Table 2— Confirming Diagnosis of Infectious Bacterial Disease

Etiology	Incubation period	Signs and symptoms	Duration of illness	Possible exposure categories	Notes on water exposure
<i>Bacillus anthracis</i>	2 days - weeks	Nausea, vomiting, malaise, bloody diarrhea, abdominal pain	Weeks	Water Food Animal contact Environment	Drinking, recreational: naturally-occurring spores, intentional contamination
<i>Campylobacter jejuni</i>	2 - 7 days	Fever, cramps, vomiting, diarrhea (can be bloody)	2 - 10 days	Water Food Animal contact Environment	Drinking: human feces, animal (mammals, poultry, waterfowl) feces
<i>Cronobacter</i> spp.	Unknown	Diarrhea possible, sometimes bloody; sepsis; meningitis	Variable; meningitis associated with brain abscesses and prolonged illness	Water Food Environment	Drinking: powdered infant formula prepared with contaminated water
<i>Enterotoxigenic Escherichia coli (ETEC)</i>	12 - 72 hours	Cramps, watery diarrhea, nausea and vomiting less common	3 - >7 days	Water Food Animal contact Person-to-person	Drinking, recreational: human feces, domestic sewage, animal feces
<i>Shiga toxin-producing Escherichia coli (STEC)</i>	1 - 8 days	Abdominal pain, vomiting, watery diarrhea that becomes bloody. Usually no fever.	5 - 10 days	Water Food Animal contact Person-to-person	Drinking, recreational: human feces, domestic sewage, animal (cattle) feces
<i>Francisella tularensis</i>	1-10 days	Tularemia can present as cutaneous ulcers, fever, chills, muscle aches, painful lymphadenopathy, headache, vomiting, abdominal pain, rash, general malaise. Symptoms may last for several days, remit, and then begin again. (http://emedicine.medscape.com/article/230923-overview)	Up to >3 months	Water Animal contact Environment	Drinking, recreational: animal (wild mammals) blood and tissue, arthropods

Etiology	Incubation period	Signs and symptoms	Duration of illness	Possible exposure categories	Notes on water exposure
<i>Legionella</i> spp.	2 – 10 days for Legionellosis 24 – 72 hours for Pontiac fever	Legionnaire's disease: Pneumonia, diarrhea, cough, vomiting, abdominal pain Pontiac fever: milder self-limiting flu-like illness (fever, headache, and muscle aches)	LD: Variable Pontiac fever: 2 – 5 days	Water Environment	Drinking, recreational, other exposures to water: aerosolized mist from cooling towers, evaporative condensers, whirlpools, fountains, large plumbing systems, and respiratory therapy equipment-inadequate disinfection/biofilm removal, dead end systems, lack of maintenance
<i>Leptospira</i> spp.	4 - 19 days (https://wwwnc.cdc.gov/travel/yellowbook/2018/infectious-diseases-related-to-travel/leptospirosis)	Fever, chills, headaches, diarrhea, vomiting, jaundice, kidney failure, stiff neck. (http://emedicine.medscape.com/article/220563-clinical)	Variable	Water Food Animal contact Environment	Drinking, recreational, other exposures to water: animal (rodents, cattle, pigs, dogs, horses, wild animals) urine and body fluids contamination water sources, cisterns exposure
<i>Non-tuberculous Mycobacterium</i> spp.	Weeks - months	Insidious onset of cough with purulent sputum, fever, weight loss, night sweats; lymphadenitis, skin, soft tissue, and skeletal infections; disseminated disease in severely immunocompromised hosts, such as AIDS patients. https://www.sciencedirect.com/science/article/pii/S1526054204900425	Variable	Water Food Animal contact Person-to-person Environment	Drinking, recreational, other exposures to water: naturally-occurring (fresh/saltwater), biofilm-associated

