For an accessible version: https://www.cdc.gov/healthywater/emergency/preparedness-resources/drinking-water-outbreak-toolkit.html

WATERBORNE

Disease Outbreak Investigation Toolkit

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

Contents

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 two[1] 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.

[1]Case 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.

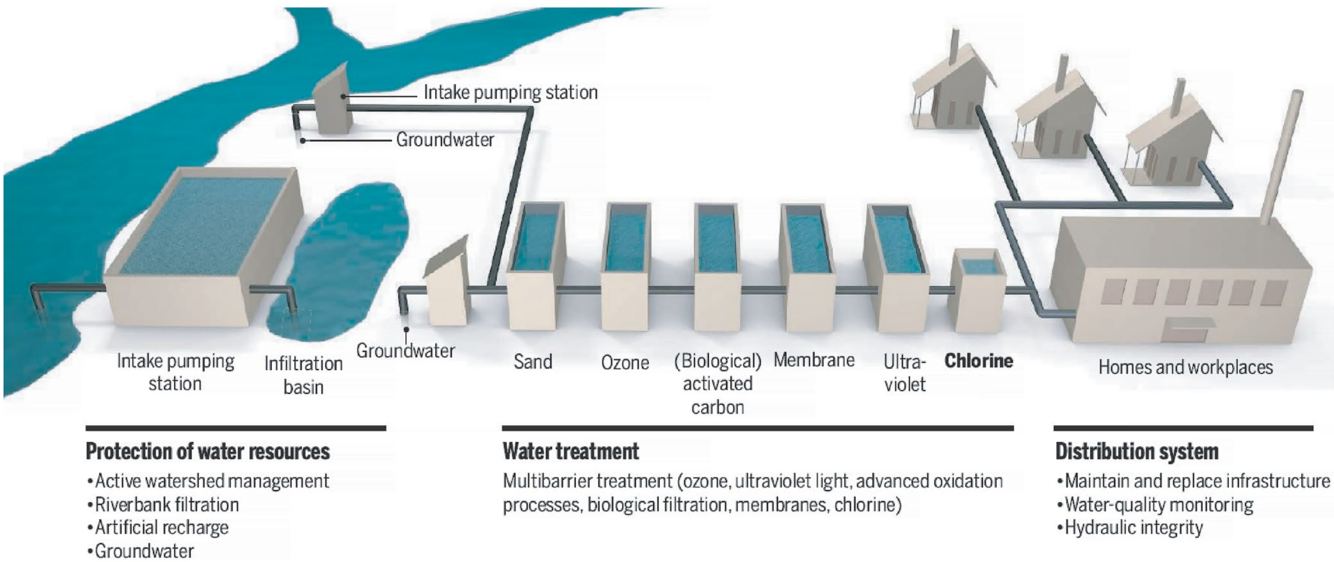


Figure 1: Drinking water system.
This figure illustrates the path water takes from water source, to water treatment, to water distribution system.

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 recreation al 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 ot 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. Learn more in the below appendix.
- **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:

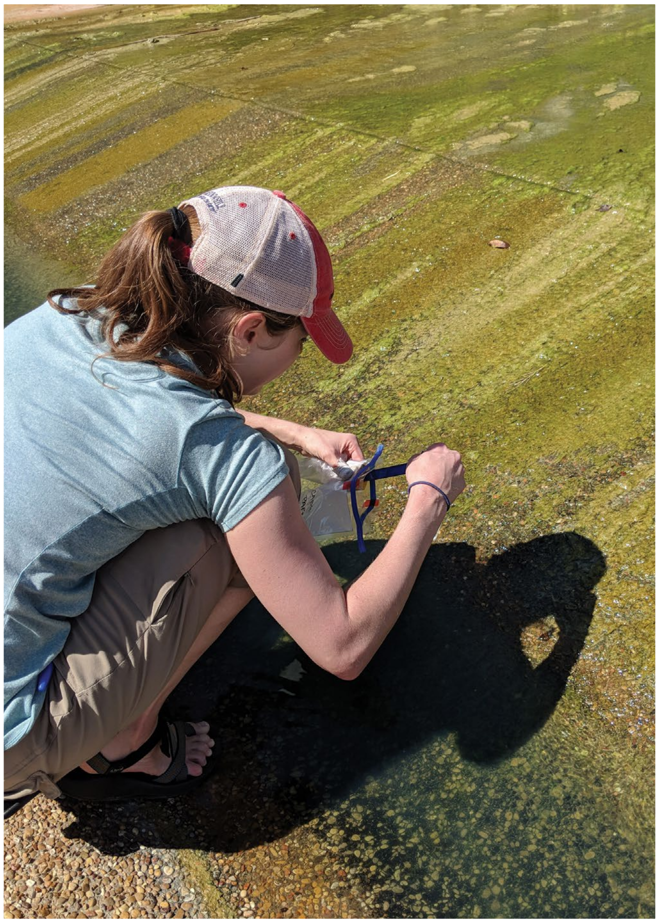
- **Goal**—What do you want people to know or do?
- **Audience(s)**—Who are you communicating with?
- **Message**—What information do you want to communicate?
- **Strategies**—How are you going to achieve your communication goal?
- **Timeline**—When are you going to do it?
- **Staffing and/or partnerships**—Who 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 diease (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 of 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	▪ Healthy swimming messages ▪ Boil water advisories
Processes and Policies	Change the way people interact with water systems	▪ Bathroom breaks at pools ▪ Diarrhea exclusion policies ▪ Point-of-use water filters
Water Treatment to Reduce Risk	Isolate people from the hazard	▪ Remediation ▪ Hyperchlorination ▪ Temporary closure of building wing ▪ Temporary closure of a beach

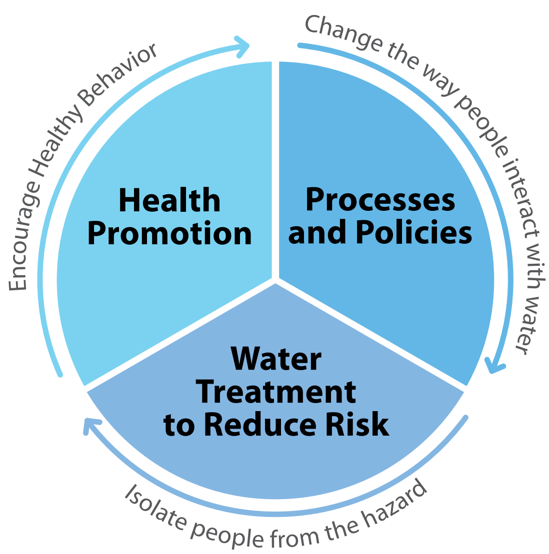


Figure 2: The cycle of the three primary public health strategies to control waterborne disease outbreaks.

