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Surveillance for Waterborne-Disease Outbreaks Associated with Recreational Water — United States, 2001–2002

and

Surveillance for Waterborne-Disease Outbreaks Associated with Drinking Water — United States, 2001–2002

DEPARTMENT OF HEALTH AND HUMAN SERVICES
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Surveillance for Waterborne-Disease Outbreaks Associated with Recreational Water — United States, 2001–2002

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Abstract

Problem/Condition: Since 1971, CDC, the U.S. Environmental Protection Agency, and the Council of State and Territorial Epidemiologists have maintained a collaborative surveillance system for collecting and periodically reporting data related to occurrences and causes of waterborne-disease outbreaks (WBDOs) related to drinking water; tabulation of recreational water-associated outbreaks was added to the survillance system in 1978. This surveillance system is the primary source of data concerning the scope and effects of waterborne disease outbreaks on persons in the United States.

Reporting Period Covered: This summary includes data on WBDOs associated with recreational water that occurred during January 2001–December 2002 and on a previously unreported outbreak that occurred during 1998.

Description of the System: Public health departments in the states, territories, localities, and the Freely Associated States are primarily responsible for detecting and investigating WBDOs and voluntarily reporting them to CDC on a standard form. The surveillance system includes data for outbreaks associated with both drinking water and recreational water; only outbreaks associated with recreational water are reported in this summary.

Results: During 2001–2002, a total of 65 WBDOs associated with recreational water were reported by 23 states. These 65 outbreaks caused illness among an estimated 2,536 persons; 61 persons were hospitalized, eight of whom died. This is the largest number of recreational water-associated outbreaks to occur since reporting began in 1978; the number of recreational water-associated outbreaks has increased significantly during this period ($p<0.01$). Of these 65 outbreaks, 30 (46.2%) involved gastroenteritis. The etiologic agent was identified in 23 (76.7%) of these 30 outbreaks; 18 (60.0%) of the 30 were associated with swimming or wading pools. Eight (12.3%) of the 65 recreational water-associated disease outbreaks were attributed to single cases of primary amebic meningoencephalitis caused by *Naegleria fowleri*; all eight cases were fatal and were associated with swimming in a lake (n = seven; 87.5%) or river (n = one; 12.5%). Of the 65 outbreaks, 21 (32.3%) involved dermatitis; 20 (95.2%) of these 21 outbreaks were associated with spas or pools. In addition, one outbreak of Pontiac fever associated with a spa was reported to CDC. Four (6.1%) of the 65 outbreaks involved acute respiratory illness associated with chemical exposure at pools.

Interpretation: The 30 outbreaks involving gastroenteritis comprised the largest proportion of recreational water-associated outbreaks during this reporting period. These outbreaks were associated most frequently with *Cryptosporidium* (50.0%) in treated water venues and with toxigenic *Escherichia coli* (25.0%) and norovirus (25.0%) in freshwater venues. The increase in the number of outbreaks since 1993 could reflect improved surveillance and reporting at the local and state level, a true increase in the number of WBDOs, or a combination of these factors.

Public Health Action: CDC uses surveillance data to identify the etiologic agents, types of aquatics venues, water-treatment systems, and deficiencies associated with outbreaks and to evaluate the adequacy of efforts (e.g., regulations and public awareness activities) for providing safe recreational water. Surveillance data are also used to establish public health prevention priorities, which might lead to improved water-quality regulations at the local, state, and federal levels.

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Introduction

During 1920–1970, statistical data regarding U.S. waterborne-disease outbreaks (WBDOs) were collected by different 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 associated with drinking water; tabulation of recreational water-associated outbreaks was added to the surveillance system in 1978 (*2–7*). The surveillance system includes data regarding outbreaks associated with drinking water, recreational water, and other types of water exposures. This *MMWR Surveillance Summary* includes data on recreational water-associated outbreaks that occurred during 2001–2002 and for a previously unreported outbreak that occurred in 1998. Data on drinking water-associated outbreaks are presented in a separate *MMWR Surveillance Summary* (*8*).

These surveillance activities are intended to 1) characterize the epidemiology of WBDOs; 2) identify changing trends in the etiologic agents that caused WBDOs and determine why the outbreaks occurred; 3) encourage public health personnel to detect and investigate WBDOs; and 4) foster collaboration among local, state, federal, and international agencies on initiatives to prevent waterborne disease transmission. Data obtained through this surveillance system are useful for identifying major deficiencies in the provision of safe recreational water. Surveillance information can influence prevention recommendations and research priorities and lead to improved water-quality regulations. However, the statistics reported in this surveillance summary represent only a portion of the burden of illness associated with recreational water exposure. The surveillance information does not include endemic waterborne disease risks, nor are reliable estimates available of the number of unrecognized WBDOs and associated cases of illness.

Background

Regulation of Recreational Water

State and local governments establish and enforce regulations to protect recreational water against naturally occurring or human-made contaminants. Standards for operating, disinfecting, and filtering public swimming and wading pools are regulated by state and local health departments and, as a result, vary throughout the United States. In 1986, EPA published guidelines for microbiologic water quality for recreational freshwater (e.g., lakes and rivers) and marine water (*9*). For freshwater, the guideline recommends that the monthly geometric mean water-quality indicator concentration be $\leq$33 CFU/100 mL for enterococci or $\leq$126 CFU/100 mL for *Escherichia coli*. For marine water, the guideline recommends that the monthly geometric mean water-quality indicator concentration be $\leq$35 CFU/100 mL enterococci. States have latitude regarding their guidelines or regulations and can post warning signs to alert potential bathers until water quality improves. Unlike treated venues, in which disinfection can be used to address the majority of problems with the microbiologic quality of water, contaminated freshwater can require weeks or months to improve or return to normal. However, pools in treated venues might need to be closed until the water has been adequately treated and filtered or the pool drained and refilled to remove protozoan contamination. Prompt identification of potential sources of contamination and remedial action is necessary to return bathing water to an appropriate quality for recreational use.

EPA's Action Plan for Beaches and Recreational Waters (Beach Watch) was developed as part of the Clean Water Action Plan (http://www.cleanwater.gov). The intent of Beach Watch is to assist state, tribal, and local authorities in strengthening and extending programs that protect users of fresh and marine recreational waters. As part of the Beaches Act of 2000, the U.S. Congress directed EPA to develop a new set of guidelines for recreational water based on new water-quality indicators. In 2002, EPA, in collaboration with CDC, began conducting a series of epidemiologic studies at fresh and marine water recreational beaches in the United States. The National Epidemiologic and Environmental Assessment of Recreational (NEEAR) Water Study (available at http://www.epa.gov/nerlcwww/neearnerl.htm) is testing rapid new water-quality methods that produce results in <2 hours and is correlating these indicators with health effects among beachgoers. The results will be used to develop new EPA water-quality guidelines for freshwater and marine water use.

Methods

Data Sources

Public health departments in the states, territories, localities, and the Freely Associated States* (FAS) have primary responsibility for detecting and investigating WBDOs, which they report voluntarily to CDC by using a standard form (CDC form 52.12, available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf).

* Composed of the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau; formerly parts of the U.S.-administered Trust Territory of the Pacific Islands.

The form solicits data on characteristics of the outbreak, including person, place, time, and location; results from epidemiologic studies conducted; specimen and water sample testing; and other factors potentially contributing to the outbreak (e.g., environmental concerns, disinfection, and filtration [Glossary]). CDC annually requests reports from state, territorial, and FAS epidemiologists or persons designated as WBDO surveillance coordinators. Numeric and text data are abstracted from the outbreak form and supporting documents and entered into a database for 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 recreational water-associated disease outbreak. First, $\geq$2 persons must have experienced a similar illness after exposure to water or air encountered in a recreational water setting. This criterion is waived for single cases of laboratory-confirmed primary amebic meningoencephalitis (PAM), single cases of wound infections, and single cases of chemical poisoning if water-quality data indicate contamination by the chemical. Second, epidemiologic evidence must implicate recreational water or the recreational water setting as the probable source of the illness.

Recreational settings include swimming pools, wading pools, whirlpools, hot tubs, spas, waterparks, interactive fountains (Glossary), and fresh and marine surface waters. When outbreak causes are analyzed, outbreaks are separated by venue. Fresh and marine waters are considered untreated venues. Treated venues refer to the remaining settings; occasionally, a private pool or wading pool involved in an outbreak is a drain-and-fill type with no additional disinfection or treatment.

† Additional terms are defined in the Glossary.

If primary cases (i.e., illness among persons exposed to contaminated water or air at a recreational water setting) and secondary cases (i.e., illness among persons who became ill after contact with a person with a primary case) 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 may be used if the population was sampled randomly or the estimated count was calculated by applying the attack rate to a standardized population.

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 on 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, PAM, wound infections, or chemical poisonings are 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 and system breakdowns 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 that an investigation was conducted optimally, nor does a classification of II, III, or IV imply that an investigation was inadequate or incomplete. Outbreaks and the resulting investigations occur under different 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

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

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

rather than I because of the relatively limited sample size available for analysis.

For the reporting period 2001–2002, WBDOs associated with drinking water and with recreational water are reported separately for the first time. The *MMWR Surveillance Summary* for drinking water-associated outbreaks (*8*) includes WBDOs related to drinking water and occupational exposures as defined in the methods section of that summary. This *MMWR Surveillance Summary* includes only outbreaks related to recreational water.

Although outbreaks of Pontiac fever have been included in previous *MMWR Surveillance Summaries*, this summary is the first to include outbreaks of Legionnaires disease (LD). Because nearly all outbreaks caused by *Legionella* species share characteristics that are distinct from other types of WBDOs, all *Legionella* outbreaks have been compiled into a single table in the drinking water-associated outbreak *MMWR Surveillance Summary* (*8*) that identifies the presumed primary use of the water implicated in the outbreak. Although all *Legionella* outbreaks are listed in that table, those related to recreational water exposure are discussed in this summary. Outbreaks of LD that occurred in association with water primarily intended for drinking or occupational use are discussed in the summary of drinking water-associated outbreaks (*8*).

Results

During 2001–2002, a total of 65 outbreaks (30 during 2001 and 35 during 2002) associated with recreational water were reported by 23 states (Tables 2–7). (Selected case descriptions are provided in the Appendix). These 65 outbreaks caused illness among 2,536 persons, resulting in 61 hospitalizations and eight deaths. Of the 65 outbreaks, 30 (46.2%) were outbreaks of gastrointestinal illness (Tables 2 and 3); 21 (32.3%) were outbreaks of dermatitis (Table 4); eight (12.3%) were outbreaks of meningoencephalitis; and six (9.2%) were outbreaks of acute respiratory illness (including one of unknown etiology, one of Pontiac fever, and four caused by chemical exposure) (Tables 5 and 6).

The median outbreak size was 15 persons (range: 1–767). Although outbreaks were distributed throughout the United States (Figure 1), Florida and Minnesota reported the largest number of outbreaks (seven and nine, respectively).

Outbreaks occurred throughout the calendar year (Figure 2) but peaked during warm weather months (May–August). Of the 30 outbreaks involving gastrointestinal illness, 23 (76.7%) occurred during the summer (June–August); the eight cases of PAM also occurred during June–August (Figure 2).

Of the 65 recreational water outbreaks, 21 (32.3%) were associated with fresh water and 44 (67.7%) with treated (e.g., chlorinated) water (Table 7). Of the 30 outbreaks of gastroenteritis, 12 (40.0%) were associated with fresh or surface water and 18 (60%) with treated (e.g., chlorinated) water venues (Figure 3).

Etiologic Agents

The infectious agent was identified or suspected in 53 (81.5%) of the 65 recreational water-associated outbreaks (Table 7). Of the 30 outbreaks involving gastroenteritis, 12 (40.0%) were caused by parasites, six (20.0%) by bacteria,

TABLE 2. Waterborne-disease outbreaks of gastroenteritis (n = 12) associated with recreational water — United States, 2001

State	Month	Class*	Etiologic agent	No. of cases (n = 782)	Source	Setting
Colorado	Jul	III	*Shigella sonnei*	33	Interactive fountain	Community
Iowa	Jun	I	*S. sonnei*	45	Wading pool	Public park
Illinois	Jul	I	*Cryptosporidium hominis*†	358	Pool	Waterpark
Minnesota	Jul	III	*Escherichia coli* O157:H7§	20	Lake	Public beach
Minnesota	Jul	IV	Norovirus	40	Lake	Public beach
Minnesota	Aug	IV	*E. coli* O26:NM	4	Lake	Community park
Nebraska	Jul	IV	*Cryptosporidium* species	157	Pools	Community
Nebraska	Jul	IV	*Cryptosporidium* species	21	Pool	Community
New Hampshire	Aug	III	AGI¶**	42	Lake	State park
Oregon	May	IV	AGI	15	Pool	Lodge
South Carolina	Jul	I	*E. coli* O157:H7	45	Lake	State park
Wyoming	Aug	III	*Cryptosporidium* species	2	Flow-through pool/hot spring††	State park

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

† The species of *Cryptosporidium* that infects humans and monkeys (**Source:** Xiao L, Fayer R, Ryan U, Upton SJ. *Cryptosporidium* taxonomy: recent advances and implications for public health. Clin Microbiol Rev 2004;17:72–97).

§ Counted as an *E.coli* O157:H7 outbreak in all statistics. Ten persons had stool specimens that tested positive for *E.coli* O157:H7, and one person had a stool specimen that tested positive for *Campylobacter jejuni*.

¶ Acute gastrointestinal illness of unknown etiology.

** *Oscillatoria* was isolated from the lake water in high concentrations, which is consistent with clinical symptoms.

†† Counted as freshwater venue in statistics.

TABLE 3. Waterborne-disease outbreaks of gastroenteritis (n = 18) associated with recreational water — United States, 2002

State	Month	Class*	Etiologic agent	No. of cases (n = 1,137)	Source	Setting
Florida	Jul	I	AGI[†]	7	Lake	Public beach
Florida	Oct	III	AGI	3	Pool	Apartment complex
Georgia	Jul	III	*Cryptosporidium* species	3	Wading pool	Child care center
Maine	Jul	IV	*Escherichia coli* O157:H7	9	Wading pool	Private home
Maine	Nov	III	AGI	33	Puddle	School
Massachusetts	Jul	II	*Cryptosporidium* species	767	Pool	Membership sport club
Michigan	Dec	IV	AGI	32	Pool	Hotel/motel
Minnesota	Jun	IV	Norovirus	11	Lake	Public beach
Minnesota	Mar	II	Norovirus	36	Pool	Hotel/motel
Minnesota	Jul	II	*Cryptosporidium* species	52	Indoor pool	Health club
Minnesota	Aug	II	*Cryptosporidium* species	41	Pool	Hotel/motel
Minnesota	Aug	II	*Cryptosporidium* species	16	Pool	Resort
Oregon	Aug	II	AGI	9	Pool	Apartment complex
Texas	Aug	IV	*Cryptosporidium hominis*[§]	54	Wading pool	Hotel/motel
Wisconsin	Mar	IV	Norovirus	15	Pool	Hotel/motel
Wisconsin	Jul	III	Norovirus[¶]	44	Lake	State park
Wyoming	May	IV	*Cryptosporidium* species	3	Lake	Lake
Wyoming	Jul	IV	*Giardia intestinalis*	2	River	River

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12.
† Acute gastrointestinal illness of unknown etiology.
§ The species of *Cryptosporidium* that infects humans and monkeys (**Source:** Xiao L, Fayer R, Ryan U, Upton SJ. *Cryptosporidium* taxonomy: recent advances and implications for public health. Clin Microbiol Rev 2004;17:72–97).
¶ Counted as a norovirus outbreak in all statistics. Two persons with primary cases had stool specimens tested; one person had a stool specimen that tested positive for norovirus, and one person had a stool specimen that tested positive for *Cryptosporidium.* Stool specimens from two persons with secondary cases were tested; one person had a stool specimen that tested positive for norovirus, and one person had a stool specimen that tested positive for *Shigella sonnei*. Illness in persons with primary cases was most consistent with norovirus infection.

