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Surveillance for Waterborne-Disease Outbreaks — United States, 1999–2000

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Surveillance for Waterborne-Disease Outbreaks — United States, 1999–2000

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Abstract

Problem/Condition: Since 1971, CDC, the U.S. Environmental Protection Agency (EPA), and the Council of State and Territorial Epidemiologists (CSTE) have maintained a collaborative surveillance system for the occurrences and causes of waterborne-disease outbreaks (WBDOs).This surveillance system is the primary source of data concerning the scope and effects of waterborne diseases on persons in the United States.

Reporting Period Covered: This summary includes data regarding outbreaks occurring during January 1999–December 2000 and previously unreported outbreaks occurring in 1995 and 1997.

Description of the System: The surveillance system includes data for outbreaks associated with drinking water and recreational water. State, territorial, and local public health departments are primarily responsible for detecting and investigating WBDOs and voluntarily reporting them to CDC on a standard form. The unit of analysis for the WBDO surveillance system is an outbreak, not an individual case of a waterborne disease. Two criteria must be met for an event to be defined as a WBDO. First, $\geq$2 persons must have experienced a similar illness after either ingestion of drinking water or exposure to water encountered in recreational or occupational settings. This criterion is waived for single cases of laboratory-confirmed primary amebic meningoencephalitis and for single cases of chemical poisoning if water-quality data indicate contamination by the chemical. Second, epidemiologic evidence must implicate water as the probable source of the illness.

Results: During 1999–2000, a total of 39 outbreaks associated with drinking water was reported by 25 states. Included among these 39 outbreaks was one outbreak that spanned 10 states. These 39 outbreaks caused illness among an estimated 2,068 persons and were linked to two deaths. The microbe or chemical that caused the outbreak was identified for 22 (56.4%) of the 39 outbreaks; 20 of the 22 identified outbreaks were associated with pathogens, and two were associated with chemical poisoning. Of the 17 outbreaks involving acute gastroenteritis of unknown etiology, one was a suspected chemical poisoning, and the remaining 16 were suspected as having an infectious cause. Twenty-eight (71.8%) of 39 outbreaks were linked to groundwater sources; 18 (64.3%) of these 28 groundwater outbreaks were associated with private or noncommunity wells that were not regulated by EPA. Fifty-nine outbreaks from 23 states were attributed to recreational water exposure and affected an estimated 2,093 persons. Thirty-six (61.0%) of the 59 were outbreaks involving gastroenteritis. The etiologic agent was identified in 30 (83.3%) of 36 outbreaks involving gastroenteritis. Twenty-two (61.1%) of 36 gastroenteritis-related outbreaks were associated with pools or interactive fountains. Four (6.8%) of the 59 recreational water outbreaks were attributed to single cases of primary amebic meningoencephalitis (PAM) caused by *Naegleria fowleri*. All four cases were fatal. Fifteen (25.4%) of the 59 outbreaks were associated with dermatitis; 12 (80.0%) of 15 were associated with hot tubs or pools. In addition, recreational water outbreaks of leptospirosis, Pontiac fever, and chemical keratitis, as well as two outbreaks of leptospirosis and Pontiac fever associated with occupational exposure were also reported to CDC.

Interpretation: The proportion of drinking water outbreaks associated with surface water increased from 11.8% during 1997–1998 to 17.9% in 1999–2000. The proportion of outbreaks (28) associated with groundwater sources increased 87% from the previous reporting period (15 outbreaks), and these outbreaks were primarily associated (60.7%)

with consumption of untreated groundwater. Recreational water outbreaks involving gastroenteritis doubled (36 outbreaks) from the number of outbreaks reported in the previous reporting period (18 outbreaks). These outbreaks were most frequently associated with *Cryptosporidium parvum* (68.2%) in treated water venues (e.g., swimming pools or interactive fountains) and by *Escherichia coli* O157:H7 (21.4%) in freshwater venues. The increase in the number of outbreaks probably reflects improved surveillance and reporting at the local and state level as well as a true increase in the number of WBDOs.

Public Health Action: CDC and others have used surveillance data to identify the types of water systems, their deficiencies, and the etiologic agents associated with outbreaks and evaluated current technologies for providing safe drinking water and safe recreational water. Surveillance data are used also to establish research priorities, which can lead to improved water-quality regulations. Only the groundwater systems under the influence of surface water are required to disinfect their water supplies, but EPA is developing a groundwater rule that specifies when corrective action (including disinfection) is required. CDC and EPA are conducting epidemiologic studies to assess the level of waterborne illness attributable to municipal drinking water in nonoutbreak conditions. Rules under development by EPA — the Ground Water Rule (GWR), the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), and Stage 2 Disinfection Byproduct Rules (DBPR) — are expected to further protect the public from contaminants and disinfection byproducts in drinking water. Efforts by EPA under the Beaches Environmental Assessment, Closure, and Health (BEACH) program are aimed at reducing the risks for infection attributed to ambient recreational water by strengthening beach standards and testing; providing faster laboratory test methods; predicting pollution; investing in health and methods research; and improving public access to information regarding both the quality of the water at beaches and information concerning health risks associated with swimming in polluted water. EPA's Beach Watch (available at http://www.epa.gov/waterscience/beaches) provides online information regarding water quality at U.S. beaches, local protection programs, and other beach-related programs. CDC partnered with a consortium of local and national pool associations to develop a series of health communication materials for the general public who attend treated recreational water venues and to staff who work at those venues. CDC has also developed a recreational water outbreak investigation toolkit that can be used by public health professionals. All of the CDC materials are accessible at the CDC Healthy Swimming website (http://www.cdc.gov/healthyswimming).

Introduction

During 1920–1970, statistical data regarding U.S. waterborne-disease outbreaks (WBDOs) were collected by multiple researchers and federal agencies (*1*). Since 1971, CDC, the U.S. Environmental Protection Agency (EPA), and the Council of State and Territorial Epidemiologists (CSTE) have maintained a collaborative surveillance system that tracks the occurrences and causes of WBDOs (*2–6*). This surveillance system includes data regarding outbreaks associated with drinking water, recreational water, and other types of water exposures. This report includes data for 1999 and 2000 and for previously unreported drinking water-associated outbreaks that occurred in 1995 and 1997.

CDC's and EPA's surveillance activities are intended to 1) characterize the epidemiology of WBDOs; 2) identify the etiologic agents that caused WBDOs and determine why the outbreaks occurred; 3) train public health personnel to detect and investigate WBDOs; and 4) collaborate with local, state, federal, and international agencies on initiatives to prevent waterborne disease. Data obtained through this surveillance system are useful for identifying major deficiencies in providing safe drinking water and recreational water. Surveillance information can influence research priorities, lead to improved water-quality regulations, and illustrate the burden of illness attributed to water.

Background

EPA Regulations

Drinking Water

Public water systems are regulated under the Safe Drinking Water Act (SDWA) of 1974 and its subsequent 1986 and 1996 amendments (*7–9*) (Box). Under SDWA, EPA is authorized to set national standards to protect drinking water and its sources against naturally occurring or man-made contaminants. The 1996 SDWA amendments require EPA to publish a list every 5 years of contaminants that are known or anticipated to occur in public water systems and that might need to be regulated. The first list was called the drinking water Contaminant Candidate List (CCL). CCL contained 60 contaminants/contaminant groups, included 10 pathogens, and was published in the *Federal Register* on March 2, 1998 (*10*). A decision concerning whether to regulate ≥5 contaminants from CCL was required by August 2001. Microbial

BOX. Environmental Protection Agency (EPA) regulations regarding drinking water, 1974–2003

Regulation/date	Description
Safe Drinking Water Act/1974 and 1986 and 1996 amendments	Authorizes EPA to set national standards to protect drinking water and its sources
Total Coliform Rule (TCR)/and Maximum Contaminant Level (MCL)/1989	Requires routine monitoring for total coliforms of all public water systems plus periodic on-site inspections for systems that take <5 samples/month to evaluate and document treatment, storage, distribution network, operation and maintenance, and overall management. Systems that collect ≥40 samples/month (i.e., typically, systems that serve >33,000 persons) violate MCL if >5.0% of the samples collected during each month are positive for total coliforms; systems that collect <40 samples/month violate MCL if two samples during the month are positive for total coliforms. If a system has a total coliform-positive sample, then 1) that sample must be tested for the presence of fecal coliforms or *Escherichia coli*, and 2) three repeat samples must be collected (four, if the system collects ≤1 routine sample/month) within 24 hours and analyzed for total coliforms. If positive, the sample must be analyzed for fecal coliforms or *Es. coli*. In addition, ≥5 routine samples must be collected during the next month of sampling, regardless of system size. For any size system, if two consecutive total coliform-positive samples occur at one site during a month, and one of these samples is also fecal coliform-positive or *Es. coli*-positive, the system has an acute violation of the Maximum Contaminant Level and must notify the state and the public immediately.
Surface Water Treatment Rule (SWTR)/1989	Covers all water systems that use surface water or groundwater under the direct influence of surface water; all systems must disinfect their water, and the majority of systems must filter their water also, unless they meet EPA-specified filter-avoidance criteria that define high-quality source water. Specific requirements include • a combined filter-effluent–performance standard for turbidity (i.e., for rapid granular filters, 0.5 nephelometric turbidity unit [NTU] maximum for 95% of measurements [taken every 4 hours] during a month) and no single NTU reading >5.0; • watershed protection, redundant disinfection capability, and other requirements for unfiltered systems; • a 0.2-mg/L disinfectant residual entering the distribution system; and • maintenance of a detectable disinfectant residual in all parts of the distribution system. This rule requires that all such systems reduce the level of *Giardia* by 99.9% (3-log reduction) and viruses by 99.99% (4-log reduction) through a combination of removal (filtration) and inactivation (disinfection).
Information Collection Rule/ 1996–1998	Requires systems serving ≥100,000 persons to provide treatment data and monitor disinfection byproducts and source water quality parameters. Surface water systems are also required to monitor *Cryptosporidium*, *Giardia*, total culturable viruses, and total and fecal coliforms or *Es. coli* ≥1 time/month for 18 months. Results provided information to facilitate development of the Long Term 2 Enhanced SWTR, which is intended to protect against microbial risks by targeting those systems with suboptimal quality source water and to balance the health risks associated with disinfection byproducts and the anticipated Stage 2 Disinfection Byproduct Rule.
Interim Enhanced Surface Water Treatment Rule (IESWTR)/1998	Follow-up to SWTR that covers all public systems using surface water or groundwater under the direct influence of surface water and serving ≥10,000 persons. Key provisions include • a 2-log *Cryptosporidium*-removal requirement for filtered systems; • strengthened combined filter-effluent–turbidity performance standards for systems using conventional filtration treatment or direct filtration (0.3 NTU maximum for 95% of measurements during a month and no single NTU reading >1.0); • individual filter turbidity monitoring provisions;

BOX (*Continued*). Environmental Protection Agency (EPA) regulations regarding drinking water, 1974–2003

Regulation/date	Description
	• disinfection profile and benchmark provisions to ensure continued levels of microbial protection while facilities take necessary steps to comply with new disinfection byproduct standards; • revision of the definition of groundwater under the influence of surface water and the watershed-control requirements for unfiltered public water systems to include detection of *Cryptosporidium*; • requirements for covers on newly finished water reservoirs; • sanitary surveys for all surface water systems regardless of size; and • an MCL goal of zero oocysts for *Cryptosporidium*.
Lead and Copper Rule/2000 changes	Streamlines requirements, promotes consistent national implementation, and reduces the burden for water systems.
Long Term 1 Enhanced SWTR (LT1ESWTR)/2002 and the Filter Backwash Recycling Rule (FBRR)/2001	Companion regulations for IESWTR; LT1ESWTR applies to public water systems that use surface water or groundwater under the direct influence of surface water and that serve <10,000 persons. FBRR regulates how treatment plants recycle water that has been used to backwash a filter or that has been extracted from treatment plant sludge. FBRR regulates the point in the treatment plant at which the contaminated recycle water may be introduced, assuring that the water is subject to the entire particle and *Cryptosporidium parvum* removal process.
Long Term 2 Enhanced SWTR (LT2ESWTR)/expected in 2003	Applies to all systems using surface water or groundwater under the influence of surface water; will provide additional protection against *Cryptosporidium*. Systems will be assigned to a treatment category on the basis of their source-water *Cryptosporidium* levels; the category then determines how much additional treatment is required.
Stage 2 Disinfection Byproduct Rule (DBPR)/expected in 2003	Will apply to community water systems and nontransient noncommunity water systems that use an alternative to ultraviolet disinfection or deliver disinfected water; systems will be required to monitor for total trihalomethanes and the sum of five haloacetic acids and comply with MCLs at each monitoring location as a locational running annual average.
Ground Water Rule (GWR) (1996 amendment to EPA's Safe Drinking Water Act)/expected to be finalized in 2003	Applies to public groundwater systems (i.e., systems that have ≥15 service connections, or regularly serve ≥25 persons daily for ≥60 days/year) or any system that mixes surface and groundwater if the groundwater is added directly to the distribution system and provided to consumers without treatment. Establishes multiple barriers to protect against bacteria and viruses in drinking water from groundwater sources; establishes targeted strategy to identify groundwater systems at high risk for fecal contamination. Key areas include • system sanitary surveys; • hydrogeologic sensitivity assessments for nondisinfected systems; • source-water microbial monitoring by systems that do not disinfect and that draw from hydrogeologically sensitive aquifers or have detected fecal indicators within the system's distribution system; • corrective action by any system with substantial deficiencies or positive microbial samples indicating fecal contamination; and • compliance monitoring for systems that disinfect to ensure that they reliably achieve 4-log (99.99%) inactivation or removal of viruses. GWR does not apply to privately owned wells that serve <25 persons (e.g., individual homeowner wells).

contamination is regulated under the Total Coliform Rule (TCR) of 1989 and the Surface Water Treatment Rule (SWTR) of 1989 (*11–13*). SWTR covers all water systems that use surface water or groundwater under the direct influence of surface water (Glossary). SWTR is intended to protect against exposure to *Giardia intestinalis*, viruses, and *Legionella*, as well as selected other pathogens. In 1998, EPA promulgated the Interim Enhanced Surface Water Treatment Rule (IESWTR) (*14*), which provides additional protection against *Cryptosporidium* and other waterborne pathogens for systems that serve ≥10,000 persons. In 2002, EPA finalized the Long Term 1 Enhanced SWTR (LT1ESWTR) for public water systems that use surface water or groundwater under the direct influence of surface water and serve <10,000 persons (*15*). LT1ESWTR was proposed in combination with the Filter Backwash Recycling Rule (FBRR), which was finalized in 2001 (*16,17*).

The 1996 Amendments require EPA to develop regulations that require disinfection of groundwater systems as necessary to protect the public health; EPA has proposed the Ground Water Rule (GWR) to meet this mandate (*18*). GWR specifies the appropriate use of disinfection in groundwater and addresses other components of groundwater systems to ensure public health protection. GWR applies to public groundwater systems (systems that have ≥15 service connections or regularly serve ≥25 persons/day for ≥60 days/year). This rule also applies to any system that mixes surface and groundwater if the groundwater is added directly to the distribution system and provided to consumers without treatment. GWR does not apply to privately owned wells. Additional protection of groundwater from both chemical and microbial contamination from shallow wells (including cesspools) is expected to be provided as a result of recent revisions to the Underground Injection Control Regulations, published December 7, 1999 (*19*).

To fill gaps in existing data regarding occurrence of microbial pathogens and other indicators of microbial contamination, occurrence of disinfection byproducts, and characterization of treatment processes, EPA promulgated the Information Collection Rule in 1996 (*20*), which required systems serving ≥100,000 persons to provide treatment data and monitor disinfection byproducts and source-water–quality parameters. Surface water systems are also required to monitor for the presence of *Cryptosporidium*, *Giardia*, total culturable viruses, and total* (Glossary) and fecal coliforms or *Escherichia coli* ≥1 time/month for 18 months. The required monitoring ended in December 1998, and data were analyzed.

EPA also made minor changes in 2000 to the Lead and Copper Rule to streamline requirements, promote consistent national implementation, and in certain cases, reduce the burden for water systems. The action levels of 0.015 mg/L for lead and 1.3 mg/L for copper remain the same (*21*).

Recreational Water

Regulation of recreational water is determined by state and local governments. Standards for operating, disinfecting, and filtering public swimming and wading pools are regulated by state and local health departments and, as a result, are varied. In 1986, EPA established a guideline for microbiological water quality for recreational freshwater (e.g., lakes and ponds) and marine water (*22*). The guideline recommends that the monthly geometric mean concentration of organisms in freshwater should be ≤33/100 mL for enterococci or ≤126/100 mL for *Es. coli*. States have latitude regarding their guidelines or regulations and can post warning signs to alert potential bathers until water quality improves. Unlike treated venues where disinfection can be used to address problems with microbiological quality of the water, contaminated freshwater can require weeks or months to improve or return to normal. Prompt identification of potential sources of contamination and remedial action is necessary to return bathing water to an appropriate quality for recreational use (*23*).

EPA's Action Plan for Beaches and Recreational Waters (Beach Watch) was developed as part of the Clean Water Action Plan.† The intent of Beach Watch is to assist state, tribal, and local authorities in strengthening and extending programs that specifically protect users of recreational waters. As part of the Beaches Act of 2000, the U.S. Congress directed EPA to also develop a new set of guidelines for recreational water based on new water-quality indicators. Beginning in 2003, EPA will be conducting a series of epidemiologic studies at recreational fresh and marine beaches in the United States. These studies will be used to develop guidelines for using the new water-quality indicators to be included in new EPA guidelines.

Data collected as part of the national WBDO surveillance system are used to describe the epidemiology of waterborne diseases in the United States. Data regarding water systems and deficiencies implicated in these outbreaks are used to assess whether regulations for water treatment and monitoring of water quality are adequate to protect the public against disease. Surveillance also enables identifying etiologic agents and environmental or behavioral risk factors that are

* Total coliforms are considered indicator organisms that typically do not cause disease but might be associated with the presence of other disease-causing organisms. Additional information regarding total coliforms is available at http://www.epa.gov/safewater/dwa/electronic/tcr.pdf.

† Additional information is available at http://www.cleanwater.gov.

responsible for these outbreaks. This information is used to inform public health and regulatory agencies, water utilities, pool operators, and other stakeholders of new or reemerging trends that might necessitate different interventions and changes in policies and resource allotment.

Methods

Data Sources

State, territorial, and local public health agencies have primary responsibility for detecting and investigating WBDOs, and they voluntarily report them to CDC on a standard form (CDC form 52.12, which is available at http://www.cdc.gov/healthyswimming). The form solicits data related to 1) characteristics of the outbreak, including person, place, time, and location of the outbreak; 2) results from epidemiological studies conducted; 3) specimen and water sample testing; and 4) factors contributing to the outbreak, including environmental factors, water distribution, and disinfection concerns. Each year, CDC requests reports from state and territorial epidemiologists or from persons designated as WBDO surveillance coordinators. Additional information regarding water quality and treatment is obtained from the state's drinking water agency as needed. Numerical and text data are abstracted from the outbreak form and supporting documents and are entered into a database before analysis.