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 is 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

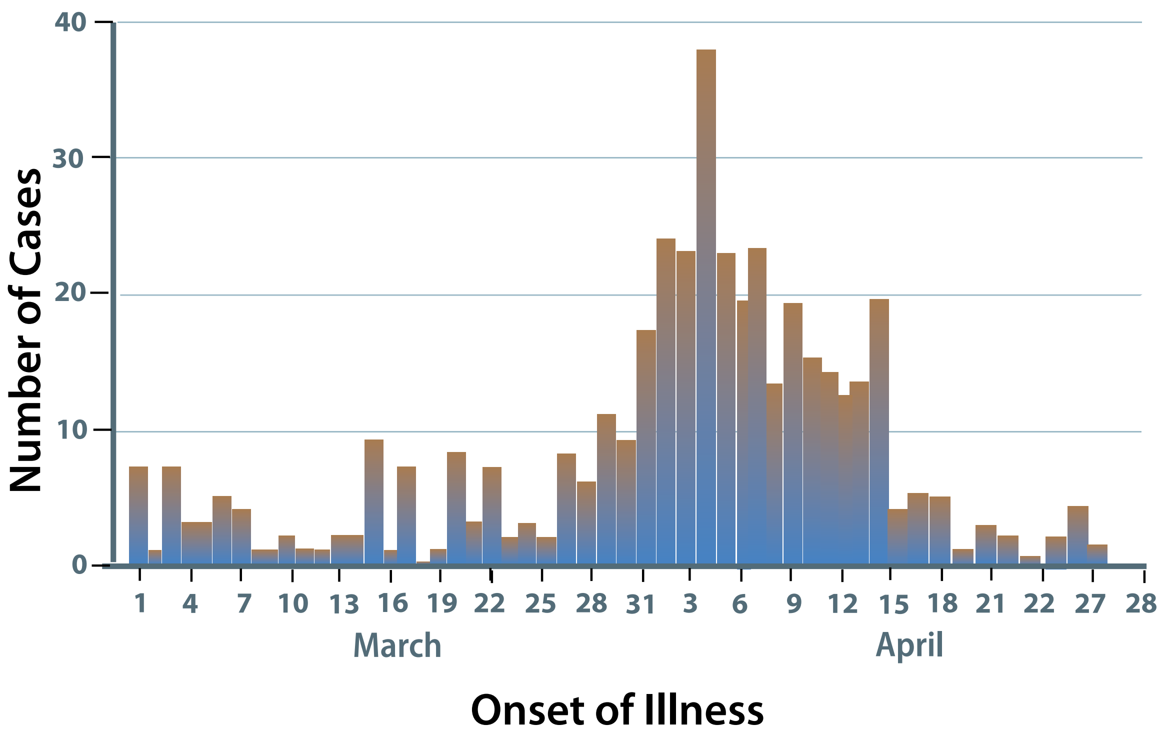
Interpretation of an Epidemic Curve

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
Bacillus anthracis	2 days - weeks	Nausea, vomiting, malaise, bloody diarrhea, abdominal pain	Weeks	Water Food Animal contact Environment	Drinking, recreational: naturally-occurring spores, intentional contamination
Campylobacter jejuni	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
Cronobacter 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
Enterotoxigenic Escherichia coli (ETEC)	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
Shiga toxin-producing Escherichia coli (STEC)	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
Francisella tularensis	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
Legionella 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
Leptospira 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
Non-tuberculous *Mycobacterium* 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
Plesiomonas shigelloides	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	Water Food Animal contact Environment	Drinking: naturally-occurring (fresh/saltwater), potentially domestic sewage
Pseudomonas aeruginosa	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	Water Person-to-person Environment	Drinking, recreational, other exposures to water: biofilm-associated, inadequate cleaning/chlorination—hot tub, pools, and water vessels
Salmonella spp.	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	Water Food Animal contact Person-to-person Environment	Drinking: human feces and urine, domestic sewage, animal (poultry, amphibians, reptiles, rodents) feces; farm runoff, meat/poultry processing plant wastes, back siphonage, inadequate disinfection
Shigella spp.	12 hours - 7 days	Fever, cramps, vomiting, tenesmus, diarrhea that can be bloody and mucoid	4 - 7 days	Water Food Person-to-person Environment	Drinking, recreational: human feces, domestic sewage; back siphonage, inadequate disinfection
Vibrio cholerae (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	Water Food Environment	Drinking: 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
Vibrio parahaemolyticus	2 - 48 hours	Cramps, nausea, vomiting, watery diarrhea, wound/ear infections	2 - 5 days	Water Food Environment	Recreational: naturally-occurring (brackish/saltwater, warm weather) + open wound
Vibrio vulnificus	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	Water Food Environment	Recreational: naturally-occurring (brackish/saltwater, warm weather) + open wound + immuno-suppression
Yersinia enterocolytica and *Y. pseudo-tuberculosis*	1 - 7 days	Appendicitis-like symptoms (fever, abdominal pain, diarrhea, vomiting), typically in older children and young adults. Y. pseudotuberculosis may cause scarlitiniform rash	1 - 3 weeks	Water Food Animal contact Person-to-person Environment	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	Water Food Animal contact Person-to-person	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	Water Food Person-to-person Environment	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	Water Food Person-to-person Environment	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	Water Food Person-to-person Environment	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
Acanthamoeba spp.	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
Acanthamoeba keratitis	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
Angiostrongylus cantonensis	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
Cryptosporidium	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
Cyclospora cayeanensis	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
Entamoeba histolytica	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
Giardia	1 - 4 weeks	Cramps, diarrhea (pale, greasy, malodorous stool), flatulence, bloating, vomiting, fatigue, fever	Days to weeks	Water Food Animal contact Person-to-person Environment	Drinking, recreational: human feces, domestic sewage, animal (beavers, ruminants, birds, dogs, cats, etc.) feces; inadequate disinfection/ filtration
Naegleria fowleri	1-9 days	Headache, fever, nausea, vomiting, neck stiffness, seizures, altered mental status, hallucinations, coma	1-18 days. Almost always fatal	Water	Recreational, drinking: Water containing Naegleria fowleri enters the nose
Toxoplasma gondii (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	Water Food Environment	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	Water Food Environment	Drinking, recreational: naturally-occurring algal blooms (fresh/brackish/saltwater)
Antimony	5 minutes – 8 hours, depending on dose	Vomiting, metallic taste	Variable	Water Food Environment	Drinking: 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	Water Food Environment	Drinking: natural deposits, agricultural/industrial contamination (freshwater); pesticides, back siphonage, indiscriminate disposa
Cadmium	Several months	Abdominal pain, salivation, nausea, vomiting, myalgia, kidney damage, lung damage, fragile bones	2 - 9 days	Water Food Environment	Drinking: 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	Water Food Environment	Drinking: 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
Lead	Weeks - months	Irritability, anorexia, abdominal pain, high blood pressure, kidney problems, Developmental delays, cerebral edema, encephalopathy, seizures, death	Weeks - months	Water Food Environment	Drinking: plumbing/water pipe corrosion (freshwater)
Nitrite	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	Water Food Environment	Drinking: natural-occurring, animal feces, agricultural contamination (freshwater); fertilizer
Pesticides (organo-phosphates or carbamates)	Minutes - few hours	Headache, nervousness, twitching, convulsions, miosis, cramps, nausea, vomiting, diarrhea, chest pain, cyanosis	Weakness/ neuropathy may last weeks	Water Food Environment	Drinking: agricultural contamination; back siphonage, seepage following soil-foundation spraying
Sodium fluoride	Minutes - months	Salty/soapy taste, numbness in mouth, vomiting, diarrhea, dilated pupils, spasms, pallor, shock, collapse; severe hypocalcemia, hyperkalemia, bone disease	Variable	Water Food Environment	Drinking: natural deposits, water treatment plant malfunction

