



WATERBORNE AND FOODBORNE DISEASE OUTBREAKS

QUICK FACTS

Each year, waterborne and foodborne disease outbreaks affect millions of people across the United States.^{1,2,3}

The number of reported drinking water-associated outbreaks involving gastroenteritis is decreasing over time and is likely linked to the fact that most Americans now get their drinking water from public water systems regulated by the EPA under the Safe Drinking Water Act (SDWA).⁴

The annual trend in reported recreational water-associated outbreaks is significantly increasing, particularly the number of outbreaks caused by *Cryptosporidium* and associated with treated recreational water.⁵

During 2008, the infectious organisms causing the greatest number of foodborne disease outbreaks were norovirus and *Salmonella*.⁶

Estimates of acute gastrointestinal illness associated with public drinking water systems in the United States range from 4 million to 33 million cases each year.^{1,2} Contaminated food consumed in the United States causes an estimated 48 million cases of acute gastrointestinal illness each year. Of these, approximately 128,000 require hospitalization and 3,000 result in death³

INTRODUCTION

Waterborne disease outbreaks and foodborne disease outbreaks occur when people are exposed to unsafe levels of man-made or naturally occurring contaminants in recreational water, drinking water, and foods. Each year, waterborne and foodborne disease outbreaks affect millions of people across the United States. Caused by bacteria, viruses, parasites, or chemical contaminants in food and water, the health effects from these outbreaks can range from gastrointestinal illness, to respiratory issues, to even death. Estimates of acute gastrointestinal illness associated with public drinking water systems underestimate the true incidence of waterborne disease, because they do not include illnesses associated with recreational water. The foodborne disease estimates do include nongastrointestinal symptoms caused by the 31 known pathogens.^{2,3}

Most waterborne and foodborne disease outbreaks are caused by bacteria, viruses, or parasites, but some result from chemical or toxin poisonings. For example, ingestion of fish or shellfish contaminated with toxins released from algae or ingestion of natural products containing toxins (e.g., poisonous mushrooms) can cause illness.

Because most microorganisms or toxins enter the body through the gastrointestinal tract (stomach, intestines, colon), nausea, vomiting, abdominal cramps, and sometimes diarrhea are likely to be the first symptoms of waterborne and foodborne disease outbreaks. Other symptoms are possible, however, depending on how the exposure occurs and the microorganism or toxin involved. Aerosol inhalation (breathing in a spray) of waterborne disease agents can cause respiratory symptoms, and skin contact can produce rashes. Fever often accompanies foodborne illnesses from microorganisms, and neurologic symptoms may occur following certain foodborne illnesses. Most waterborne and foodborne infections cause diarrheal illness, ranging from mild to severe. Persons in susceptible populations and some healthy persons can develop severe complications, such as hemorrhagic colitis, bloodstream infection, meningitis, joint infection, kidney failure, paralysis, miscarriage, and other problems. The most severe illnesses tend to occur in the very old, the very young, those with weakened immune systems, and healthy people exposed to very high doses or very potent toxins.

Despite similarities, waterborne and foodborne disease outbreaks are sufficiently different to warrant different tracking systems and different prevention measures. This chapter first addresses waterborne disease outbreaks and reviews the trends for disease outbreaks from drinking water, followed by the trends for recreational water. The chapter concludes with a discussion of foodborne disease outbreaks.

WHAT ARE WATERBORNE DISEASE OUTBREAKS?

A waterborne disease outbreak is an incident in which two or more people experience an infectious disease, chemical poisoning, or toxin-related illness associated with water. To be classified as a waterborne disease outbreak in a surveillance system, the report must include epidemiological investigation data implicating water as the probable source of the illness.⁷ (An epidemiological investigation is a scientific and medical study of what causes a disease outbreak and how it is spread from person to person.) The suspected water source in these waterborne disease outbreaks may be drinking water, recreational water, water not intended for drinking (e.g., water used for agricultural purposes or in a cooling tower) or water of unknown intent. The exposure may occur through



ingestion, inhalation, taking water in through the nose or through skin contact with the contaminated water. The agent associated with the waterborne disease outbreak may be a microorganism, chemical, or toxin.

HOW ARE WE TRACKING WATERBORNE DISEASE OUTBREAKS?