Etiology	Incubation period	Signs and symptoms	Duration of illness	Possible exposure categories	Notes on water exposure
<u>Plesiomonas shigelloides</u>	24 - 48 hours	Diarrhea (usually watery), vomiting, fever, chills, and abdominal pain. Usually a self-limiting infection. (https://www.dhs.wisconsin.gov/publications/p4/p42155.pdf)	1 - 7 days	<u>Water</u> <u>Food</u> <u>Animal contact</u> <u>Environment</u>	<u>Drinking:</u> naturally-occurring (fresh/saltwater), potentially domestic sewage
<u>Pseudomonas aeruginosa</u>	8 hours - >5 days (http://emedicine.medscape.com/article/970904-clinical)	Generalized rash, pustules, ear infection, corneal infection, healthcare-associated (UTI, pneumonia, septicemia, etc.)	Variable	<u>Water</u> <u>Person-to-person</u> <u>Environment</u>	<u>Drinking, recreational, other exposures to water:</u> biofilm-associated, inadequate cleaning/chlorination—hot tub, pools, and water vessels
<u>Salmonella spp.</u>	6 - 72 hours 7-28 days for typhoid/paratyphoid fevers	Fever, cramps, vomiting, diarrhea. S. Typhi and S. Paratyphi cause typhoid, characterized by fever, headache, constipation, myalgias, and abdominal pain	4 - 7 days	<u>Water</u> <u>Food</u> <u>Animal contact</u> <u>Person-to-person</u> <u>Environment</u>	<u>Drinking:</u> human feces and urine, domestic sewage, animal (poultry, amphibians, reptiles, rodents) feces; farm runoff, meat/poultry processing plant wastes, back siphonage, inadequate disinfection
<u>Shigella spp.</u>	12 hours - 7 days	Fever, cramps, vomiting, tenesmus, diarrhea that can be bloody and mucoid	4 - 7 days	<u>Water</u> <u>Food</u> <u>Person-to-person</u> <u>Environment</u>	<u>Drinking, recreational:</u> human feces, domestic sewage; back siphonage, inadequate disinfection
<u>Vibrio cholerae</u> (toxin)	1-5 days	Profuse watery diarrhea (rice-water stool), vomiting, reduced skin turgor. Severe dehydration and death can occur within hours	3 - 7 days	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking:</u> human feces, domestic sewage, naturally-occurring (saltwater, warm weather)

Etiology	Incubation period	Signs and symptoms	Duration of illness	Possible exposure categories	Notes on water exposure
<i>Vibrio parahaemolyticus</i>	2 - 48 hours	Cramps, nausea, vomiting, watery diarrhea, wound/ear infections	2 - 5 days	<u>Water</u> <u>Food</u> <u>Environment</u>	Recreational: naturally-occurring (brackish/saltwater, warm weather) + open wound
<i>Vibrio vulnificus</i>	Around 16 hours	Vomiting, abdominal pain, diarrhea, bacteremia, wound infections. More common in the immunocompromised and in those with chronic liver disease	2 - 8 days	<u>Water</u> <u>Food</u> <u>Environment</u>	Recreational: naturally-occurring (brackish/saltwater, warm weather) + open wound + immuno-suppression
<i>Yersinia enterocolytica</i> and <i>Y. pseudotuberculosis</i>	1 - 7 days	Appendicitis-like symptoms (fever, abdominal pain, diarrhea, vomiting), typically in older children and young adults. <i>Y. pseudotuberculosis</i> may cause scarlatiniform rash	1 - 3 weeks	<u>Water</u> <u>Food</u> <u>Animal contact</u> <u>Person-to-person</u> <u>Environment</u>	Drinking: animal (pigs, rodents) feces and urine