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

Investigating Harmful Algal Blooms

IN THIS SECTION:

Harmful Algal Blooms Can Harm People and Animals

"Harmful algal bloom (HAB)" is a general term used to describe the rapid growth of algae or cyanobacteria (also called blue-green algae) in water that can harm people, animals, or the local ecology. Algae more frequently bloom in salt or brackish water. Cyanobacteria more frequently bloom in fresh water. Toxins from HABs can contaminate surface water and food sources, such as fish or shellfish. A HAB can be identified when a bloom is visible in the water or HAB toxins are detected in water or food.

Exposure to harmful algae, cyanobacteria, or their toxins can cause a range of mild to severe symptoms in humans and animals. For example, exposure can occur through:

- Skin contact during activities like swimming
- Breathing in tiny airborne droplets or mist contaminated with HAB toxins or cells
- Eating food or drinking water contaminated with HAB toxins or cells
- Swallowing water contaminated with HAB toxins or cells during recreational activities (for example, swimming)

Health effects depend on the type and amount of toxin, algal cells, or cyanobacterial cells in the air, water, or food and the route and degree of exposure. Humans and animals can experience a variety of health effects that may range from mild to severe.

Animals such as dogs, cattle, birds, and fish might experience health effects before people when HABs are present in the water because of physiological characteristics as well as the animals' behaviors, such as drinking or swimming in water that contains HABs. Animals that live in water or eat shellfish can be at higher risk because they cannot avoid contaminated water or food.

Visit CDC's HAB-Associated Illnesses website for more information on illnesses, sources of exposure, risk factors, and prevention.

Investigating Harmful Algal Bloom Events and Associated Illnesses Using a One Health Approach

The One Health approach recognizes that the health of people is connected to the health of animals, plants, and the environment, and engages partners from multiple disciplines. Organizations that partner with health departments to address HABs using a One Health approach can include state agencies with environmental or animal health responsibilities, poison control centers, universities, healthcare facilities, and research institutions.

People who suspect they became ill from a HAB exposure might seek treatment from poison control centers, healthcare providers, or health departments. If illnesses are reported to the health department, the health department can begin compiling case interview and environmental data to help determine if a HAB-associated illness has occurred. They can further assess the data by collaborating with partners to review exposure, symptom, clinical, and environmental data. Health departments can enter these data into public health surveillance systems, such as the national One Health Harmful Algal Bloom System (OHHABS).

Workflow example:

HAB Event Occurs
- People are exposed to water contaminated by the HAB (for example, while swimming)

Ill People Seek Care
- Poison Control Center
- State/local health department
- Medical provider

Health Department Investigates
- Poison control data
- Case interviews
- Clinical data
- Environmental data (routine monitoring or in response to a possible HAB)

Health Department Assessment
- Collaborate with partners
- Review exposure, signs, symptoms, clinical, and environmental data

Health Department Enters Data in OHHABS
- Health department or designated partners enter data

Jurisdictional Partnership and Interagency Activities

Possible roles of partners who might coordinate with health departments to identify HAB events and support One Health responses when there are illnesses:

Environmental staff and agencies (for example, Department of Natural Resources, Department of Parks and Recreation, Department of Environmental Protection, waterbody managers) can:

- Report HAB events and environmental data for human and animal cases of illness to the One Health Harmful Algal Bloom System (OHHABS).
- Monitor water quality or respond to suspected HABs by sampling water to look for specific genera or test for toxins.
- Monitor satellite imagery (for example, using the CyAN app) and other information to identify new blooms.
- Collect and review illness complaints from staff or the public, and forward to the health department.
- Maintain a database of jurisdiction-reported HAB events or water quality monitoring data.
- Provide data on water quality conditions through websites or interactive maps.
- Coordinate with federal agencies (for example, the U.S. Army Corps of Engineers) on jointly managed waterbodies.
- Coordinate with drinking water authorities if the impacted waterbody is a drinking water source.
- Post advisories at state park beaches and boat ramps.
- Maintain a website about HABs and conduct outreach to the public.
- Provide HAB sample collection protocols and training, including guidance for residents on private lakes and other private water bodies.
- Engage citizen scientists through programs such as the National Oceanic and Atmospheric Administration's (NOAA) Phytoplankton Monitoring Network (PMN).