Definitions[§]

The unit of analysis for the WBDO surveillance system is an outbreak, not an individual case of a waterborne disease. Two criteria must be met for an event to be defined as a WBDO. First, $\geq$2 persons must have experienced a similar illness after either ingestion of drinking water or exposure to water encountered in recreational or occupational settings. This criterion is waived for single cases of laboratory-confirmed primary amebic meningoencephalitis and for single cases of chemical poisoning if water-quality data indicate contamination by the chemical. Second, epidemiologic evidence (Table 1) must implicate water as the probable source of the illness. For drinking water, reported outbreaks caused by contaminated water or ice at the point of use (e.g., a contaminated water faucet or serving container) are not classified as WBDOs.

If primary cases (i.e., among persons exposed to contaminated water) and secondary cases (i.e., among persons who became ill after contact with primary persons) are distinguished on the outbreak report form, only primary cases are included in the total number of cases. If both actual and estimated case counts are included on the outbreak report form, the estimated case count can be used if the population was sampled randomly or the estimated count was calculated by applying the attack rate to a standardized population.

Public water systems, which are classified as either community or noncommunity (Glossary), are regulated under SDWA. Of the approximately 170,000 public water systems in the United States, 113,000 (66.5 %) are noncommunity systems, of which 93,000 are transient systems (i.e., public water systems that regularly serve $\geq$25 of the same persons for $\geq$6 months/year [e.g., highway rest stations, restaurants, and parks with their own public water systems]) and 20,000 are nontransient systems (Glossary). A total of 54,000 systems (31.8%) are community systems. Community water systems serve approximately 264 million persons in the United States (96.0% of the U.S. population). Approximately 11 million persons (4.0%) rely on private or individual water systems (*24,25*) (Glossary). These statistics exclude outbreaks associated with these sources because they are not intended for drink-

§ Additional terms are defined in the glossary.

TABLE 1. Classification of investigations of waterborne-disease outbreaks — United States*

Class†	Epidemiologic data	Water-quality data
I	Adequate§ Data were provided regarding exposed and unexposed persons, and the relative risk or odds ratio was $\geq$2 or the p-value was <0.05	Provided and adequate Historical information or laboratory data (e.g., the history that a chlorinator malfunctioned or a water main broke, no detectable free-chlorine residual, or the presence of coliforms in the water)
II	Adequate	Not provided or inadequate (e.g., stating that a lake was crowded)
III	Provided, but limited Epidemiologic data were provided that did not meet the criteria for Class I, or the claim was made that ill persons had no exposures in common besides water, but no data were provided	Provided and adequate
IV	Provided, but limited	Not provided or inadequate

* Outbreaks of *Pseudomonas* and other water-related dermatitis and single cases of primary amebic meningoencephalitis or of illness resulting from chemical poisoning are not classified according to this scheme.
† On the basis of epidemiologic and water-quality data that were provided on CDC form 52.12.
§ Adequate data were provided to implicate water as the source of the outbreak.

ing and are not considered to be public water systems. Also excluded from these statistics are the millions of persons who use noncommunity systems while traveling or working.

In this surveillance system, outbreaks associated with water not intended for drinking (e.g., lakes, springs, and creeks used by campers and boaters; irrigation water and other nonpotable sources with or without taps) are also classified as individual systems (Glossary). Sources used for bottled water are also classified as individual systems; bottled water is not regulated by EPA but is subject to regulation by the Food and Drug Administration (FDA).

Each drinking water system associated with a WBDO is classified as having one of the deficiencies in the following list. If >1 deficiency is noted on the outbreak report form, the deficiency that most likely caused the outbreak is noted. Deficiency classifications are as follows:

1: untreated surface water;
2: untreated groundwater;
3: treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, or inadequate or no filtration);
4: distribution system deficiency (e.g., cross-connection, contamination of water mains during construction or repair, or contamination of a storage facility); and
5: unknown or miscellaneous deficiency (e.g., contaminated bottled water) or water source not intended for drinking (e.g., irrigation water tap).

Recreational waters include swimming pools, wading pools, whirlpools, hot tubs, spas, water parks, interactive fountains, and fresh and marine surface waters. Although the WBDO surveillance system includes whirlpool- and hot tub-associated outbreaks of dermatitis caused by *Pseudomonas aeruginosa*, wound infections resulting from waterborne organisms are not included.

Outbreak Classification

WBDOs reported to the surveillance system are classified according to the strength of the evidence implicating water as the vehicle of transmission (Table 1). The classification scheme (i.e., Classes I–IV) is based on the epidemiologic and water-quality data provided with the outbreak report form. Epidemiologic data are weighted more than water-quality data. Although outbreaks without water-quality data might be included in this summary, reports that lack epidemiologic data were excluded. Outbreaks of dermatitis and single cases of either primary amebic meningoencephalitis or illness resulting from chemical poisoning were not classified according to this scheme. Weighting of epidemiologic data does not preclude the relative importance of both types of data. The purpose of the outbreak system is not only to implicate water as the vehicle for the outbreak, but also to understand the circumstances that led to the outbreak.

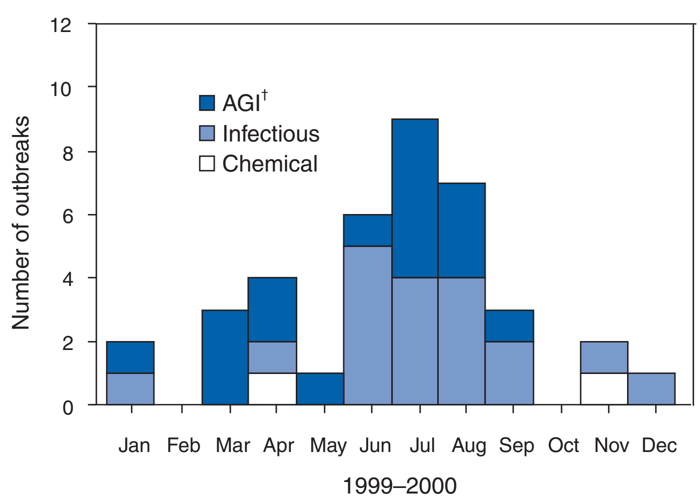
A classification of I indicates that adequate epidemiologic and water-quality data were reported (Table 1); however, the classification does not necessarily imply whether an investigation was optimally conducted. Likewise, a classification of II, III, or IV should not be interpreted to mean that the investigations were inadequate or incomplete. Outbreaks and the resulting investigations occur under various circumstances, and not all outbreaks can or should be rigorously investigated. In addition, outbreaks that affect fewer persons are more likely to receive a classification of III, rather than I, on the basis of the relatively limited sample size available for analysis.

Results

Outbreaks Associated with Drinking Water

During 1999–2000, a total of 39 outbreaks associated with drinking water were reported by 25 states (see Appendix A for selected case descriptions). One of the 39 outbreaks was a multistate outbreak of *Salmonella* Bareilly that included cases from 10 states. Of the 39 total drinking water outbreaks, 15 outbreaks were reported for 1999 and 24 for 2000. Florida reported the most outbreaks (15) during this period. These 39 outbreaks caused illness among an estimated 2,068 persons; 122 persons were hospitalized, and two died. The median number of persons affected in an outbreak was 13.5 (range: 2–781). Outbreaks peaked during the summer months (Figure 1), June–August.

FIGURE 1. Number of waterborne-disease outbreaks associated with drinking water, by etiologic agent and month — United States, 1999–2000 (n = 38)*



* One outbreak of *Salmonella* Bareilly was not included.
† Acute gastrointestinal illness of unknown etiology.

Nine of the 39 (23.1%) outbreaks were assigned to Class I on the basis of epidemiologic and water-quality data; three (7.7%) were Class II; 25 (64.1%) were Class III; and 1 was Class IV (Table 1). One of two outbreaks associated with a chemical etiology was not assigned a class because that outbreak was a single case of illness resulting from nitrate poisoning associated with consumption of water from a private well. Outbreaks are listed by state (Tables 2 and 3) and are tabulated by the etiologic agent, the water system type (Table 4), and by the type of deficiency and type of water system type (Table 5).

Etiologic Agents

Twenty (51.3%) of the 39 outbreaks were of known infectious etiology; 17 (43.6%) were of unknown etiology; and two (5.1%) were attributed to chemical poisoning. Of the 20 outbreaks with known infectious etiology, seven (35.0%) were caused by parasites; nine (45.0%) were caused by bacteria; and four (20.0%) were caused by viruses (Figure 2) (Appendix A).

Parasites. Seven outbreaks affecting 57 persons were attributed to parasitic infection: six *Giardia* outbreaks and one *Cryptosporidium* outbreak. Six outbreaks of *Giardia* associated with drinking water affected 52 persons from five states: Florida (two outbreaks), New Mexico (one), New Hampshire (one), Minnesota (one), and Colorado (one). These outbreaks occurred in January (one), June (one), July (one), August (one), and September (two). Four outbreaks were associated with well water systems, and two were associated with surface water systems. Two outbreaks caused by *G. intestinalis* involved possible contamination of wells by animal feces. *G. intestinalis* can infect mammalian hosts, which in turn, can serve as reservoirs for human infection. Water treatment failure was a factor in two other outbreaks of *Giardia*.

Bacteria. Nine outbreaks affecting an estimated 1,166 persons were attributed to bacterial infection: four *Es. coli* O157:H7 outbreaks, one *Campylobacter jejuni*, one *Salmonella* Typhimurium, one *Sa.* Bareilly, and two mixed *Ca. jejuni* and shiga toxin-producing *Es. coli* (O157:H7 or O111) outbreaks.

TABLE 2. Waterborne-disease outbreaks associated with drinking water — United States, 1999 (n = 15)*

State	Month	Class†	Etiologic agent	Number of cases	Type of system§	Deficiency¶	Source	Setting
California	Jul	III	AGI**	31	Ncom	2	Well	Camp
Florida	Jan	III	AGI	4	Com	2	Well	Community
Florida	Jan	III	*Giardia intestinalis*	2	Ind	2	Well	Household
Florida	Mar	III	AGI	6	Com	4	River/stream	Apartment
Florida	Mar	III	AGI	3	Com	4	Well	Community
Florida	May	III	AGI	3	Ind	2	Well	Household
Florida	Aug	III	AGI††	4	Com	4	River/stream	Apartment
Missouri	Jun	II	*Salmonella* Typhimurium	124	Com	3	Well	Community
New Jersey	Nov	IV	Sodium hydroxide	2	Com	3	Well	Community
New Mexico	Jul	I	Small round-structured virus§§	70	Ncom	3	Spring	Camp
New York	Aug	I	*Escherichia coli* O157:H7, *Campylobacter jejuni*¶¶	781	Ncom	2	Well	Fairgrounds
Texas	Nov	I	*Es. coli* O157:H7	22	Com	3	Well	Community
Washington	Jul	II	AGI	46	Ind	1	River/creek	Household
Washington	Aug	I	AGI	68	Ncom	2	Well	Soccer match
Wisconsin	Apr	NA***	Nitrate	1	Ind	2	Well	Household

* An outbreak is defined as 1) ≥2 persons experiencing a similar illness after ingestion of drinking water and 2) epidemiologic evidence that implicates water as the probable source of the illness.

† On the basis of epidemiologic and water-quality data provided on CDC form 52.12.

§ Com = community; Ncom = noncommunity; Ind = individual; community and noncommunity water systems are public water systems that serve ≥15 connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for ≥6 months/year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks). Individual water systems are not owned or operated by a water utility and serve <15 connections or <25 persons. Outbreaks associated with water not intended for drinking (e.g., lakes, springs, and creeks used by campers and boaters; irrigation water; and other nonpotable sources with or without taps) are also classified as individual systems.

¶ 1 = untreated surface water; 2 = untreated groundwater; 3 = treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, and inadequate or no filtration); 4 = distribution system deficiency (e.g., cross-connection, contamination of water mains during construction or repair, and contamination of a storage facility); and 5 = unknown or miscellaneous deficiency (e.g., contaminated bottled water).

** Acute gastrointestinal illness of unknown etiology.

†† Unidentified chemical poisoning.

§§ Three persons had stool specimens that tested positive for small round-structured virus, and one person's stool specimen tested positive for *Ca. jejuni*.

¶¶ A total of 126 persons had stool specimens that tested positive for *Es. coli* O157:H7; 43 persons had stool specimens that tested positive for *Ca. jejuni*. One person's stool specimen tested positive for both organisms.

*** Not applicable, see Table 1.

TABLE 3. Waterborne-disease outbreaks associated with drinking water — United States, 2000 (n = 24)*

State	Month	Class†	Etiologic agent	Number of cases	Type of system§	Deficiency¶	Source	Setting
California	Jul	I	Norwalk-like virus	147	Ncom	2	Well	Camp
California	Jul	I	*Escherichia coli* O157:H7	5	Ind	5	River/creek	Camp
California	Sep	III	AGI**	63	Ind	5	Irrigation system	Football game
Colorado	Aug	III	*Giardia intestinalis*	27	Ncom	3	River	Resort
Florida	Mar	III	AGI††	19	Com	3	Well	Trailer park
Florida	Apr	III	AGI	21	Com	3	Well	Trailer park
Florida	Apr	I	AGI	71	Ind	2	Well	Community
Florida	Jun	III	AGI§§	2	Ind	2	Well	Household
Florida	Jul	III	AGI	3	Ind	2	Well	Household
Florida	Jul	III	AGI	3	Ind	2	Well	Household
Florida	Aug	III	AGI	4	Ind	2	Well	Household
Florida	Sep	III	*G. intestinalis*	2	Ind	4	Well	Household
Florida	Dec	III	*Cryptosporidium parvum*	5	Com	4	Well	Community
Idaho	Apr	III	*Es. coli* O157:H7	4	Ind	5	Irrigation canal	Household
Idaho	Jun	III	*Campylobacter jejuni*	15	Ncom	2	Spring	Camp
Idaho	Jul	III	AGI	65	Ncom	2	Well	Restaurant
Kansas	Jun	III	Norwalk-like virus	86	Ncom	2	Well	Reception hall
Minnesota	Jun	III	*G. intestinalis*¶¶	12	Ncom	2	Well	Camp
New Hampshire	Sep	III	*G. intestinalis*	5	Ind	3	Well	Household
New Mexico	Jul	II	*G. intestinalis*	4	Ind	5	River	Rafting trip
Ohio	Aug	I	*Es. coli* O157:H7	29	Com	4	Surface water***	Fairgrounds
Utah	Aug	III	*Ca. jejuni*†††	102	Ind	5	Irrigation water	Football camp
West Virginia	Jun	III	Norwalk-like virus	123	Ncom	3	Wells	Camp
Multistate	Apr–Aug	I	*Salmonella* Bareilly	84	Ind	5§§§	Municipal/spring§§§	Wells/bottled water***

* An outbreak is defined as 1) ≥2 persons experiencing a similar illness after ingestion of drinking water and 2) epidemiologic evidence that implicates water as the probable source of the illness.

† On the basis of epidemiologic and water-quality data provided on CDC form 52.12.

§ Com = community; Ncom = noncommunity; Ind = individual; community and noncommunity water systems are public water systems that serve ≥15 service connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for ≥6 months/year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks). Individual water systems are not owned or operated by a water utility and serve <15 connections or <25 persons. Outbreaks associated with water not intended for drinking (e.g., lakes, springs, and creeks used by campers and boaters; irrigation water; and other nonpotable sources with or without taps) are also classified as individual systems.

¶ 1 = untreated surface water; 2 = untreated groundwater; 3 = treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, and inadequate or no filtration); 4 = distribution system deficiency (e.g., cross-connection, contamination of water mains during construction or repair, and contamination of a storage facility); and 5 = unknown or miscellaneous deficiency (e.g., contaminated bottled water).

** Acute gastrointestinal illness of unknown etiology.

†† Persons also reported rashes in addition to acute gastrointestinal illness.

§§ One person had a stool specimen that tested positive for *Blastocystis hominis*.

¶¶ Eight persons had stool specimens that tested positive for *G. intestinalis*; one stool specimen tested positive for *Dientamoeba fragilis*.

*** Type of water was not specified on report form.

††† Thirty-seven persons had stool specimens that tested positive for *Ca. jejuni*; four persons' stool specimens tested positive for *Es. coli* O157:H7, and three persons had stool that tested positive for *Es. coli* O111.

§§§ The outbreak implicated both drinking water from private wells and springs and water bottled by one facility. The bottling facility used two sources of water.

The two outbreaks with multiple pathogens caused the two largest bacterial drinking water outbreaks reported during this study period.

Viruses. During this period, four outbreaks involving viral gastroenteritis were reported. A total of 426 persons reported illness; no hospitalizations or deaths were reported in association with these four viral outbreaks. Three of the four outbreaks occurred in camp facilities in California, New Mexico, and West Virginia. All three water sources were noncommunity groundwater sources.

Chemicals. During 1999, two outbreaks involving chemical contamination were reported. A total of three persons were affected by contamination of drinking water from nitrate and sodium hydroxide.

Unidentified Etiologic Agents. Seventeen outbreaks involving gastroenteritis of unknown etiology were reported from four states, affecting an estimated 416 persons and resulting in five hospitalizations. Testing for certain enteric pathogens (including ova and parasite testing) was attempted in five of the 17 outbreaks. In a June 2000 outbreak affecting 2 persons, stool specimens collected from one person tested negative for *G. intestinalis* but positive for *Blastocystis hominis*. However, whether *B. hominis* was the cause of the reported illness is unclear, and the pathogenicity of

TABLE 4. Waterborne-disease outbreaks associated with drinking water, by etiologic agent and type of water system — United States, 1999–2000 (n = 39)

	Type of water system*							
	Community		Noncommunity		Individual		Total	
Etiologic agent	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases
AGI†	6§	57	3	164	8	195	**17**	**416**
Giardia intestinalis	0	0	2	39	4	13	**6**	**52**
Escherichia coli O157:H7	2	51	0	0	2	9	**4**	**60**
Norwalk-like viruses (NLV)	0	0	3	356	0	0	**3**	**356**
Salmonella species¶	1	124	0	0	1	84	**2**	**208**
Campylobacter jejuni	0	0	1	15	1	102	**2**	**117**
Es. coli O157:H7/*Ca. jejuni*	0	0	1	781	0	0	**1**	**781**
Small round-structured virus	0	0	1	70	0	0	**1**	**70**
Cryptosporidium parvum	1	5	0	0	0	0	**1**	**5**
Sodium hydroxide	1	2	0	0	0	0	**1**	**2**
Nitrate	0	0	0	0	1	1	**1**	**1**
Total	**11**	**239**	**11**	**1,425**	**17**	**404**	**39**	**2,068**
Percentage	**28.2**	**11.6**	**28.2**	**68.9**	**43.6**	**19.5**	**100.0**	**100.0**

* Community and noncommunity water systems are public water systems that serve ≥15 service connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for ≥6 months/year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks). Individual water systems are not owned or operated by a water utility and serve <15 connections or <25 persons. Outbreaks associated with water not intended for drinking (e.g., lakes, springs, and creeks used by campers and boaters; irrigation water; and other nonpotable sources with or without taps) are also classified as individual systems.
† Acute gastrointestinal illness of unknown etiology.
§ One outbreak of four cases was caused by an unidentified chemical.
¶ One outbreak was serotype Typhimurium, and one outbreak was serotype Bareilly.