Since 1971, the Centers for Disease Control and Prevention (CDC), in collaboration with the U.S. Environmental Protection Agency (EPA) and the Council of State and Territorial Epidemiologists, has maintained the Waterborne Disease and Outbreak Surveillance System (WBDOSS) as the primary source of data on occurrences and causes of waterborne disease outbreaks. Since 2009, waterborne disease outbreaks have been electronically reported by state health departments to the National Outbreak Reporting System which also includes foodborne, person-to-person, and animal-to-person outbreaks.⁸ The system includes data on waterborne disease outbreaks associated with the following:

- Drinking water
- Water not intended for drinking (excluding recreational water)
- Water of unknown intent
- Recreational water (natural and treated water)

Water testing to demonstrate contamination or identify the cause is preferred, but not required for the incident to be included in the surveillance system for drinking water outbreaks. Chemicals (including disinfection by-products) in drinking water or in recreational water that cause health effects are included in the surveillance system. Both incidents of adverse health effects from water exposure and from volatilization leading to poor air quality are included.

The surveillance data are studied to determine the epidemiology (cause and spread) of waterborne disease in the United States. Trends and deficiencies in water systems associated with waterborne disease outbreaks are used to determine if regulations for water treatment and water quality monitoring are adequate to protect public health. Similarly, trends in disease and outbreaks associated with recreational water are used to identify the types of aquatic environments linked with outbreaks.

Trends in outbreaks are also used to evaluate the effectiveness of regulations and public awareness campaigns to promote healthy and safe swimming.⁴

Outbreaks listed in the surveillance database represent only a portion of the health burden associated with water exposure. This is because they do not include individual cases of waterborne disease but rather reports involving two or more people. Single cases of chemical exposure, wound infection and other illnesses (e.g., *Naegleria* infections) that are in some way linked to water exposure, and aquatic facility-related health events (e.g., chemical mixing accidents or air quality problems) can be reported but are not analyzed as waterborne disease outbreaks.⁷

Not all outbreaks are detected and investigated by the state or local public health jurisdiction or reported to the CDC. This is another reason why the surveillance data from waterborne disease outbreaks do not provide a reliable estimate of all waterborne disease in the United States. However, the surveillance information is valuable for determining disease trends and the role of environmental contamination of drinking and recreational water in causing disease.