Animal staff and agencies (for example, Department of Fisheries and Wildlife, Department of Agriculture, State Agricultural Extension, and the state public health veterinarian) can:

- Report HAB-associated cases of illness in wildlife, livestock, and domestic animals to the health department or into OHHABS.
- Receive, follow up on (for example, collect data about symptoms, activities, and water conditions), or triage illness reports from a variety of sources.
- Evaluate illness reports, support local health district investigations, and work with the health department to classify reports according to existing case definitions.
- Provide information to the public and veterinarians about HABs and how to prevent health effects in animals (for example, pets, livestock).
- Develop and distribute outreach materials to medical care providers and health departments (for example, via a bulletin, website, social media, meetings, conference calls).
- Make extension services aware of available resources and methods that can be used to mitigate HAB events.
- Participate in interagency workgroups to learn about and support HAB coordination efforts.
- Provide additional expertise related to agricultural water or settings (for example, irrigation distribution systems, farms, ranches).

Universities and research institutions can:

- Identify and quantify HAB species in samples collected for monitoring and in response to blooms or fish kills.
- Research environmental factors that affect HAB growth and develop models to predict the onset and toxicity of HAB events.
- Develop student programs to provide surge capacity support for health departments (for example, the University of North Carolina's Team Epi-Aid).
- Research specific lakes or geographic areas such as the Ohio Department of Higher Education (ODHE) Harmful Algal Bloom Research Initiative.
- Develop risk communication material for HABs, such as the Environmental Research Institute of the States' HABs Risk Communication Hub and the Water Research Foundation's Development of a Risk Communication Tool Kit for Cyanotoxins.
- Research socioeconomic impacts and effects of HABs (for example, Woods Hole Oceanographic Institution [WHOI] and NOAA Report on U.S. Socio-Economic Effects of Harmful Algal Blooms).

Poison control centers can:

- Respond to public health emergencies.
- Provide advice and guidance on HAB exposures or adverse health effects.
- Assist with reporting (see Using Poison Center Information to Identify a Harmful Algal Bloom (HAB) Outbreak in Utah).
- Provide data on inquiries related to toxins in specific settings or due to specific exposures.
- Provide information to states about upticks in calls about HABs or HAB toxins using existing algorithms.

Other partners to engage include healthcare providers, veterinarians, beach operators and staff, lake and homeowner associations, drinking water utilities, fishing and wildlife guides, hunters, environmental groups, agricultural groups, and the public.

Federal agencies—such as the Centers for Disease Control and Prevention (CDC), U.S. Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), and U.S. Army Corps of Engineers (USACE)—can assist with an outbreak response. Depending on the location and nature of the HAB, other federal agencies (for example, Bureau of Indian Affairs or the National Park Service) might be involved.

Key Federal Partners

Centers for Disease Control and Prevention (CDC)

CDC provides useful toolkits and communications resources for information about OHHABS and HABs. Resources include the OHHABS partner toolkit, health promotion materials, and factsheets.

For technical assistance, health communication support, or consultation in state and local response to HABs, contact OHHABS@cdc.gov.

HAB-associated cases of illness outbreaks through the OHHABS and the National Outbreak Reporting System (NORS), respectively. For technical assistance with reporting HAB events and cases, contact OHHABS@cdc.gov. For assistance with reporting outbreaks, contact NORSWater@cdc.gov.

Environmental Protection Agency (EPA)

EPA provides useful toolkits and tracking information on the Cyanobacterial Harmful Algal Blooms (CyanoHABs) in Water Bodies website. Resources include guidance on managing cyanotoxins in recreational waters and preventing, controlling, and treating surface waters with a HAB.

Contact EPA CyanoHABS for more information at EPACyanoHABS@epa.gov, or visit the EPA Office of Water and Regions Contact Information page.

National Oceanic and Atmospheric Administration (NOAA)

NOAA's National Centers for Coastal Ocean Science (NCCOS) maintains rapid response capabilities that help state and local coastal public health and resource managers have ready access to critical data on the types of HAB species and toxins that are present during a HAB event.

- The Analytical Response Team acts as one of the primary responders to HABs and associated animal mortality events, providing rapid and accurate identification of harmful algae and their associated toxins.
- The HAB Event Response Program provides immediate assistance to help federal, state, and local officials manage events and advance the understanding of HABs as they occur. Depending on need, the program may provide access to toxin analysis, training, and technical assistance and support ship-based offshore sampling.

Contact NCCOS HAB Event Program for more information or to inquire about support at nccos.hab.event.response@noaa.gov.

HAB-Associated Illness and Outbreak Response

1. Detect a Possible HAB Event, Case, or Outbreak

Health departments might receive human and animal illness reports from a variety of sources, including the public, healthcare and veterinary providers, automated email case notifications from poison control centers, health department or lake association referrals, hotlines (via phone, email, and online form submission), social media notices, and referrals from environmental and animal organizations and agencies (for example, the Department of Fisheries and Wildlife or the Department of Agriculture). Water utilities or managers of recreational bodies of water (for example, a beach operator) might notify local and state health departments of a HAB event in drinking or recreational water.

Epidemiologic data

- **Illness complaint systems** provide a means for the public, healthcare providers, veterinarians, and others to report public health concerns to health departments. Online complaint forms that automatically notify health department staff might expedite the identification and review of complaints.
- **Interviews with people who potentially have a HAB-associated illness** provide important clues about the source of exposure. Once health department staff receive a health complaint, they might initiate a complaint investigation. Health department staff might contact the complainant by phone and conduct a structured interview using a standardized questionnaire.
- **Regular reviews of the data** identify patterns in the geographic distribution of illnesses and the time periods when people became ill, which helps health departments identify outbreaks. Some states mandate that healthcare providers report certain HAB-associated illnesses.
- **Increased calls to poison control centers** can also indicate an outbreak. CDC warns state health departments when there is an uptick of calls about specific poisonings. In collaboration with CDC, poison control centers can follow up with callers to ask additional questions about exposures and symptoms.
- **Medical and veterinary providers** can notify local and state health departments of unusual or increased cases of HAB-associated illnesses within their hospitals or clinics; these reports might include additional clues from patient histories.