Table 3— Confirming Diagnosis of Infectious Viral Disease

Etiology	Incubation period	Signs and symptoms	Duration of illness	Possible exposure categories	Notes on water exposure
Hepatitis A	15 - 50 days	Diarrhea, jaundice, flu-like symptoms	Variable 2 weeks - 3 months	<u>Water</u> <u>Food</u> <u>Animal contact</u> <u>Person-to-person</u>	Drinking: human feces and urine, domestic sewage; back siphonage, inadequate disinfection
Norovirus	12 - 48 hours	Nausea, vomiting, watery, large-volume diarrhea; fever rare	1 - 3 days	<u>Water</u> <u>Food</u> <u>Person-to-person</u> <u>Environment</u>	Drinking: human feces and vomit, domestic sewage
Rotavirus	1 - 3 days	Low-grade fever, vomiting, severe watery diarrhea, dehydration, inappetence. Temporary lactose intolerance may occur	4 - 8 days	<u>Water</u> <u>Food</u> <u>Person-to-person</u> <u>Environment</u>	Drinking, recreational: human feces, domestic sewage
Other viral agents (astroviruses, caliciviruses, adenoviruses , parvoviruses)	12 - 72 hours	Headache, fever possible, nausea, vomiting, diarrhea, malaise, rash	2 - 9 days	<u>Water</u> <u>Food</u> <u>Person-to-person</u> <u>Environment</u>	Drinking, recreational: human feces, domestic sewage

Table 4—Confirming Diagnosis of Infectious Parasitic Disease

Etiology	Incubation period	Signs and symptoms	Duration of illness	Possible exposure categories	Notes on water exposure
<i>Acanthamoeba spp.</i>	Unknown (possibly weeks or months)	Encephalitis: Fever, headache, mental status change, loss of coordination, other neurologic problems Cutaneous: firm, reddish nodules, non-healing ulcers, or abscesses Other symptoms depending on organ system affected.	Variable (weeks, months, encephalitis is usually fatal.)	Water Environment	Drinking: used for nasal or sinus rinsing
<i>Acanthamoeba keratitis</i>	Unknown (possibly days or weeks)	Eye pain, eye redness, blurred vision, sensitivity to light, sensation of something in the eye, excessive tearing	Variable (weeks, months)	Water Food Person-to-person Environment	Drinking: when used for cleaning and storing contact lenses
<i>Angiostrongylus cantonensis</i>	1 week - >1 month	Severe headache, neck stiffness, nausea, vomiting, paresthesias, seizures, other neurologic symptoms	weeks to months	Water Food	Drinking: whole animal (snail/slug) and body fluids
<i>Cryptosporidium</i>	2-10 days	Low-grade fever, cramps, nausea, vomiting, anorexia, prolonged diarrhea (usually watery)	In those with Healthy immune systems, symptoms resolve within 2-3 weeks. Might remit and relapse over weeks to months	Water Food Animal contact Person-to-person Environment	Drinking/recreational: human feces, domestic sewage, animal (ruminants, cats, rodents) feces, animal waste; inadequate disinfection/filtration
<i>Cyclospora cayanensis</i>	1 – 11 days	Cramps, nausea, vomiting, anorexia, weight loss, prolonged diarrhea (usually watery), fatigue	May remit and relapse over weeks to months	Water Food	Drinking: human feces, domestic sewage
<i>Entamoeba histolytica</i>	Few days to several months, typically 2 – 4 weeks	Lower abdominal pain, diarrhea (can be bloody), fever, chills, liver abscess	May last weeks to months	Water Food Person-to-person Environment	Drinking: human feces, domestic sewage; inadequate disinfection/filtration, back siphonage, water and sewer lines in same pits