TABLE 4. Waterborne-disease outbreaks of dermatitis (n = 21) associated with recreational water — United States, 2001–2002

State	Year	Month	Etiologic agent	No. of cases (n = 435)	Source	Setting
Alaska	2002	Feb	*Pseudomonas aeruginosa**[†]	110	Pool/spa	Hotel/motel
Alaska	2002	Feb	*P. aeruginosa*[§]	3	Pool/spa	Hotel/motel
Colorado	2002	May	*P. aeruginosa*[†]	12	Pool/spa	Hotel/motel
Florida	2001	Mar	*P. aeruginosa*[§]	34	Pool	Hotel/motel
Florida	2001	Mar	*P. aeruginosa*[†]	53	Spa	Hotel/motel
Florida	2001	Apr	*P. aeruginosa*[§]	7	Spa	Apartment complex
Iowa	2002	Mar	*P. aeruginosa*[§]	24	Pool/spa	Hotel/motel
Maine	2001	Feb	*P. aeruginosa*[§]	21	Spa	Hotel/motel
Maryland	2001	Nov	*P. aeruginosa*[§]	8	Spa	Private residence
Maryland	2002	Feb	*P. aeruginosa*[§]	3	Spa	Membership club
Minnesota	2001	May	*P. aeruginosa**[†]	6	Spa	Resort
Nebraska	2001	Mar	*P. aeruginosa*[§]	9	Pool/spa	Hotel/motel
Ohio	2002	Feb	*P. aeruginosa*[†]	18	Spa	Hotel/motel
Ohio	2002	Mar	*P. aeruginosa**[†]	31	Pool/spa	Hotel/motel
Oregon	2002	Jul	Avian schistosomes[§]	19	Lake	Lake
Pennsylvania	2001	May	*P. aeruginosa*[†]	2	Spa	Hotel/motel
Pennsylvania	2001	May	*P. aeruginosa*[§]	42	Spa	Hotel/motel
Pennsylvania	2001	May	*Bacillus* species[†]	20	Spa	Hotel/motel
Pennsylvania	2001	Jun	*Staphylococcus* species[§]	3	Spa	Hotel/motel
Washington	2001	Aug	*P. aeruginosa*[†]	3	Spa	Hotel/motel
Wisconsin	2001	Nov	*P. aeruginosa*[§]	7	Spa	Hotel/motel

* Laboratory-confirmed case.
† Organism isolated from water.
§ Suspected etiology on the basis of clinical syndrome and setting.

TABLE 5. Waterborne-disease outbreaks of meningoencephalitis, acute respiratory infection, and Pontiac fever (n = 10) associated with recreational water — United States, 2001–2002

State	Year	Month	Class*	Etiologic agent	Illness	No. of cases (n = 80)	Source	Setting
Florida	2002	Jul	NA†	*Naegleria fowleri*	Meningoencephalitis	1	Lake	Park
Florida	2002	Jul	NA	*N. fowleri*	Meningoencephalitis	1	Lake	Lake
Georgia	2002	Aug	NA	*N. fowleri*	Meningoencephalitis	1	River	River
Georgia	2002	Jun	IV	ARI§	Acute respiratory	4	Spa	Private residence
Illinois	2002	Aug	I	*Legionella* species¶**	Pontiac fever	68	Spa	Hotel/motel
Oklahoma	2001	Jun	NA	*N. fowleri*	Meningoencephalitis	1	Lake	Lake
Texas	2001	Aug	NA	*N. fowleri*	Meningoencephalitis	1	Lake	Lake
Texas	2001	Aug	NA	*N. fowleri*	Meningoencephalitis	1	Lake	Lake
Texas	2001	Aug	NA	*N. fowleri*	Meningoencephalitis	1	Lake	Lake
Texas	2002	Aug	NA	*N. fowleri*	Meningoencephalitis	1	Lake	Lake

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12.
† Not applicable.
§ Acute respiratory infection of unknown etiology; *Legionella* species suspected.
¶ Also listed in Table 2 in Blackburn B, Craun GF, Yoder JS, et al. Surveillance for waterborne-disease outbreaks associated with drinking water—United States, 2001–2002. In: Surveillance Summaries (October 22, 2004). MMWR 2004;53(No. SS-8):23–45 but only counted in statistics pertaining to this summary.
** The spa filter was positive for *Legionella dumoffii*.

TABLE 6. Waterborne-disease outbreaks involving chemical exposures* (n = 4) associated with recreational water — United States, 2001–2002

State	Year	Month	Etiologic agent	Illness	No. of cases (n = 102)	Source	Setting
Alaska	2002	Sep	Chlorine gas	Acute respiratory	30	Pool	University
Ohio	2002	Jun	Chlorine gas	Acute respiratory	20	Wave pool	Waterpark
West Virginia	2002	Oct	Chloramines†	Acute respiratory	32	Indoor pool	Hotel/motel
Wisconsin	2001	Sep	Chloramines†	Acute respiratory	20	Indoor pool	School

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12.
† Suspected etiology on the basis of clinical syndrome and setting.

and five (16.7%) by viruses; the remaining seven (23.3%) were of unknown etiology (Figure 3) (Table 7). *Cryptosporidium* species remained the most common cause of outbreaks associated with treated swimming water (50.0%), and toxigenic *E. coli* serotypes and norovirus were the most commonly identified causes (25.0% each) of outbreaks associated with fresh water exposure (Figure 3).

The etiologic agent was suspected or identified in 34 (97.1%) of the 35 nongastroenteritis-related recreational outbreaks: 18 were caused by *Pseudomonas aeruginosa*, eight by *Naegleria fowleri*, one by *Legionella* species, one by *Bacillus* species, one by *Staphylococcus* species, one by avian schistosomes, and four by chlorine-based pool chemicals (Tables 4–7). One outbreak of unknown etiology was consistent with *Legionella* species on the basis of observed symptoms resembling Pontiac fever and the epidemiologically implicated mode of transmission.

Gastroenteritis Outbreaks

Parasites. Of the 12 parasitic recreational water-associated outbreaks of gastroenteritis, 11 (91.6%) were caused by *Cryptosporidium* species, and one was caused by *Giardia intestinalis*. Nine (75.0%) of these 12 parasitic outbreaks occurred in chlorinated venues.

During the 2001–2002 summer swim seasons, three outbreaks of *Cryptosporidium* species occurred that were related to fecal contamination; each outbreak affected >100 persons. In July 2001, an outbreak occurred in a Nebraska community, causing 157 illnesses. In this outbreak, contamination was introduced into a wading pool by a fecal accident and subsequently spread via infected swimmers to multiple community pools. At an Illinois waterpark (July 2001), 358 persons became ill with cryptosporidiosis after the introduction of fecal contamination into facility pools. A sustained outbreak of cryptosporidiosis (July 2002) at a Massachusetts health club sickened 767 persons. Epidemiologic evidence indicated that infections associated with pool use occurred throughout the summer, with transmission peaking during a heat wave in mid-August.

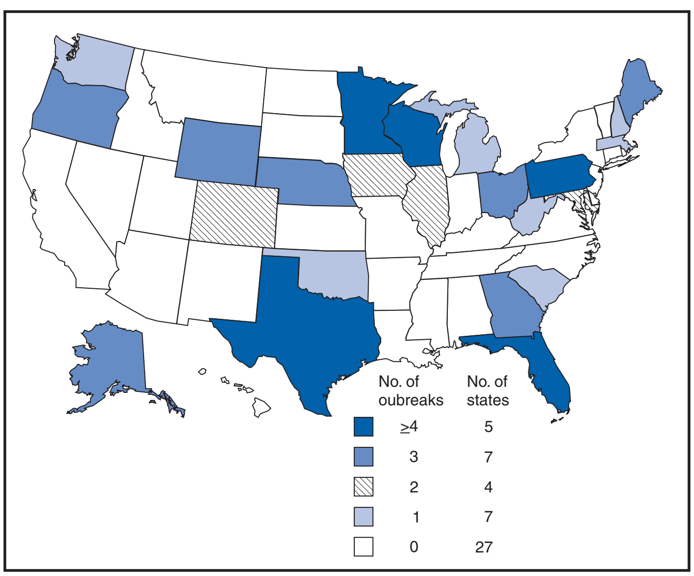
Bacteria. Six recreational water-associated outbreaks of gastroenteritis were attributed to bacterial pathogens, three of which were linked to freshwater sources. Twenty cases (Minnesota, July 2001) of *E. coli* O157:H7 occurred among persons who had visited a lakefront beach located in a metropolitan area. The environmental investigation at the lake identified high fecal coliform levels, and the beach was closed for

TABLE 7. Waterborne-disease outbreaks (n = 65) associated with recreational water, by etiologic agent and type of water — United States, 2001–2002

	Type					
	Treated		Fresh		Total	
Etiologic agent	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases
Bacterial	**24**	**571**	**3**	**69**	**27**	**640**
Pseudomonas aeruginosa	18*	393	0	0	**18**	**393**
Escherichia coli (O157:H7, O26:NM)	1	9	3†	69	**4**	**78**
Shigella sonnei	2	78	0	0	**2**	**78**
Bacillus species	1	20	0	0	**1**	**20**
Legionella species	1	68	0	0	**1**	**68**
Staphylococcus species	1	3	0	0	**1**	**3**
Parasitic	**9**	**1,469**	**12**	**34**	**21**	**1,503**
Cryptosporidium species	9	1,469	2	5	**11**	**1474**
Naegleria fowleri	0	0	8	8	**8**	**8**
Giardia intestinalis	0	0	1	2	**1**	**2**
Avian schistosomes	0	0	1*	19	**1**	**19**
Unknown	**5**	**63**	**3**	**82**	**8**	**145**
AGI§	4	59	3	82	**7**	**141**
ARI¶	1	4	0	0	**1**	**4**
Viruses	**2**	**51**	**3†**	**95**	**5**	**146**
Norovirus	2	51	3†	95	**5**	**146**
Chemical	**4**	**102**	**0**	**0**	**4**	**102**
Chlorine gas	2	50	0	0	**2**	**50**
Chloramines	2*	52	0	0	**2**	**52**
Total	**44**	**2,256**	**21**	**280**	**65**	**2,536**
Percentage	**(67.7)**	**(89.0)**	**(32.3)**	**(11.0)**	**(100)**	**(100)**

* Includes outbreaks of suspected etiology on the basis of clinical syndrome and setting.
† Includes one mixed-pathogen outbreak.
§ Acute gastrointestinal illness of unknown etiology.
¶ Acute respiratory illness of unknown etiology.

FIGURE 1. Number of waterborne-disease outbreaks (n = 65) associated with recreational water, by state — United States, 2001–2002*

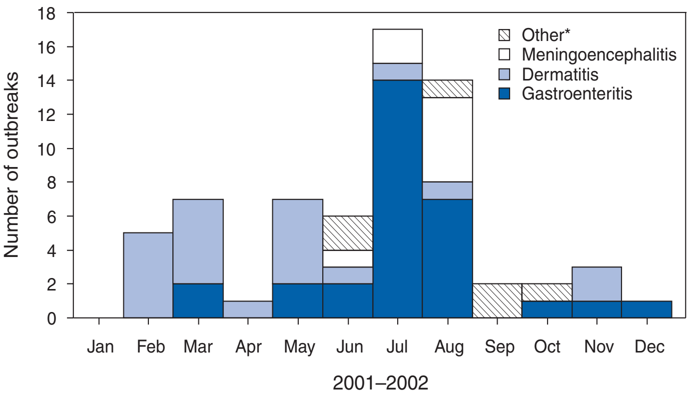


* Numbers are dependent on reporting and surveillance activities in individual states and do not necessarily indicate that more outbreaks occur in a given state.

the rest of the season. Five of the ill persons subsequently reported attending child care centers during or shortly after their illness, and a secondary outbreak resulted.

Three bacterial outbreaks of gastroenteritis (two of *Shigella sonnei* and one of *E. coli* O157:H7) occurred in venues using chlorinated tap water with no additional disinfection. In June 2001, an outbreak of *S. sonnei* in Iowa affected 45 persons, and 24 secondary infections occurred (*10*). Illnesses were linked epidemiologically to use of a drain-and-fill municipal wading pool. The pool was filled each day with drinking water, had no recirculation or disinfection system, and was frequented by diaper-aged children. Pool water tested positive for fecal coliforms (Glossary) and *E. coli*. Subsequent to the outbreak, a communitywide outbreak of shigellosis involving multiple local child care centers occurred. Another outbreak (Maine, July 2002) affecting nine persons at a private home was caused by *E. coli* O157:H7 in a toddler wading pool. One child was hospitalized. The pool was filled with tap water but was not additionally treated (i.e., filtered or recirculated). High bather density and a fecal accident might have contributed to the outbreak. In July 2001 in Colorado, 33 persons were infected by *S. sonnei* after exposure to an interactive fountain, which was at sidewalk level with no barriers to public access. The fountain, which was used frequently for recreation, especially by young children, used chlorinated city water that was recirculated with no additional treatment.

FIGURE 2. Number of waterborne-disease outbreaks (n = 65) associated with recreational water, by illness and month — United States, 2001–2002



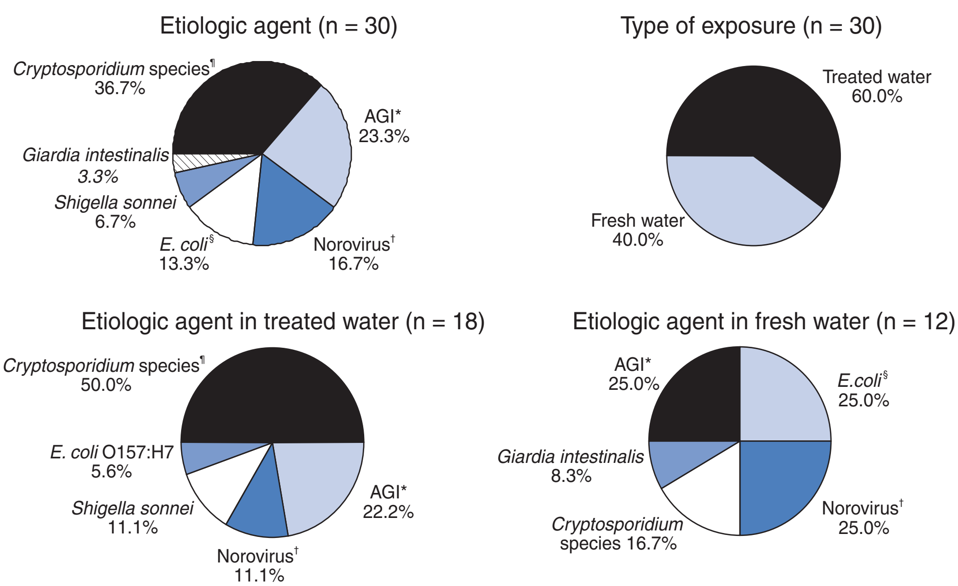
* Acute respiratory illness, Pontiac fever, or chemical exposure.