Clinical/laboratory data

- Patient illness information can help health departments determine if a patient's illness is associated with an outbreak.
  - Health departments can review medical records to identify additional patients 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.
- Access to clinical testing for HAB toxins is limited. However, CDC and certain private and academic labs can measure some toxins in biological specimens to verify exposure.

Environmental monitoring programs

- Water quality testing can identify risks and potential sources of contamination. Many states mandate public reporting (advisories) of decreased water quality in drinking water systems.
- Beach monitoring programs can identify decreased water quality, including the presence or increased levels of harmful algae, cyanobacteria, or toxins.
- Some events that can increase the risk for HABs (for example, by increasing the amount of nutrients or water temperature) can also be monitored. These events include floods, droughts, sewer system overflows, and water system outages.
- National data on water quality relevant to HABs include:
  - USGS data on water, including water levels, streamflow, temperatures, and more.
  - NOAA data on rainfall.
  - National Weather Service weather data, including information on rivers, lakes, and rainfall.
  - EPA's CyAN app, a free app that can be used to monitor cyanobacteria occurrence.
- Complaints from the public to environmental health agencies, water utilities, or the water regulatory agency offer another source of environmental data.

Investigative tools

In addition to standard tools such as a case line list, maps, or epidemic curves, health departments can report data to surveillance systems. Some health departments have developed standardized forms to use during health investigations. Furthermore, when an environmental agency receives laboratory results from water sampling, agency staff can share this information with:

- Local, regional, or state public health authorities
- Public affairs managers, state or regional HAB coordinators, and appropriate water quality agency staff
- State management officials (for example, if the water body is located within their jurisdiction)
- Drinking water program staff and the water utility, if the water body is a potential source of drinking water

Finally, OHHABS, a CDC surveillance system, can be used by health departments to report data after an investigation is complete. Data from standardized human or animal forms, laboratory findings, and medical records can be entered in the surveillance database.

2. Define and Find Cases

Health department staff develop case definitions for investigations and weigh the strength of evidence linking the case to a HAB exposure. The case classification used in an investigation might evolve over time as more information becomes available.

Developing a case definition for a HAB-associated outbreak

Consider the following when formulating a HAB-associated illness case definition:

- Signs and symptoms of the illness
- The HAB species or toxin, if known
- Signs and symptoms typically caused by that toxin or algal or cyanobacterial species
- Time between exposure and illness onset

Case definitions can vary across states and territories. See Wisconsin's Case Reporting and Investigation Protocol and CDC's HAB event, human case, and animal case definitions for examples.

Environmental investigation

During a HAB event, the health department can conduct a source investigation in coordination with the state environmental agency to determine if there is an ongoing risk to the public. The investigation could include visiting the site to assess current water conditions, taking photos of water conditions, collecting water samples, or collecting fish or shellfish.

Based on case investigation findings from a human or animal illness complaint, the health department might coordinate water sampling and analysis with the state environmental agency. The state public health laboratory might also analyze samples collected by the state environmental agency, veterinarians, or the public.

3. Control Outbreaks/Illnesses Through Remediation and Outreach

HAB mitigation typically focuses on reducing exposures in humans and animals. Various physical, chemical, and biological measures can control HABs in surface water, and there are treatment processes to remove cyanobacterial cells and toxins from drinking water. The control measure used might depend on site-specific characteristics of the body of water with the HAB event.

Interventions to protect public health—such as public messaging, health advisories, beach or water body closures, or shellfish harvest restrictions—might be implemented in advance of water testing or while results are pending.

Expect toxin or cell concentrations and their public health risks to vary by the type of HAB event or toxin. Toxin or cell concentration values used for public health action (for example, beach closures) can vary by jurisdiction and type of exposure. For multiple toxins, there are limited data to provide clear guidance on risk. NOAA has worked to improve tools for monitoring multiple HAB toxins.

CDC's Crisis and Emergency Risk Communication (CERC) program provides trainings, tools, and resources to help health communicators, emergency responders, and leaders of organizations communicate effectively during emergencies. The CERC manual, tools, templates, and trainings are available on the CERC website. Please email cercrequest@cdc.gov with any questions or requests for trainings or materials.

Drinking Water Health Advisories

In 2015, EPA published 10-day Drinking Water Health Advisories for two types of cyanotoxins: microcystins and cylindrospermopsin. The advisories state that for children younger than 5 years old, toxin levels in drinking water should not exceed 0.3 micrograms per liter for microcystin and 0.7 micrograms per liter for cylindrospermopsin.

For all other ages, EPA recommends that toxin levels not exceed 1.6 micrograms per liter for microcystin and 3.0 micrograms per liter for cylindrospermopsin. If toxin concentrations are above these levels, the public should be notified not to drink the water. Boiling the water will not remove toxins and could increase the concentration of toxins.

The World Health Organization's (WHO) Toxic Cyanobacteria in Water Guide provides additional considerations for developing management strategies and monitoring programs for cyanobacteria in drinking water.

Recreational Water Health Advisories

In 2019, EPA issued Recommended Recreational Ambient Water Quality Criteria or Swimming Advisories for two types of cyanotoxins: microcystins and cylindrospermopsin. The values recommended by EPA for microcystins and cylindrospermopsin were based on children's recreational exposures. This is because children's behavior and development can lead to higher exposures compared with other age groups. Toxin levels should not exceed 8 micrograms per liter for microcystins and 15 micrograms per liter for cylindrospermopsin. The recommendations are also protective of older age groups.

EPA recommendations for monitoring methods and testing are focused on toxins; these recommendations are based on the 2003 World Health Organization (WHO) Guidelines for Safe Recreational Water Environment. However, some states might use the cyanobacteria cell, chlorophyll *a*, or microcystin levels outlined in the 2003 WHO recreational guidance or the updated 2021 WHO guidelines on recreational water quality as alternative monitoring guidelines. State recreational water guidelines might also consider the greater risk cyanotoxins pose for children and people with weakened immune systems and use lower levels to trigger issuing a health advisory than the levels from the WHO guidelines.