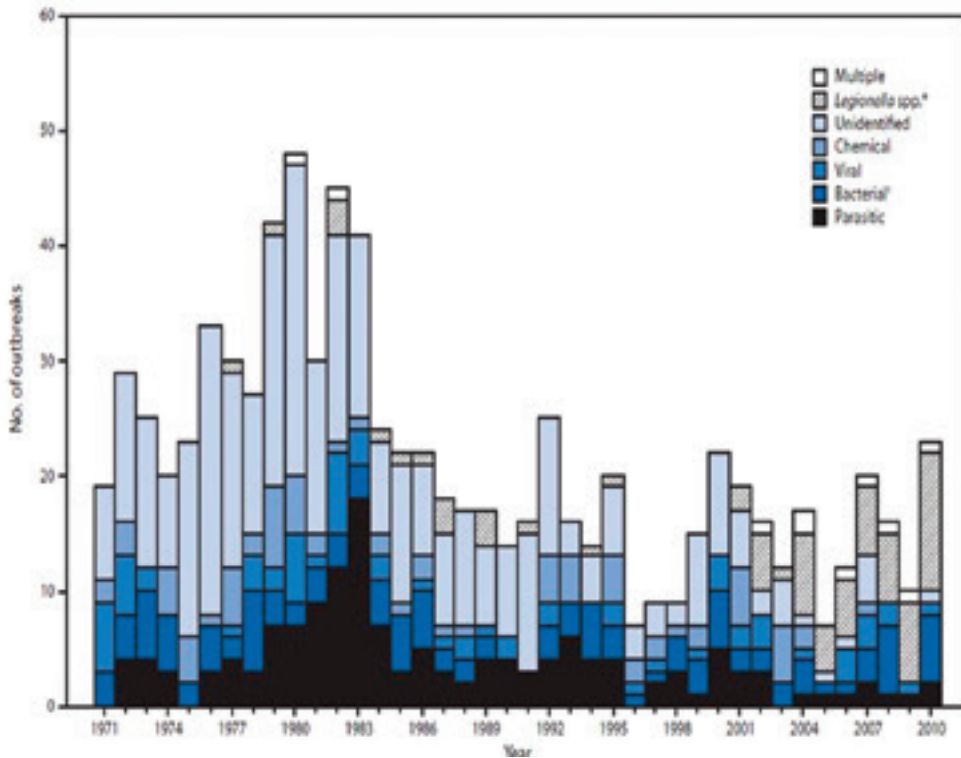
WHAT ARE THE STATUS AND TRENDS FOR WATERBORNE DISEASE OUTBREAKS

Between 1971 and 2010, 1,758 waterborne disease outbreaks were reported, sickening more than 600,000 people and causing more than 365 deaths. Of the 1,758 outbreaks, 851 (48%) were associated with drinking water; 777 (44%) were associated with recreational water; and 130 (7%) were associated with water not intended for drinking or water of unknown intent.^{5,9}

DRINKING WATER

From 2009-2010, 33 drinking water-associated outbreaks were reported. These 33 outbreaks resulted in 1,040 illnesses, 85 hospitalizations, and nine deaths.^{5,9} The number of reported drinking water-associated outbreaks of gastroenteritis is decreasing over time. This is likely linked to the fact that most Americans now get their drinking water from public water systems regulated by the EPA under the Safe Drinking Water Act (SDWA). (More information about the SDWA and how drinking water systems are regulated can be found in the Drinking Water Quality module of this report.)⁴

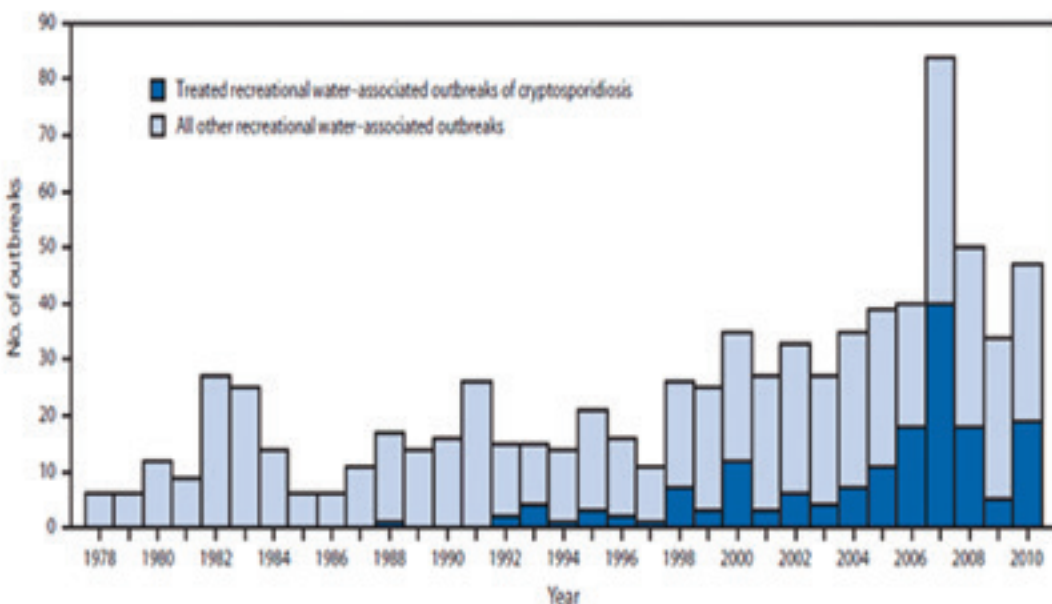
Figure 1. Number of waterborne disease outbreaks associated with drinking water (n=851)*, by year and etiology—United States, 1971–2010⁹



* Legionnaires' disease (LD) was reported to WBDOS beginning in 2001. Legionnaires' disease outbreaks before 2001 were added retrospectively during the 2007–2008 reporting period.

† Includes all bacteria except Legionella.

Figure 2. Waterborne disease outbreaks associated with recreational water (n=789) United States, 1978–2010⁵



Not only has drinking water quality improved, but so has the ability to identify the agents causing the waterborne disease outbreaks. As a result, there have been fewer unidentified disease-causing agents in recent years (Figure 1).⁹ Organisms and toxins are added to the list of agents as reliable detection methods are developed.