TABLE 5. Waterborne-disease outbreaks associated with drinking water, by type of deficiency and type of water system — United States, 1999–2000 (n = 39)

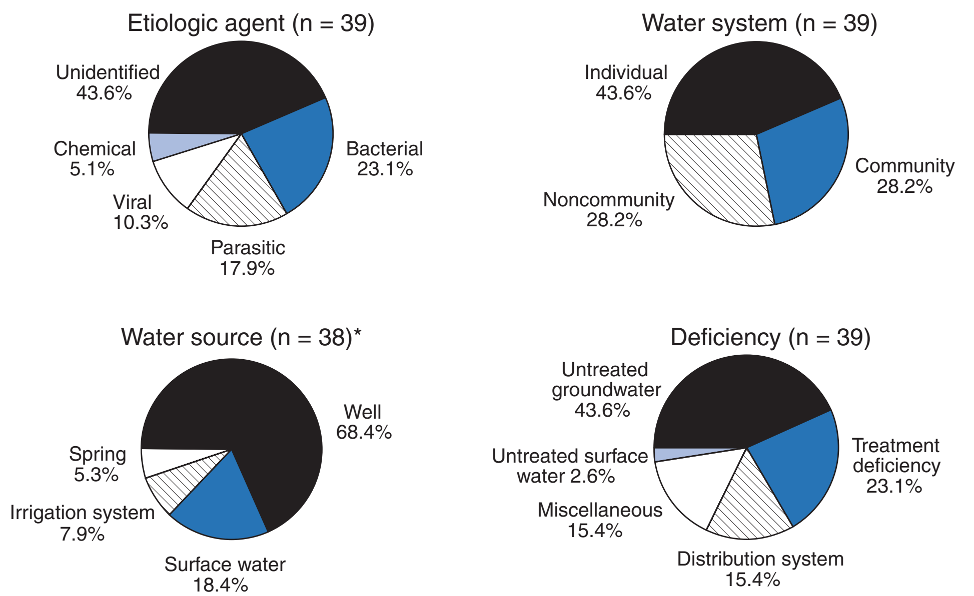
	Type of water system*							
	Community		Noncommunity		Individual		Total	
Type of deficiency†	Outbreaks	%	Outbreaks	%	Outbreaks	%	Outbreaks	%
Untreated surface water	0	0	0	0	1	5.9	**1**	**2.6**
Untreated groundwater	1	9.0	8	72.7	8	47.0	**17**	**43.6**
Inadequate treatment	5	45.5	3	27.3	1	5.9	**9**	**23.1**
Distribution system	5	45.5	0	0	1	5.9	**6**	**15.4**
Miscellaneous or unknown	0	0	0	0	6	35.3	**6**	**15.4**
Total	**11**	**100.0**	**11**	**100.0**	**17**	**100.0**	**39**	**100.0**

* Community and noncommunity water systems are public water systems that serve ≥15 service connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for ≥6 months/year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks). Individual water systems are not owned or operated by a water utility and serve <15 connections or <25 persons. Outbreaks associated with water not intended for drinking (e.g., lakes, springs, and creeks used by campers and boaters; irrigation water; and other nonpotable sources with or without taps) are also classified as individual systems.
† Examples of treatment deficiencies include temporary interruption of disinfection, chronically inadequate disinfection, or inadequate or no filtration; examples of distribution system deficiencies include cross-connection, contamination of water mains during construction or repair, or contamination of a storage facility; and examples of unknown or miscellaneous deficiencies include contaminated bottled water.

B. hominis has been debated in the scientific community (*26*). Stool specimens were negative for parasitic and bacterial enteric pathogens in two outbreaks in Washington (July 1999 and August 1999) and in two Florida outbreaks (March 1999 and April 2000) (Appendix A).

In addition, suspected pathogens were noted in four other outbreak reports submitted. On the basis of symptoms of illness, Norwalk-like virus (NLV) was suspected in an Idaho outbreak among firefighters that caused 65 illnesses and four hospitalizations, but the outbreak was not laboratory-confirmed. *G. intestinalis* was suspected in an April 2000 outbreak in a Florida trailer park affecting 21 persons, on the basis of the incubation period and symptoms reported. In another outbreak in a Florida trailer park in March 2000 among 19 persons, a bacterial pathogen was suspected as the cause of the outbreak on the basis of the symptoms, which included conjunctivitis and dermatitis in addition to gastroenteritis. A chemical agent was suspected as the cause of illness among four residents in a Florida apartment building who had a cross-connection between their drinking water and

FIGURE 2. Waterborne-disease outbreaks associated with drinking water, by etiologic agent, water system, water source, and deficiency — United States, 1999–2000 (n = 39)



* One outbreak of *Salmonella* Bareilly was not included.

a toilet flush-valve. The residents of the apartment had noted blue tap water before onset of illness on multiple occasions before an improper flush valve in the toilet tank was discovered.

Four outbreaks of gastroenteritis were associated with consumption of untreated water from private wells. These four outbreaks occurred in Florida and affected 3–4 persons each. In July 2000, flooding was a possible contributor to two outbreaks. Water in each of the homes tested positive for coliforms and did not have adequate disinfection.

Water-Quality Data

Water-quality data (i.e., information regarding the presence of coliform bacteria, pathogens, or chemical contaminants) were available for 35 (89.7%) of the 39 drinking water outbreaks. Two reports of outbreaks of confirmed or suspected infectious etiology and two reports of outbreaks of confirmed or suspected chemical etiology did not provide water-quality data.

Of the 36 reports of outbreaks with a suspected or confirmed infectious etiology, 33 outbreaks provided water-quality data. Twenty-six (78.8%) of the 33 outbreaks with a suspected or confirmed infectious etiology reported a positive coliform, total coliform, or fecal coliform result. Organisms also were detected in the water in two of these outbreaks. In August 2000, *Ca. jejuni* was detected in the water in a mixed *Ca. jejuni*/*Es. coli* O157:H7 outbreak in Utah, although shiga toxins were not detected. *Es. coli* O157:H7 was found in the water in a July 2000 California outbreak. In a 2000 Colorado outbreak, the presence of *G. intestinalis* was demonstrated in a sample from the water holding tank, despite the lack of coliform data.

Of the three outbreaks with either a confirmed or suspected chemical etiology, only one demonstrated that the chemical had been directly in the water. Tap water was tested after the health department was notified that an infant had methemoglobinemia. Both fecal coliforms and 28 mg/L of nitrate were detected in the water. For an outbreak where burns and gastroenteritis were reported and linked to a sodium hydroxide spill, a pH test of the water that could indicate whether $NaOH$ or another basic substance had spilled into the water was not documented. However, the environmental assessment indicated the tank contents had emptied into the water. A third suspected chemical outbreak involving a cross-connection between a toilet flush-valve and the drinking water system did not have water-quality data available.

In 11 of the 35 outbreaks, water was not sampled for coliforms until >1 month after the first case associated with the outbreak was reported (range: 5–16 weeks). In four of these 11 outbreaks, the water samples did not test positive for coliforms (fecal or total), chemicals, or pathogens. Instead, these were confirmed as outbreaks by epidemiologic data or by reports that treatment deficiencies had occurred.

Water Systems and Water Sources

Eleven (28.2%) of the 39 drinking water outbreaks were associated with community systems, 11 (28.2%) with noncommunity systems, and 17 (43.6%) with individual water systems (Tables 4 and 5). Ten (25.6%) of the 39 drinking water outbreaks were associated with surface water, including three outbreaks that implicated irrigation water not intended for consumption. Twenty-nine (74.4%) of the 39 drinking water outbreaks, including the outbreak associated with bottled water, were associated with groundwater sources (wells and springs).

Five (45.5%) of the 11 outbreaks associated with community water systems were caused by treatment deficiencies; one

(9.0%) outbreak was related to contaminated, untreated groundwater, and five (45.5%) outbreaks were related to problems in the water distribution system. Two of the five distribution system problems were related to cross-connections between the distribution system and an irrigation well. The third outbreak related to a community water source had a household cross-connection between the toilet water and main kitchen tap. One outbreak of *Cr. parvum* (Florida, December 2000) was related to a repeated history of water main breaks. In another outbreak in Ohio in August 2000, deficiencies in the distribution system of a fairgrounds might have allowed back-siphonage of animal manure into the water used by food and beverage vendors.

Ten (90.1%) of 11 outbreaks associated with noncommunity water systems occurred in groundwater systems. Seven of the 10 groundwater outbreaks were linked to untreated wells, and one of the 10 involved consumption of untreated spring water. Two of the 10 outbreaks were related to treatment deficiencies in water taken from wells or a spring and were associated with outbreaks of NLV and a small round-structured virus. An outbreak associated with *G. intestinalis* related to consumption of surface water occurred when a pump failure and a defective filter cartridge resulted in river water entering the drinking water holding tank without filtration. No information concerning chlorine levels from water samples was provided.

Nine (52.9%) of 17 outbreaks associated with individual water systems occurred in groundwater systems. Eight of these groundwater systems were wells that were not treated routinely; one outbreak of giardiasis occurred when the filtration system for a well was inadvertently turned off. Five (31.3%) of the 16 outbreaks occurred when persons drank water not intended for direct consumption from irrigation systems or when they consumed surface water that had been ineffectively or improperly treated. One (6.3%) of the 16 outbreaks in a system occurred in a home where creek water on the property was directly consumed without treatment.

Of the nine bacterial outbreaks, four occurred in groundwater systems (one was associated with a deficiency in the distribution system, one with a treatment deficiency, and two occurred in untreated systems). Six of seven parasitic outbreaks occurred in groundwater systems: three occurred in untreated systems; two involved problems in the distribution system; and one was related to a treatment deficiency. All four viral outbreaks occurred in noncommunity groundwater systems. Two occurred in untreated wells, and two were related to treatment deficiencies in a spring and well. Two chemical outbreaks were related to treatment deficiencies in well water. Fourteen of the 17 outbreaks of unknown etiology were linked to groundwater systems. Ten of these 14 outbreaks occurred in untreated systems; two were related to distribution system problems, and two were related to treatment deficiencies.

Outbreaks Associated with Recreational Water

During 1999–2000, a total of 23 states reported 59 outbreaks associated with recreational water (Tables 6–9) (see Appendix B for selected case descriptions). Twenty-three outbreaks were reported for 1999, and 36 for 2000. The states that reported the largest number of outbreaks were Florida (14 outbreaks) and Minnesota (eight outbreaks). These

TABLE 6. Waterborne-disease outbreaks of gastroenteritis associated with recreational water — United States, 1999 (n = 15)

State	Month	Class*	Etiologic agent	Illness	Number of cases	Source	Setting
California	Jun	III	AGI†	Gastroenteritis	23	Pool	Apartment complex
Connecticut	Jul	II	*Escherichia coli* O121:H19	Gastroenteritis	11	Lake	Lake
Florida	Mar	III	*Campylobacter jejuni*	Gastroenteritis	6	Pool	Private home
Florida	Aug	I	*Shigella sonnei*, *Cryptosporidium parvum*§	Gastroenteritis	38	Interactive fountain	Beach park
Florida	Aug	IV	*Cr. parvum*	Gastroenteritis	6	Pool	Private home
Florida	Sep	III	*Es. coli* O157:H7	Gastroenteritis	2	Ditch water	Community
Idaho	Jun	IV	Norwalk-like virus	Gastroenteritis	25	Hot springs	Resort
Illinois	Jun	III	AGI	Gastroenteritis	25	Lake	Lake
Massachusetts	Jul	III	*Giardia intestinalis*	Gastroenteritis	18	Pond	Pond
Minnesota	Jul	III	*Cr. parvum*	Gastroenteritis	10	Pool	Trailer park
Nebraska	Jun	IV	*Es. coli* O157:H7	Gastroenteritis	7	Wading pool	Child care center
New York	Jun	II	Norwalk-like virus	Gastroenteritis	168	Lake	County park
Washington	Aug	I	*Es. coli* O157:H7	Gastroenteritis	36	Lake	State park
Wisconsin	Jul	IV	*Cr. parvum*	Gastroenteritis	10	Pool	Municipal pool
Wisconsin	Aug	II	*Es. coli* O157:H7	Gastroenteritis	5	Lake/pond	Swimming beach

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12.
† Acute gastrointestinal illness of unknown etiology.
§ Five persons had stool specimens that tested positive for *Shigella sonnei*; two stools tested positive for *Cryptosporidium parvum*.

TABLE 7. Waterborne-disease outbreaks of gastroenteritis associated with recreational water — United States, 2000 (n = 21)

State	Month	Class*	Etiologic agent	Illness	Number of cases	Source	Setting
Colorado	Aug	I	*Cryptosporidium parvum*	Gastroenteritis	112	Pool	Municipal pool
Florida	May	IV	AGI†	Gastroenteritis	2	Lake	Lake
Florida	Jul	III	AGI	Gastroenteritis	4	Outdoor spring	County park
Florida	Jul	III	*Cr. parvum*	Gastroenteritis	3	Pool	Apartment complex
Florida	Aug	III	*Cr. parvum*	Gastroenteritis	5	Pool	Country club
Florida	Aug	I	*Cr. parvum*	Gastroenteritis	19	Pool	Resort
Florida	Aug	III	AGI	Gastroenteritis	9	Pool	Motel
Florida	Aug	III	*Cr. parvum*	Gastroenteritis	5	Pool	Condominium
Georgia	Jun	II	*Cr. parvum*	Gastroenteritis	36	Pools§	Community
Maine	Jul	II	AGI	Gastroenteritis	32	Lake/pond	Swimming beach
Minnesota	Jul	II	*Cr. parvum*¶	Gastroenteritis	220	Lake	Swimming beach
Minnesota	Jul	IV	*Shigella sonnei***	Gastroenteritis	15	Lake/pond	Swimming beach
Minnesota	Jul	III	*Cr. parvum*	Gastroenteritis	7	Pool	Day camp
Minnesota	Jul	II	*Cr. parvum*	Gastroenteritis	6	Pool	Hotel
Minnesota	Aug	II	*Sh. sonnei*	Gastroenteritis	25	Lake	Public beach
Minnesota	Aug	IV	*Cr. parvum*	Gastroenteritis	4	Pool	Municipal pool
Missouri	Sep	III	*Shigella flexneri*	Gastroenteritis	6	Wading pool	Community
Nebraska	Jun	I	*Cr. parvum*	Gastroenteritis	225	Pools	Community
Ohio	Jun	I	*Cr. parvum*	Gastroenteritis	700	Pool	Private swim club
South Carolina	Jul	IV	*Cr. parvum*	Gastroenteritis	26	Pool	Community
Wisconsin	Jan	IV	Norwalk-like virus	Gastroenteritis	9	Pool	Motel

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12.
† Acute gastrointestinal illness of unknown etiology.
§ Persons swam in a community pool and an inflatable pool.
¶ Seventeen persons had stool specimens that tested positive for *Cr. parvum*. One person had a stool specimen that tested positive for *Giardia intestinalis*. One person had a stool specimen that tested positive for both organisms.
** Fourteen of 15 stool specimens tested positive for *Shigella*; one person tested positive for *Cr. parvum*; and one tested positive for both.

TABLE 8. Waterborne-disease outbreaks of meningoencephalitis, keratitis, leptospirosis, and Pontiac fever associated with recreational water — United States, 1999–2000 (n = 8)

State	Year	Month	Class*	Etiologic agent	Illness	Number of cases	Source	Setting
California	2000	Apr	NA†	*Naegleria fowleri*	Meningoencephalitis	1	Mudhole	Mudhole
Florida	1999	Oct	NA	*N. fowleri*	Meningoencephalitis	1	Pond	Pond
Florida	2000	—§	NA	*N. fowleri*	Meningoencephalitis	1	—	—
Guam	2000	Jul	II	*Leptospira interrogans*	Leptospirosis	21	Lake	Adventure race
Vermont	2000	Feb	NA	Bromine	Chemical keratitis	3	Pool	Pool
Texas	1999	Sep	II	Unknown¶	Acute respiratory infection	12	Hot tub	Ranch
Texas	2000	Jul	NA	*N. fowleri*	Meningoencephalitis	1	Lake	Lake
Wisconsin	2000	May	I	*Legionella pneumophila*	Pontiac fever	20	Whirlpool	Motel

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12.
† Not applicable.
§ The month the outbreak occurred was not reported; the source and setting were not reported.
¶ Clinical specimens tested negative for *Legionella pneumophila* serotypes 1 and 6, adenovirus, influenza virus, and parainfluenza virus.

59 outbreaks affected 2,093 persons and resulted in 25 hospitalizations and four deaths. The median size of the outbreak was 10 persons (range: 1–700).

Of the 59 outbreaks, 36 were outbreaks of gastroenteritis (Tables 6 and 7); 15 were outbreaks of dermatitis (Table 9); four were cases of meningoencephalitis; and the remaining four outbreaks were of leptospirosis, chemical keratitis, acute respiratory infection of unknown etiology, and Pontiac fever (Table 8). Thirty-one (86.1%) of the 36 outbreaks involving gastroenteritis occurred during the summer months (i.e., June–August) (Figure 3). Outbreaks of dermatitis associated with recreational water contact were reported more frequently in February, March, June, and July. The four cases of primary amebic meningoencephalitis occurred in the warmer months (April–October).

Etiologic Agents

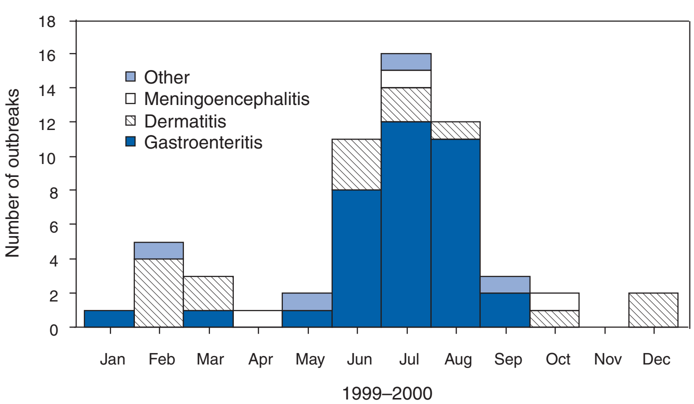
Of the 59 recreational water outbreaks, 44 (74.6%) were of known infectious etiology (Tables 6–9). Of the 36 outbreaks involving gastroenteritis, 17 (47.2%) were caused by parasites; nine (25.0%) by bacteria; three (8.3%) by viruses; one (2.8%) by a combination of parasites and bacteria; and the remaining six (16.7%) were of unknown etiology (Figure 4).

TABLE 9. Waterborne-disease outbreaks of dermatitis associated with recreational water — United States, 1999–2000 (n = 15)

State	Year	Month	Class*	Etiologic agent	Number of cases	Source	Setting
Alaska	2000	Oct	NA†	*Pseudomonas aeruginosa*§	29	Pool/hot tub	Hotel
Arkansas	1999	Jun	NA	*P. aeruginosa*§	10	Pool	Community
Arkansas	2000	Feb	NA	*P. aeruginosa*§	26	Pool/ hot tub	Motel
California	2000	Jun	IV	Schistosomes**	6	Pond	Pond
California	2000	Jul	IV	Schistosomes**	4	Pond	Pond
Colorado	1999	Feb	NA	*P. aeruginosa*¶§	19	Hot tub	Hotel
Colorado	1999	Dec	NA	*P. aeruginosa*††	5	Hot tub	Ski lodge
Florida	2000	Aug	NA	*P. aeruginosa*††	6	Hot tub	Apartment complex
Maine	2000	Feb	NA	*P. aeruginosa*¶	9	Hot tub/pool	Hotel
Maine	2000	Mar	NA	*P. aeruginosa*§	11	Hot tub	Hotel
Minnesota	2000	Dec	NA	*P. aeruginosa*¶	16	Hot tub	Private
Oregon	1999	Jul	IV	Schistosomes**	2	Lake	Lake
Vermont	1999	Jun	NA	*P. aeruginosa*††	9	Hot tub	Hotel
Vermont	1999	Feb	NA	*P. aeruginosa*††	11	Hot tub	Vacation home
Washington	2000	Mar	NA	*P. aeruginosa*††	10	Pool/hot tub	Motel

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12.
† Not applicable.
§ Organism isolated from water.
¶ Laboratory-confirmed case.
** Suspected etiology on the basis of clinical syndrome and setting.
†† Suspected etiology on the basis of clinical syndrome.