Table: WHO (2003) Recreational Guidance/Action Levels for Cyanobacteria, Chlorophyll *a*, and Microcystin[a]

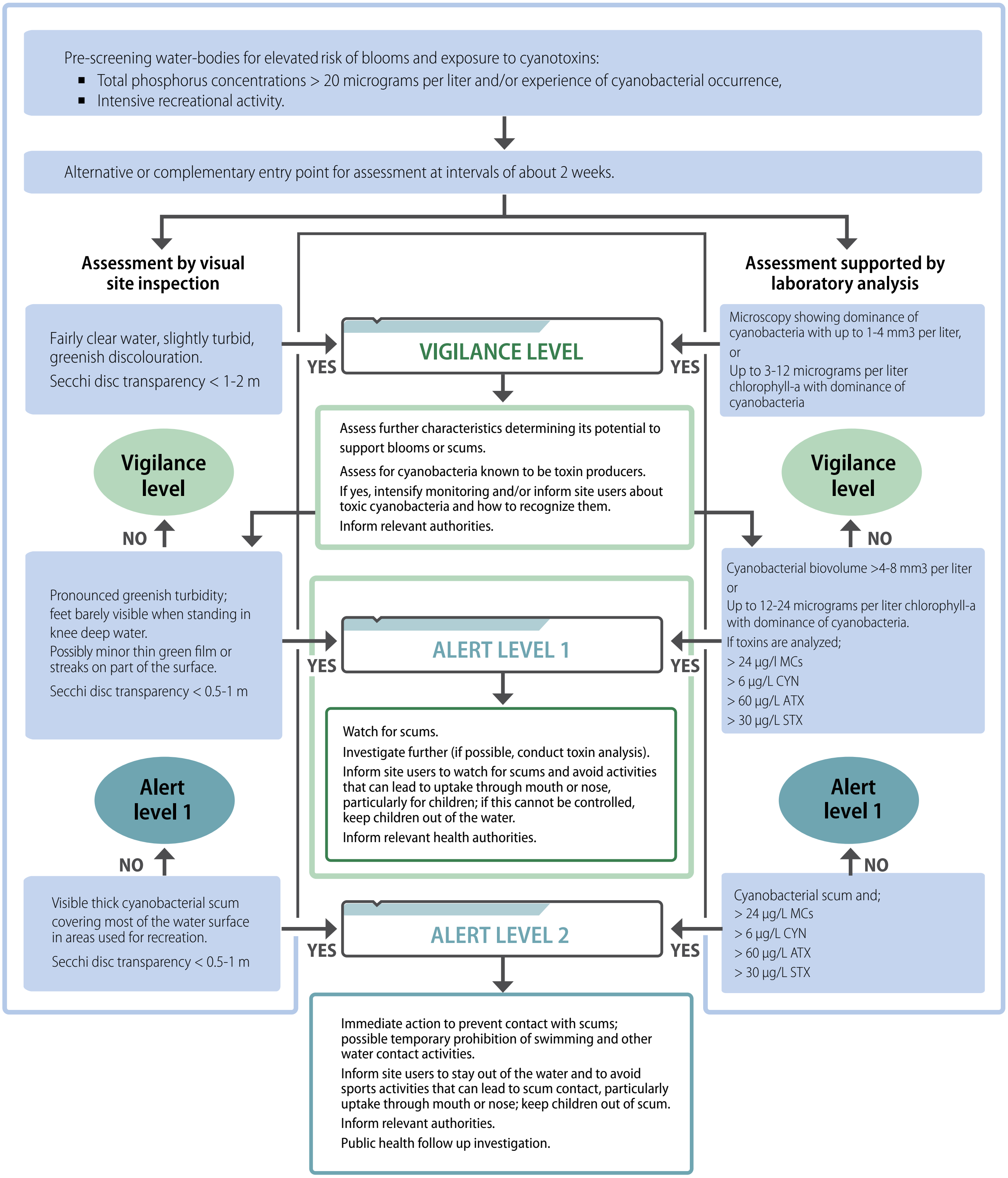
Relative Probability of Acute Health Effects	Cyanobacteria (cells/mL)	Chlorophyll *a* (µg/L)	Estimated Microcystin levels (µg/L)[b]
Low	< 20,000	< 10	< 10
Moderate	20,000 – 100,000	10 – 50	10 – 20
High	>100,000 – 10,000,000	50 – 5,000	20 – 2,000
Very High	>10,000,000	>5,000	>2,000

Source modified from [a]EPA's Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters – Table (Based on 2003 World Health Organization (WHO) Guidelines for Safe Recreational Water Environment)

[b]WHO (2003) derived the microcystin concentrations from the cyanobacterial cell density levels.

Figure: **Alert level framework for monitoring and managing cyanobacteria in recreational water bodies**[a]

To access an accessible version of this flowchart, Please click here.



[a]Source: modified from: Chorus & Testai (*Toxic cyanobacteria in water*, 2021). 2021 World Health Organization (WHO) Guidelines on Recreational Water Quality

– Figure 5.1. Alert level framework for monitoring and managing cyanobacteria in recreational water bodies[a].

Outreach

There are multiple ways to provide information about HAB safety and health effects to the public including:

- Social media
- Radio
- Television
- Press release to the media
- Door-to-door communication

The best way to provide this information will depend on the specific community and its needs. Examples of information that could be communicated:

- Sharing HAB information and advisory updates, including
  - Posting and lifting of advisories at local bodies of water
  - Updates about control measures
  - Changes in health advice
- Encouraging the public to:
  - Report potential HAB events and HAB-associated illnesses in humans and animals to their health department
  - Contact their healthcare provider or the Poison Control hotline (1-800-222-1222) if they think a HAB made them sick
  - Contact a veterinarian for an evaluation if they think a HAB made the animal sick
  - Contact their health department for more information about HABs

Outreach to healthcare providers, veterinarians, and health departments can include:

- Developing and distributing outreach materials via bulletins, websites, newsletters, social media, meetings, conference calls, or other channels. These materials can:
  - Encourage healthcare providers and veterinarians to report suspected HAB-associated illnesses cases to their health department and tell them how to get assistance with reporting
  - Provide guidance to healthcare providers and veterinarians on recognizing HAB-associated illnesses, diagnostic testing, and case management

4. Decide Whether the Outbreak Is Over

A HAB-associated illness outbreak ends when the bloom has ended, or mitigation measures result in the public no longer being at risk. When the outbreak is over, ensure members of the community affected by the outbreak are informed that there is no longer a risk.