Etiology	Incubation period	Signs and symptoms	Duration of illness	Possible exposure categories	Notes on water exposure
<i>Giardia</i>	1 - 4 weeks	Cramps, diarrhea (pale, greasy, malodorous stool), flatulence, bloating, vomiting, fatigue, fever	Days to weeks	<u>Water</u> <u>Food</u> <u>Animal contact</u> <u>Person-to-person</u> <u>Environment</u>	Drinking, recreational: human feces, domestic sewage, animal (beavers, ruminants, birds, dogs, cats, etc.) feces; inadequate disinfection/filtration
<i>Naegleria fowleri</i>	1-9 days	Headache, fever, nausea, vomiting, neck stiffness, seizures, altered mental status, hallucinations, coma	1-18 days. Almost always fatal	<u>Water</u>	Recreational, drinking: Water containing <i>Naegleria fowleri</i> enters the nose
<i>Toxoplasma gondii</i> (enteric exposure)	4 - 28 days	Generally asymptomatic. 20% may develop cervical lymphadenopathy and/or flu-like symptoms. Immunocompromised patients can get CNS disease, myocarditis, or pneumonitis	Months	<u>Water</u> <u>Food</u> <u>Environment</u>	Drinking: animal (cat) feces; inadequate filtration

Table 5— Confirming Diagnosis of Non-infectious etiologies

Etiology	Incubation period	Signs and symptoms	Duration of illness	Possible exposure categories	Notes on water exposure
Algal toxins	Few hours - years	May be in stages: vomiting, nausea, vomiting, fever, headache; then liver damage, multiple organ failure. Also, skin irritation, sore throat, muscle and joint pain, mouth ulcers, seizures	Variable	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking,</u> <u>recreational:</u> naturally-occurring algal blooms (fresh/brackish/saltwater)
Antimony	5 minutes – 8 hours, depending on dose	Vomiting, metallic taste	Variable	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking:</u> natural deposits, industrial contamination (freshwater)
Arsenic	5 minutes – 8 hours, depending on dose	Vomiting, cramps, diarrhea, cancer, skin changes, encephalopathy and peripheral neuropathy with high-dose exposure; lower-dose, chronic exposure may not produce GI symptoms	Several days	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking:</u> natural deposits, agricultural/industrial contamination (freshwater); pesticides, back siphonage, indiscriminate disposal
Cadmium	Several months	Abdominal pain, salivation, nausea, vomiting, myalgia, kidney damage, lung damage, fragile bones	2 - 9 days	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking:</u> natural deposits, agricultural/mining/industrial contamination (freshwater); galvanized pipe corrosion, volcanic eruptions, metal refinery discharge, waste battery and paint runoff
Copper	Minutes - hours, depending on dose	Nausea, vomiting with blue or green vomitus, liver or kidney damage	Variable	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking:</u> natural deposits, agricultural/mining/industrial contamination (freshwater); surface water copper treatment or cooling from power plants, copper pipes and fittings, plumbing material corrosion, fungicides

Etiology	Incubation period	Signs and symptoms	Duration of illness	Possible exposure categories	Notes on water exposure
<u>Lead</u>	Weeks - months	Irritability, anorexia, abdominal pain, high blood pressure, kidney problems, Developmental delays, cerebral edema, encephalopathy, seizures, death	Weeks - months	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking:</u> plumbing/water pipe corrosion (freshwater)
<u>Nitrite</u>	1 - 2 hours Variable, depending on dose and concentration	Headache, dizziness, loss of consciousness, nausea, vomiting, cyanosis (blue baby syndrome- bluish skin and brownish blood)	Hours - days	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking:</u> natural-occurring, animal feces, agricultural contamination (freshwater); fertilizer
<u>Pesticides</u> (organophosphates or carbamates)	Minutes - few hours	Headache, nervousness, twitching, convulsions, miosis, cramps, nausea, vomiting, diarrhea, chest pain, cyanosis	Weakness/ neuropathy may last weeks	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking:</u> agricultural contamination; back siphonage, seepage following soil-foundation spraying
<u>Sodium fluoride</u>	Minutes - months	Salty/soapy taste, numbness in mouth, vomiting, diarrhea, dilated pupils, spasms, pallor, shock, collapse; severe hypocalcemia, hyperkalemia, bone disease	Variable	<u>Water</u> <u>Food</u> <u>Environment</u>	<u>Drinking:</u> natural deposits, water treatment plant malfunction

¹ Please refer to National Outbreak Reporting System (NORS) Guidance document for more information regarding exposure categories.

Notes





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