Viruses. During 2001–2002, five recreational water-associated outbreaks of gastroenteritis were attributed to norovirus (Glossary), causing illness in 146 persons. An outbreak of gastroenteritis in July 2001 in Minnesota that affected 40 persons was linked to a community swimming beach at a lake. Epidemiologic evidence indicated that this waterborne outbreak might have been part of a larger communitywide norovirus outbreak occurring during that time. An outbreak (Wisconsin, July 2002) of 44 primary cases was reported among persons swimming at a Lake Michigan state park, and 22 secondary cases were reported among park visitors. Of the 44 persons with primary cases, 21 (49%) continued to use the beach and swim after illness onset. Although the majority of illnesses were consistent with norovirus infection, the outbreak was attributed to three pathogens: norovirus, *S. sonnei*, and *Cryptosporidium* species. The county health department closed the beach to swimming after finding 2,419 *E. coli* CFU/100 mL in beach water samples. Water samples collected before the outbreak had not exceeded EPA's 235 CFU/100 mL single-sample maximum guideline. Although the source of the fecal contamination was not identified, multiple sources were suspected; high levels of bacteria in Lake Michigan can also be affected by weather conditions and low lake levels. The same beach was closed on five other occasions during the summer when water samples exceeded the guideline; each closing occurred ≤48 hours after a rainfall event. This is the first documented outbreak associated with use of a Great Lakes beach since this surveillance system was created.

Two outbreaks of norovirus infection were associated with swimming pools. In one such outbreak, 36 persons (Minnesota, March 2002) associated with three youth sports teams became ill after swimming in a hotel pool and spa.

Other. During 2001–2002, seven recreational water outbreaks involving gastroenteritis of unknown etiology were reported, including four in swimming pools, two in lakes, and one in a water puddle. In one outbreak (New Hampshire, August 2001), 42 children became ill with nausea, vomiting, and diarrhea after swimming in a state park lake. *Oscillatoria* was isolated from the lake water in high concentrations, which was consistent with the clinical symptoms manifested. An estimated 33 children became ill (Maine, November 2001) after playing in a large puddle, an activity not usually associated with illness. The puddle was caused by an overflowing septic tank and excessive rain; high levels of *E. coli* were identified in the water.

FIGURE 3. Waterborne-disease outbreaks of gastroenteritis associated with recreational water, by etiologic agent and type of exposure — United States, 2001–2002



* Acute gastrointestinal illness of unknown etiology.
† Includes one mixed pathogen outbreak.
§ Includes outbreaks of *Escherichia coli* O157:H7 and O26:NM.
¶ Includes two outbreaks of *Cryptosporidium hominis*.

Nongastroenteritis Outbreaks

Dermatitis. During 2001–2002, a total of 21 outbreaks of dermatitis were identified (Table 4). An outbreak in Oregon during 2002 that sickened 19 persons was associated with swimming in freshwater lakes and rivers and was consistent with cercarial dermatitis (Glossary).

The 20 remaining outbreaks were associated with pool and spa use and affected 416 persons. *P. aeruginosa* was confirmed in water or filter samples from eight outbreaks, three of which also had a clinical isolate of *P. aeruginosa*. In the remaining 12 outbreaks, *Pseudomonas* was suspected on the basis of the clinical syndrome and setting. In eight dermatitis outbreaks, the affected persons (e.g., members of youth sports teams traveling for a tournament or persons attending birthday parties) were attending events at a hotel and used a hotel spa during the event.

In multiple outbreaks in Pennsylvania (May 2001), participants in a youth soccer tournament had folliculitis (Glossary), and ≥3 different local hotel spas were implicated. Although 64 cases were identified, officials estimated that >150 persons became ill. Determining the number of affected persons was difficult because players from other states participated in the tournament. Contributing factors to these outbreaks included inadequate spa maintenance, nonadherence to the bather load limit, and failure to shower before and after spa use.

Meningoencephalitis. Eight cases of laboratory-confirmed PAM attributed to *N. fowleri* occurred during 2001–2002 (Table 5). All eight persons died from infection after having summertime contact with lake or river water. In three cases, the infected person was reported to have had contact with sediment from the lake or river bottom while diving or stirring up the soil (*11*).

Chemical. During 2001–2002, four outbreaks that affected 102 persons were attributed to chemical exposure in recreational water settings (Table 6). Two outbreaks that occurred in outdoor pool settings were attributed to buildup of chloramines (Glossary), a class of disinfection byproducts/irritants (*12–14*). In pools, chloramines result from the combination of chlorine used for disinfection and organic compounds (e.g., saliva, perspiration, urine, body oils) deposited in the water. Chloramines can accumulate in the pool water and volatilize into the air. In indoor pools with inadequate ventilation, levels can increase to the point that respiratory irritation occurs; contact with water with high levels can cause dermatitis and irritation of mucous membranes (*12–14*). In October 2002, a total of 32 hotel guests in West Virginia who were exposed to an indoor pool and surrounding area reported symptoms of cough, eye and throat irritation, and difficulty breathing. The proportion of exposed persons who became ill increased with duration of indoor pool air or water exposure. Illness was likely caused by the buildup of chloramines in the pool area.

Two chemical outbreaks were related to respiratory exposures to chlorine gas at swimming pools. In Alaska (September 2002), a maintenance worker mistakenly mixed chlorine and hydrochloric acid, leading to the release of chlorine gas, and in Ohio (June 2002), workers failed to shut down the chlorine feed system during waterline repairs.

Other. One outbreak of acute respiratory illness identified as Pontiac fever (Illinois, 2002) sickened 68 persons and was linked epidemiologically to use of a hotel spa (Table 5). Another outbreak (Georgia, June 2002) involved acute respiratory infections of unknown etiology. Four persons affected in this outbreak reported symptoms that included nausea, headache, chills, and fever after bathing in a spa at a private residence. Although urine specimens were tested for *L. pneumophila*, no infectious agent was identified.

Previously Unreported Outbreaks

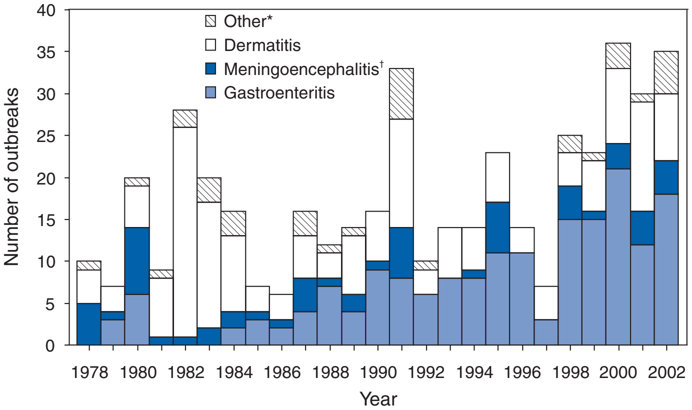
A previously unreported recreational water-associated outbreak occurred in Colorado in June 1998. Five family members became ill with nontuberculous mycobacterial respiratory disease; two were hospitalized (*15*). Illness was linked epidemiologically and environmentally to an in-home spa exposure, both by contact and inhalation. Multiple species of nontuberculous mycobacteria were isolated from the spa water, including *Mycobacterium avium* complex and *M. fortuitum*. Inadequate disinfection levels, lack of monitoring of pH and disinfection levels, and having the spa inside the living area were contributing factors to this outbreak. This type of spa-associated pneumonitis has been described previously (*16*).

Discussion

Trends in Outbreak Reporting

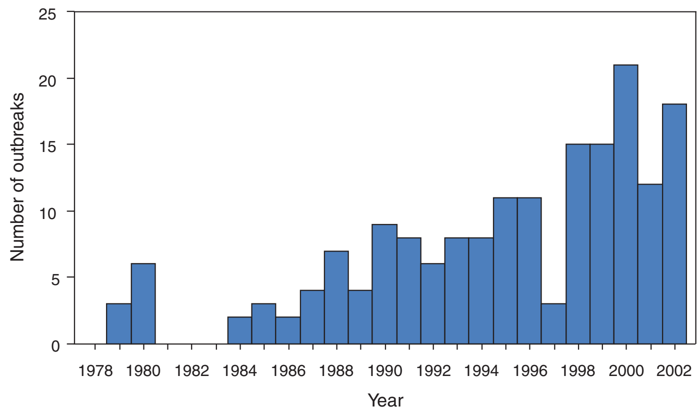
The number of recreational water-associated outbreaks has increased significantly since 1993 (Pearson's correlation = 0.77; p<0.01) and is at the highest 2-year level (65 outbreaks for 2001–2002, compared with 59 outbreaks for 1999–2000 [*2*]) since CDC began receiving such reports in 1978 (Figure 4). The increase since 1993 is also significant for reported outbreaks of gastrointestinal illness (Pearson's correlation = 0.67; p = 0.034) (Figure 5) and for outbreaks of nongastrointestinal illness (Pearson's correlation = 0.74; p = 0.014). Whether this reflects a true increase in the number of outbreaks or reflects increasing attendance at aquatics venues (e.g., waterparks, [*17*]), increased recognition of the potential health concerns associated with recreational water (which has led to improved surveillance and investigation), or a combination of these factors is unknown. Factors influencing the sensitivity of this reporting system have been discussed previously (*2*). The increased reporting of gastrointestinal illness outbreaks since 1993 might reflect a true increase in the number of outbreaks occurring. This is indicated because the reported increase is

FIGURE 4. Number of waterborne-disease outbreaks (n = 445) associated with recreational water by year and illness — United States, 1978–2002



* Includes keratitis, conjunctivitis, otitis, bronchitis, meningitis, hepatitis, leptospirosis, Pontiac fever, and acute respiratory illness.
† Also includes data from report of ameba infections (**Source:** Visvesvara GS, Stehr-Green JK. Epidemiology of free-living ameba infections. J Protozool 1990;37:25S–33S).

FIGURE 5. Number of waterborne-disease outbreaks of gastroenteritis (n = 176) associated with recreational water, by year — United States, 1978–2002



associated primarily with treated venues (Figure 6) as a result of contamination of pool water by *Cryptosporidium* (Figure 7), reflecting the emergence of the naturally chlorine-resistant *Cryptosporidium* as a human pathogen since 1980 (*18*). In contrast, the high numbers of outbreaks reported by Florida and Minnesota might be attributable to enhanced surveillance and investigative activities rather than to a higher incidence of WBDOs compared with other states.

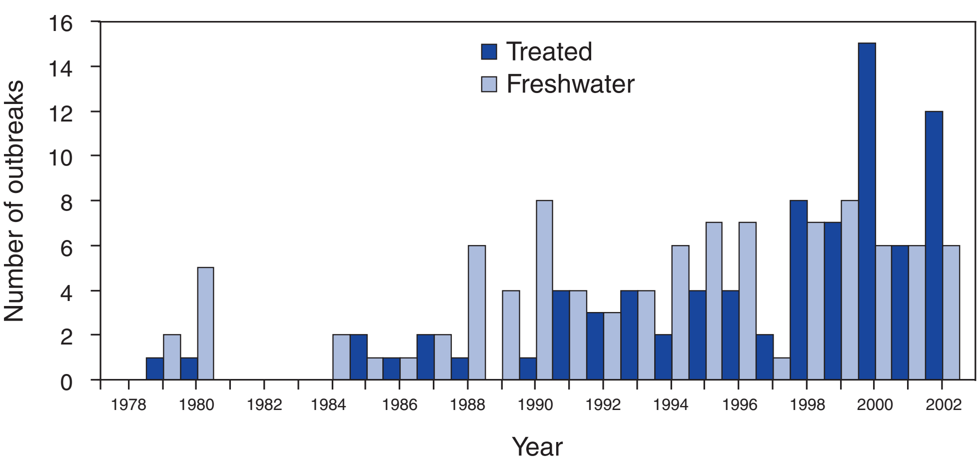
One key limitation of the data collected as part of the WBDO surveillance system is that the information pertains only to disease outbreaks rather than endemic illness. The epidemiologic trends and water-quality concerns observed in outbreaks might not necessarily reflect or correspond with trends associated with endemic waterborne illness. To address this problem, EPA and CDC are collaborating on the NEEAR Water Study to assess the magnitude of waterborne illness associated with routine, nonoutbreak-associated exposure to marine and freshwater recreational areas.

Gastroenteritis-Associated Outbreaks

Fecal contamination of recreational water that can lead to outbreaks of gastroenteritis occurs through different means. Because swimming is essentially communal bathing, rinsing of soiled bodies and fecal accidents from swimmers can cause contamination of the water. Unintentional ingestion of recreational water contaminated with pathogens can then lead to gastrointestinal illness, even in nonoutbreak settings (*19,20*). Fresh and marine waters are also subject to fecal contamination from point sources (i.e., sewage releases), watersheds (i.e., runoff from agricultural, forest, and residential areas), and floods. Wild and domestic animals, as well as infected humans, can be sources of certain pathogens, including *Giardia intestinalis*, *Cryptosporidium*, and toxigenic *E. coli*. Weather conditions (e.g., wind, rain, and drought) can also affect the water quality, and high air temperatures can cause overcrowding and decreased water quality in pools and lakes.

Of the 65 recreational WBDOs reported during 2001–2002, the largest proportion reported (46.2%) involved gastroenteritis, compared with 61.0% during 1999–2000 (*2*). As during the previous reporting period, *Cryptosporidium* accounted for the largest percentage of outbreaks involving

FIGURE 6. Number of waterborne-disease outbreaks of gastroenteritis (n = 176) associated with recreational water, by water type — United States, 1978–2002



gastroenteritis (36.7%) (Figure 3) (Table 7). Of the 30 outbreaks involving gastrointestinal illness, 18 (60.0%) occurred in treated systems (i.e., pools). In treated venues, 50% of the outbreaks were attributed to *Cryptosporidium* (Figure 3). During 1993–2002, *Cryptosporidium* accounted for >65% of outbreaks occurring in treated venues (Figure 7).