FIGURE 3. Number of waterborne-disease outbreaks associated with recreational water, by illness and month — United States, 1999–2000 (n = 58)*



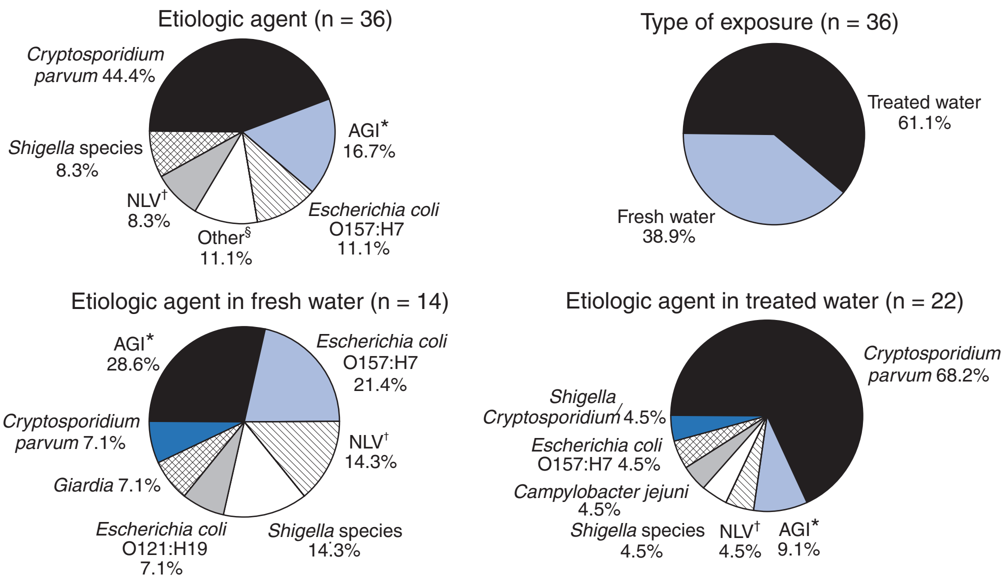
* Information regarding the month was not provided for one outbreak of meningoencephalitis.

Of the 23 nongastroenteritis-related recreational outbreaks, seven were attributed to *P. aeruginosa*, four to free-living amoebae, one to *Leptospira* species, one to *Legionella* species, and one to bromine (Tables 8 and 9). Nine nongastroenteritis-related recreational outbreaks were of unknown etiology, eight of which were suspected but not confirmed to be caused by *P. aeruginosa* or schistosomes. The ninth outbreak of unknown etiology was suspected to be caused by a virus or by *Legionella pneumophila* on the basis of observed symptoms and the epidemiologically implicated vehicle of transmission. Of the 59 recreational water outbreaks, 21 (35.6%) were associated with fresh or surface water, and 37 (62.7%) with treated (e.g., chlorinated) water. Information regarding the water venue for an outbreak of meningoencephalitis was not provided.

Parasites. Sixteen of the 17 parasitic recreational water outbreaks involving gastroenteritis were caused by *Cr. parvum*. The seventeenth outbreak was caused by *G. intestinalis*. Fifteen of the 17 parasitic outbreaks occurred in chlorinated venues; in these outbreaks, inadequate treatment, disrupted chlorine disinfection, or suboptimal pool maintenance were contributing factors to the outbreaks. *Cr. parvum* is highly resistant to chlorine disinfection and can survive for days in adequately chlorinated pools; therefore, suboptimal chlorination of the pool might not be the sole factor contributing to the occurrence of an outbreak.

Three outbreaks of laboratory-confirmed cryptosporidiosis occurred during the 1999 summer swim season. During the 2000 summer swim season, three substantial outbreaks of *Cr. parvum* occurred that were related to swimming in municipal pools. In August 2000, an outbreak occurred in Colorado that affected 112 persons attending a private pool party. In June 2000, the two other cryptosporidiosis outbreaks, one in Ohio affecting 700 persons and the other in Nebraska affecting 225 persons (*27*), occurred among members of private swim clubs. In both outbreaks, the protracted nature of the outbreaks during ≥2 months was the result of repeated recontamination of the pools by infected persons continuing to swim; 37 (18%) of 205 persons interviewed in the Nebraska outbreak admitted to swimming while symptomatic, and 32% swam while ill or during the 2 weeks after their

FIGURE 4. Waterborne-disease outbreaks of gastroenteritis associated with recreational water, by etiologic agent and type of exposure — United States, 1999–2000



* Acute gastrointestinal illness of unknown etiology.
† Norwalk-like virus.
§ These included outbreaks of *Campylobacter jejuni*, *Giardia*, *Escherichia coli* O121:H19 and one mixed *Shigella/Cryptosporidium* outbreak.

illness (*27*). Another outbreak (Florida, August 2000) was associated with the outbreak that occurred in Ohio. A family who were members of the implicated swim club in the Ohio outbreak were vacationing with a sick child. While in a pool in Florida, the infant had two fecal accidents. The resulting outbreak caused five cases of diarrheal illness and two hospitalizations.

Eight other outbreaks of cryptosporidiosis occurred in treated venues during the 2000 swim season. Two outbreaks of gastroenteritis occurred in untreated venues: one in a freshwater lake in Minnesota in July 2000 and one in a Massachusetts pond in July 1999 (Appendix B).

Four cases of laboratory-confirmed primary amebic meningoencephalitis attributed to *Naegleria fowleri* occurred during this 2-year reporting period. All four persons were aged $\leq$19 years. Three of the persons died from infection after having contact with a pond, lake, or mud hole. The fourth person's freshwater exposure could not be determined; that person had fallen from a jet ski into an unspecified body of water, sustained injuries, and died from an infection shortly after it was detected.

Bacteria. Nine recreational outbreaks involving gastroenteritis were attributed to bacterial pathogens, and five of the nine were linked to freshwater sources. Five cases (Wisconsin, August 1999) of *Es. coli* O157:H7 occurred among persons who had visited the same swimming beach. After a review of potential risk factors, the only common link found was swimming at the implicated beach. The popular beach featured a shallow, dammed area that was used for wading. Total and fecal coliforms were detected in water samples collected before and during the outbreak, although the levels detected did not exceed levels of EPA-recommended guidelines for microbiologic quality of water (*22*). One sample that was tested for *Es. coli* O157:H7 was negative. *Es. coli* O157:H7 was implicated in another outbreak among 36 persons (August 1999) who visited a state park in Washington. *Es. coli* O121:H19 was implicated in an outbreak in a Connecticut community (July 2000). *Shigella sonnei* was implicated in two outbreaks that occurred at swimming beaches in Minnesota (July and August 2000).

Nonfreshwater sources were implicated in four bacterial recreational water outbreaks involving gastroenteritis. In March 1999, an outbreak of *Ca. jejuni* was associated with a private pool in Florida that did not have continuous chlorine disinfection and reportedly had ducks swimming in the pool. Outbreaks of *Shigella flexneri* and *Es. coli* O157:H7 (Missouri, September 2000 and Nebraska, June 1999) occurred among children using unchlorinated wading pools. Fecal accidents were factors contributing to the contamination of the water in both outbreaks. *Es. coli* O157:H7 also was implicated as a cause of illness in an outbreak (Florida, September 1999) among two young children who had been playing in ditch water. Both clinical specimens and water samples tested positive for *Es. coli* O157:H7.

Two nongastroenteritis-related recreational water outbreaks were also reported. One outbreak of leptospirosis was reported among 21 persons who participated in an adventure race in Guam in July 2000 (Table 8). These persons reported multiple outdoor exposures, including running through jungles and savannahs, swimming in a river and a reservoir, and bicycling and kayaking in the ocean. *Leptospira* was confirmed by serology, and an epidemiologic investigation demonstrated that swimming in the reservoir, submerging one's head in the water, and swallowing water while swimming were risk factors for illness. Water samples were not tested, and an environmental assessment of the reservoir was not conducted. The second nongastroenteritis-related recreational water outbreak was an outbreak of Pontiac fever epidemiologically linked to use of a whirlpool at a hotel.

Viruses. During 1999–2000, three outbreaks of NLV (Calicivirus) that affected a total of 202 persons were reported. Two NLV outbreaks occurred in untreated systems; one outbreak of NLV occurred (Idaho, June 1999) at a resort and water park and affected 25 persons. The pool implicated in the investigation was untreated because the source of the pool's water was a natural hot springs that was high in mineral content. The investigators noted that geothermal pools used for swimming are not required to be regulated by public health officials in that locale. The pool implicated by the investigation also had been implicated in a previous outbreak of NLV in June 1996.

Other. During 1999–2000, six recreational water outbreaks involving gastroenteritis of unknown etiology were reported. One outbreak (Florida, August) involved a motel pool that was cloudy and dirty at the time of exposure. Nine persons who swam in this pool and did not share any other common exposure became ill with gastroenteritis. Disinfectant residuals and operation of the filtration system at the time of the investigation were deficient. Problems were also noted with the equipment used for adjusting pH.

Another outbreak (Florida, August 1999) among 38 persons who visited a beach park was attributed to both *Sh. sonnei* and *Cr. parvum* (*28*). Illness was epidemiologically linked to playing in an interactive fountain at the park, ingesting water, and consuming food and beverages at the fountain. The fountain's recirculation, filtration, and disinfection systems were not approved by the health department and were inadequate or not completely operational at the time of its use. Samples of the fountain water tested positive for coliforms but did not test positive for fecal coliforms. Nevertheless, the cause of the outbreak was determined to be the fountain, which was closed until the health department's concerns could be remedied.

Three cases of chemical keratitis (Vermont, February 2000) resulted from exposure to bromine in a hotel swimming pool. Bromine levels were >5 ppm (acceptable bromine levels are 1–3 ppm), and the pH level was >8.5. Patrons who spent time with their heads underwater with their eyes open were affected.

Twelve persons affected in an outbreak (Texas, September 1999) reported symptoms that included exhaustion, sore muscles, headache, chills, and fever after attending a conference at a guest ranch. One woman reported a miscarriage during her illness. Exposure to a hot tub, defined as either immersion or being near the hot tub, was associated with illness. Although clinical specimens (urine, blood, sputum, and throat swabs) were tested for organisms, including *Leg. pneumophila* serogroups 1 and 6, influenza virus, parainfluenza virus, and adenovirus, no infectious agent was identified. No testing for biologic or chemical agents was performed on water samples because the hot tub had already been drained, refilled, and hyperchlorinated before the environmental investigation.

During the 1999–2000 reporting period, 15 outbreaks of dermatitis were identified (Table 9). Three of these outbreaks were associated with swimming in freshwater and were assumed to be cercarial dermatitis caused by contact with the larval form (cercariae) of schistosomes, which are present in freshwater environments. Two of these dermatitis outbreaks occurred in lakes in California that were associated with past cases of cercarial dermatitis. The onset of dermatitis occurred within hours after swimming in the lake and resolved after a limited number of days (median days of illness were 2 and 3 days [range: 2–3 and 3–5 days], respectively). The 12 remaining outbreaks were associated with pool and hot tub use and affected 5–29 persons each. *P. aeruginosa* was confirmed in clinical isolates in 3 of the 12 outbreaks and was confirmed in water/filter samples in five outbreaks, two of which also had a clinical isolate. In eight of these outbreaks of dermatitis, specific treatment deficiencies or problems were identified. Outbreaks in Arkansas (June 1999), Florida (August 2000), Colorado (December 1999), and Washington (March 2000) were attributed to deficiencies in treatment.

In one outbreak of dermatitis (Maine, February 2000), nine persons reported rash in addition to headache, fever, fatigue, and sore throat (*29*). Swimming in the hot tub or swimming in the pool was a risk factor. The pool and hot tub were on separate filtration systems, and both were used by the majority of persons in the outbreak. Low levels of free chlorine were found in the pool and hot tub, but the presence of chlorinate isocyanurates (chlorine stabilizers) might have influenced measured levels of free chlorine. A clinical isolate of *P. eruginosa* was obtained from an ill person; *P. aeruginosa* also was isolated from the pool filter even after the pool had been cleaned twice.

P. aeruginosa was isolated from clinical specimens and water samples in an outbreak at a Colorado hotel that affected 19 persons in February 1999 (*28*), 13 of whom were children aged <15 years. Symptoms were not limited to rash; they included diarrhea, vomiting, nausea, fever, fatigue, muscle aches, joint pain, swollen lymph nodes, and subcutaneous nodules on hands and feet. Because of the severity and range of symptoms, clinical specimens were examined for enteric bacterial and parasitic pathogens as well as *Legionella* species, *Leptospira* species, and *Entamoeba histolytica* but did not test positive for any of these etiologic agents. Swabs taken from the hot tub floor and rail were positive for *P. aeruginosa* and other *Pseudomonas* species. Pool and hot tub records indicated that chlorine and pH had declined below the state-mandated levels at the time of exposure. Epidemiologic evidence implicated the hot tub as the likely vehicle of exposure for the outbreak. In both the Colorado outbreak and the Maine outbreak that occurred in February 2000, an offsite contractor had been engaged to monitor disinfectant and pH levels. Insufficient communication between pool staff and the remote monitoring company might have contributed to extended periods of usage with inadequate disinfection (*28*).

Outbreaks Associated with Occupational Exposure to Water

Two outbreaks not associated with drinking or recreational water exposure were reported during this period (Table 10). One outbreak of leptospirosis (Hawaii, August 1999) occurred among persons landscaping a pond. Leptospirosis was confirmed serologically for the two persons who had contact with the pond. Both persons reported multiple skin abrasions and were exposed to the pond water for a period of 5–10 days. One of the two persons was hospitalized.

An outbreak of acute respiratory illness occurred among sugar beet processing plant workers (Minnesota, August 2000). Of the 15 cases identified, 13 were hospitalized. Serology for 4 (26.7%) of the 15 persons tested positive for *Leg. pneumophila*; three (20.0%) persons were confirmed positive for *Leg. pneumophila* by sputum polymerase chain reaction (PCR). Fourteen (93.3%) of the 15 persons worked on a crew that had performed high-pressure cleaning in one area of the plant; the fifteenth patient had conducted high-pressure cleaning elsewhere in the plant. The sources of water for the high-pressure cleaning contained 10^5 colony-forming unit (CFU)/mL of *Leg. pneumophila* and endotoxin levels of 22,200 endotoxin units/mL. Although the attack rate, symptoms, and laboratory findings were consistent with an outbreak of Pontiac fever, endotoxin exposure might have contributed to this outbreak.

Previously Unreported Outbreaks

Three previously unreported drinking water outbreaks that occurred in 1995 and 1997 were submitted during this reporting period (Table 11). An illegal cross-connection (Washington, July 1995) between a domestic water supply

TABLE 10. Waterborne-disease outbreaks associated with occupational exposures — United States, 1999–2000 (n = 2)

State	Year	Month	Class*	Etiologic agent	Exposure	Number of cases	Source	Setting
Hawaii	1999	Aug	IV	*Leptospira*	Contact with pond water	2	Pond	Outdoor landscaping
Minnesota	2000	Aug	III	Pontiac fever†	High-pressure cleaning using lagoon water	15	Plant lagoon	Sugar beet plant

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12.
† Endotoxin was also isolated from environmental samples; the role of endotoxin is unclear.

TABLE 11. Waterborne-disease outbreaks associated with drinking water that were not included in the previous surveillance summaries — United States, 1995–1997 (n = 3)*

State	Year	Month	Class*	Etiologic agent	Number of cases	Type of system§	Deficiency¶	Source	Setting
Washington	1995	Jul	III	*Giardia intestinalis***	87	Com	4	Well	Community
California	1997	Nov	III	Nitrite (sodium metaborite)	7	Com	4	Mixed river/groundwater	Hospital cafeteria
New York	1997	Dec	I	Norwalk-like virus	1,450	Ncom	3	Well	Ski resort

* An outbreak is defined as 1) ≥2 persons experiencing a similar illness after either ingestion of drinking water or exposure to water used for recreational purposes and 2) epidemiologic evidence that implicates water as the probable source of illness.

† On the basis of epidemiologic and water-quality data provided on CDC form 52.12.

§ Com = community; Ncom = noncommunity; Ind = individual; Community and noncommunity water systems are public water systems that serve ≥15 connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for ≥6 months/year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks). Individual water systems are not owned or operated by a water utility and serve <15 connections or <25 persons. Outbreaks associated with water not intended for drinking (e.g., lakes, springs, and creeks used by campers and boaters; irrigation water; and other nonpotable sources with or without taps) are also classified as individual systems.

¶ 1 = untreated surface water; 2 = untreated groundwater; 3 = treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, and inadequate or no filtration); 4 = distribution system deficiency (e.g., cross-connection, contamination of water mains during construction or repair, and contamination of a storage facility); and 5 = unknown or miscellaneous deficiency (e.g., contaminated bottled water).

** Thirty-three persons had stool specimens that tested positive for *G. intestinalis*. One specimen tested positive for *Entamoeba coli*. One other specimen tested positive for *Blastocystis hominis*. One cultured specimen tested positive for *Campylobacter jejuni*.

and an irrigation system at a plant nursery resulted in contamination of multiple wells in a community. Eighty-seven cases of gastroenteritis were reported, and one hospitalization was recorded. *G. intestinalis* was determined in 33 (52.4%) of 63 stool specimens; *Entamoeba coli* and *B. hominis* were each found in one stool specimen. One (7.1%) of 14 stool specimens that were cultured for *Ca. jejuni* tested positive.

NLV was implicated as the cause of an outbreak (New York, December 1997) of 1,450 cases at a restaurant at a ski resort. Epidemiologic data implicated water or consumption of ice made from water as the cause of the outbreak. The environmental assessment revealed possible problems with the well operation and location. The chlorinator for the well had been malfunctioning and had already been disconnected before the assessment. Testing of the water by the local health department determined that neither a free nor total chlorine residual was detectable in the potable water supply and indicated the presence of fecal coliforms. In addition, the well was located <24 inches away from a stream. During the period the chlorinator was not functioning, the pump for the well had been continuously pumping water. Surface water that might have been introduced into the water supply, plus a deficiency in treatment of the water, played a key role in the outbreak.

Seven persons who were either employees or visitors at a hospital (California, November 1997) were symptomatic for methemoglobinemia in one outbreak. An epidemiologic investigation indicated that the only shared exposure among these persons was a visit to the hospital cafeteria and the consumption of a carbonated beverage with ice from the self-service soda dispenser. The onset of symptoms occurred 1–5 minutes after or while drinking a carbonated beverage. One person was hospitalized, and no deaths occurred. The environmental investigation discovered a cross-connection in the plumbing system that might have allowed water from the cooling tower, which had been recently shock-treated with sodium metaborate, to be drawn into the drinking water system. Sodium metaborate has been associated with nitrate poisoning and methemoglobinemia in past incidents (*30*).