RECREATIONAL WATER

Recreational water illness and outbreaks are associated with both treated (e.g., disinfected swimming pools) and untreated water (e.g., lakes, rivers, oceans). Many waterborne pathogens are commonly found in the environment and spread through shared bodies of water, such as swimming pools, lakes, rivers, and the ocean. In addition, new waterborne pathogens have emerged in recent decades (e.g., the chlorine-tolerant parasite *Cryptosporidium* and toxigenic *E. coli*). Between 1978 (first year of recreational water outbreak reporting) and 2010, the CDC received reports of 789 recreational water-associated outbreaks sickening more than 38,000 persons and causing 18 deaths. The annual trend is increasing, particularly the number of outbreaks involving *Cryptosporidium* (Figure 2). From 2009-2010, 81 recreational water-associated disease outbreaks were reported to the CDC, causing 1,326 illnesses and 62 hospitalizations.⁵

Factors contributing to recreational water-associated outbreaks include the following:

- Low disinfectant levels
- Inadequate water quality monitoring
- Increased attendance during large events
- Breakdown of equipment and lengthy detection times
- Lack of needed cleaning of spas to minimize biofilm buildup
- Accumulation of combined chlorines in pools coupled with inadequate indoor air ventilation
- Adequately trained aquatics staff not on site
- Unclear communication chains for problem resolution
- Lack of awareness by the general public of appropriate healthy swimming behaviors
- Heavy rainfall events
- People swimming while ill with diarrhea

WHAT YOU CAN DO

DRINKING WATER

Public drinking water supplies in the United States are generally safe but might be compromised during unusual events, such as flooding. In these cases, turn to local media outlets for announcements from public health officials. These officials will alert you to possible water safety issues and might recommend water use restrictions, use of only boiled or bottled water for drinking and food preparation, and other safety measures. If you use a private water supply (e.g., water from a private well or spring), make sure the water is tested periodically for drinking water contaminants, particularly if illness occurs and you suspect it is caused by waterborne toxins or pathogens.

RECREATIONAL WATER

Swimmers can reduce the risk of recreational water-associated illness by taking a few simple steps. If you are swimming in a treated pool or spa, check the level of disinfection to verify that it is properly maintained. If you plan to swim in a natural, untreated water body, such as a river, lake, or ocean, consult local health officials for swimming advisories. These recreational waters can sometimes be contaminated by failing septic systems, illegal discharges, bypasses from sewage collection systems, harmful algal blooms, and other problems. Swimmers should always observe the following guidelines:

- Do not swim while ill with diarrhea
- Do not swallow recreational water
- Practice good hygiene before, during, and after swimming activities (e.g., shower before and after swimming)
 - Shower with soap before swimming
 - Take children on bathroom breaks or check diapers frequently (every 30–60 minutes)
 - Change diapers in bathroom or diaper changing area and not at poolside
 - Wash children (especially their rear end) with soap and water before swimming
 - Avoid swimming in lakes, rivers, or the ocean following heavy rainfall.

ADDITIONAL RESOURCES

- CDC's Healthy Swimming Web site has information on preventing illness when swimming at www.cdc.gov/healthywater/swimming.

WHAT ARE FOODBORNE DISEASE OUTBREAKS?

A foodborne disease outbreak is an incident in which two or more people experience a similar illness after ingesting a common food.¹⁰

HOW ARE WE TRACKING FOODBORNE DISEASE OUTBREAKS?

As an agency within the U.S. Department of Health and Human Services (HHS), the CDC leads federal efforts to gather data on foodborne illnesses, assists states with the investigation of multistate foodborne illness outbreaks, and other outbreaks upon request by the states, and conducts analyses to help monitor the effectiveness of prevention and control efforts. The CDC is not a food safety regulatory agency but works closely with the food safety regulatory agencies, in particular with HHS's U.S. Food and Drug Administration (FDA) and the Food Safety and Inspection Service within the United States Department of Agriculture (USDA). The CDC also plays a key role in building state and local health department epidemiology, laboratory, and environmental health functions to support foodborne disease surveillance and outbreak response. Notably, CDC data can be used to help document the effectiveness of regulatory interventions.¹¹

Because each state provides the resources and capacity for state surveillance efforts, surveillance for foodborne illness is largely dependent upon reporting through state health departments. The CDC has worked with each state to develop efficient surveillance systems to aid in early identification of foodborne disease outbreaks and has developed several networks connecting foodborne disease epidemiologists in each state. The goal of these networks is to maintain open communication between states to ensure faster action in times of multistate foodborne disease outbreaks.