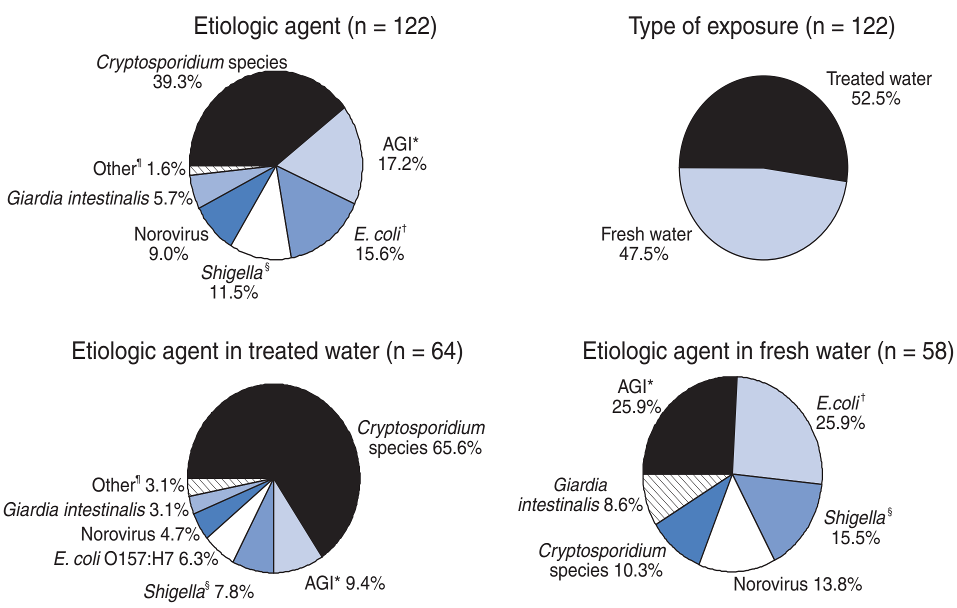
Unlike other organisms, which are more susceptible to the levels of chlorine typically maintained in a pool, *Cryptosporidium* oocysts (Glossary) are highly chlorine-resistant and require increased levels of chlorine and longer contact times (Glossary) with chlorine for inactivation. *Cryptosporidium* can survive for days in public health–mandated chlorine concentrations required for pools (1–2 ppm free chlorine). Certain outbreak reports noted inadequate pool maintenance as a contributing factor to the outbreak. Although low chlorine levels are unlikely to have been the cause of cryptosporidiosis outbreaks, the deficiency serves to indicate deterioration of water quality caused by overcrowding or the introduction of fecal contamination.

The frequent reporting of low chlorine levels in outbreaks indicates a disturbing lack of awareness among pool operators concerning the role of chlorine and pH control as the major protective barrier against infectious disease transmission in pools. In addition, inadequate disinfectant levels in any pool increases the risk for transmission of chlorine-susceptible pathogens (e.g., *E. coli* O157:H7 and *Shigella* species) if an infected swimmer contaminates the pool. Analysis of >22,000 pool-inspection records indicated that the majority of pool inspections had ≥1 pool code violation for water quality, recirculation system, or pool management, and 8.3% of inspections resulted in immediate pool closure (*21*). This emphasizes the need for increased vigilance to ensure that pool operators and staff are appropriately trained regarding the need to follow guidelines (available at http://www.cdc.gov/healthyswimming/ poolstaff.htm) to prevent the spread of recreational water illnesses and to ensure proper pool maintenance (i.e., disinfection, pH control, and filtration) (*22*).

The treated-venue outbreaks of chlorine-susceptible pathogens (e.g., *S. sonnei* and *E. coli* O157:H7) reported in this summary all occurred in pools that were not adequately chlorinated. Two *S. sonnei* outbreaks were in public venues (i.e., an interactive fountain without water treatment and a drain-and-fill wading pool), which underscores the need for health authorities and operators to be vigilant about the necessity for including disinfection and filtration in all designs for public swimming venues (including interactive fountains and wading pools) that are easily used and accessed by the public, particularly young children. The outbreak of *E. coli* O157:H7 occurred in a home wading pool with no disinfection or filtration. The use of tap water to fill these wading pools means that the water is essentially untreated upon filling (i.e., when unchlorinated tap water from a home well is used) or shortly thereafter (i.e., when chlorinated tap water is used, and the chlorine dissipates rapidly) and offers little protection against the spread of pathogens. Thus, these venues present a high risk for exposure if persons ill with diarrhea swim and fecal contamination occurs. These pools should be used with caution and, at a minimum, should be drained and cleaned after each use. Education of users should alert them to the potential for disease transmission and stress that children with diarrhea should refrain from swimming in them. Use of these pools in institutional settings (e.g., child care centers that have substantial numbers of toddler and diaper-aged children) should be avoided.

Use of recreational water venues can lead to amplification of disease and to communitywide transmission. Communal use of recreational water makes it ideal for amplification of enteric illness circulating in communities. Whether

FIGURE 7. Waterborne-disease outbreaks of gastroenteritis associated with recreational water, by etiologic agent and type of exposure — United States, 1993–2002



* Acute gastrointestinal illness of unknown etiology.
† Includes *Escherichia coli* O157:H7, *E. coli* O26:NM, and *E. coli* O121:H19.
§ Includes *Shigella sonnei* and *Shigella flexneri*.
¶ These included outbreaks of *Salmonella* and *Campylobacter*.

swimming venues serve as the initial exposure event or an intermediary amplification mode for community enteric illness, public health officials might wish to alert pool operators, child care centers, schools, and other establishments that include recreational water facilities when increases in enteric illness are noted in the community. These community alerts would serve to increase awareness and improve vigilance regarding maintenance and water-quality parameters (i.e., disinfection, pH levels, and filtration) needed to prevent further amplification of most enteric pathogens.

During 2001–2002, a total of 12 gastroenteritis outbreaks were reported after freshwater exposure. Certain outbreaks occurred in beach areas that had substantial numbers of families bathing and swimming in the water. A common element noted in these reports was the presence of diaper-aged children in the water, diaper changing on the beach, and washing of young children in the water. 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 swim in fresh or marine water venues. As part of its Beaches Action Plan, EPA is developing guidelines and information for users of fresh and marine waters (available at http://www.epa.gov/waterscience/beaches).

Use of untreated geothermal or hot spring water in recreational venues should be examined closely by public health officials. In one outbreak of cryptosporidiosis (Wyoming, 2001), untreated hot spring water was used to fill flow-through swimming pools. Hot springs, which feature high levels of minerals and elevated temperatures, are potentially ideal venues for pathogen growth (e.g., *Naegleria, Acanthamoeba,* and *Legionella*) or contamination by users with enteric illness. Two outbreaks of gastroenteritis have been reported previously at waterparks that used untreated mineral spring water (*2,4*). Compared with disinfected pools, these geothermal water-supplied pools pose an increased risk to swimmers because of their confined volume and lack of disinfection and filtration. Improved consumer education about the natural state of this water, guidelines to raise awareness about swimmer hygiene and health restrictions, and exploration of supplementary treatment might help prevent future outbreaks in these enclosed, untreated mineral-water pools.

The number of norovirus outbreaks increased from three during 1999–2000 to five during 2001–2002 (*2*). This increase might be attributable to improvements in the awareness, availability, and use of laboratory detection methods for norovirus over previous years. During 2001–2002, tests for norovirus and other possible agents of viral origin appeared to be more routinely performed and documented in the outbreaks that were reported to CDC compared with previous reporting periods. A viral etiology was suspected in certain outbreaks of acute gastrointestinal illness of unknown etiology. Viral outbreaks are still likely to be underreported because improved technology for detection of viruses in stool and water samples is still 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 pathogens are available from CDC (*23*). Investigators are also encouraged to contact CDC and EPA regarding testing of water samples.

Outbreaks Involving Dermatitis

This summary describes 21 outbreaks of dermatitis, continuing the increase in reported outbreaks documented in the previous two summaries (1997–1998: eight outbreaks [*3*]; 1999–2000: 15 outbreaks [*2*]). Of the 21 dermatitis outbreaks, 20 (95.2%) were associated with spa or pool use, and 18 were thought to result from *P. aeruginosa* infections. In addition to skin infections, spas have also been associated with ear infections (*Pseudomonas*), Pontiac fever/acute respiratory illness (*Legionella*), and a previously unreported outbreak of *Mycobacterium avium* complex/*M. fortuitum* (*15*). The majority of these reports noted inadequate disinfection of the water or deficient maintenance. Because the higher temperatures commonly used in spas deplete disinfectant levels at a more rapid rate, greater vigilance is required to maintain optimal spa water-quality parameters. Analysis of data from 5,209 spa inspections indicated that 2,958 (56.8%) identified $\geq$1 violation, and 11% of spa inspections resulted in immediate closure (*24*). This finding highlights the need for spa operators to actively check and maintain adequate disinfectant levels and other maintenance parameters. Strict adherence to maintaining optimal spa water quality (free chlorine: 3–5 ppm; pH: 7.2–7.8) should prevent the majority of such outbreaks (*25*).

Eight reported outbreaks of spa-associated rashes occurred among persons attending events (youth sports tournaments or birthday parties) who were exposed at hotel facilities during the events. These outbreaks might have been detected because the close relationship among event participants allowed discussion of shared illness and facilitated reporting. However, outbreak reports also cited inadequate disinfection, bather overload, and improper hygiene (no showering after activities and before water entry) as contributing factors to these outbreaks. Combining inadequate maintenance with substantial numbers of users who can easily overload the disinfection capacity of the spa water might facilitate bacterial amplification and the spread of disease. As a result, spa and pool operators should consider enhancing maintenance levels, making water-quality checks more frequently, enhancing health education, and enforcing bather loads, particularly during heavy bather use (e.g., large sports tournaments or other events).

One presumed outbreak of cercarial dermatitis occurred among persons who swam in a freshwater lake. This syndrome is caused by an allergic response after penetration of the epidermis by avian larval schistosomes. Although the extent of the problem of cercarial dermatitis caused by freshwater exposure is unknown, it probably occurs more frequently than is reported to the WBDO surveillance system. Schistosomes occur naturally in ecosystems in which snails, birds, or aquatic mammals coexist, and a substantial number of freshwater lakes in the United States are therefore potential sources of illness among swimmers. To prevent further illnesses, swimmers should pay careful attention to where they swim, avoid shallow swimming areas known to be snail habitats in lakes associated with cercarial dermatitis (particularly areas with onshore winds), and report any incidents to their local health department (*26*).

Outbreaks Involving PAM

The eight deaths associated with PAM reported during 2001–2002 were all linked to freshwater exposure. Typically, these infections are associated with swimming in freshwater bodies in the late summer months because the free-living ameba *N. fowleri* is thermophilic (i.e., it proliferates in warmer waters). The amebae are believed to enter through the nasal passage and then travel to the olfactory lobe of the brain. The mortality associated with infection by *N. fowleri*, particularly among young children, indicate that greater resources should be devoted to educating the public and investigating the efficacy of potential prevention measures. To reduce risk, swimmers might wish to avoid swimming in freshwater venues when water temperatures are high and water levels are low, and should minimize forceful entry of water up the nasal passages during jumping or diving activities (i.e., by holding one's nose or wearing nose plugs) and avoid digging in the sediment while under water (*11*).

Outbreaks Associated with Chemical Exposure

Four outbreaks resulted from chemical exposures in treated aquatics venues resulting in acute respiratory symptoms. Two were a result of release of chlorine gas (used for disinfection) subsequent to improper maintenance and handling. The extreme health effects that might be caused by exposure to chlorine gas underscore the need for better training of pool operators who deal with gaseous chlorine as part of their daily activities. Two other outbreaks appeared to be related to accumulation of chloramines, a class of pool disinfection chemical byproducts or irritants (*12–14*), in the water and air surrounding indoor pools. These outbreaks illustrate that optimal indoor air quality at pools is critical to a safe and healthy swimming experience (*12–14*). More data are needed on indoor pool air quality so air-handling systems can be better designed to rid these venues of contaminating chloramines. Pool operators should be made aware that ventilation of these disinfection byproducts is key to avoiding future outbreaks and that effective pool management and education of swimmers about safe hygiene practices (e.g., showering before swimming and refraining from urinating in the pool) will minimize chloramine formation.

The mechanism for reporting chemical outbreaks is not as straightforward as it is for infectious disease outbreaks. Because communicable disease specialists are in different sections of health departments or in different agencies from environmental health or emergency response personnel, they might not learn about acute recreational water-related chemical exposures. As a result, water-related chemical outbreaks are more likely than infectious disease outbreaks to be underreported. Closer communication and cross-training between these groups to recognize and investigate outbreaks might serve to improve future detection and reporting.

Prevention

Prevention and control of recreational water-associated outbreaks requires a multifaceted approach. This approach should combine appropriate public health practices, environmental remediation, improved beach/pool maintenance and staff training, and enhanced education of the swimming public about infectious disease transmission at aquatic venues combined with simple, implementable protection measures.

Conclusion

Data collected as part of the national WBDO surveillance system are used to describe the epidemiology of waterborne diseases in the United States. Identification of the etiologic agents and deficiencies 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 authorities should be able to detect and recognize recreational water-associated outbreaks and implement appropriate prevention and control measures. Improved communication among local and state public health departments, regulatory agencies, recreational water facilities, and the public would aid the detection and control of outbreaks. Routine reporting or sharing of inspection data between environmental health, infectious disease, and surveillance staff located within one or more agencies at the local or state level and with agencies in neighboring jurisdictions is recommended.

When an outbreak occurs, the timely collection of clinical specimens and water samples for testing and commencement of an environmental investigation might lead to more rapid detection of the etiologic agent and the source of water contamination. However, the course of an investigation reflects 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, investigations cannot always be completed thoroughly. WBDO investigations typically require input from persons trained in 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 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 recreational water treatment and collection of large-volume water samples to identify pathogenic viruses, bacteria, 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 information or testing for *Legionella* should be made to CDC's Respiratory Diseases Branch, Division of Bacterial and Mycotic Diseases, at 404-639-2215. Requests for tests for parasites should be made to CDC's Division of Parasitic Diseases, NCID, at 770-488-7756.

Additional information is available from

- CDC's Healthy Swimming website at http://www.healthyswimming.org, which includes recreational water health communication and education materials for the general public and pool maintenance staff (e.g., information regarding disinfection, guidelines on response to fecal accidents [*27*], and fact sheets concerning recreational water illnesses); technical information regarding laboratory diagnostics; and an outbreak investigation toolkit that can be used by public health professionals;
- EPA's Beach website at http://www.epa.gov/OST/beaches;
- 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 770-488-7756 or FAX at 770-488-7761; an electronic version of CDC's reporting form (CDC 52.12, rev. 01/2003) is available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf.

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References

1. Craun GF, ed. Waterborne diseases in the United States. Boca Raton, FL: CRC Press, Inc., 1986.
2. Lee SH, Levy DA, Craun GF, Beach MJ, Calderon RL. Surveillance for waterborne-disease outbreaks—United States, 1999–2000. In: CDC Surveillance Summaries, November 22, 2002. MMWR 2002;51(SS-8): 1–47.
3. Barwick RS, Levy DA, Craun GF, Beach MJ, Calderon RL. Surveillance for waterborne disease outbreaks—United States, 1997–1998. In: CDC Surveillance Summaries, May 26, 2000. MMWR 2000;49 (No. SS-4):1–34.
4. Levy DA, Bens MS, Craun GF, Calderon RL, Herwaldt BL. Surveillance for waterborne-disease outbreaks—United States, 1995–1996. In: CDC Surveillance Summaries, December 11, 1998. MMWR 1998;47(No. SS-5):1–34.
5. Kramer MH, Herwaldt BL, Craun GF, Calderon RL, Juranek DD. Surveillance for waterborne-disease outbreaks—United States, 1993–1994. In: CDC Surveillance Summaries, April 12, 1996. MMWR 1996;45 (No. SS-1):1–33.
6. Moore AC, Herwaldt BL, Craun GF, Calderon RL, Highsmith AK, Juranek DD. Surveillance for waterborne disease outbreaks—United States, 1991–1992. In: CDC Surveillance Summaries, November 19, 1993. MMWR 1993:42(No. SS-5):1–22.
7. Herwaldt BL, Craun GF, Stokes SL, Juranek DD. Waterborne-disease outbreaks, 1989–1990. In: CDC Surveillance Summaries, December 1991. MMWR 1991;40(No. SS-3):1–21.
8. Blackburn B, Craun GF, Yoder JS, et al. Surveillance for waterborne-disease outbreaks associated with drinking water—United States, 2001–2002. In: *S*urveillance Summaries, October 22, 2004. MMWR 2004;53(No. SS-8):23–45.