Outbreaks Not Classified as WBDOs

Outbreaks attributed to drinking water that was contaminated or potentially contaminated at the point of use rather than at the source or in the distribution system are not classified as WBDOs. Six outbreaks, causing illness among a total of 102 persons, are in this category. None of the six outbreaks reflected a common vehicle of contamination: one outbreak of *Cr. parvum* was epidemiologically associated with ice consumption; a school-based outbreak of *Sh. sonnei* was related to consumption of water from a dispenser stored in a bathroom facility; a third outbreak involved water taken from a garden hose (the water had been stored in an ice chest before consumption at a private residence); and a fourth outbreak associated with bottled water that might have been contaminated at the point of use. Two of the six reported point-of-use outbreaks involving a suspected chemical exposure occurred in food service facilities, but water testing was not performed to verify the presence of the chemical; and, because of the relatively limited number of cases associated with these incidents, the epidemiologic information was not adequate to include these incidents as outbreaks.

Data from six other possible or confirmed outbreaks were also not included in this analysis. One confirmed outbreak of leptospirosis was related to travel outside the United States or its territories and therefore was excluded. This outbreak occurred among student travelers who became ill after their return from Ecuador. Three cases of leptospirosis were confirmed by laboratory testing among the cohort, and four additional cases were suspected. Three other outbreaks of *G. intestinalis, Cr. parvum,* and NLV could not be included in the analysis. Although these outbreaks were probably caused by a recreational water exposure, the data provided did not meet the criteria for inclusion (i.e., the outbreaks did not meet the criteria for Classes I–IV).

Two additional outbreaks were excluded because of inadequate information: one outbreak of dermatitis caused by in-home bathing and one potential drinking water outbreak of *Cr. parvum* in a New England community. This outbreak of *Cr. parvum* occurred in a community near another reported community outbreak of *G. intestinalis* and *Cr. parvum* in 1999. The pond implicated in the recreational water outbreak of *G. intestinalis* also served as a surface water source, which was intermittently mixed into the municipal drinking water that supplied the community. However, not all the persons received their drinking water from the municipal water source. Although raw surface water samples later tested positive for *Cr. parvum* by immunomagnetic spectroscopy (IMS), household water samples either tested negative, were not tested, or the results were not provided. The epidemiologic information and water-quality information provided were not conclusive.

Discussion

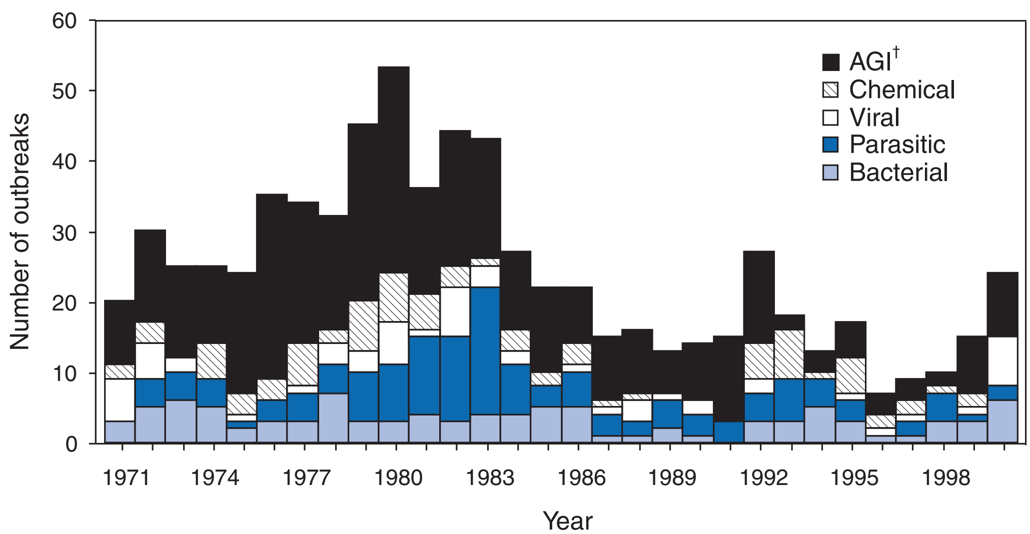
Considerations Regarding Reported Results

The WBDO surveillance system provides information concerning epidemiologic and etiologic trends in outbreaks. In previous years, a decrease in the number of drinking water-associated outbreaks had been observed. However, the cumulative number of drinking water outbreaks reported for the 1999–2000 period demonstrates a reversal of this trend (Figures 5 and 6). The number of recreational water outbreaks has been gradually increasing for the past 15 years and is at the highest level since CDC began receiving such reports in 1978.

Although the number of outbreaks reported through the surveillance system has increased, the significance of this increase is unclear. Whether this indeed reflects a true increase in the number of outbreaks that occurred in the United States is unknown. Not all outbreaks are recognized, investigated, and then reported to CDC or EPA, and studies have not been performed that assess the sensitivity of this system and indicate what percentage of actual outbreaks this system is able to detect. Multiple factors exist that can influence whether WBDOs are recognized and investigated by local, territorial, and state public health agencies: the size of the outbreak; severity of disease caused by the outbreak; public awareness of the outbreak; routine laboratory testing for organisms; requirements for reporting cases of diseases; and resources available to the local health departments for surveillance and investigation of probable outbreaks. This surveillance system probably underreports the true number of outbreaks because of the multiple steps required before an outbreak is identified and investigated. In addition, changes in the capacity of local, county, and state public health agencies and laboratories to detect an outbreak might influence the numbers of outbreaks reported in each state relative to other states. The states with the majority of outbreaks reported during this period might not be the states where the majority of outbreaks actually occurred. An increase in the number of outbreaks reported could either reflect an actual increase in outbreaks or an improved sensitivity in surveillance practices.

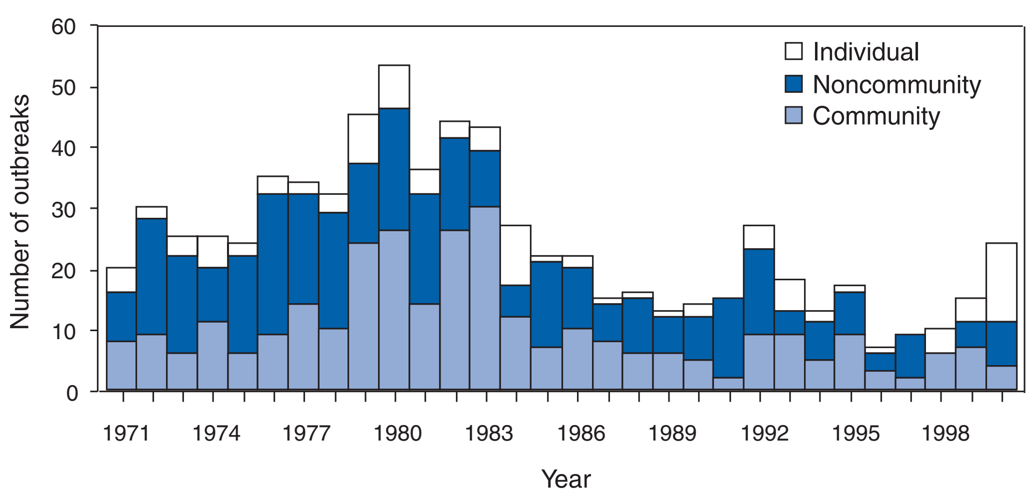
Recognition of WBDOs also is dependent on certain outbreak characteristics; outbreaks associated with serious illness or affecting a substantial number of persons are more likely to receive attention from health authorities. Outbreaks involving acute diseases, including those characterized by a

FIGURE 5. Number of waterborne-disease outbreaks associated with drinking water, by year and etiologic agent — United States, 1971–2000 (n = 730)*



* The total from previous reports has been corrected from n = 691 to n = 688.
† Acute gastrointestinal illness of unknown etiology.

FIGURE 6. Number of waterborne-disease outbreaks associated with drinking water, by year and type of water system — United States, 1971–2000 (n = 730)*



* The total from previous reports has been corrected from n = 691 to n = 688.

short incubation period, are more readily identified than outbreaks associated with chronic, low-level exposure to an agent (e.g., certain chemicals) or are associated with organisms that have a longer incubation period (e.g., certain parasitic organisms). Outbreaks involving larger drinking water systems (e.g., community systems) are more likely to be detected than outbreaks that involve noncommunity systems because these systems serve mostly nonresidential areas and transient populations. Outbreaks associated with individual systems are the most likely to be underreported because they typically involve a limited number of persons. Recreational outbreaks where persons congregate in one venue and then are geographically dispersed can be difficult to document.

The identification of the etiologic agent of a WBDO depends on the timely recognition of the outbreak so that appropriate clinical and environmental samples can be collected. The laboratory involved in the testing of specimens must have the capacity and capability to test for a particular organism. In certain cases, specific tests must be requested. Routine testing of stool specimens at laboratories will include tests for the presence of enteric bacterial pathogens and might also include an ova and parasite examination. However, *Cr. parvum*, one of the most commonly reported waterborne parasites, is not often included in standard ova and parasite examinations and in certain instances, must be specifically requested (*31*). During 1999–2000, tests for NLV and other possible agents of viral origin were rarely performed or documented in the outbreaks that were reported to CDC. Collection of water-quality data depends primarily on local and state statutory requirements, the availability of investigative personnel, and the technical capacity of the laboratories that test the water. Furthermore, certain outbreaks can substantially alter the relative proportion of cases of waterborne disease attributed to a particular agent. The number of reported cases is typically an approximate figure, and the method and accuracy of the approximation vary among outbreaks.

One key limitation of the data collected as part of the WBDO surveillance system is that the information collected pertains only to outbreaks of waterborne illness. The epidemiologic trends and water-quality concerns observed in outbreaks might not necessarily reflect or correspond with trends associated with endemic waterborne illness. CDC and EPA are collaborating on a series of epidemiologic studies to assess the magnitude of nonoutbreak waterborne illness associated with consumption of municipal drinking water and with exposure to recreational marine and freshwaters.

Outbreaks Associated with Drinking Water

The number of outbreaks reported during 1999 (15) and 2000 (24) is higher than the number reported during 1997 (7) and 1998 (10). As described previously, the number of drinking water outbreaks had declined (*2,3*). The increase in reported outbreaks should be carefully interpreted. Although the number of drinking water outbreaks has changed, the total number of persons affected by a drinking water outbreak during 1999–2000 (n = 2,027) is comparable to what was initially reported in 1997–1998 (n = 2,038) and 1995–1996 (n = 2,567) (*2,3*). Changes in surveillance and reporting of outbreaks might have improved detection of outbreaks affecting limited, private systems that in turn, affect a relatively limited number of persons. However, the increase in outbreaks that affect persons in limited, private systems merits further investigation by public health and water-quality agencies.

Certain states reported drinking water outbreaks for the first time in >10 years (e.g., Connecticut since 1976 or Utah since 1986). California reported multiple drinking water outbreaks after reporting no outbreaks in 1997 and 1998, and compared with other years during 1990–2000, the number of reported outbreaks in California increased slightly. The number of outbreaks reported by Florida also increased. Although the numbers of reported outbreaks increased overall, the seasonality of the drinking water outbreaks is consistent with previous years, with the number peaking during the summer months. The observed increase in the number of outbreaks is associated with an increase in outbreaks associated with consumption of untreated water from both surface and groundwater sources, but specifically private wells.

The percentage of drinking water outbreaks associated with surface water during 1999–2000 was 17.9% (i.e., seven outbreaks) (Figure 2). This percentage is higher than the 11.8% reported during 1997–1998 period (i.e., two outbreaks). However, three of the seven surface water outbreaks reported during 1999–2000 were associated with the direct ingestion of surface water without any treatment or with inadequate individual treatment. Two of these outbreaks were associated with consumption of water during outdoor excursions where point-of-use treatment (e.g., filtration or disinfection) might have been attempted and was either inadequate to protect health or was inconsistently or incorrectly applied. The third outbreak occurred after a household had run out of potable water and instead served untreated creek water to their guests. These three outbreaks illustrate that the public might be unaware that surface water, despite its clarity, is prone to contamination by organisms. Surface waters should not be directly consumed without being treated at the point of use or boiled. Manufacturers of point-of-use devices and the National Sanitation Foundation (NSF) provide information regarding different devices, instructions for use, and their ability to make water safe for human consumption.[¶] The remaining four outbreaks comprise approximately 11% of all drinking water outbreaks, an equivalent percentage to that reported in 1997–1998. These four outbreaks were associated with systems that routinely received treatment. One outbreak of giardiasis occurred at a resort (Colorado, August 2000) served by a noncommunity system. The increased demand for water during the summer, coupled with multiple treatment failures, resulted in the delivery of unfiltered and nondisinfected water to the resort. These multiple failures illustrate the importance of routine maintenance, specifically among noncommunity systems, which do not have consistent demand for water year-round. Two outbreaks (Florida, March 1999 and August 1999) were associated with cross-connections: one to an irrigation well and another to a toilet. Another surface water outbreak (Ohio, August 2000) at a fairgrounds was suspected to have resulted from back-siphonage into the drinking water from an animal manure site. These outbreaks indicate that even when treatment of water at the source is adequate, deficiencies in the distribution system or at the home can result in illness. Such deficiencies are preventable, and the public should be informed of how to detect and avoid creating cross-connections.

Twenty-eight (71.8%) of the 39 outbreaks related to drinking water were associated with groundwater sources. This number is an 87% increase from the number reported in the previous period (i.e., 15). Seventeen of the 28 outbreaks (60.7%) were linked to consumption of untreated groundwater; eight of 28 (28.6%) outbreaks were associated with treatment deficiencies; and three (10.7%) were linked to deficiencies in the distribution system. The observed pattern of deficiencies is contrary to what was observed in the previous reporting period, where the majority of groundwater outbreaks were associated with treatment or distribution system problems. This pattern indicates that untreated groundwater systems are increasingly associated with outbreaks of illness. Groundwater systems, with the exception of systems influenced by surface water, are not routinely required to use filtration or treatment that would be expected to reduce the number of pathogens in the water. EPA's pending GWR[**] is expected to establish multiple barriers in groundwater systems to protect against bacteria and viruses in drinking water from groundwater sources and should establish a targeted strategy to identify groundwater systems at high risk for fecal contamination.

Twenty-six of these 28 groundwater outbreaks had a well as the implicated water source, and two were linked to a spring. The percentages of outbreaks associated with wells and springs were similar during this reporting period to the 1997–1998 period. Although GWR is expected to have public health benefits, these protections extend primarily to community groundwater systems. Of the 26 well-related outbreaks that occurred during the 1999–2000 period, only eight of 26 were associated with community wells. Ten were associated with individual private wells, and eight were associated with noncommunity wells. These systems would not necessarily benefit from the promulgation of GWR, and therefore, the quality of water in wells remains a public health concern. Approximately 14–15 million households in the United States rely on a private, household well for drinking water each year, and >90,000 new wells are drilled throughout the United States each year (*32*). In addition, contamination of a private well is not only a health concern for the household served by the well, but can impact households using other nearby water supplies and could potentially contaminate the aquifer.[††] Additional education efforts should be targeted towards well owners, users, well drillers, and local and state drinking water personnel to encourage practices that best ensure safe drinking water for private well users.

Three outbreaks were associated with direct consumption of water from irrigation systems, comprising approximately 8% of drinking water outbreaks (Figure 2). Cross-connections to irrigation systems were implicated as contaminating factors in three other irrigation-related outbreaks. Irrigation waters are not regulated under the Safe Drinking Water Act, because they are typically intended for agricultural purposes, not for human consumption. Therefore, irrigation water would not be expected to be treated to reduce the level of microorganisms or other contaminants potentially in the water to the same standards as water intended for consumption. In one outbreak, children drank directly from an irrigation canal while playing outside a home. In two other outbreaks, water was directly consumed from an irrigation tap by sports team members. In the first instance, the sports team consumed water from a labeled irrigation tap despite being informed that the water was not intended for consumption. In the second instance, two teams drank from taps on the field

¶ Additional information is available at http://www.nsf.org.

** Additional information is available at http://www.epa.gov/safewater/gwr.html.

†† Although EPA does not regulate private wells and will not regulate them as part of the proposed GWR, EPA lists recommendations for protecting private water supplies at http://www.epa.gov/safewater/pwells1.html and provides links to other sources of information.

because no other source of potable water was available on field.

The multistate outbreak of *Sa.* Bareilly, which was detected through CDC's *Salmonella* Outbreak Surveillance Algorithm (SODA), epidemiologically implicated the consumption of bottled water as a risk factor for illness. This is the first widespread outbreak implicating bottled water in the United States. Previous bottled water outbreaks occurred in New Jersey in 1973 (*33*), Pennsylvania in 1980 (*34*), and in the Northern Mariana Islands in 1993 (*4*). Bottled water standards and regulations, unlike the majority of drinking water standards, are not set and enforced by EPA but by FDA. FDA regulates bottled water as a packaged food product and bases their bottled water standards on EPA's tap water standards. In addition, bottled water might be subject to state and voluntary industry regulation. Bottled water, before this outbreak, had not been identified as a vehicle for transmission of infectious organisms in the United States, although a bottled water outbreak of *Ca. jejuni* associated with consumption of water bottled in Greece was documented during the 1997–1998 surveillance period (*2*). Because of the wide geographic distribution of bottled water products, an outbreak associated with the consumption of bottled water would be difficult to recognize. FDA, EPA, CDC, and the bottled water industry together should address concerns regarding consumption of bottled water and public health.

Overall, the number of outbreaks associated with the five drinking water deficiencies (untreated surface water, untreated groundwater, treatment deficiency, distribution system deficiency, and unknown/miscellaneous deficiency) increased in each category from the 1997–1998 levels. The percentage of outbreaks caused by a treatment deficiency and distribution system problem decreased relative to reported increases in the other three categories. Although problems with treatment and with distribution systems remain critical concerns for safe drinking water, the public's lack of understanding of the risk associated with consumption of untreated water and the assumption that all water is suitable for consumption is a concern also.

The relative proportion and number of outbreaks associated with different water systems also differs from the figures from the 1997–1998 period (Figure 2). Outbreaks in community systems increased from 8 to 11 outbreaks (37.5% increase); noncommunity outbreaks doubled from 5 to 11; and individual system outbreaks quadrupled, increasing from 4 to 17 outbreaks. However, the proportion of outbreaks in community systems decreased from 47.1% during 1997–1998 to 28.2% during 1999–2000, whereas the relative proportion of outbreaks in individual systems increased from 23.5% during 1997–1998 to 43.6 during 1999–2000. In addition, the number of outbreaks reported that were associated with individual systems during this period is the highest reported level since 1984. The drinking water quality of community systems, which typically have been the focus of increased EPA regulation, has continually improved. But noncommunity systems and individual systems, which are not regulated to the same extent, are continuing problems. The majority of these individual system outbreaks are linked to currently unregulated groundwater supplies, specifically private wells. The populations served by these systems merit increased attention by public health officials.