FOODNET

The Foodborne Diseases Active Surveillance Network (FoodNet) is the foodborne disease component of the CDC's Emerging Infections Program (EIP).¹² Established in 1995, FoodNet is a collaborative project among the CDC, 10 EIP sites, the USDA, and the FDA. FoodNet conducts active surveillance for laboratory-diagnosed infections transmitted commonly through food, including *Campylobacter*, *Cryptosporidium*, *Cyclospora*, *E. coli* O157, *Listeria*, *Salmonella*, *Shigella*, *Vibrio*, and *Yersinia*. FoodNet also conducts related studies, such as case-control and cohort studies and surveys of physicians and laboratories, to help public health officials better understand the cause and spread of foodborne diseases in the United States and the impact of food safety policies.

The goals of FoodNet are

- Determine the burden of foodborne illness in the United States, and monitor trends in the burden of specific foodborne illness over time
- Determine how much foodborne illness results from eating specific foods, such as meat, poultry, eggs, and produce
- Disseminate information that can lead to improvements in public health practice and the development of interventions to reduce the burden of foodborne illness

NORS (FORMERLY eFORS)

States use a web-based system called the National Outbreak Reporting System (NORS) to report outbreaks of foodborne disease.¹³ (NORS is also used for reporting waterborne disease outbreak as well as enteric disease outbreaks associated with contact with infected persons or animals or through the environment.) This system uses a standard reporting form so states can easily inform the CDC of the results of outbreak investigations. The CDC receives an average of 1,200 reports of foodborne outbreaks each year. Data collected by the NORS system are available on the CDC Website (<http://www.cdc.gov/foodsafety/fdoss/index.html>) and are periodically reviewed and summarized in published reports.

PULSENET USA

Coordinated by the CDC, PulseNet USA is the national subtyping network for surveillance of foodborne infections. Network participants include state and local health departments and federal agencies (CDC, USDA/Food Safety and Inspection Service, FDA).¹³

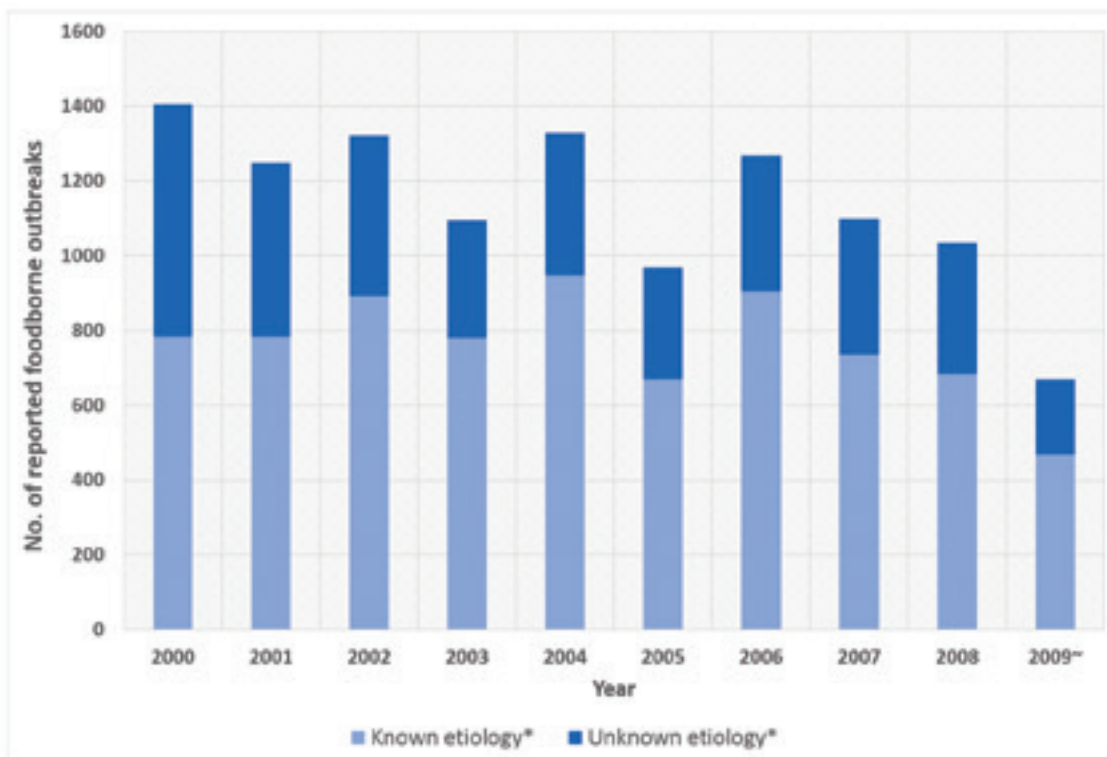
PulseNet participants perform standardized molecular analysis or “fingerprinting” of foodborne disease-causing bacteria. This is done by pulsed-field gel electrophoresis (PFGE). PFGE can be used to distinguish strains of organisms, such as *Escherichia coli* O157:H7, *Salmonella*, *Shigella*, *Listeria*, or *Campylobacter*, at the DNA level. DNA fingerprints or patterns are submitted electronically to this national database at the CDC. PulseNet is available on-demand to participants, allowing for rapid comparison of patterns. Each year, more than 40,000 DNA fingerprints of foodborne bacteria are submitted to the PulseNet USA database, and more than 300 clusters of infections are detected by the network.