5. Help Prevent Future Outbreaks by Summarizing, Interpreting, and Reporting Findings

Reporting HAB Events, Cases, and Outbreaks

- Local Health Departments
  - Most states require that local health departments report foodborne or waterborne outbreaks, including HAB-associated illness outbreaks, to their state, territorial, or freely associated state health department.
- State and Territorial Health Departments
  - Report HAB-associated illness outbreaks (two or more cases of human illness) to NORS.
    - NORS captures aggregate information about outbreaks. It does not capture details about individual exposures or information about animal cases.
  - Report HAB events or cases of HAB-associated illness in humans or animals to OHHABS.
    - State health departments can decide to grant OHHABS access to partners (for example, environmental, animal health, poison control, and health department staff) to expedite reporting.
    - HAB events are classified as suspected or confirmed, and HAB-associated human or animal cases are classified as suspected, probable, or confirmed.
    - Find OHHABS forms and guidance on the Using OHHABS page. Email OHHABS@cdc.gov for technical assistance.

Learning From Outbreak Investigations

HABs might increase in frequency and severity due to climate change, farming practices and other land use, storm and wastewater runoff, and other environmental factors. Identifying HABs and resulting illnesses is critical to determine their patterns of occurrence, to protect recreational and drinking water and food supplies, and to alert the public when there is a problem.

Surveillance for HAB-associated human and animal illnesses and outbreaks provides standardized information about the number of cases occurring each year, where and when illnesses are occurring across the United States, and symptoms and signs in humans and animals from exposure to HABs. These data help to better define the effects of HABs on humans, animals, and the environment.

Resources

General Resources

State:

- Florida: Resource Guide for Public Health Response to Harmful Algal Blooms in Florida
- Kansas: HABs Agency Response Plan
- New Jersey: 2020 Cyanobacterial HAB Freshwater Recreational Response Strategy
- New York: HABs Program Guide and HAB Action Plans
- Ohio: HAB Response Strategy for Recreational Waters
- Ohio: Public Water System HAB Response Strategy
- Rhode Island: HAB and Shellfish Biotoxin Monitoring and Contingency Plan
- Utah: Algal Bloom (Cyanobacteria) Response Plan
- Virginia: HAB Response Plan
- Wisconsin: Communicable Disease Case Reporting and Investigation Protocol: Cyanobacteria & Cyanotoxin Poisoning
- Wisconsin: Harmful Algal Blooms Toolkit

Federal:

- Centers for Disease Control and Prevention (CDC): Harmful Algal Bloom (HAB)–Associated Illness
- National Oceanic and Atmospheric Administration (NOAA): Harmful Algal Blooms
- US Environmental Protection Agency (EPA): Cyanobacterial Harmful Algal Blooms (CyanoHABs) in Water Bodies
- US Environmental Protection Agency (EPA): State Laboratories that Analyze for Cyanobacteria and Cyanotoxins
- US Environmental Protection Agency (EPA): State HAB Monitoring Programs and Resources
- US Environmental Protection Agency (EPA): Cyanotoxins Preparedness and Response Toolkit (CPRT)
- National Oceanic and Atmospheric Administration (NOAA): Federal HAB-Related Biospecimen Labs Inventory

International and Non-Governmental Organization (NGO):

- Government of Western Australia: HABs in Agriculture
- Interstate Technology Regulatory Council: Strategies for Preventing and Managing Harmful Cyanobacterial Blooms (HCB-1)
- Interstate Technology Regulatory Council: Strategies for Preventing and Managing Benthic Harmful Cyanobacterial Blooms (HCB-2)
- Merck: Merck Veterinary Manual
- New England Interstate Water Pollution Control Commission: HAB Control Methods

Drinking Water Resources

State:

- California: Cyanobacteria and Cyanotoxins in Drinking Water
- Ohio: Treatment of Blue-Green Algae in Pond Water
- Ohio: Guidance During Drinking Water HAB Advisories
- Ohio: Drinking Water Advisories for Ohio Public Water Systems
- Ohio: Public Water Systems
- Ohio: Guidance for Public Water Systems: Developing a HAB General Plan
- Ohio: Contingency Plan Template
- Utah: Developing a Cyanotoxin Management Plan

Federal:

- CDC: Drinking Water Advisory Communication Toolbox
- CDC: Crisis and Emergency Risk Communication
- EPA: Managing Cyanotoxins in Public Drinking Water System
- EPA: Cyanotoxin Management Tools for Public Water Systems
- EPA: Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water

International and NGO:

- American Water Works Association and Water Research Foundation: Resources on Cyanobacteria/Cyanotoxins
- Government of Canada: Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Cyanobacterial Toxins
- Australia Water Quality Research: RR 74: Management Strategies for Cyanobacteria (Blue-Green Algae): a Guide for Water Utilities
- World Health Organization: Technical Brief: Management of Cyanobacteria in Drinking-Water Supplies
- World Health Organization: Identifying, Assessing, and Managing Drinking-Water Quality Risks in Surface-Water Catchments
- Global Water Research Coalition: International Guidance Manual for the Management of Toxic Cyanobacteria

Recreational Fresh Water Resources

State:

- California: California Voluntary Guidance for Response to HABs in Recreational Inland Waters
- California: SWAMP's California Freshwater Harmful Algal Bloom Field Guide
- California: Resources for Mitigating HABs
- Kansas: Info for Lake Managers
- Minnesota: Tools for Local Government Agencies: Harmful Algal Bloom–Related Illness
- Ohio: Algae Information for Recreational Waters
- Oregon: Recreational Use Public Health Advisory Guidelines
- Oregon: Advisory, Sampling, and LPHA Guidance
- Utah: 2021 Recreational Health Advisory Guidance for Harmful Algal Blooms
- Utah: Signage: Harmful Algal Blooms

Federal:

- CDC: Illness and Symptoms: Cyanobacteria in Fresh Water
- EPA: Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Waters
- EPA: Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters
- EPA: EPA Preparing for HABs Season Webinar: Planning and Responding to Cyanotoxins in Recreational Waters, June 20, 2019
- EPA: Communicating about Cyanobacterial Blooms and Toxins in Recreational Waters
- USGS: Field and Laboratory Guide to Freshwater Cyanobacteria HABs for Native American and Alaska Native Communities
- USGS: National Field Manual for Collection of Water-Quality Data