The etiologic agent was not identified in 17 (43.6%) of 39 outbreaks (Figure 2). These outbreaks of unknown etiology comprised the largest group of outbreaks, followed by outbreaks caused by bacteria (nine), parasites (seven), viruses (four), and chemicals (two). During 1997–1998, parasites accounted for the largest percentage of the 17 outbreaks (six [35.3%]), followed by unidentified pathogens (five [29.4%]), bacteria (four [23.5%]), chemicals (two [11.6%]), and viruses (zero [0%]). The number of outbreaks per type of agent were increased for all categories during 1999–2000, with the exception of chemicals. Although the number of reported viral outbreaks increased, indicating an improvement in the availability and usage of laboratory detection methods during previous years, viral outbreaks are probably substantially underreported. Although viruses were suspected in other outbreaks, specifically in those of unknown etiology, testing for viruses was not performed. The technology for detection of viruses in stool and water samples has improved, but testing for viruses is not widely practiced. Investigators are encouraged to submit clinical specimens to CDC or state laboratories that conduct these tests. Guidelines for collecting stool specimens for identification of viral organisms are available from CDC (*35*). Investigators are also encouraged to contact CDC and EPA regarding testing of water samples.

Only two outbreaks of chemical origin were identified during this surveillance period, the same number as was reported during the 1997–1998 period. One outbreak related to a spill of sodium hydroxide at a community water treatment plant demonstrated the need for safe water treatment practices. The other outbreak was a single case of methemoglobinemia in an infant who required hospitalization after having been fed boiled water taken from a private well. Coordination of public health messages is critical; an intervention that was intended to reduce the transmission of infections agents concentrated the chemicals present in the water. These figures, as in the past, probably underrepresent the actual waterborne chemical poisonings that occur. Multiple factors can explain the low reporting rate, including the likelihood that 1) the majority of waterborne chemical poisonings typically occur in private residences and affect a relatively limited number of persons; 2) exposures to chemicals through drinking water might cause illness that is difficult to link to a chemical exposure; 3) the mechanisms for reporting waterborne chemical poisonings to the WBDO surveillance system are not as established for chemicals as they are for WBDOs attributed to infectious agents; and 4) health-care providers and those affected might not as easily recognize chemical poisonings. As a result of these factors, WBDOs of chemical poisonings are less likely to be reported to public health officials.

Strengthening the capacity of local and state public health epidemiologists and environmental health specialists to detect and investigate outbreaks remains a priority at CDC and EPA. As part of that effort, CDC and EPA should partner with the states, CSTE, and the Association of Public Health Laboratories to develop training materials and online resources that would be useful and easily accessible to local and state public health personnel. Although no federal regulation exists for monitoring private wells, developing educational materials targeted towards the general public, informing them of ways to maintain the safety and water quality of their wells would be valuable. In addition, health messages regarding the consumption of nonpotable water and appropriate point-of-use treatment should be developed and distributed to the public.

Outbreaks Associated with Recreational Water

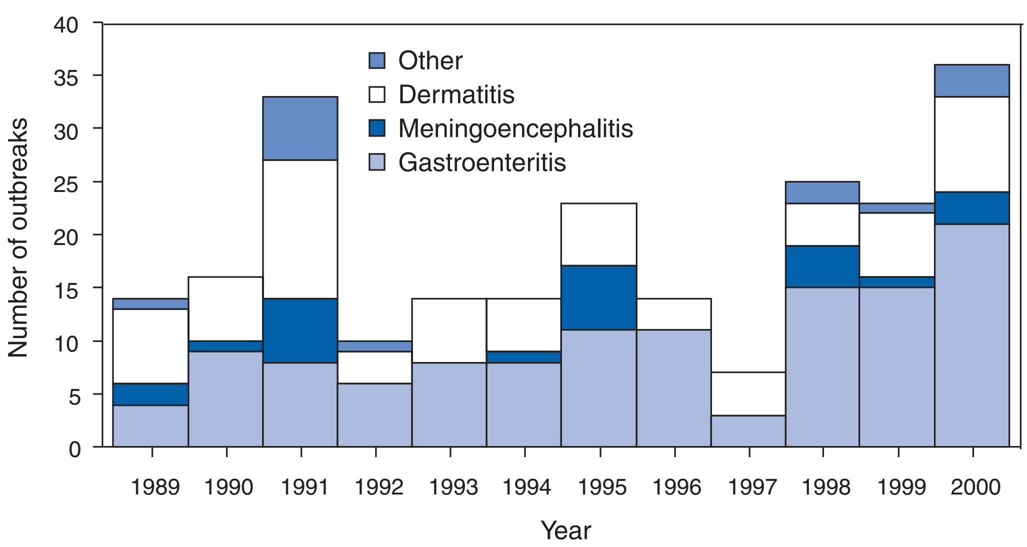
Of the 59 recreational WBDOs, those involving gastroenteritis were most frequently reported (n = 36). The 15 outbreaks reported in 1999 and 21 outbreaks reported in 2000 equal or surpass the number reported in 1998, which previously was the highest number of outbreaks involving recreational water-related gastroenteritis reported in one year since the inception of the surveillance system. Together, the outbreaks involving gastroenteritis reported during the 1999–2000 period are higher than the 18 outbreaks documented in the previous reporting period (Figures 7 and 8). Since 1989, the number of gastroenteritis-related outbreaks has been gradually increasing, and this increase is statistically significant (p = 0.01).

Because swimming is essentially a shared water activity or communal bathing, rinsing of soiled bodies and overt fecal accidents cause contamination of the water. Unintentional ingestion of recreational water contaminated with pathogens can then lead to gastrointestinal illness, even in nonoutbreak settings (*36,37*). Fresh and marine waters are also subject to other modes of contamination from point sources (i.e., sewage releases), watersheds (i.e., runoff from agriculture and residential areas), and floods.

Outbreaks involving gastroenteritis are more frequently observed during the swimming season, which usually starts on Memorial Day weekend (the last weekend in May) and ends Labor Day weekend (the first weekend in September). However, swimming also occurs year-round in indoor venues and in states with more temperate climates. Outbreaks of illness by month (Figure 3) include two outbreaks that occurred noticeably outside the summer months: one outbreak in a Florida pool in March and another outbreak in an indoor pool in Wisconsin in January.

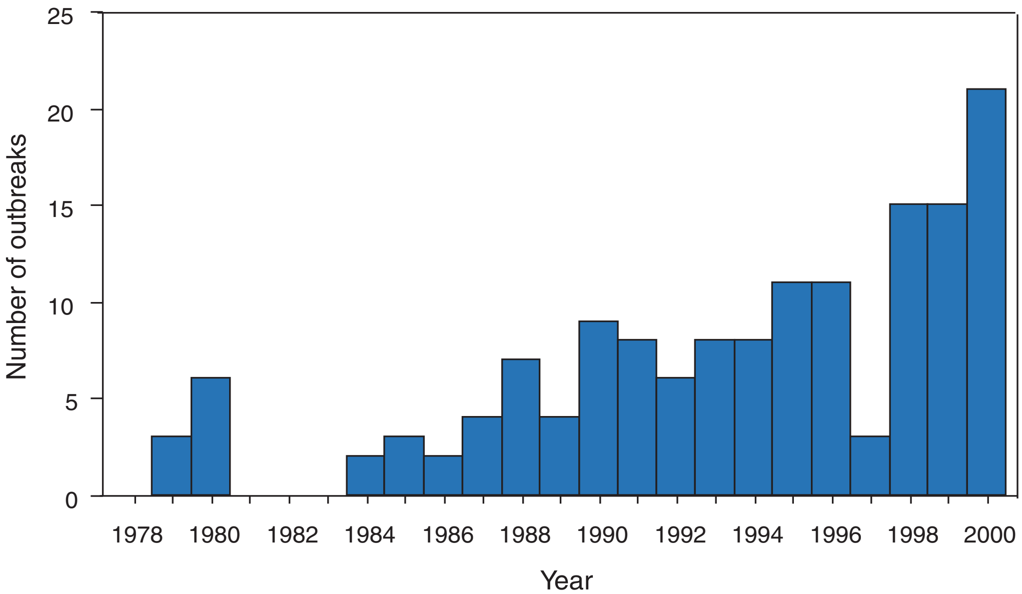
As during the previous reporting period, *Cr. parvum* accounted for the largest percentage of outbreaks involving gastroenteritis (44.4%), followed by *Es. coli* O157:H7 (11.1%), NLV (8.3%), and *Shigella* (8.3%). An outbreak of *G. intestinalis* was also reported in 1999. The last reported recreational water outbreak of *Giardia* occurred in 1996. Outbreaks of *Ca. jejuni*, *Es. coli* O121:H19, and a mixed *Sh. sonnei*/*Cr. parvum* outbreak were also reported for the first time to the surveillance system. Outbreaks of unknown etiology comprised 16.7% of the recreational water outbreaks involving gastroenteritis.

FIGURE 7. Number of waterborne-disease outbreaks associated with recreational water, by year and illness — United States, 1989–2000 (n = 229)*



* The total from previous reports has been corrected from n = 171 to n = 170.

FIGURE 8. Number of outbreaks involving gastroenteritis associated with recreational water, by year and illness — United States, 1978–2000 (n = 146)



Twenty-two (61.1%) of the 36 outbreaks of gastroenteritis occurred in treated systems (i.e., pools) that would usually be expected to be chlorinated or disinfected to prevent transmission of infectious agents after unintentional ingestion. However, the term *treated system* might pertain to systems not routinely treated, including wading pools, interactive fountains, and in one case, an untreated pool that was served by a natural hot springs source. Multiple interrelated factors can impede disinfection in treated venues, including an increased bather load in a pool, high levels of organic material (e.g., fecal material or environmental or skin debris) and ultraviolet light, all of which deplete chlorine residuals that usually maintain protection in the system. In certain outbreaks, fecal material was indicated on the report as a contributing factor to the outbreak; the majority of fecal accidents were attributed to young children who were in or near the water at the time the accident occurred.

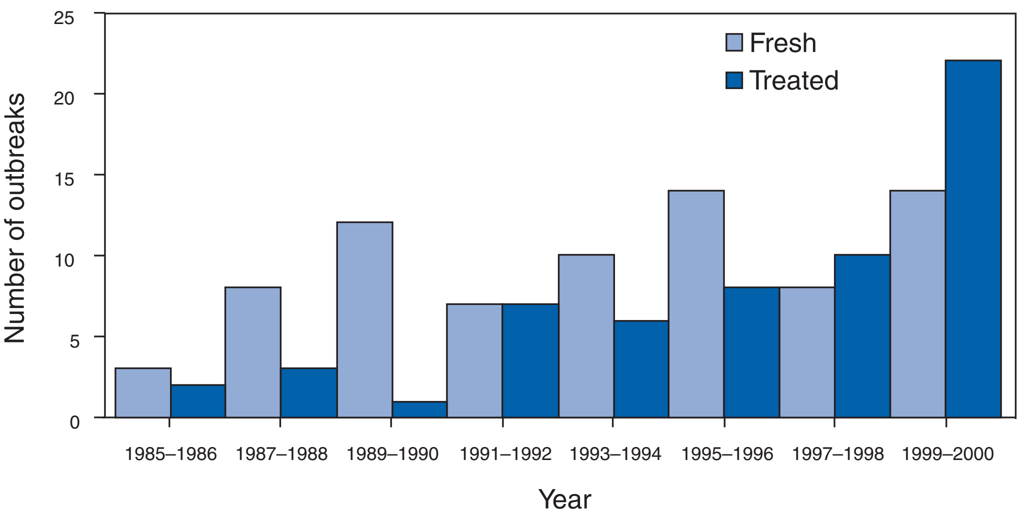
Unlike previous years, a substantial number of different bacterial and viral organisms were reported as causing gastrointestinal illness in these treated recreational water venues (Figure 9). Nevertheless, >66% of these outbreaks were attributed to *Cr. parvum* (Figure 4). Unlike other organisms, which are more susceptible to the levels of chlorine typically found in a pool, *Cr. parvum* is highly chlorine-resistant and requires increased levels of chlorine and longer contact times with chlorine for inactivation. *Cr. parvum* can survive for days in public health-mandated chlorine concentrations required for pools. In addition, its relatively limited size (4–6 µm) can allow it to pass through particulate filtration systems during recirculation of water in the pool. Because a low number of oocysts might cause illness in a person, even ingestion of a limited amount of water can cause infection. Although the number of *Cr. parvum* outbreaks has been steadily increasing during 1990–2000, multiple explanations could exist for the increase. The properties of the organism, coupled with the popularity of swimming and the tendency of persons to aggregate in larger water venues, increases the likelihood that swimming water can become contaminated and that swimmers will ingest the water and become infected. However, the increases in outbreaks could be explained by a higher awareness of *Cr. parvum* as a potential cause of illness among swimmers by the public health community and the recreational water industry and, as a result, are more likely to be detected.

The majority of these *Cr. parvum* outbreak investigations noted inadequate pool maintenance. Although low chlorine levels are unlikely to have been the cause of the outbreaks, the frequent reporting of low chlorine levels in these outbreaks indicates a disturbing lack of awareness concerning the role of chlorine and pH control as the major protective barrier against infectious disease transmission in pools. Inadequate disinfectant levels in any pool increases the risk for transmission of chlorine-sensitive pathogens (e.g., *Es. coli* O157:H7 or *Shigella* species) if an infected swimmer contaminates the pool. Pool operators and staff should be appropriately trained regarding the spread of recreational water illnesses and the critical role of pool maintenance (i.e., disinfection, pH control, and filtration) in preventing WBDOs.[§§]

Fourteen outbreaks involving gastroenteritis after freshwater exposure were reported during 1999–2000, compared with eight during 1997–1998. *Es. coli* O157:H7 accounted for the most outbreaks of known etiology (three), followed by NLV (two), *Shigella* species (two), *Es. coli* O121:H19 (one), *G. intestinalis* (one), and *Cr. parvum* (one). Four outbreaks were of unknown etiology. Certain outbreaks occurred in beach areas that had substantial numbers of families bathing and swimming in the water. Again, a common element noted

§§ Guidelines for pool operators and other information related to recreational water illnesses is available at http://www.cdc.gov/healthyswimming.

FIGURE 9. Number of outbreaks involving gastroenteritis associated with recreational water, by water type — United States, 1985–2000 (n = 135)



in these reports was the presence of diaper-aged children in the water, diaper-changing on the beach, and even washing off young children in the water. One incident involved persons who swam in a lake that was had posted signs indicating that the lake was unsafe for swimming.

Reports of infants and children swimming when they have diarrhea is a problem common to both freshwater systems and treated venues. Although health communication messages have been targeted in the past for treated venues, similar messages should be provided to those who swimming in freshwater venues. EPA, as part of the Beaches Action Plan, is developing guidelines and information for users of freshwaters.¶¶ Geothermal pools and hot springs should be examined closely. In one outbreak, pools in a complex were exempt from public health regulation because they were naturally occurring hot springs and mineral waters. Hot springs, which feature high levels of minerals and elevated temperatures, are potentially ideal venues for microbial growth or contamination. These springs and geothermal pools pose an increased risk to swimmers, compared with treated pools because of their lack of disinfection and filtration. Improved consumer and staff education and supplementary treatment might be necessary to prevent future outbreaks in these enclosed freshwater pools.

Twelve of the 15 outbreaks of dermatitis were associated with hot tub or pool use. The majority of these reports of dermatitis are associated with deficient maintenance and inadequate disinfection of the water. The higher temperatures commonly found in hot tubs deplete disinfectant levels at a more rapid rate; hot tub operators should be encouraged to actively check and maintain adequate disinfectant levels. In addition to rashes, reports have been received of other symptoms. In Alaska, three of 29 persons reported nausea. In the two Maine outbreaks, persons also reported headache, fatigue, and other symptoms. The Colorado outbreak was notable for its severe symptomatology and an extended duration of illness. Extended and painful rashes associated with *P. aeruginosa* outbreaks are unusual but have been documented (*38,39*). One report (*39*) also indicates that a substantial number of children are being affected by these outbreaks. In the Colorado outbreak of *P. aeruginosa*, the persons affected were primarily children, but no indication was provided that age was a risk factor for infection. More remarkable is the observed duration of illness. Certain persons reported chronic illness (i.e., rash, joint pain, abdominal pain, and chest pain) that lasted ≥6 weeks. Using remote pool monitoring services in two of these outbreaks underscores the need for training pool staff regarding the role of monitoring service and prompt communication between service and pool operators when problems are detected.

Three outbreaks of dermatitis that occurred after persons swam in fresh or marine water were presumed to be caused by an allergic reaction to the cercariae, the larval form of certain nonhuman species of schistosomes. Cercarial dermatitis was an identified problem in two of these lakes, and signs posted by the health department regarding this problem were ignored by swimmers. The extent of the problem of cercarial dermatitis caused by freshwater exposure is unknown, although it probably occurs more frequently than what is reported to the surveillance system. As schistosomes occur naturally in ecosystems that bring snails and birds or aquatic mammals close together, a substantial number of freshwater lakes in the United States might cause illness among swimmers. Swimmers should pay careful attention to where they swim, avoid shallow swimming areas known to be appropriate snail habitats in lakes associated with cercarial dermatitis, and report any incidents to their local health department to prevent further illnesses.

¶¶ Additional information is available at http://www.epa.gov/waterscience/beaches.

The four deaths associated with primary amebic meningoencephalitis (PAM) reported during the 1999–2000 period were all linked to freshwater exposure. Typically, these cases are associated with swimming in freshwater bodies in the late summer months because *N. fowleri*, which has been implicated in >90% of the cases reported to CDC, proliferate in warm, stagnant waters. Previous cases of PAM have been reported from states with more temperate climates (e.g., California, Florida, and Texas) or from areas with hot springs. The amoebas associated with PAM are believed to enter through the nasal passage. Preventing forceful entry of water up the nasal passages during jumping or diving by holding one's nose or wearing nose plugs could reduce the risk for infection.

Swimming in waters contaminated by animal urine was the likely explanation for an outbreak of leptospirosis among persons participating in an adventure race in Guam. *Leptospira* species can be found frequently in wild animal urine, and can be contracted through inhalation of aerosolized water or ingestion of water while swimming. Leptospirosis can also be acquired through abrasions. In this instance, the exposure was associated with immersion of persons' heads in a body of water while they swam and swallowed water. Although outdoor swimming is not necessarily dangerous, swimmers should be educated regarding the potential risks resulting from swimming in areas that are not secured from wild animal use.

An increased level of bromine, which is used to disinfect pools and hot tubs, caused certain cases of chemical keratitis. Inadequate disinfection of a whirlpool resulted in an outbreak of legionellosis among 20 persons who stayed at a motel. Safe disinfection practices and appropriate pool maintenance protocols should be communicated to operators and managers of facilities that treat recreational water.

Outbreaks Associated with Occupational Exposures to Water

Two outbreaks that do not fit into the previous categories were reported to CDC by Minnesota and Hawaii. Outbreaks associated with exposure to aerosolized water have previously occurred but have not been reported to the WBDO surveillance system (*40,41*). These outbreaks are discussed in this report to demonstrate that water exposures are not limited to ingestion and contact (e.g., through swimming), and these outbreaks are preventable. Using barrier masks to prevent inhalation of aerosolized water or disinfection of water that is not being used for drinking or swimming purposes could have prevented the respiratory illnesses associated with these two outbreaks.