WHAT ARE THE STATUS AND TRENDS FOR FOODBORNE DISEASE OUTBREAKS

Foodborne illness is not characterized by a single set of symptoms, nor are the most common symptoms (vomiting, nausea, abdominal cramps and diarrhea) unique to foodborne illness. Thus, some cases remain undetected and are lost among the background of illnesses with similar symptoms. This holds true for both foodborne illness with an infectious origin, which includes most cases, and also for noninfectious foodborne illness caused by toxins.

These limitations notwithstanding, more than 1,000 foodborne disease outbreaks are typically reported to CDC each year (Figure 3). Among FBDs with a confirmed etiology, norovirus is the most common cause, followed by *Salmonella* (Figure 4).⁶ An enhanced outbreak reporting system and improved analytical methods to detect norovirus in the mid-to late-1990s increased the number of reported outbreaks. During the period of 2009-2010, both the number of food-borne *Salmonella* serotype Enteritidis outbreaks (76) and *E. coli* O157:H7 outbreaks (53) remained above their *Healthy People 2010* targets,^{6,15} for all modes of transmission.

Figure 3. Number of reported foodborne disease outbreaks by year—United States, 2000–2009¹⁴



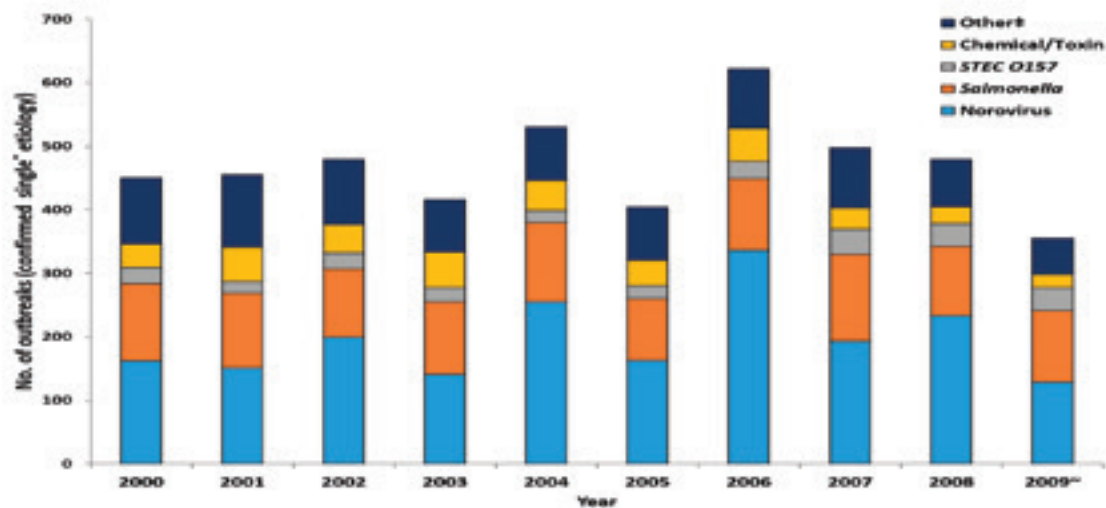


Figure 4. Number of foodborne disease outbreaks with confirmed etiology, by year and etiologic agent—United States, 2000–2009¹⁴