9. Environmental Protection Agency. Bacteriological ambient water quality criteria marine and fresh recreational waters. Cincinnati, OH: National Service Center for Environmental Publications, 1986. EPA publication no. 440584002.
10. CDC. Shigellosis outbreak associated with an unchlorinated fill-and-drain wading pool—Iowa, 2001. MMWR 2001;50:797–800.
11. CDC. Primary amebic meningoencephalitis—Georgia, 2002. MMWR 2003;52:962–4.
12. Massin N, Bohadana AB, Wild P, Héry M, Toamain JP, Hubert G. Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming pools. Occup Environ Med 1998;55:258–63.
13. Gaginaire F, Axim S, Bonnet P, Hecht G, Hére M. Comparison of the sensory irritation response in mice to chlorine and nitrogen trichloride. J Appl Toxicol 1994;14:405–9.
14. Emanuel BP. The relationship between pool water quality and ventilation. Environmental Health 1998;61:17–20.
15. Mangione EJ, Huitt G, Lenaway D, et al. Nontuberculous mycobacterial disease following hot tub exposure. Emerg Infect Dis 2001;7:1039–42.
16. Rickman OB, Ryu JH, Fidler ME, Kalra S. Hypersensitivity pneumonitis associated with *Mycobacterium avium* complex and hot tub use. Mayo Clin Proc 2002;77:1233–7.
17. McNeal M. U.S. waterpark attendance breaks seventh straight record! World Waterpark Association News, May 2000.
18. Guerrant RL. Cryptosporidiosis: an emerging highly infectious threat. Emerg Infect Dis 1997;3:51–7.
19. Pruss A. Review of epidemiological studies on health effects from exposure to recreational water. International J Epidemiol 1998;27:1–9.
20. Calderon RL, Mood EW, Dufour AP. Health effects of swimmers and nonpoint sources of contaminated water. Int J Environ Health Res 1991;1:21–31.
21. CDC. Surveillance data from swimming pool inspections—selected states and counties, United States, May–September 2002. MMWR 2003;52:513–6.
22. CDC. Swimming pools: safety and disease control through proper design and operation. Atlanta, GA: US Department of Health and Human Services, Public Health Service, CDC, 1976; DHHS publication no. (CDC) 88-8319.
23. CDC. “Norwalk-like viruses”: public health consequences and outbreak management. MMWR 2001;50(No. RR-9):1–18.
24. CDC. Surveillance data from public spa inspections—United States, May–September 2002. MMWR 2004;53:553–5.
25. CDC. Suggested health and safety guidelines for public spas and hot tubs. Atlanta, GA: US Department of Health and Human Services, Public Health Service, CDC, 1981; DHHS publication no. (CDC) 99-960.
26. Verbrugge LM, Rainey JJ, Reimink RL, Blankespoor HD. Swimmer’s itch: incidence and risk factors. Am J Pub Health 94:738–41.
27. CDC. Responding to fecal accidents in disinfected swimming venues. MMWR 2001;50:416–7.

Appendix

Selected Case Descriptions of Outbreaks Associated with Recreational Water

Outbreak date(s)	State in which outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
Parasites				
July 2001	Illinois	*Cryptosporidium hominis*	358	A waterpark was implicated in the outbreak. *Cryptosporidium* was laboratory-confirmed in stool samples and the pool water. A fecal accident by a park visitor was the likely source of contamination. Waterpark records indicate that one fecal or vomit accident every 1–2 days was usual, and a subsequent investigation revealed that on the day most strongly associated with case illness, a fecal accident had occurred. Clean-up procedures in place (closing the pool for 20–30 minutes, removing organic material, and checking free-chlorine levels) were adequate for formed stool but not for liquid feces or *Cryptosporidium* inactivation (**Source:** CDC. Responding to fecal accidents in disinfected swimming venues. MMWR 2001;50:416–7). The use of a common water circulation and filtration system for multiple pools might have contributed to cross-contamination and a larger number of cases. Hyperchlorination of the waterpark pool water apparently halted the outbreak.
August 2001	Wyoming	*Cryptosporidium* species	2	A recreational facility with multiple flow-through pools using untreated hot spring water was the source of exposure. The pools were fed by hot springs via cooling ponds and the pools were drained and cleaned once a week. No chlorination or filtration requirements were in place for the water from the hot spring.
July 2002	Massachusetts	*Cryptosporidium* species	767	A full-service sports club was the source of infection. Routine inspections had revealed no major problems with the newly constructed outdoor pool area. The epicenter of the outbreak appears to have been the slide pool, but because all the pools in the children's pool complex were serviced by a single filtration system, making a final determination was difficult. Epidemiologic evidence indicated that infection from the pool was ongoing all summer, but that transmission peaked in mid-August during a massive heat wave.
July 2002	Minnesota	*Cryptosporidium* species	52	Illness was associated with a health club indoor swimming pool in which schoolchildren were taking swimming lessons. An investigation revealed that in the 2 weeks before the outbreak, the chlorine feeder had been out of service, and the chlorine had been administered by hand. The flow meters had not been working, and the rate-of-flow meter readings were not monitored or documented. The filter sand bed was later discovered to be missing 8 of the required 18 vertical inches of sand. After the outbreak, the recirculation pump, filter, and flow-meter were replaced with pool code-compliant models.
July 2002	Georgia	*Cryptosporidium* species	3	Children at a child care center became ill after a reported fecal accident in a wading pool for young children. Records on water treatment for the pool were not available.
July 2002	Wyoming	*Giardia intestinalis*	2	A river that was used by local residents for swimming, surfing (with river boards), and kayaking was the implicated site. It was in an undeveloped area, access to the site was completely open, and the possibility of human or animal contamination was high.
August 2002	Georgia	*Naegleria fowleri*	1	A previously healthy boy aged 11 years received a diagnosis of primary amebic meningoencephalitis after hospital admission with symptoms of headache, seizures, and vomiting. He later died. He had swum in a local river 9 days earlier. Environmental investigation revealed a high river temperature (91.4°F [33°C]) and low water level; and *N. fowleri* was isolated from river water samples (**Source:** CDC. Primary amebic meningoencephalitis—Georgia, 2002. MMWR 2003;52:962).

Outbreak date(s)	State in which outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
August 2002	Texas	*C. hominis*	54	The common exposure for those who became ill was a wading pool at a resort hotel. Investigators believe that use of the wading pool by diaper-aged children led to its contamination.
August 2002	Minnesota	*Cryptosporidium* species	16	An all-inclusive lakeside resort with adult and children's swimming pools was the site of the outbreak. Initial inspection of the pool documented zero free chlorine in the water, and pool water-quality records for this time ranged from incomplete to nonexistent. A direct connection between the well water system and the swimming pool, and a recirculation rate that was <50% of the required rate probably contributed to the outbreak. The pools and spa were closed for the remainder of the season.
Bacteria				
July 2001	Minnesota	*Escherichia coli* O157:H7	20	A lake beach located in a metropolitan area was the outbreak source. Environmental investigation identified high fecal coliform levels but did not detect any failed sewage systems in lake homes that might have contributed. The beach was closed for the rest of the season; ongoing monitoring indicated that the fecal coliform levels did not decrease for the rest of the summer. City officials believed that the high number of geese that occupied the beach during the summer might have contributed to the elevated overall fecal coliform levels.
July 2001	South Carolina	*E. coli* O157:H7	45	A swimming beach at a state park was the site of the outbreak. Fecal contamination directly at the beach or of the stream that fed the lake was suspected. Lake water exceeded guidelines for fecal coliforms in subsequent testing.
Viruses				
July 2001	Minnesota	Norovirus	40	The outbreak was associated with use of a freshwater lake beach. Forty persons became ill, and 27 secondary cases were identified. The beach was frequented by diaper-aged children but lacked any hand-washing facilities. Two incidents of a child vomiting on the beach were reported. Epidemiologic evidence indicates that this waterborne outbreak might have been part of a larger norovirus outbreak occurring in the community during that time.
March 2002	Wisconsin	Norovirus	15	Fifteen of 19 persons from four related families became ill after swimming in a hotel pool. The most commonly reported symptoms were vomiting (87%) and diarrhea (80%).
March 2002	Minnesota	Norovirus	36	Team members of three youth sports teams and family members became ill after staying at a hotel. The most common symptoms were vomiting (81%), diarrhea (56%), cramps (53%), and fever (44%). The environmental health assessment and epidemiologic evidence implicated the hotel pool as the source of the infection.
July 2002	Wisconsin	Norovirus, *Cryptosporidium* species, *Shigella sonnei*	44	Persons became ill after swimming at a state park beach located on one of the Great Lakes. The most frequently reported symptoms were vomiting (75%), diarrhea (66%), and fatigue (34%). Additionally, 22 secondary cases were identified. Environmental investigation revealed high *E. coli* levels on multiple occasions after the outbreak. Contamination might have resulted from bathers or dumping of sewage from boats moored offshore. Of the 44 persons with primary cases, 21 (49%) admitted to beach use and swimming after their onset of illness. After the investigation, beach-closure policies were changed, and the beach was subsequently closed to swimming five times, in each instance ≤48 hours after a rainfall event. This is the first documented disease outbreak associated with the Great Lakes since reporting began in 1978.

Outbreak date(s)	State in which outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
Chemicals				
September 2001	Wisconsin	Chloramines	20	Members of a school swim team reported symptoms after swimming at the school's indoor pool. The most commonly reported symptoms were hair loss (95%), skin rash (85%), and breathing difficulties (60%). The automatic chlorine monitoring system had been malfunctioning, and the chlorine feeder was operated manually. This might have caused high levels of chlorine to be fed into the pool, leading to an accumulation of chloramines. Breathing difficulties were likely caused by exposure to the water and air after accumulation of chloramines at the indoor pool.
June 2002	Ohio	Chlorine gas	20	Eleven persons were taken to the hospital with nausea and respiratory symptoms after a release of chlorine gas at a waterpark. Two boys aged 12 years were admitted; the others were released. Repairs had recently been made to the waterlines feeding the pool. The chlorine disinfection feed system was probably not shut down when the water flow stopped during repair, resulting in chlorine gas release.
September 2002	Alaska	Chlorine gas	30	A maintenance worker and young swimmers experienced severe respiratory symptoms at a campus pool after the maintenance worker mistakenly mixed chlorine and hydrochloric acid. Of 30 persons who were taken to area hospitals, 15 were hospitalized. The worker was refilling the hypochlorite drum and mistakenly refilled with acid that was in a similarly colored drum. A lack of sufficient and appropriate pool operator training and failure to verify the contents of chemical containers were implicated as contributing causes of this incident.
October 2002	West Virginia	Chloramines	32	Persons staying at a hotel who were exposed to indoor pool air and water became ill. The most common symptoms were cough (84%), eye irritation (78%), throat irritation (66%), and difficulty breathing (41%). The proportion of exposed persons who became ill increased with increased duration of exposure to air around the swimming pool and swimming pool water. Water quality parameters did not meet state standards, with pH $\geq$8.5 and combined chlorine $\geq$0.7 ppm.
Other				
March 2001	Florida	*Pseudomonas aeruginosa*	53	Infections involved team members who stayed at a hotel and used the spa. Inspection determined that the water was turbid and contained high bacterial levels, including *Pseudomonas.* Contributing factors to this outbreak were inadequate chlorination and bather overload.
May 2001	Pennsylvania	*P. aeruginosa*	42	Participants in a youth sports tournament experienced folliculitis after using a hotel spa that was subsequently identified as having a high bacterial count. Contributing factors to this outbreak were failure to shower before spa use, not adhering to the bather load limit, and inadequate spa maintenance. The following two outbreaks involved participants in the same tournament who stayed at different hotels. In addition to the 64 cases identified by these three reports, >150 persons associated with this tournament became ill.
May 2001	Pennsylvania	*P. aeruginosa*	2	Participants in a youth sports tournament experienced folliculitis after using a hotel spa. The contributing factors were the same as those in the other May 2001 Pennsylvania outbreak involving *P. aeruginosa*. Investigators were not able to determine the scope of the outbreak as those affected lived out of state and did not cooperate with the investigation.

Outbreak date(s)	State in which outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
May 2001	Pennsylvania	*Bacillus* species	20	Participants in a youth sports tournament developed folliculitis after using a hotel spa. The contributing factors were the same as those associated with the other two May 2001 Pennsylvania outbreaks.
May 2001	Minnesota	*P. aeruginosa*	6	An in-room spa (a noncommercial model) at a resort was implicated in this outbreak of folliculitis. Five persons (83.3%) also reported a sore throat. *P. aeruginosa* was cultured from both skin and spa water.
February 2002	Alaska	*P. aeruginosa*	110	Persons experienced folliculitis after their hotel stay and use of the pool or spa. *P. aeruginosa* was isolated from skin swabs as well as pool and spa water. Examination of chlorination records revealed that the free-chlorine levels for both the pool and spa were outside the acceptable range 75% of the time. Employees lacked required training and certification.
February 2002	Ohio	*P. aeruginosa*	18	Fifteen females experienced folliculitis after staying at a hotel during a sports competition. They all reported use of the spa. Upon inspection, the spa was determined to have no residual chlorine; the pH was 8.0, and the autocontroller for disinfection was turned off. Environmental samples taken from the spa and pool tested positive for *P. aeruginosa.* Three other hotel guests also became ill.
March 2002	Ohio	*P. aeruginosa*	31	Persons attending a birthday pool party initially reported rashes after their visit, and other ill hotel guests were identified. The pool alarm was sounding at the time of the original inspection. No certified pool operator was employed. A remote monitoring service was engaged to oversee chlorination. Inspection revealed that the connections from the controller were reversed for acid and chlorine feed.
Unknown				
November 2002	Maine	Acute gastrointestinal illness of unknown etiology	33	Children were playing in a puddle during recess. The puddle was a result of excess rains and an overflowing septic tank and had high levels of *E. coli*. Children were believed not to have washed their hands after playing in the puddle and before eating lunch.

Glossary

cercarial dermatitis Dermatitis caused by contact/skin perforation by the cercariae (larval stage) of certain species of schistosomes (parasites) whose normal hosts are birds and nonhuman mammals. This allergic response does not lead to parasitic infestation in humans and produces no long-term disease.

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).

chloramines Disinfection by-products form when free chlorine combines with nitrogen-containing compounds (e.g., urine or perspiration). They can cause eye, skin, lung, and throat irritations and have low disinfection capability. They accumulate in water and the air over pools.