International and NGO:

- Association of Public Health Laboratories: A Freshwater Algal Toxin Guidance Document for Public Health Laboratories
- Germany: Federal Environment Agency, Current approaches to cyanotoxin risk assessment, risk management and regulations in different countries

Marine Water Resources

State:

- Florida: HABs: Harmful Algae Blooms
- Florida: Shellfish Harvesting Area and Aquaculture Lease Map
- Rhode Island: Emergency Shellfish Harvesting Closure in Local Waters
- Rhode Island: Harmful Algae Bloom Biotoxins
- Washington State Sea Grant (University of Washington): Harmful Algal Blooms (HAB)

Federal:

- CDC: Illness and Symptoms: Marine (Saltwater) Algal Blooms
- CDC: 2020 Yellow Book | Health Information for International Travel: Food Poisoning from Marine Toxins
- EPA: EPA Preparing for HABs Season Webinar: Planning and Responding to HABs in Coastal Waters, May 23, 2019
- FDA: Marine Biotoxin Management - Video
- NOAA: Gulf of Mexico HAB Forecast

Case and Environmental Reporting Resources

State Case Reporting Form:

- Florida: Florida Department of Health
- Minnesota: Minnesota Department of Health
- Ohio: Ohio Department of Health
- Illinois: Illinois Department of Public Health

State Environmental Form:

- California Water Quality Monitoring Council: Freshwater and Estuarine HAB Report Form
- Florida Department of Environmental Protection: Algal Bloom Sampling Status
- Indiana State Department of Health: HAB Report Form
- New York Department of Environmental Conservation: HAB Report Form

Outreach Resources for Local Government Agencies, Physicians, Veterinarians, and the Public

For Local Government Agencies

- CDC: One Health Harmful Algal Bloom System Partner Toolkit
- EPA: Cyanotoxins Preparedness and Response Toolkit (CPRT)
- California Water Quality Monitoring Council: Bloom Season Outreach Letter to Local Health Officers and Environmental Health Directors

For Healthcare Providers

- CDC: Cyanobacterial Blooms: Information for Healthcare Providers
- California Water Quality Monitoring Council: Resources for Medical Professionals
- Ohio: Information for Physicians
- Wisconsin: Blue-Green Algae: Resources for Health Professionals

For Veterinarians

- American Veterinary Medical Association: Harmful algal blooms (HABs)
- CDC: Cyanobacterial Blooms: Information for Veterinarians
- California Water Quality Monitoring Council: Resources for Veterinarians
- Michigan: HABs: Veterinarians
- Minnesota: Harmful Algal Bloom-Related Illness Information for Veterinarians

For the Public

- CDC: Communication Resources
- EPA: Look Out for Harmful Algal Blooms Infographic
- EPA: Important Online Resources on HABs
- Michigan: Pets and Livestock
- Oregon: FAQs: Cyanobacteria (Harmful Algae) Blooms and Recreational Advisories
- Oregon: Fishing and Blue-green Algae Blooms
- Oregon: Cyanobacteria Blooms in Privately Owned Ponds and Lakes
- Vermont: Cyanobacteria: Guidance for Vermont Communities
- Washington Sea Grant: Gathering Safe Shellfish in Washington
- Wisconsin: Fact Sheets

Figure: Alert level framework for monitoring and managing cyanobacteria in recreational water bodies

To return to the flowchart on page 36, Please click here.

A flow chart for identifying alert level for monitoring cyanobacteria in recreational water bodies. The flow chart starts from the top with pre-screening phase.

The pre-screening criteria for elevated risk of blooms and exposure to cyanotoxins include: A total phosphorous concentration threshold of greater than 20 micrograms per liter and/or cyanobacterial occurrence, and whether the body of water has intensive recreational use.

From there, the chart denotes a two week interval for assessment by either visual assessment or laboratory analysis. For visual assessment, criteria of slightly turbid water, a greenish discoloration, or a Secchi disc transparency level of less than 1-2 meters indicates movement to a vigilance level. Criteria for lab analysis is dominance of cyanobacteria to 1-4 mm^3 per liter or up 3-12 micrograms per liter of chlorophyll-a with dominance of cyanobacteria. If these criteria are met, the chart moves the water-body into vigilance level, which indicates the need to assess further for characteristics of blooms or whether cyanobacteria are known toxin producers to adapt monitoring processes if needed. Additionally, users should inform relevant health authorities at this level.

The next visual criteria includes pronounced greenish turbidity that obscures one's feet in knee-deep water with possible film or streaks on the surface of the water . Criteria for lab analysis includes cyanobacterial biovolume of over 4-8mm^3 per liter or up to 12-24 micrograms per liter of cyanobacteria dominant chlorophyll-a. If analyzing toxins at this stage, user can refer to the following thresholds:

- Over 60 micrograms per liter ATX
- Over 30 micrograms per liter STX
- Over 24 micrograms per liter MCs
- Over 6 micrograms per liter CYN

If any of these visual or laboratory criteria are met, the flow chart indicates the water-body will move to alert level one. At alert level one, action includes watching for scums, investigating further, informing site users to watch for scum, warning site users to avoid uptake through the nose or mouth, and if these risk factors cannot be limited to keeping children out of the water. Additionally, users should inform relevant health authorities at this level.

Criteria for alert level two should then be assessed. Visual criteria for alert level two is the presence of visible thick cyanobacterial scum covering most of the water's surface or a Secchi disc transparency less than 0.5-1 meter. The alert level two criteria for lab analysis includes cyanobacterial scum and:

- Over 60 micrograms per liter ATX
- Over 30 micrograms per liter STX
- Over 24 micrograms per liter MCs
- Over 6 micrograms per liter CYN

If alert level two criteria is reached, immediate action to prevent scum exposure must be taken. Inform site users to stay out of water and avoid activities that can lead to scum contact, particularly through the mouth or nose, and keep children out of scum. Inform relevant health authorities and follow up with a public health investigation.

[a]**Source: modified from: Chorus & Testai (*Toxic cyanobacteria in water*, 2021).** 2021 World Health Organization (WHO) Guidelines on Recreational Water Quality
– Figure 5.1. Alert level framework for monitoring and managing cyanobacteria in recreational water bodies[a].

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

CS336995-A