Outbreaks Associated with Beaches and Coastal Waters

Although few waterborne disease outbreaks associated with marine waters are reported to WBD OSS, evidence from multiple sources shows that contamination of coastal marine and Great Lakes swimming waters is common and that swimmers in these waters are at increased risk for gastrointestinal illness.⁵ In 2000, Congress passed the Beaches Environmental Assessment and Coastal Health (BEACH) Act that established criteria for testing, monitoring, and notifying public users of possible bacterial contamination of coastal recreational waters. The EPA administers that program to promote improved water quality at coastal and Great Lakes beaches. The major objectives of the EPA Beach Monitoring Program include strengthening recreational water quality programs nationwide and creating

scientific improvements that support timely recreational water monitoring and reporting. Research to improve indicators of recreational water quality is an important collaboration between the EPA and the CDC.

The BEACH Program is improving public access to information about the quality of the water at public beaches and health risks associated with swimming in polluted water. The EPA operates a website called BEACON—Beach Advisory and On-Line Closing Notification (<https://www.epa.gov/waterdata/beacon-20-beach-advisory-and-closing-online-notification>), which is an online directory of information about the water quality at our nation's beaches, local protection programs, and other beach-related programs.¹⁶

Harmful Algal Blooms

Infectious microorganisms are not the only sources of waterborne disease outbreaks found in coastal waters. Naturally occurring algae periodically grow excessively, or bloom, under favorable environmental conditions. When the bloom is comprised of one of a few dozen algal types that produce potent toxins, the result is called harmful algal bloom (HAB), which can cause illness in humans and animals.¹⁷ HABs can occur in marine, estuarine, and fresh waters, including drinking water reservoirs and recreational waters.

The most common human illnesses associated with marine HABs are neurotoxic shellfish poisonings, paralytic shellfish poisonings, and ciguatera fish poisoning.¹⁸ All are caused by consumption of shellfish or fish contaminated with an algal toxin. In addition, recent work has shown that aerosols containing the toxin produced by *Karenia brevis* (the organism that produces Florida red tide) can induce respiratory symptoms, especially in people who are occupationally exposed, such as lifeguards,¹⁹ and in people with asthma.²⁰

In contrast, most of the illnesses associated with freshwater HABs (cyanoHABs) have been in animals that drank pond water contaminated with anatoxins (from cyanobacteria). Historically, the reported human illnesses associated with freshwater

HABs have been primarily due to very high dose, acute exposures from drinking water contaminated with cyanotoxins.²¹

The extent of human illness caused by environmental exposure to algal toxins in drinking and recreational waters is unknown, but virtually every coastal state in the United States has reported recurring blooms (Figure A). Algal toxins include some of the most potent natural chemicals known, and any community using surface water for drinking or recreation could be exposed.

Figure A. Major HAB-related events in the United States²²



WHAT YOU CAN DO

Although foodborne pathogens are not confined to certain foods, raw or undercooked foods of animal origin, such as meat, poultry, and eggs, are the most likely to cause foodborne illness. Seafood and unpasteurized milk are also common sources of foodborne pathogens.

A few simple precautions can reduce the risk of foodborne diseases.

- Thoroughly cook all meat, poultry, seafood, and eggs.
- Use a meat thermometer to measure the internal temperature of meat and poultry.
- Cook eggs until both the white and the yolk are firm.
- Wash fresh produce in running tap water, and discard the outermost leaves of a head of lettuce or cabbage.
- Avoid leaving cut produce at room temperature for many hours because bacteria grow well on cut surfaces of fruits and vegetables.
- Refrigerate leftovers promptly.
- Wash your hands with soap and water before preparing food. Avoid preparing food for others if you yourself have a diarrheal illness. Changing a baby's diaper while preparing food is a bad idea that can easily spread illness.
- Don't cross-contaminate one food with another. Wash hands, utensils, and cutting boards after they have been in contact with raw meat or poultry and before they touch another food. Put cooked meat on a clean platter, rather back on one that held the raw meat.

ADDITIONAL RESOURCES

- Detailed information on how to handle and cook food to minimize exposure to foodborne pathogens can be found at www.foodsafety.gov.
- Food Safety is addressed on CDC's Web site at www.cdc.gov/foodsafety/prevention.html.
- The FDA Web site provides more tips for safe handling of raw produce. <http://www.fda.gov/Food/ResourcesForYou/Consumers/ucm114299.htm>.



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