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).

combined chlorine level See chloramines. The level of chlorine that has combined with organic compounds in the water and is no longer an effective disinfectant.

contact time The length of time water is exposed to a disinfectant; usually measured in minutes (e.g., chlorine contact time).

Cryptosporidium hominis The taxonomy of *Cryptosporidium* has evolved as a result of advancements in molecular methodology and genotyping. The former *C. parvum* now refers to a species that is zoonotic and infects ruminants and humans. *C. hominis* refers to the species of *Cryptosporidium* that is infective only in humans and monkeys. Both species were referred to previously as *C. parvum*.

disinfection by-products Chemicals formed in water through reactions between organic matter and disinfectants. Includes chloramine, an irritant of the eyes, nose, and throat.

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

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).

folliculitis Inflammation of hair follicles. Spa-associated folliculitis is usually associated with infection by *Pseudomonas aeruginosa.*

free, residual chlorine level The concentration of chlorine in water that is not combined with other constituents, thus serving as an effective disinfectant.

freshwater Surface water (e.g., water from lakes, rivers, or ponds) that has not been treated in any way to enhance its safety for recreational use.

interactive fountain A fountain intended for (or accessible to) recreational use. In contrast, noninteractive (ornamental) fountains intended for public display rather than recreational use are often located in front of buildings and monuments, and their water is not easily accessible for public use.

marine water Untreated recreational water at an ocean setting.

norovirus A group of related, single-stranded RNA, nonenveloped viruses (genus Norovirus, family *Caliciviridae*) that cause acute gastroenteritis in humans. Norovirus was recently approved as the official genus name for the group of viruses provisionally described as Norwalk-like viruses (NLV).

oocyst The infectious stage of *Cryptosporidium* species and certain other coccidian parasites with a protective wall that facilitates survival in water and other environments and renders the parasite extremely resistant to chlorine.

recreational water venue A body of water used for the purpose of recreation (e.g., swimming, soaking, and athletics) including any structure that encloses this water. Can include lakes, rivers, the ocean, and man-made venues (e.g., swimming pools, spas, and waterparks).

spa Any structure, basin, chamber, or tank (located either indoors or outdoors) containing a body of water intended to be used for recreational or therapeutic use that usually contains a waterjet or aeration system. It is operated at high temperatures and is usually not drained, cleaned, or refilled after each use. Sometimes referred to as a *hot tub* or *whirlpool*.

treated water Water that has undergone a disinfection process (e.g., chlorination, filtration) for the purpose of making it safe for recreation. This usually refers to any recreational water in an enclosed, manufactured structure but might include swimming or wading pools, fountains, or spas filled with untreated or treated tap water that receives no further treatment.

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.

Surveillance for Waterborne-Disease Outbreaks Associated with Drinking Water — United States, 2001–2002

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Abstract

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

Reporting Period Covered: This summary includes data on WBDOs associated with drinking water that occurred during January 2001–December 2002 and on three previously unreported outbreaks that occurred during 2000.

Description of the System: Public health departments in the states, territories, localities, and the Freely Associated States are primarily responsible for detecting and investigating WBDOs and voluntarily reporting them to CDC on a standard form. The surveillance system includes data for outbreaks associated with both drinking water and recreational water; only outbreaks associated with drinking water are reported in this summary.

Results: During 2001–2002, a total of 31 WBDOs associated with drinking water were reported by 19 states. These 31 outbreaks caused illness among an estimated 1,020 persons and were linked to seven deaths. The microbe or chemical that caused the outbreak was identified for 24 (77.4%) of the 31 outbreaks. Of the 24 identified outbreaks, 19 (79.2%) were associated with pathogens, and five (20.8%) were associated with acute chemical poisonings. Five outbreaks were caused by norovirus, five by parasites, and three by non-*Legionella* bacteria. All seven outbreaks involving acute gastrointestinal illness of unknown etiology were suspected of having an infectious cause. For the first time, this *MMWR Surveillance Summary* includes drinking water-associated outbreaks of Legionnaires disease (LD); six outbreaks of LD occurred during 2001–2002. Of the 25 non-*Legionella* associated outbreaks, 23 (92.0%) were reported in systems that used groundwater sources; nine (39.1%) of these 23 groundwater outbreaks were associated with private noncommunity wells that were not regulated by EPA.

Interpretation: The number of drinking water-associated outbreaks decreased from 39 during 1999–2000 to 31 during 2001–2002. Two (8.0%) outbreaks associated with surface water occurred during 2001–2002; neither was associated with consumption of untreated water. The number of outbreaks associated with groundwater sources decreased from 28 during 1999–2000 to 23 during 2001–2002; however, the proportion of such outbreaks increased from 73.7% to 92.0%. The number of outbreaks associated with untreated groundwater decreased from 17 (44.7%) during 1999–2000 to 10 (40.0%) during 2001–2002. Outbreaks associated with private, unregulated wells remained relatively stable, although more outbreaks involving private, treated wells were reported during 2001–2002. Because the only groundwater systems that are required to disinfect their water supplies are public systems under the influence of surface water, these findings support EPA's development of a groundwater rule that specifies when corrective action (including disinfection) is required.

Public Health Action: CDC and EPA use surveillance data 1) to identify the types of water systems, their deficiencies, and the etiologic agents associated with outbreaks and 2) to evaluate the adequacy of technologies for providing safe drinking water. Surveillance data are used also to establish research priorities, which can lead to improved water-quality regulations. CDC and EPA recently completed epidemiologic studies that assess the level of waterborne illness attributable to municipal drinking water in nonoutbreak conditions. The decrease in outbreaks in surface water systems is attributable primarily to implementation of provisions of EPA rules enacted since the late 1980s. Rules under development by EPA are expected to protect the public further from microbial contaminants while addressing risk tradeoffs of disinfection byproducts in drinking water.

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Introduction

During 1920–1970, statistical data regarding U.S. waterborne-disease outbreaks (WBDOs) were collected by different 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 associated with drinking water; tabulation of recreational water-associated outbreaks was added to the surveillance system in 1978 (*2–7*). The surveillance system includes data regarding outbreaks associated with drinking water, recreational water, and other types of water exposures. This *MMWR Surveillance Summary* includes data for drinking water-associated outbreaks that occurred during 2001–2002 and for three previously unreported outbreaks that occurred in 2000. Recreational water-associated outbreaks are presented in a separate *MMWR Surveillance Summary* (*8*).

These surveillance activities are intended to 1) characterize the epidemiology of WBDOs; 2) identify changing trends in the etiologic agents that caused WBDOs and determine why the outbreaks occurred; 3) encourage public health personnel to detect and investigate WBDOs; and 4) foster collaboration among local, state, federal, and international agencies on initiatives to prevent waterborne disease transmission. Data obtained through this surveillance system are useful for identifying major deficiencies in providing safe drinking water. Surveillance information can influence research priorities and lead to improved water-quality regulations. However, the statistics reported in this surveillance summary represent only a portion of the burden of illness associated with drinking water exposure. The surveillance information does not include endemic waterborne disease risks, nor are reliable estimates available of the number of unrecognized WBDOs and associated cases of illness.

Background

EPA Drinking Water Regulations

Public water systems are regulated under the Safe Drinking Water Act (SDWA) of 1974 and its subsequent 1986 and 1996 amendments (Table 1) (*9–11*). SDWA authorizes EPA to set national standards to protect drinking water and its sources against naturally occurring or human-made contaminants. Microbial contamination is regulated under the Total Coliform Rule (TCR), Surface Water Treatment Rule (SWTR), Interim Enhanced SWTR (IESWTR), and Long Term 1 Enhanced SWTR (LT1ESWTR). In addition, EPA's lead, copper, and arsenic rules prescribe action levels at which a system must take corrective steps (*12,13*). These rules have been described previously (*2*).

TABLE 1. Environmental Protection Agency regulations regarding drinking water, by year enacted — United States, 1974–2003

Regulation	Year
Safe Drinking Water Act (SDWA)	1974
Interim Primary Drinking Water Standards	1975
National Primary Drinking Water Standards	1985
SDWA amendments	1986
Surface Water Treatment Rule (SWTR)	1989
Total Coliform Rule	1989
Lead and Copper Regulations	1990
SDWA Amendments	1996
Information Collection Rule	1996
Interim Enhanced SWTR	1998
Disinfectants and Disinfection By-Products (D-DBPs) Regulation	1998
Contaminant Candidate List	1998
Unregulated Contaminant Monitoring Regulations	1999
Groundwater Rule (proposed)	2000
Lead and Copper Rule — action levels	2000
Long Term 1 Enhanced SWTR	2002
Long Term 2 Enhanced SWTR	2003
Stage 2 D-DBP Rule	2003

All public water systems are required by TCR to monitor for total coliforms at a prescribed frequency (*14,15*). SWTR (*16*) and IESWTR (*17*) apply to public systems that serve ≥10,000 persons and that use surface water or groundwater under the direct influence of surface water and are intended to protect the public against exposure to *Giardia intestinalis*, *Cryptosporidium*, viruses, *Legionella*, and selected other pathogens. LT1ESWTR applies to public systems that serve <10,000 persons and is intended to improve the control of microbial pathogens, especially *Cryptosporidium* (*18,19*). An additional regulation, the Filter Backwash Recycling Rule, requires the return of recycle flows to the water treatment process so microbial contaminant removal is not compromised (*19,20*).

Recently proposed microbial and disinfection byproducts regulations include the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) and the Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR). These regulations were developed simultaneously to address risk tradeoffs between control of pathogens and limiting exposure to disinfection byproducts (DBPs) that can form in water from the disinfection process used to control microbial pathogens (*21*).

LT2ESWTR (*22,23*) mandates source-water monitoring for *Cryptosporidium* and additional treatment for filtered systems on the basis of source-water concentrations; inactivation of *Cryptosporidium* by all unfiltered systems; disinfection profiling and benchmarking to ensure continued levels of microbial protection while system operators take steps to comply with new DBP limits; and covering, treating, or implementing a risk-management plan for uncovered finished water-storage facilities.

DBPR applies to all community and nontransient, noncommunity water systems that add a disinfectant other than ultraviolet light (*24*). DBPR requires systems to meet maximum contaminant levels at each monitoring site in the distribution system, determine if they are experiencing short-term peaks in DBP levels, and better identify monitoring sites at which consumers are exposed to high DBP levels.

The 1996 amendments require EPA to develop regulations that mandate disinfection of groundwater systems as necessary to protect the public health. The proposed Ground Water Rule (GWR) (information available at http://www.epa.gov/safewater/gwr.html) will specify when corrective action, including disinfection, is required to protect consumers from bacteria and viruses (*25*). Proposed requirements include periodic sanitary surveys to identify deficiencies, hydrogeologic sensitivity assessments for undisinfected systems, source-water microbial monitoring from certain systems, and compliance monitoring for systems that disinfect to ensure adequate inactivation or removal of viruses. SDWA's Wellhead Protection Program requires every state to develop a program to delineate wellhead protection areas in which sources of contamination are managed to minimize groundwater contamination (*25*). Additional protection of groundwater sources, especially from contamination by shallow wells and cesspools, is provided by the Underground Injection Control Regulations (*26*).

Every 5 years, EPA is also required to publish a list of contaminants that are known or anticipated to occur in public water systems and that might need to be regulated. The first drinking water Contaminant Candidate List (CCL) was issued in 1998 and included 50 chemical and 10 microbial contaminants (*27*); however, EPA decided not to regulate any of the waterborne pathogens included in CCL. EPA also must establish criteria for a program to monitor unregulated contaminants and publish a list of contaminants to be monitored (*28–30*). Microorganisms were included among the contaminants for which analytical methods are available (*Aeromonas*) and contaminants for which analytical methods are being developed (*Helicobacter pylori*, cyanobacteria, coxsackieviruses, microsporidia, adenoviruses, and caliciviruses). An ongoing screening survey for *Aeromonas*, and selected chemical contaminants will help determine whether these should be considered or excluded for regulation.

Methods

Data Sources

Public health departments in the states, territories, localities, and the Freely Associated States* (FAS) have primary responsibility for detecting and investigating WBDOs, which they report voluntarily to CDC by using a standard form (CDC form 52.12, available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf). The form solicits data on characteristics of the outbreak, including person, place, time, and location; results from epidemiologic studies conducted; specimen and water sample testing; and other factors potentially contributing to the outbreak (e.g., environmental concerns, disinfection, and filtration [Glossary]). CDC annually requests reports from state, territorial, and FAS epidemiologists or persons designated as WBDO surveillance coordinators and obtains additional information regarding water quality and treatment as needed. Numeric and text data are abstracted from the outbreak form and supporting documents and entered into a database for analysis.

Definitions†

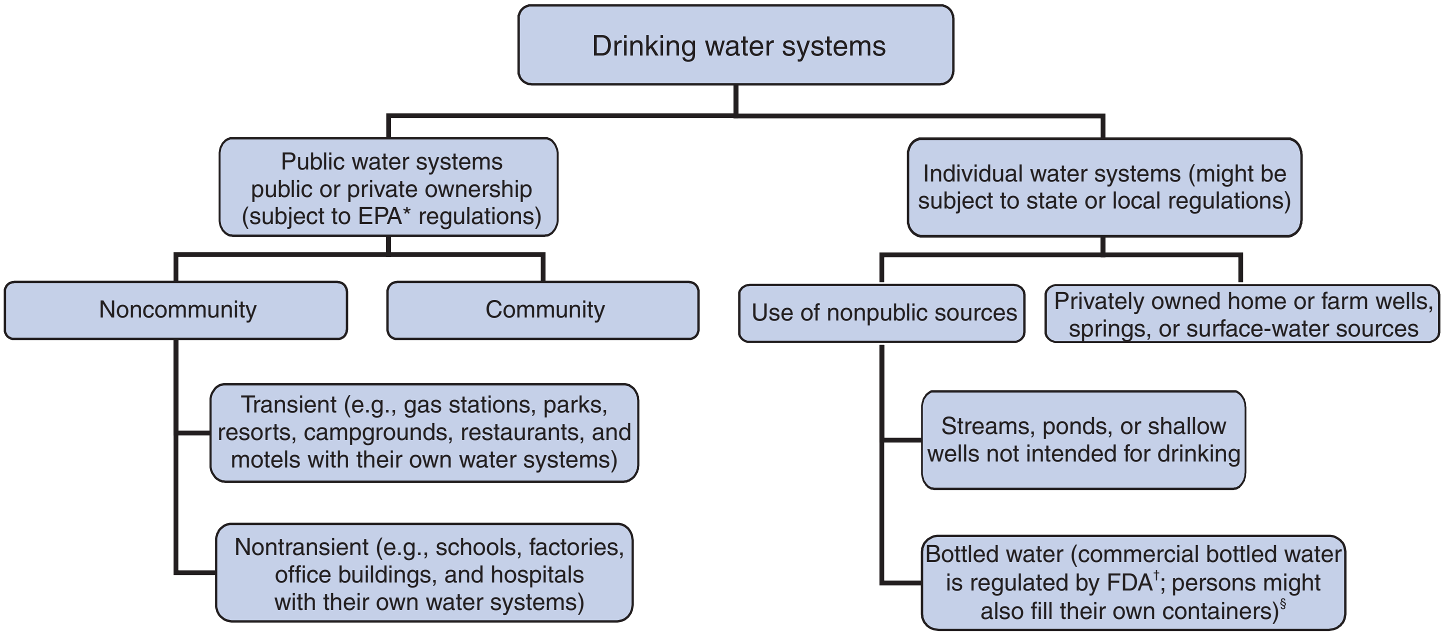
The unit of analysis for the WBDO surveillance system is an outbreak, not an individual case of a waterborne disease. Two criteria must be met for an event to be defined as a drinking water-associated disease outbreak. First, ≥2 persons must have experienced a similar illness after exposure to water. This criterion is waived for single cases of laboratory-confirmed primary amebic meningoencephalitis (PAM) and for single cases of chemical poisoning if water-quality data indicate contamination by the chemical. Second, epidemiologic evidence must implicate drinking water as the probable source of the illness. 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 drinking water-associated outbreaks, and WBDOs associated with cruise ships are not summarized in this report.