Conclusion

Data collected as part of the national WBDO surveillance system are used to describe the epidemiology of waterborne diseases in the United States. Data regarding water systems and deficiencies implicated in these outbreaks are used to assess whether regulations for water treatment and monitoring of water quality are adequate to protect the public's health. Identification of the etiologic agents responsible for these outbreaks is also critical because new trends might necessitate different interventions and changes in policies and resource allotment.

Surveillance for waterborne agents and outbreaks occurs primarily at the local and state level. Local and state public health agencies need to detect and recognize WBDOs and implement appropriate prevention and control measures. Improved communication among local and state public health departments, regulatory agencies, water utilities, and recreational water facilities would aide the detection and control of outbreaks. Routine reporting or sharing of water-quality data with the health department is recommended. Other means of improving surveillance at the local, state, and federal level could include the additional review and follow-up of information gathered through other mechanisms (e.g., issuances of boil-water advisories or reports of illness associated with agents thought to be waterborne).

One repeated observation regarding outbreak data collected as part of the WBDO system was that the timely collection of clinical specimens and water samples for testing and commencement of an environmental investigation would have resulted in an improved ability to detect the outbreak's etiologic agent and the source of water contamination. However, the course of an investigation is influenced by the ability and capacity of public health departments and laboratories to recognize and investigate potential outbreaks of illness. Even when personnel are available to investigate a potential outbreak in a timely manner, a common observation is that investigations cannot always be completed thoroughly. WBDO outbreak investigations typically require input from different disciplines, including infectious disease epidemiology, environmental epidemiology, clinical medicine, sanitation, water engineering, and microbiology. Either further cross-training of existing personnel needs to be implemented or additional personnel and resources need to be made available or linked to those who typically investigate reports of WBDOs.

State health departments can request epidemiologic assistance and laboratory testing from CDC to investigate WBDOs. CDC and EPA can be consulted regarding engineering and environmental aspects of drinking water and recreational water treatment and regarding collection of large-volume water samples to identify pathogenic viruses and parasites, which require special protocols for their recovery. Requests for tests for viral organisms should be made to CDC's Viral Gastroenteritis Section, Respiratory and Enterovirus Branch, Division of Viral and Rickettsial Diseases, National Center for Infectious Diseases (NCID), at 404-639-3577. Requests for tests for parasites should be made to CDC's Division of Parasitic Diseases, NCID, at 770-488-7760.

Additional information is available from

- EPA's Safe Drinking Water Hotline at 800-426-4791, on the Internet at http://www.epa.gov/safewater, or by e-mail at hotline-sdwa@epa.gov;
- CDC's NCID website at http://www.cdc.gov/ncidod;
- CDC's Healthy Swimming website at http://ww.cdc.gov/healthyswimming; includes recreational water health communication materials for the general public and pool maintenance staff (e.g., information regarding disinfection, guidelines on response to fecal accidents [*42*], fact sheets concerning recreational water illnesses), and an outbreak investigation toolkit that can be used by public health professionals;
- CDC's Voice and Fax Information System, 888-232-3228 (voice) or 888-232-3299 (fax). Choose cryptosporidiosis in the disease category; and
- for reporting WBDOs, CDC's Division of Parasitic Diseases, NCID, at 770-488-7760 or by fax at 770-488-7761.

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Appendix A

Selected Case Descriptions of Outbreaks Associated with Drinking Water

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
Parasites				
January 1999	Florida	*G. intestinalis*	2	Persons became ill after drinking well water. Environmental inspection revealed that pigs were maintained 15 feet from the well. Fecal coliforms were not detected in the water samples, but data indicated inadequate levels of chlorine.
June 2000	Minnesota	*G. intestinalis*	12	Initial water testing confirmed the presence of fecal coliforms in the drinking water where persons were working in a wildlife refuge. Further investigation of the well revealed that a drain line from the well pit had been connected to the sewer line, allowing contamination of the water by raw sewage.
July 2000	New Mexico	*G. intestinalis*	4	Persons drinking water provided by others during a rafting trip became ill. The water was either incorrectly purified river water or river water that was untreated before consumption.
August 2000	Colorado	*G. intestinalis*	27	A resort experienced multiple failures in the pumping mechanism and filtration system during drinking water treatment that resulted in untreated river water entering the drinking water supply. The water supply included a mix of spring water and conventionally treated river water that usually was pumped into and held in a water storage tank. A failure in the primary system was reported; the backup pump was used, and multiple filtration cartridges were later determined to be defective. Although water in the holding tank was usually chlorinated, because of the demands placed on the system during the summer season, chlorine might not have had adequate time to inactivate *Giardia* cysts. *Giardia* was identified in samples from 5 of the 27 affected persons and in the finished water in the holding tank.
September 2000	Florida	*G. intestinalis*	2	Persons became ill after drinking water contaminated from a cross-connection between watering troughs for exotic animals and the drinking water system, which created an opportunity for back-siphonage of the trough water. Coliforms were present in the water, but fecal coliforms were not detected in the water samples. Data indicated inadequate levels of chlorine.

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
September 2000	New Hampshire	*G. intestinalis*	5	Household members used a private well where the water-filtration system had inadvertently been shut off during a 1-month period by construction workers. The water was not otherwise treated (e.g., chlorination).
December 2000	Florida	*Cryptosporidium parvum*	5	An outbreak occurred among persons who had consumed water from a community system well. The well had a series of breaks and repairs, including a break reported days before initial reports of illness. Investigation revealed low levels of chlorine (0.03 mg/L) in the tap water.
Bacteria				
June 1999	Missouri	*Salmonella* Typhimurium	124	Persons consumed water from a community well that was routinely disinfected by chlorine, but investigators reported that chlorine had been inadequate at the time of the outbreak. Seventeen persons were hospitalized.
August 1999	New York	*Ca. jejuni* and *Es. coli* O157:H7	781	A fairground was served primarily by chlorinated water, but certain vendors used water from an unchlorinated shallow well to make beverages and ice. Epidemiologic data associated illness (including 71 hospitalizations and two deaths) with consumption of water from that well. Drought conditions had lowered the water table and heavy rains occurring during the fair might have contributed to contamination of the well by surface water. Dye tests revealed a cross-connection between a dormitory septic system and a well on the fairgrounds, but did not confirm the presence of a hydraulic connection between a nearby manure storage site and the implicated well. However, testing had occurred 2 months after the outbreak and after Hurricane Floyd had passed through the area, raising the water table. Therefore, the possibility of a previous connection during the time of the fair could not be ruled out. Although stool sampling of ill persons indicated the presence of both *Es. coli* O157:H7 and *Ca. jejuni*, only *Es. coli* O157:H7 was identified in water samples.
November 1999	Texas	*Es. coli* O157:H7	22	A city well water supply was implicated because all 22 persons received municipal water and had no other common exposures. Water quality data indicated that the routinely chlorinated water was inadequately chlorinated for weeks during the beginning of the outbreak. Subsequent to the outbreak, a new chlorination system was installed for the water supply.

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
April 2000	Idaho	*Es. coli* O157:H7	4	Children reportedly drank water from the canal in their backyard while playing. Water from the affected household and from the canal located near the home was tested. Coliforms were not present in the home's tap water, but 100 fecal coliforms/100 mL were present in the canal water. Agricultural runoff might have contributed to contamination of the canal water.
June 2000	Idaho	*Ca. jejuni*	15	Contaminated groundwater was implicated in this outbreak among persons attending a geology summer camp. The source of water was a spring box, a device used to collect water, that was incorrectly constructed, potentially allowing contamination by surface water and agricultural runoff. Water samples from the spring box were positive for total coliforms but negative for fecal coliforms. Breaks in the line running from the spring to the camp were noted. Water in the campsite hose tested positive for both total and fecal coliforms.
July 2000	California	*Es. coli* O157:H7	5	Campers ingested filtered creek water both directly and in food reconstituted with creek water. They reported defecating near the campsite, and they had defecated in the water while swimming. In addition, deer droppings, a possible source of *Es. coli* O157:H7, were found near the creek. Although campers also reported swimming in the creek, swimming could not be implicated as an exposure. Illness was confirmed through laboratory tests.
August 2000	Utah	*Ca. jejuni* and *Es. coli* O157:H7	102	Participants at a football camp drank from an irrigation system tap that was not intended for human consumption. No hospitalizations or deaths were reported. *Ca. jejuni* was the most commonly isolated organism among submitted stool specimens and was also isolated from water samples; *Es. coli* O157:H7 and O111 were also isolated from stool specimens, but shiga toxins for these organisms were not found in water samples.
August 2000	Ohio	*Es. coli* O157:H7	29	Persons who had attended a county fair were confirmed for *Es. coli* O157:H7 by stool culture. Additional cases of gastrointestinal illness were identified in the community; however, either they could not be laboratory-confirmed as *Es. coli* O157:H7 or they were probably secondary cases. Nine of the 29 culture-confirmed persons were hospitalized. Other potential risk factors (e.g., a particular food item, beverage, or direct exposure to animals) could not be implicated. However, consumption of food and beverages sold within a particular area of the fairgrounds was a substantial

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
				exposure. Investigation revealed that the branch of the distribution system supplying the vendors in the implicated area also supplied an animal show barn. Spigots connecting hoses to both the animal areas and the concession stands were not equipped with backflow-prevention devices. Therefore, possible back-siphonage might have resulted in contamination of the water supply used for human consumption. Although, water samples taken from the municipal system supplying the fair and water taken after the closure of the fair were negative for coliforms, one spigot serving the implicated vendor area tested positive for coliforms, but negative for *Es. coli*.
April–August 2000	10 Southeastern states: Alabama, Arkansas, Georgia, Kentucky, Louisiana, Missouri, North Carolina, Tennessee, Virginia, and West Virginia	*Salmonella* Bareilly	84	The outbreak was detected by CDC's Surveillance Outbreak Detection Algorithm. Forty-three of the 84 persons were enrolled in a case-control study with 76 matched controls. The outbreak was associated with drinking bottled water and water from private wells or springs. Twenty-five persons drank water from private wells; *Sa.* Bareilly was recovered from one patient's well. The majority of source wells were located in a limestone area in the southeastern United States; wells drilled in limestone are subject to contamination from different sources, including surface water. Among eight persons who did not drink well or spring water in the week before illness, the consumption of either of two brands of water bottled by one company was epidemiologically implicated as a risk factor for illness. A Food and Drug Administration (FDA) traceback investigation of the two implicated brands (spring water and "infant water," water marketed specifically for consumption by infants) linked the bottled water to one facility in the southeastern United States. An investigation of the facilities determined that the two implicated products had different sources, but water flowed through the same lines before bottling. Infant water was derived from a municipal source and passed through multiple treatment steps at the facility (separate from the spring water), and then stored before the bottling process. The bottling process included two filtration steps, ultraviolet irradiation and an nonautomated ozonization step. The bottled spring water came from water transported from a spring in north Georgia. After the spring water was fluoridated at the plant, the spring water shared the same treatment and bottling path as the infant water. Logs from daily in-house testing did not indicate coliforms; however, raw spring water samples tested by an independent laboratory in June were positive for total coliforms. Environmental samples collected

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
				by CDC and FDA during the investigation did not yield *Sa.* Bareilly, but one of the 105 samples taken from a lot of bottled water produced in September was positive for *Es. coli*, and two of 105 samples were positive for other coliforms. Treatment provided should have been adequate to prevent contamination of the bottled water, but finding coliforms implies that interruption of treatment or suboptimal operation might have allowed fecal contamination of the bottled water. Inspection of the treatment process did not reveal any obvious deficiencies; therefore, the source of the contamination remains unknown.
Viruses				
July 1999	New Mexico	Small round-structured virus	70	At a scout camp, a spring box influenced by surface water was the key factor in the outbreak. Small round-structured virus was observed in stool samples from three of 22 specimens submitted. An association with consumption of water or any drinks prepared with water was observed, although the numbers were not statistically significant. No other food items were associated with the outbreak. Assessment of the drinking water system indicated that the spring box was situated at a lower elevation than the latrines and other buildings with individual septic systems. Water samples taken from the well and distribution system were positive for fecal coliforms.
June 2000	West Virginia	Norwalk-like virus	123	Multiple cohorts of camp attendees reported gastrointestinal illness occurring during a multiweek period. Consumption of food items and a history of swimming were ruled out as vehicles of transmission. The epidemiologic information could not statistically implicate water as the vehicle of exposure; however, the environmental investigation determined that two wells that provided the drinking water were located near a lagoon and one well was visibly contaminated with sewage. Fecal coliforms were isolated from both wells.
June 2000	Kansas	Norwalk-like virus	86	Persons who attended two different parties at a reception hall on 2 separate days became ill. The facility's well water was the only common source between the two groups, and the water was not filtered or treated. Norwalk-like virus was isolated from individual stool specimens from both groups. Inspection of the well serving the facility indicated improper well construction, and sampled water tested positive for coliforms.

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
July 2000	California	Norwalk-like virus	147	Untreated well water at a camp facility was implicated. Testing identified fecal and total coliforms in one of the wells and in the areas of the distribution system serving the recreational vehicles and tent areas in the campground.
Chemicals				
April 1999	Wisconsin	Nitrate	1	An infant was fed formula prepared with boiled tap water from a private well for ≥2 days after the household ran out of bottled water normally used to prepare infant formula. The infant became ill, was hospitalized, and was treated to reverse increased methemoglobin levels. Subsequent testing of the tap water revealed the presence of fecal coliforms and nitrate. Inorganic tests for metals were negative.
November 1999	New Jersey	Sodium hydroxide	2	Lack of a check valve at a community well resulted in spillage of approximately 200 gallons of sodium hydroxide into a 110,000-gallon well during a multihour period. Although only two persons reported illness, a cohort estimated at 100–1,000 persons might have been affected. The first person to report an adverse effect suffered a first-degree burn from showering in the contaminated water. The second person suffered cramps, presumably from ingestion of the water.
Unidentified etiologic agents				
January 1999	Florida	Unknown	4	A well was improperly constructed, and water was not routinely disinfected or filtered. Persons interviewed indicated water had been turbid before the outbreak. Two water samples indicated coliforms were present.
March 1999	Florida	Unknown	3	An outbreak occurred at an apartment building that usually received municipal water from a well disinfected with chlorine. The outbreak involved a cross-connection within the apartment complex to an irrigation well. Total coliforms were found in samples taken after the outbreak had occurred, but fecal coliforms were not found. A stool specimen from one of the affected persons tested negative for bacterial and parasitic enteric pathogens.
March 1999	Florida	Unknown	6	Outbreak involved a cross-connection to an irrigation well from a municipal surface water system. The municipal water system was routinely treated and filtered. The irrigation well in question was in unsatisfactory sanitary condition and was located 25 feet from a commercial septic system and 10 feet from a garbage container. No clinical testing was performed.

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
May 1999	Florida	Unknown	3	An outbreak occurred after persons in the household began drinking well water. Well was located 10 feet from a chicken coop. Duration of illness was approximately 60 days. No clinical results were provided. Chlorine residuals were not detected in water samples.
July 1999	California	Unknown	31	An outbreak occurred among persons who visited a camp cabin. Diarrhea, vomiting, and cramps were reported. Median incubation period was 24 hours, and median duration of illness was 24 days. The well used for drinking water was not routinely disinfected or filtered. Water samples tested positive for fecal coliforms.
July 1999	Washington	Unknown	46	Persons had consumed untreated creek water, but tests for *Cryptosporidium parvum*, *G. intestinalis*, *Shigella* species, *Salmonella*, *Ca. jejuni*, *Es. coli* O157:H7, and *Yersinia enterocolitica* performed on stool specimens were all negative. One stool specimen was positive for *Blastocystis hominis* and another for *Endolimax nana*. The median incubation period before onset of illness among the 46 persons was 34 hours (range: 10–95.5 hours), and their median duration of illness was 38 days (range: 2–192 days).
August 1999	Washington	Unknown	68	Participants of a soccer match reported gastrointestinal illness. The most commonly reported symptoms were diarrhea (72%), vomiting (78%), and nausea (84%). No one food or beverage item was implicated, but drinking any beverage prepared on site was a substantial risk for illness. Although contaminants were not identified, the soccer match took place at a polo field that reportedly had horse manure at the site. Coliforms were found in the water tested, but samples taken from the wellhead and the clubhouse were negative for *Es. coli*. Stool specimens tested negative for enteric bacteria and parasites.
April 2000	Florida	Unknown	71	Clinical testing was attempted when the outbreak occurred among persons who drank water from untreated wells. A sinkhole in a local lake had developed, allowing water to be directed into the aquifer. Before the sinkhole was plugged, water from 78 of the surrounding wells was tested. Nineteen of the wells were negative for coliforms; 33 were positive for total coliforms; and 26 were positive for fecal coliforms. *Cryptosporidium* was found in one of the wells. After the sinkhole was plugged, 58 wells were negative for coliforms; 21 wells were positive for total coliforms; and none

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
				was positive for fecal coliforms. No enteric pathogens were identified in one clinical specimen that was submitted. No viral testing of either clinical specimens or water samples was reported.
June 2000	Florida	Unknown	2	An outbreak was associated with consumption of untreated well water; two persons reported diarrhea that lasted approximately 60 days. The stool specimen collected from one person tested negative for *Giardia* but positive for *B. hominis*. The well was located in an area that had experienced flooding and heavy rainfall before the outbreak. The affected persons indicated that dark residue and air bubbles had appeared in their water around the time of illness. Environmental assessment confirmed that the well was in unsatisfactory sanitary condition and noted the presence of grit and air bubbles in the water. Total coliforms were observed in water samples taken after disinfection of the well, although fecal coliforms were absent. The conclusion of the investigators was that the well might have been contaminated by surface water.
September 2000	California	Unknown	63	An outbreak occurred after football players consumed water after a game from an irrigation system coupler located on the playing field. The water was not intended for human consumption and was subject to contamination from back-siphonage of surface water that collected around the sprinkler heads and control valves. Both total and fecal coliforms >16,000 most probable number/100 mL were isolated from the irrigation source water. No hospitalizations or deaths resulted. Because the median incubation period was 12 hours (range: 5–31 hours) and the median duration of illness was also 12 hours (range: 1 hour–3 days), the outbreak was probably of viral or bacterial origin.

Appendix B

Selected Case Descriptions of Outbreaks Associated with Recreational Water

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
Parasites				
July and August 1999	Wisconsin and Florida	*Cryptosporidium parvum*	10 and 6, respectively	Both outbreaks were linked to private swimming pools; chlorine levels had not been tested in either of these outbreaks.
July 1999	Minnesota	*Cr. parvum*	10	Chlorine levels were inadequate at a trailer park swimming pool because the chlorinator needed repair.
July 1999	Massachusetts	*Giardia intestinalis*	18	The common exposure for persons affected was swimming in a local pond. Giardiasis was laboratory-confirmed. Although the source water was not tested for *G. intestinalis*, water tests for the pond indicated high levels of total coliforms.
June 2000	Ohio	*Cr. parvum*	700	A swimming pool at a private club was implicated. An investigation determined that additional risk factors for cryptosporidiosis (e.g., drinking municipal water, eating unpasteurized food, or visiting a local zoo) were not statistically significant. However, the investigation did determine that a substantial risk factor for illness was oral contact with water. The pool consisted of a zero-entry–level pool (i.e., a simulated beach entry) that was connected to both a baby wading pool and adult pool with a water slide. Review of pool records indicated that on ≥2 days, the chlorine residual was inadequate, including on days when the bather load was high and air temperature hot. In addition, multiple fecal accidents had been reported. Testing of water samples at CDC, using Environmental Protection Agency (EPA) Method 1622, demonstrated the presence of *Cr. parvum* oocysts in the water.*
June 2000	Nebraska	*Cr. parvum*	225	Surveillance conducted by a county health department revealed a cluster of laboratory-confirmed cases of cryptosporidiosis, primarily among persons who were members of two private clubs with swimming facilities (clubs A and B). Case-control studies were conducted among members of the two clubs. Swimming and being splashed with pool water at club A was statistically associated with illness. Club A had four pools: outdoor adult and baby pools and

*CDC. Protracted outbreaks of cryptosporidiosis associated with swimming pool use—Ohio and Nebraska, 2000. MMWR 2000;50:406–10.