Different types of drinking water systems are used for outbreak classification (Figure 1). Public water systems, which are classified as either community or noncommunity systems (Glossary), are regulated under SDWA. Of the approximately 161,000 public water systems in the United States, 108,000

* Composed of the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau; formerly parts of the U.S.-administered Trust Territory of the Pacific Islands.

† Additional terms are defined in the Glossary.

FIGURE 1. Types of drinking water systems used for outbreak classification



* Environmental Protection Agency.
† Food and Drug Administration.
§ In certain instances, bottled water is used in lieu of a community supply or by noncommunity systems.

(67.1%) are noncommunity systems, including 88,000 transient systems and 20,000 nontransient systems (Glossary), and 53,000 (32.9%) are community systems. Despite representing a minority of water systems, community systems serve 273 million persons (approximately 93.9% of the U.S. population) (*31*). Furthermore, a limited number of community systems (3,900 [7.4%]) provide water to 81% of the community system population (*31*). Noncommunity, nontransient systems provide water to 6.3 million persons, and 23.3 million persons use noncommunity, transient systems (by definition, these populations also use another type of water system at their residences, except for the limited number of permanent residents of nontransient systems) (*31*). Although the majority of public water systems (90.9%) are supplied by groundwater, more persons (66.2%) drink from public systems served by surface water. Approximately 17 million persons (6.0%) rely on private, individual water systems (*31*) (Glossary).

In this surveillance system, drinking water-associated outbreaks involving 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 a deficiency. 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, such as irrigation water).

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 2). The classification scheme (i.e., Classes I–IV) is based on the epidemiologic and water-quality data provided on 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. Single cases of PAM or chemical poisoning are

TABLE 2. Classification of investigations of waterborne-disease outbreaks — United States

Class	Epidemiologic data	Water-quality data
I	Adequate Data provided about exposed and unexposed persons, with relative risk or odds ratio ≥2 or p-value ≤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., laboratory testing of water not conducted)
III	Provided but limited Epidemiologic data provided that did not meet the criteria for Class I, or claim made that ill persons had no exposures in common besides water, but no data provided	Provided and adequate
IV	Provided but limited	Not provided or inadequate

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 and system breakdowns that led to the outbreak.

A classification of I indicates that adequate epidemiologic and water-quality data were reported (Table 2). However, the classification does not necessarily imply that an investigation was conducted optimally, nor does a classification of II, III, or IV imply that an investigation was inadequate or incomplete. Outbreaks and the resulting investigations occur under different 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 because of the relatively limited sample size available for analysis.

For the reporting period 2001–2002, WBDOs associated with drinking water and with recreational water are reported separately for the first time. The *MMWR Surveillance Summary* of recreational water-associated outbreaks (*8*) includes WBDOs related to recreational water as defined in the methods section of that summary. This *MMWR Surveillance Summary* includes waterborne outbreaks related to drinking water, those occurring in occupational settings, those associated with *Legionella* species, and other miscellaneous outbreaks.

Although outbreaks of Pontiac fever have been included in previous *MMWR Surveillance Summaries* of WBDOs, this summary is the first to include outbreaks of Legionnaires disease (LD). Because nearly all outbreaks attributed to *Legionella* species share characteristics that are distinct from other types of WBDOs, all *Legionella* outbreaks have been compiled into a single table in this report that identifies the primary use of the water implicated in the outbreak. Although all *Legionella* outbreaks are listed in this table, only those that occurred in association with water primarily intended for drinking or occupational use are discussed in this summary. Outbreaks of LD that occurred in association with water intended primarily for recreational use are discussed in the summary of recreational water-associated outbreaks (*8*).

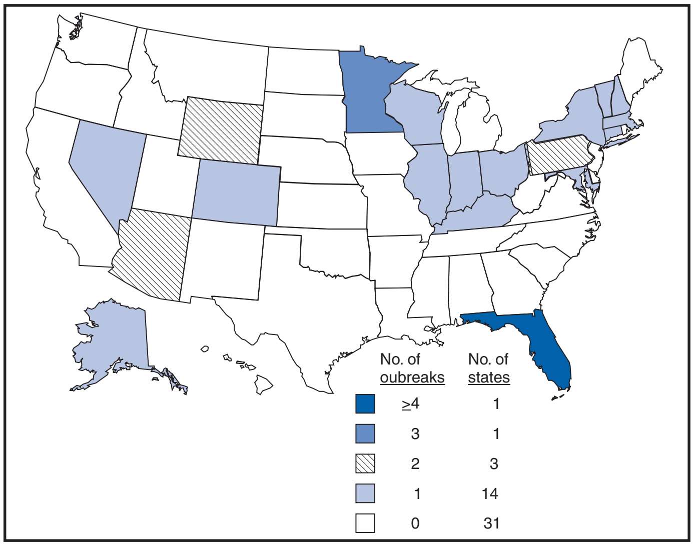
Because the parameters used in this summary to assess drinking water-associated outbreaks (i.e., water system type, water source, and deficiency) do not permit adequate evaluation of the characteristics associated with *Legionella* outbreaks, such parameters are not applied to *Legionella* outbreaks. For this reason, *Legionella* outbreaks are counted not in tables and statistics that include these parameters, but only in those related to the total number of drinking water outbreaks and the etiologic agent of these outbreaks.

Results

During 2001–2002, a total of 31 outbreaks (19 during 2001 and 12 during 2002) associated with drinking water were reported by 19 states (Figure 2) compared with 39 outbreaks during 1999–2000 (Figures 3 and 4). (Selected case descriptions are located in the Appendix). These 31 outbreaks caused illness among an estimated 1,020 persons, resulting in 51 hospitalizations and seven deaths. The median number of persons affected in an outbreak was six (range: 2–230). Outbreaks peaked during June–September (Figure 5). Florida reported the most outbreaks (eight) during this reporting period.

On the basis of epidemiologic and water-quality data, nine (29.0%) of the 31 outbreaks were assigned to Class I, two (6.5%) to Class II, 19 (61.3%) to Class III, and one (3.2%) to Class IV. Outbreaks were analyzed by state (Tables 3, 4, and 5) and tabulated by etiologic agent and water system type (Table 6), type of deficiency and water system (Table 7), and type of deficiency and water source (Table 8). Outbreaks attributable to *Legionella* are excluded from the analysis of outbreaks by etiologic agent, water system, amd type of deficiency.

FIGURE 2. Number of waterborne-disease outbreaks* (n = 31) associated with drinking water, by state — United States, 2001–2002



* Numbers are dependent on reporting and surveillance activities in individual states and do not necessarily indicate that more outbreaks occur in a given state.

Etiologic Agents

Of the 31 outbreaks, 19 (61.3%) were of known infectious etiology, seven (22.6%) were of unknown etiology, and five (16.1%) were attributed to chemical poisoning. The outbreaks of known infectious etiology included six (19.4%) that were caused by *Legionella* species, five (16.1%) by viruses, five (16.1%) by parasites, and three (9.7%) by bacteria other than *Legionella* species (Figure 6).

Unidentified Etiologic Agents

Seven outbreaks affecting 117 persons were reported that involved acute gastrointestinal illness of unknown etiology (AGI); no hospitalizations or deaths resulted from these illnesses. Stool specimen testing to identify a causative agent was attempted in only one of these outbreaks. In another of these outbreaks, norovirus was suspected on the basis of symptoms and incubation period in an outbreak of gastrointestinal illness at a church camp in Pennsylvania. However, no confirmatory testing was done of patient samples or of the implicated water. No suspected etiologic agent was noted for any of the other outbreaks in this category.

Legionella Species

Six outbreaks were attributed to *Legionella* species. These are described on page 33 of this report.

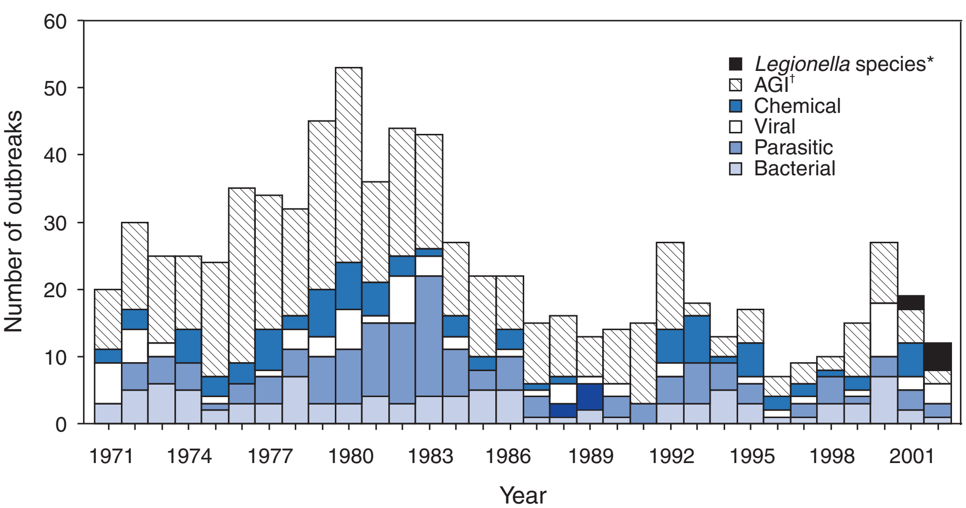
Viruses

Five outbreaks affecting 727 persons were attributed to viral infections, all attributed to norovirus. Of the six outbreaks affecting the most persons reported in this summary, five were caused by norovirus. Illnesses from these five outbreaks resulted in two hospitalizations and one death.

Parasites

Five outbreaks affecting 30 persons were attributed to parasitic infection: three *Giardia intestinalis* outbreaks, one *Cryptosporidium* outbreak, and one *Naegleria fowleri* outbreak. Illnesses from these outbreaks resulted in five hospitalizations and two deaths; both deaths were caused by *N. fowleri* infection.

FIGURE 3. Number of waterborne-disease outbreaks (n = 764) associated with drinking water, by year and etiologic agent — United States, 1971–2002



* Beginning in 2001, Legionnaires disease was added to the surveillance system, and *Legionella* species were classified separately.
† Acute gastrointestinal illness of unknown etiology.

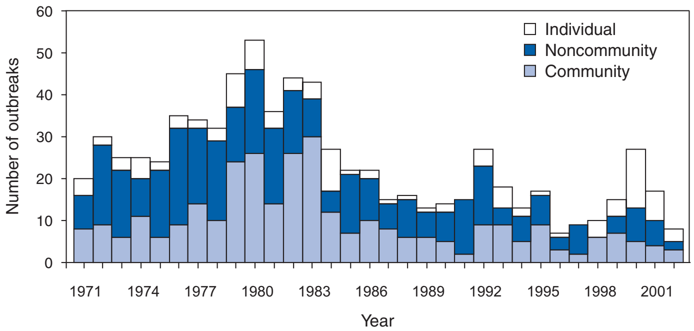
Chemicals

Five outbreaks affecting 39 persons were attributed to chemical contamination. Two were caused by high levels of copper and a third by high levels of copper and other metals. One outbreak was caused by ethylene glycol contamination of a school's water supply and one by ethyl benzene, toluene, and xylene contamination of bottled water. Illnesses from these five outbreaks resulted in no hospitalizations or deaths.

Bacteria (Other Than *Legionella* Species)

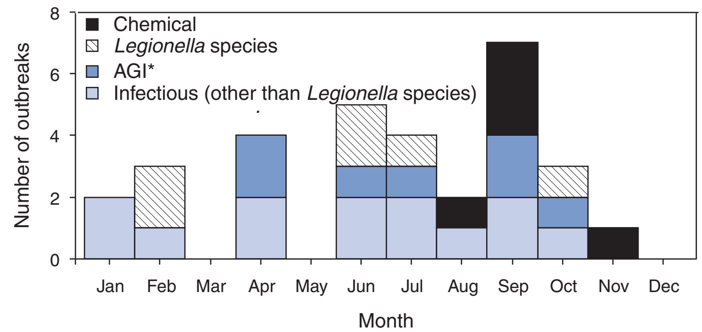
Three outbreaks affecting 27 persons were attributed to bacterial infection (other than *Legionella* species): one *Escherichia coli* O157: H7 outbreak, one

FIGURE 4. Number of waterborne-disease outbreaks (n = 758)* associated with drinking water, by year and type of water system — United States, 1971–2002



* Excludes outbreaks of Legionnaires disease.

FIGURE 5. Number of waterborne-disease outbreaks (n = 31) associated with drinking water, by etiologic agent and month — United States, 2001–2002



* Acute gastrointestinal illness of unknown etiology.

TABLE 3. Waterborne-disease outbreaks (n = 17) associated with drinking water — United States, 2001

State	Month	Class	Etiologic agent	Predominant illness	No. of cases (n = 508)	Type of system*	Deficiency†	Source	Setting
Alaska	Jun	I	*Campylobacter jejuni* and *Yersinia enterocolitica*§	Gastroenteritis	12	Ncom	2	Well	Bunkhouse
Colorado	Feb	III	*Giardia intestinalis*	Gastroenteritis	6	Com	3	River/stream	Community
Florida	Apr	III	AGI¶	Gastroenteritis	3	Ind	3	Well	Household
Florida	Apr	III	AGI	Gastroenteritis	4	Ind	3	Well	Household
Florida	Apr	III	*G. intestinalis*	Gastroenteritis	6	Ind	2	Well	Household
Florida	Jul	III	AGI	Gastroenteritis	4	Ind	3	Well	Household
Florida	Aug	III	Ethylene glycol	Gastroenteritis	3	Com	4	Well	School
Florida	Sep	III	Ethyl benzene, toluene, xylene	Gastroenteritis	2	Ind	5	Spring (bottled)	Bottled water
Illinois	Oct	II	AGI	Gastroenteritis	79	Ncom	5	Well	School
Indiana	Aug	IV	*Cryptosporidium* species	Gastroenteritis	10	Ind	3**	Well	Household
Minnesota	Sep	III	Copper and other minerals	Gastroenteritis	4	Ncom	4	Well	Church
Minnesota	Nov	III	Copper	Gastroenteritis	28	Com	4	Well	School
Ohio	Sep	III	Copper	Gastroenteritis	2	Com	4	River/stream	Steel plant
Pennsylvania	Jun	II	AGI	Gastroenteritis	19	Ncom	3	Well	Camp
Wisconsin	Jan	I	*C. jejuni*	Gastroenteritis	13	Ind	2	Well	Household
Wyoming	Jan	I	Norovirus	Gastroenteritis	230	Ncom	2	Well	Lodge
Wyoming	Sep	I	Norovirus	Gastroenteritis	83	Ncom	3	Well	Restaurant

* 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 of the year but not year-round (e.g., factories or schools), whereas transient systems provide water to places in which persons do not remain for long periods of time (e.g., restaurants, highway rest stations, or parks). Individual water systems are small systems not owned or operated by a water utility that 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 or storage container).