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
				indoor adult and baby pools. The two outdoor pools shared a filtration system, whereas the two indoor pools had separate filtration systems but were connected by a pipe used to equilibrate the water level of the pools. Fecal accidents had occurred before the outbreak. Review of the pool maintenance logs revealed a 2-day period when the baby pool had not been chlorinated.[†]
June 2000	Georgia	*Cr. parvum*	36	Persons reported illness after attending a private pool party where, in addition to swimming in a neighborhood pool, party attendees also swam in an inflatable pool. Inadequate chlorine levels were detected in the neighborhood pool. No treatment was documented for the inflatable pool.
July 2000	Minnesota	*Cr. parvum*	7	Inadequate chlorination and filtration were documented in this outbreak among attendees at a day camp.
July 2000	Minnesota	*Cr. parvum*	6	Information from interviews implicated a hotel pool in an outbreak of cryptosporidiosis among members of a baseball team. Both whirlpool and pool samples were negative for *Cr. parvum*.
July 2000	Florida	*Cr. parvum*	3	Inadequate water quality and low chlorine levels were documented in an outbreak at an apartment complex. Fecal material had been visible in the pool at the apartment complex.
July 2000	South Carolina	*Cr. parvum*	26	Water-quality data from a neighborhood pool implicated in an outbreak of cryptosporidiosis were inconclusive. Coliform tests were negative; however, these tests were conducted after the outbreak had occurred and the pool had been treated with high levels of chlorine. Chlorine levels at the time of and after the outbreak were unreported. Certain factors might have contributed to the outbreak, including a history of symptomatic children swimming in the pool before the outbreak and increased rain activity that might have decreased the water quality by diluting chlorine levels or facilitated runoff into the pool.
July 2000	Minnesota	*Cr. parvum*	220	An outbreak of cryptosporidiosis occurred at a public swimming beach. A total of 220 persons reporting illness were asked questions regarding swimming exposure and food consumed while at the beach. Exposure to the water (i.e., getting the head wet while swimming) was associated with

[†] CDC. Protracted outbreaks of cryptosporidiosis associated with swimming pool use—Ohio and Nebraska, 2000. MMWR 2000;50:406–10.

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
				illness. The inspection conducted by the county health department did not identify any plumbing deficiencies at the beach clubhouse. Reports of construction on a sewer line were investigated, but the investigators determined that the source of contamination was persons washing babies in the lake while changing diapers on the beach.
August 2000	Colorado	*Cr. parvum*	112	The epidemiologic investigation implicated swimming in the main pool or having contact with the water as a risk factor for illness among the persons who attended a private party at a municipal pool. Although the main pool shared a silica-sand filtration system with a smaller, adjacent wading pool, contact with the wading pool was a substantial risk factor.
August 2000	Florida	*Cr. parvum*	19	Exposure to the pool at a resort was a substantial risk factor for infection. In addition, infection was associated with longer times of exposure to the resort pool water. Complaints of cloudy water and diapered children swimming in the pool were reported.
August 2000	Florida	*Cr. parvum*	5	This outbreak was linked to the outbreak that occurred in Ohio in June 2000. A family from Ohio who were members of the implicated swim club vacationed in Florida. While in a pool in Florida, the ill infant had two fecal accidents.
August 2000	Florida	*Cr. parvum*	5	Illness was associated with swimming in a pool, and one infected child reportedly swam while ill. Water quality information was not available.
August 2000	Minnesota	*Cr. parvum*	4	This outbreak was detected through routine surveillance. All four were interviewed by the state health department and queried about history of illness and exposures to water, food, animals, and child care centers. All four persons reported swimming in the same municipal swimming pool. No corrective action was taken. The outbreak was reported after the pool had closed at the end of the swimming season.
Bacteria				
August 1999	Wisconsin	*Es. coli* O157:H7	5	Swimmers who had visited the same beach became ill. The popular beach featured a shallow, dammed area that was used for wading. Total and fecal coliforms were detected in water samples collected before and during the outbreak, although the levels did not exceed regulatory levels for microbiologic quality of water. One sample that was tested for *Es. coli* O157:H7 was negative.

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
August 1999	Washington	*Es.* O157:H7	36	A freshwater outbreak occurred among visitors to a state park. Swimming in the lake, getting lake water in the mouth, and swallowing water from the lake were all associated with illness. In addition, *Es. coli* O157:H7 was laboratory-confirmed among the affected persons, including seven hospitalizations, and isolated from samples of sediment from the lake as well as the water.
May 2000	Wisconsin	*Legionella pneumophila*	20	A whirlpool was implicated in a serologically confirmed outbreak of Pontiac fever among 20 persons who visited a hotel. *L. pneumophila* group 5 bacteria were isolated from the whirlpool but not from the swimming pool. Additional samples collected from sand filters, a water heater, and a shower also were negative for *L. pneumophila*. Disinfectant levels for both the whirlpool and pool were inadequate at the time of the outbreak. Analysis of responses to questionnaires administered to motel visitors revealed that only whirlpool and swimming pool exposures were substantial risk factors for illness. No other possible common exposures demonstrated associations with illness. The investigation concluded from both the epidemiologic and environmental data that the whirlpool was the likely vehicle of transmission.
July 2000	Connecticut	*Es. coli* O157:H7	11	The outbreak occurred among persons who lived in or visited the same community during the last 2 weeks of July. An environmental assessment of both well water and lake water was conducted. The well water system was found to be in compliance with drinking water standards, and samples from two wells and ice made from this water were all negative for total coliforms. Lake water sampled after the outbreak was negative for *Es. coli* and shiga toxins but was positive for total and fecal coliforms. No other environmental problem at the lake was identified, and animal feces collected from local wildlife tested negative for *Es. coli* O157 or any other shiga toxin–producing isolates. The environmental assessment, combined with epidemiologic evidence, implicated swimming at the lake and swallowing water as substantial risk factors for illness. During this same time period, a toddler with severe diarrhea reportedly had swum in the water during a 1-week period while ill.
July 2000	Minnesota	*Shigella sonnei*	15	Fifteen persons reported illness after swimming at a freshwater lake. Of these, 13 tested positive for *Sh. sonnei*, one for *Cr. parvum*, and one for both organisms.

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
August 2000	Minnesota	*Sh. sonnei*	25	The only shared exposure among the affected persons was swimming in a particular area of a public beach. Seventeen persons from >5 families who separately attended the beach on the same day became ill; these persons did not all attend the beach together and did not consume the same food products at the beach. Eight other persons, who were identified through routine surveillance, also reported swimming at the beach on the date in question. Water samples collected ≥2 days after the implicated day did not test positive for *Shigella* organisms. Because of the substantial number of children swimming at the lake, a fecal accident was the likely source of contamination.
Viruses				
June 1999	New York	Norwalk-like virus	168	The outbreak was associated with swimming in shallow water at a freshwater lake. Feces had been removed from the lake that day by lifeguards.
June 1999	Idaho	Norwalk-like virus	25	The outbreak occurred at a resort and water park. The pool implicated in the investigation was untreated. The source of the pool's water was a natural hot springs that was high in mineral content and was not chlorinated or filtered. The investigators noted that geothermal pools used for swimming are not required to be regulated by public health officials in that locale. The same pool had been implicated in a previous outbreak of Norwalk-like virus in June 1996.
January 2000	Wisconsin	Norwalk-like virus	9	A motel pool was linked to the outbreak. The affected persons had attended a party where diapered infants were in the water; they became ill in ≤48 hours after attending the event. Stool specimens collected from these persons tested positive for Norwalk-like virus by reverse-transcriptase polymerase chain reaction and were negative for enteric bacteria.
Other				
June 1999	Illinois	Unknown	25	Persons reported gastrointestinal illness after swimming in a community lake. A septic system failure had occurred, resulting in sewage contamination of the lake. Tests of the lake water on ≥2 dates before and after the first case was reported were all positive for fecal coliforms.
June 1999	California	Unknown	23	An outbreak of suspected viral etiology occurred among persons who attended three separate pool parties at an apartment complex. Initially, the outbreak was reported as a possible foodborne outbreak, but no food items had been

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
				shared among the persons who had attended the three parties. Moreover, persons who only ate and did not swim in the pool did not report illness. Stool specimens collected from two persons tested negative for bacterial and parasitic pathogens. No indication was provided that viral testing was done. The health department conducted a physical inspection of the pool and examined pool maintenance records. No water testing was performed by the health department, nor were pool maintenance records available for the dates immediately after the day of exposure, although reported chlorine levels seemed adequate. However, swimmers reported that on the day in question, the pool was overcrowded and that toddlers were swimming in the pool.
August 1999	Florida	*Sh. sonnei* and *Cr. parvum*	38	The outbreak occurred among persons who visited a beach park, and it was attributed to both *Sh. sonnei* and *Cr. parvum*. Illness was epidemiologically linked to playing in an interactive fountain at the park, ingesting water, and consuming food and beverages at the fountain. The fountain's recirculation and disinfection systems were not approved by the health department and were inadequate or not completely operational at the time of its use. Samples of the fountain water tested positive for coliforms but did not test positive for fecal coliforms. Nevertheless, the cause of the outbreak was determined to be the fountain, which was closed until the health department's concerns could be remedied.[§]
September 1999	Texas	Unknown	12	Persons reported symptoms that included exhaustion, sore muscles, headache, chills, and fever after attending a conference at a Texas guest ranch. One woman reported a miscarriage during her illness. Exposure to a hot tub, defined as either immersion or being near the hot tub, was associated with illness. Although clinical specimens (urine, blood, sputum, and throat swabs) were tested for organisms, including *Leg. pneumophila* serogroups 1 and 6, influenza virus, parainfluenza virus, and adenovirus, no infectious agent was identified. No testing for biologic or chemical agents was performed on water samples because the hot tub had already been drained, refilled, and hyperchlorinated before the environmental investigation.

[§] CDC. Outbreak of gastroenteritis associated with an interactive water fountain at a beachside park—Florida, 1999. MMWR 2000;49:565–8.

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
February 2000	Vermont	Bromine	3	Chemical keratitis resulted from exposure to bromine in a hotel swimming pool. Bromine levels were >5 ppm (acceptable bromine levels are 1–3 ppm), and the pH level was >8.5. Patrons that spent time with their heads underwater with their eyes open were affected.
March 2000	Maine	*P. aeruginosa*	11	An outbreak of dermatitis affected persons who had stayed at a hotel during a sports tournament. These persons reported having a rash that was accompanied by other symptoms, including ear infection, cough, headache, and joint pain. *P. aeruginosa* was isolated from water samples from both the pool and hot tub. The investigator also indicated that disinfection might have been hindered by a high number of swimmers and the addition of water to the leaking pool.
May 2000	Florida	Unknown	2	Persons became ill after swimming in a lake that was not licensed as a bathing area and had signs posted indicating that the area was unsafe for swimming. No water testing results were available before or after the incident. The lake had been closed for swimming for years, and routine samples had not been collected.
July 2000	Maine	Unknown	32	Swimming at a beach in a campground was epidemiologically implicated in an outbreak of gastrointestinal illness. Affected persons reported a combination of symptoms, including diarrhea, vomiting, nausea, cramps, and headache that lasted 5–48 days. Only one stool specimen was collected, which tested negative for bacterial pathogens; therefore, the outbreak was of suspected viral etiology. However, no tests for parasitic organisms were reported. The environmental assessment and interviews indicated that the presence of diapered children, a heavy bather load, and warm water temperatures were contributing factors to the outbreak. Water samples tested negative for coliforms.
July 2000	Florida	Unknown	4	Affected persons reported swimming in a freshwater spring that had a history of inadequate water quality. Water samples from the spring's swimming areas were positive for total and fecal coliforms on multiple dates. Drinking water at this facility was also tested but was negative for coliforms.
August 2000	Florida	Unknown	9	A motel pool that was cloudy and dirty at the time of exposure was implicated. Persons who swam in the pool and did not share any other common exposure became ill with gastroenteritis. Disinfectant residuals and operation of the fil-

Outbreak date(s)	State where outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
				tration system at the time of the investigation were deficient. Problems had also occurred with the equipment used for adjusting pH.
October 2000	Alaska	*P. aeruginosa*	29	In an outbreak of dermatitis, the median number of persons in the implicated hotel pool and hot tub was greater than the maximal bather loads permitted. The maximum bather load for the pool was nine persons, and for the hot tub, six persons. On the basis of interviews, the median numbers of persons were determined to be 12 (range: 4–20) in the pool and 10 (range: 3–20) in the hot tub. The pool and hot tub were on separate filtration systems. Sand from the pool filter and water from the filter both tested positive for *P. aeruginosa*. The filtration system was suspected as having malfunctioned sometime during the day of exposure and had been unable to maintain adequate levels of disinfection to accommodate the excessive bather load.

Glossary

Action level A specified concentration of a contaminant in water. If this concentration is reached or exceeded, certain actions (e.g., further treatment and monitoring) must be taken to comply with a drinking water regulation.

Back-siphonage A reversal of the normal flow of water or other liquid caused by a negative-pressure gradient (e.g., within a water system).

Boil-water advisory A statement to the public advising that tap water must be boiled before drinking it.

Cercarial dermatitis Dermatitis caused by contact with the cercariae (larval stage) of certain species of schistosomes whose normal hosts are birds and nonhuman mammals.

Class Waterborne-disease outbreaks are classified according to the strength of the epidemiologic and water-quality data implicating water as the source of the outbreak (see Table 1).

Coagulation The process of adding chemicals to water to destabilize charges on naturally occurring particles to facilitate their subsequent aggregation and removal by flocculation or filtration.

Coliforms All aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 95°F (35°C).

Community water system A public water system that serves year-round residents of a community, subdivision, or mobile home park that has ≥15 service connections or an average of ≥25 residents for ≥60 days/year.

Contact time The length of time water is exposed to a disinfectant (e.g., chlorine contact time).

Cross-connection Any actual or potential connection between a drinking water supply and a possible source of contamination or pollution (e.g., a wastewater line).

Cyst The infectious stage of *Giardia intestinalis* and certain other protozoan parasites that have protective walls that facilitate their survival in water and other environments.

Disinfection by-products Chemicals formed in water through reactions between organic matter and disinfectants.

Distribution system Water pipes, storage reservoirs, tanks, and other means used to deliver drinking water to consumers or store it before delivery.

Excystation The release of the internal (i.e., encysted) contents (e.g., trophozoites or sporozoites) from cysts or oocysts.

Fecal coliforms Coliforms that grow and produce gas at 112.1°F (44.5°C) within 24 hours.

Filter backwash Water containing the material obtained by reversing the flow of water through a filter to dislodge the particles that have been retained on it.

Filtration The process of removing suspended particles from water by passing it through one or more permeable membranes or media of limited diameter (e.g., sand, anthracite, or diatomaceous earth).

Finished water	The water (e.g., drinking water) delivered to the distribution system after treatment, if any.
Flocculation	The water-treatment process after coagulation that uses gentle stirring to cause suspended particles to form larger, aggregated masses (floc). The aggregates are removed from the water by a separation process (e.g., sedimentation, flotation, or filtration).
Free, residual chlorine level	The concentration of chlorine in water that is not combined with other constituents, thus serving as an effective disinfectant.
Groundwater system	A system that uses water extracted from the ground (i.e., a well or spring).
Groundwater under the direct influence of surface water	Any water beneath the surface of the ground with substantial occurrence of insects or other macrooganisms, algae, or large-diameter pathogens (e.g., *Giardia intestinalis* or — for subpart H systems serving ≥10,0000 persons only — *Cryptosporidium parvum,* or substantial and relatively rapid shifts in water characteristics (e.g., turbidity, temperature, conductivity, or pH that closely correlate to climatological or surface water conditions. Direct influence must be determined for individual sources in accordance with criteria established by the state. The state determination of direct influence might be based on site-specific measurements of water quality or documentation of well construction characteristics and geology with field evaluation.
Heterotrophic microflora	Microorganisms that use organic material for energy and growth.
Infant water	Bottled waters that are marketed for direct consumption by infants or use in mixing with infant formula.
Individual (or private) water system	A water system not owned or operated by a water utility and that serves <15 residences or farms not having access to a public water system.
Maximum-contaminant level	The maximum permissible concentration (i.e., level) of a contaminant in water supplied to any user of a public water system.
Nephelometric turbidity units	The units in which the turbidity of a sample of water is measured when the degree to which light is scattered is assessed with a nephelometric turbidimeter.
Noncommunity water system	A public water system that 1) serves an institution, industry, camp, park, hotel, or business that is used by the public for ≥60 days/year, 2) has ≥15 service connections or serves an average of ≥25 persons, and 3) is not a community water system.
Nontransient noncommunity water systems	Public water systems that serve ≥25 of the same persons for ≥6 months/year (e.g., a factory or school).
Oocyst	The infectious stage of *Cryptosporidium parvum* and certain other coccidian parasites with a protective wall that facilitates survival in water and other environments.
Public water system	A system, classified as either a community water system or a noncommunity water system, that provides piped water to the public for human consumption and is regulated under the Safe Drinking Water Act.
Raw water	Surface water or groundwater that has not been treated in any way.

Reverse osmosis A filtration process that removes dissolved salts and metallic ions from water by forcing it through a semipermeable membrane. This process is also highly effective in removing microbes from water.

Source water Untreated water (i.e., raw water) used to produce drinking water.

Surface water The water in lakes, rivers, reservoirs, and oceans.

Total coliforms Nonfecal and fecal coliforms that are detected by using a standard test. Total coliforms are a group of closely related bacteria that are usually free-living in the environment, but are also normally present in water contaminated with human and animal feces. With certain exceptions, they do not cause disease. Specifically, coliforms are used as a screen for fecal contamination as well as to determine the efficiency of treatment and the integrity of the water distribution system. The presence of total coliforms in drinking water indicates that the system is either fecally contaminated or vulnerable to fecal contamination.

Transient non-community water systems Public water systems that regularly serve ≥25 of the same persons for ≥6 months/year (e.g., highway rest stations, restaurants, and parks with their own public water systems).

Turbidity The quality (e.g., of water) of having suspended matter (e.g., clay, silt, or plankton) that results in loss of clarity or transparency.

Untreated water Surface water or groundwater that has not been treated in any way (also called raw water).

Water quality indicator A microbial, chemical, or physical parameter that indicates the potential risk for infectious diseases associated with using the water for drinking, bathing, or recreational purposes. The best indicator is one whose density or concentration correlates best with health hazards associated with a type of hazard or pollution.

Water utility A water provider that distributes drinking water to a community through a network of pipes.

Watershed An area from which water drains to a single point; in a natural basin, the area contributing flow (i.e., water) to a place or point on a stream.

Watershed-control program A program to protect a watershed from contamination or pollution.

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