§ Six persons had stool specimens that tested positive for *C. jejuni*, and one person had stool specimens that tested positive for *Y. enterocolitica.*

¶ Acute gastrointestinal illness of unknown etiology.

** Intentional bypass of a reverse osmosis filter occurred. Historically, filter bypass has been classified as treatment deficiency rather than as untreated water.

Campylobacter jejuni outbreak, and an outbreak involving infection with two different bacteria (of 12 clinically ill persons, six tested positive for *C. jejuni* and one tested positive for *Yersinia enterocolitica*). Illnesses from these three outbreaks resulted in three hospitalizations and no deaths.

Water-Quality Data

Water-quality data (i.e., information regarding the presence of coliform bacteria, pathogens, or chemical contaminants or data regarding levels of disinfectants such as chlorine) were available for 29 (93.5%) of the 31 outbreaks. Among the 26

TABLE 4. Waterborne-disease outbreaks (n = 8) associated with drinking water — United States, 2002

State	Month	Class	Etiologic agent	Predominant illness	No. of cases (n = 432)	Type of system*	Deficiency†	Source	Setting
Arizona	Jul	I	Norovirus	Gastroenteritis	71	Com	5	Well	Golf Course
Arizona	Oct	I	*Naegleria fowleri*	Meningoencephalitis	2	Com	2	Well	Community
Connecticut	Jun	I	Norovirus	Gastroenteritis	142	Ncom	2	Well	Camp
Florida	Sep	III	AGI§	Gastroenteritis, rash	3	Ind	2	Well	Household
Florida	Sep	III	AGI	Gastroenteritis	5	Ind	2	Well	Household
Kentucky	Sep	III	*E. coli* O157:H7	Gastroenteritis	2	Ind	2	Well	Household
New Hampshire	Jul	III	Norovirus	Gastroenteritis	201	Ncom	2	Well	Camp
New York	Apr	III	*Giardia intestinalis*	Gastroenteritis	6	Com	4	Well/spring	Trailer park

* 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 of the year, but not year-round (e.g., factories or schools), whereas transient systems provide water to places in which persons do not remain for long periods of time (e.g., restaurants, highway rest stations, or parks). Individual water systems are small systems not owned or operated by a water utility that 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 or storage container).

§ Acute gastrointestinal illness of unknown etiology.

TABLE 5. Waterborne-disease outbreaks (n = 9 total; 6 attributed to drinking water) caused by *Legionella* species — United States, 2001–2002

State	Month/Year	Class	Etiologic agent	Predominant illness	Primary water use	No. of cases (n = 282)	Setting
Maryland	Oct 2002	III	*Legionella pneumophila, L. anisa*	Legionnaires disease	Drinking	2	Hospital
Massachusetts	Jun 2002	III	*Legionella* species	Legionnaires disease	Drinking	16	Nursing Home
Minnesota	Feb 2001	III	*Legionella* species	Legionnaires disease	Drinking	2	Hospital
Nevada	Feb 2001	I	*L. pneumophila*	Legionnaires disease	Drinking	20	Hotel
Pennsylvania	Jun 2002	I	*Legionella* species	Legionnaires disease	Drinking	12	Nursing home
Vermont	Jul 2002	III	*Legionella* species	Legionnaires disease	Drinking	28	Government building complex
Illinois*	Aug 2002	I	*Legionella* species	Pontiac fever	Recreational	68	Hotel
Ohio†	Mar 2001	I	*Legionella* species	Legionnaires disease	Occupational (Automotive plant)	17	Automotive plant
Tennessee§	Apr 2002	I	*L. anisa*	Pontiac fever	Decorative (Ornamental fountain)	117	Restaurant

* This outbreak is discussed in the *MMWR Surveillance Summary* that discusses recreational water-associated disease outbreaks (Yoder JS, Blackburn BG, Craun GF, et al. Surveillance for waterborne-disease outbreaks associated with recreational water—United States, 2001–2002. In: Surveillance Summaries, October 22, 2004. MMWR 2004;53(No. SS-8):1–21 and is not counted in statistics that summarize drinking water.

† This outbreak is discussed in the occupational outbreaks section of this summary and is not counted in statistics that summarize drinking water.

§ This outbreak is discussed in the appendix of this summary and is not counted in statistics that summarize drinking water.

outbreaks with a suspected or confirmed infectious etiology, 24 (92.3%) provided bacterial water-quality testing data; a positive total or fecal coliform result from the implicated water was reported for 14 (58.3%) of these 24, including 10 (58.8%) of the 17 outbreaks of confirmed infectious etiology, and four (57.1%) of the seven outbreaks of suspected infectious etiology (i.e., AGI). The etiologic organism that caused the outbreak was recovered from the implicated water in 10 (41.7%) of these 24 outbreaks; however, these were the only 10 outbreaks that were tested specifically for the causative microorganism. *Legionella* species were detected in the implicated water in all six outbreaks caused by this organism, and etiologic organisms were also recovered from an outbreak of *N. fowleri* in Arizona (October 2002), from an outbreak of *C. jejuni* in Wisconsin (January 2001), and from two outbreaks of norovirus in Wyoming (January 2001 and September 2001).

All five reports of outbreaks of chemical etiology provided water-quality data. In four of these outbreaks, the contaminant that caused the outbreak was recovered directly from the implicated water, including copper in two outbreaks (Minnesota, November 2001 and Ohio, September 2001), copper and seven other metals in one outbreak (Minnesota, September 2001) and ethyl benzene, toluene, and xylene in one

TABLE 6. Waterborne-disease outbreaks (n = 25) associated with drinking water, by etiologic agent and type of water system (excluding outbreaks caused by *Legionella* species) — United States, 2001–2002

	Type of water system*							
	Community		Noncommunity		Individual		Total	
Etiologic agent	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases
Unknown	**0**	**0**	**2**	**98**	**5**	**19**	**7**	**117**
AGI†	0	0	2	98	5	19	**7**	**117**
Viruses	**1**	**71**	**4**	**656**	**0**	**0**	**5**	**727**
Norovirus	1	71	4	656	0	0	**5**	**727**
Parasitic	**3**	**14**	**0**	**0**	**2**	**16**	**5**	**30**
Giardia intestinalis	2	12	0	0	1	6	**3**	**18**
Cryptosporidium species	0	0	0	0	1	10	**1**	**10**
Naegleria fowleri	1	2	0	0	0	0	**1**	**2**
Chemical	**3**	**33**	**1**	**4**	**1**	**2**	**5**	**39**
Copper	2	30	0	0	0	0	**2**	**30**
Copper and other minerals	0	0	1	4	0	0	**1**	**4**
Ethyl benzene, toluene, xylene	0	0	0	0	1	2	**1**	**2**
Ethylene glycol	1	3	0	0	0	0	**1**	**3**
Bacterial (other than *Legionella* species)	**0**	**0**	**1**	**12**	**2**	**15**	**3**	**27**
Campylobacter jejuni	0	0	0	0	1	13	**1**	**13**
C. jejuni and *Yersinia enterocolitica*	0	0	1	12	0	0	**1**	**12**
Escherichia coli O157:H7	0	0	0	0	1	2	**1**	**2**
Total	**7**	**118**	**8**	**770**	**10**	**52**	**25**	**940**
Percentage	**(28.0)**	**(12.6)**	**(32.0)**	**(81.9)**	**(40.0)**	**(5.5)**	**(100.0)**	**(100.0)**

* 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 of the year, but not year-round (e.g., factories or schools), whereas transient systems provide water to places in which persons do not remain for long periods of time (e.g., restaurants, highway rest stations, or parks). Individual water systems are small systems not owned or operated by a water utility that 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.

TABLE 7. Waterborne-disease outbreaks (n = 25) associated with drinking water, by type of deficiency and type of water system (excluding outbreaks caused by *Legionella* species) — United States, 2001–2002

	Type of water system*							
	Community		Noncommunity		Individual		Total	
Type of deficiency†	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1: Untreated surface water	0	0	0	0	0	0	**0**	**0**
2: Untreated groundwater	1	14.3	4	50.0	5	50.0	**10**	**40.0**
3: Treatment deficiency	1	14.3	2	25.0	4	40.0	**7**	**28.0**
4: Distribution system	4	57.1	1	12.5	0	0	**5**	**20.0**
5: Miscellaneous or unknown	1	14.3	1	12.5	1	10.0	**3**	**12.0**
Total	**7**	**100.0**	**8**	**100.0**	**10**	**100.0**	**25**	**100.0**

* 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 of the year, but not year-round (e.g., factories or schools), whereas transient systems provide water to places in which persons do not remain for long periods of time (e.g., restaurants, highway rest stations, or parks). Individual water systems are small systems not owned or operated by a water utility that 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 non-potable 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 deficiences include contaminated bottled water or storage container.

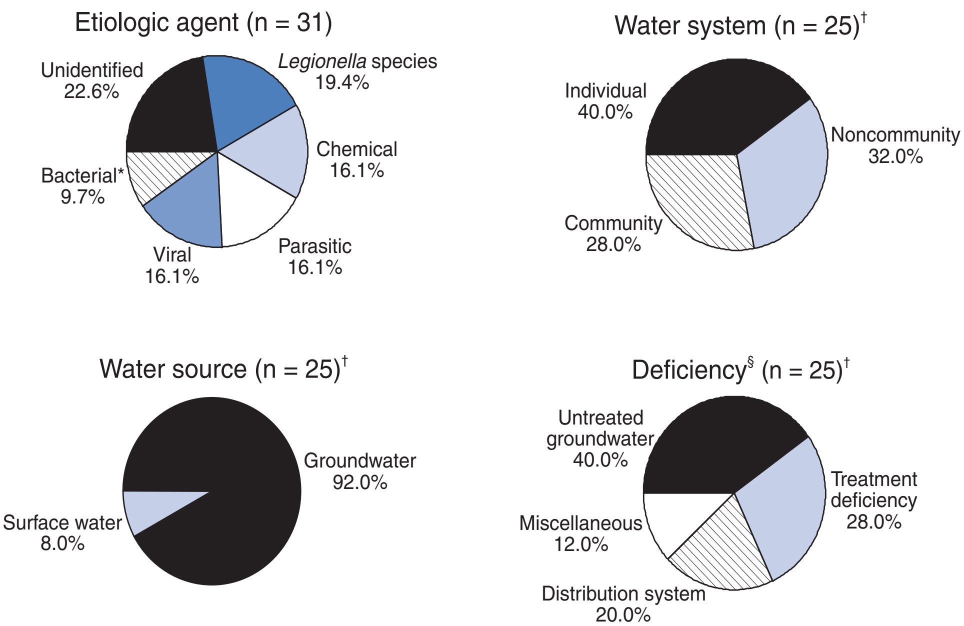
outbreak (Florida, September 2001). The contaminant was not recovered from the tested water in an outbreak (Florida, August 2001) that resulted from ethylene glycol contamination caused by a cross-connection during an improperly performed air-conditioning system repair. However, the sample was collected >24 hours after the contaminating event, and a high degree of clinical suspicion of the contaminating agent existed on the basis of the appearance and smell of the water and on the description of the mechanical error.

TABLE 8. Waterborne-disease outbreaks (n = 25) associated with drinking water, by type of deficiency and source (excluding outbreaks caused by *Legionella* species) — United States, 2001–2002

	Source					
	Groundwater		Surface water		Total	
Type of deficiency*	No.	(%)	No.	(%)	No.	(%)
1: Untreated surface water	0	0	0	0	**0**	**0**
2: Untreated groundwater	10	43.5	0	0	**10**	**40.0**
3: Treatment deficiency	6	26.1	1	50.0	**7**	**28.0**
4: Distribution system	4	17.4	1	50.0	**5**	**20.0**
5: Miscellaneous or unknown	3	13.0	0	0	**3**	**12.0**
Total	**23**	**100.0**	**2**	**100.0**	**25**	**100.0**

* 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 deficiences include contaminated bottled water or storage container.

FIGURE 6. Drinking water-associated outbreaks, by etiologic agent, water system, water source, and deficiency — United States, 2001–2002



* Other than *Legionella* species.
† Excludes outbreaks attributed to *Legionella* species.
§ No outbreaks were attributed to untreated surface water.

Water Systems and Water Sources

Because outbreaks caused by *Legionella* species are not included in statistics resulting from parameters that describe water systems and water sources, they are excluded from this section. The 25 remaining drinking water outbreaks serve as the focus of these parameters.

Seven (28.0%) of these 25 outbreaks were associated with community systems, eight (32.0%) with noncommunity systems, and ten (40.0%) with individual water systems (Tables 6 and 7) (Figure 6). Of the 25 outbreaks, 23 (92.0%) were associated with groundwater sources, including 21 involving wells: one outbreak involved water derived from both a well and spring, and one involved bottled spring water. Two (8.0%) of the 25 outbreaks were associated with surface water that derived from a river or stream.

Among the seven outbreaks associated with community water systems, one (14.3%) was caused by contaminated, untreated groundwater; one (14.3%) was related to a treatment deficiency; and four (57.1%) were related to problems in the water distribution system. One (14.3%) community outbreak of an unknown deficiency resulted in 71 cases of illness when participants at a golf tournament consumed contaminated water and ice. The number of illnesses in the other outbreaks varied (range: 2–28).

Among the eight outbreaks associated with noncommunity water systems, four (50.0%) were caused by contaminated, untreated groundwater; two (25.0%) were related to treatment deficiencies; one (12.5%) was related to a problem in the water distribution system; and one (12.5%) had an unknown deficiency.

Among the 10 outbreaks associated with individual water systems, five (50.0%) were caused by contaminated, untreated groundwater; four (40.0%) were related to treatment deficiencies; and one (10.0%) had an unknown deficiency. These outbreaks affected limited populations (range: 2–13 cases).

All three of the bacterial (other than *Legionella* species) outbreaks occurred in association with groundwater systems (all were untreated wells). Four (80.0%) of the five parasitic outbreaks occurred in association with groundwater systems: two were associated with untreated wells; one occurred after the homeowners intentionally bypassed a reverse osmosis system that had run out of treated water; and one was associated with a distribution deficiency in a treated well/spring combination source. All five viral outbreaks occurred in association with groundwater systems: three were associated with untreated wells; one was related to a treatment deficiency in a chlorinated well; and one had an unknown deficiency. Four (80.0%) of the five chemical outbreaks occurred in association with groundwater systems: three were related to distribution system deficiencies in well water, and one was related to an unknown deficiency in a bottled water product that had a spring as its source. All seven outbreaks of unknown etiology were linked to groundwater systems: four were associated with treatment deficiencies of chlorinated wells, and three were associated with unknown deficiencies in wells (one chlorinated and two untreated).

Among the 23 outbreaks related to groundwater systems, 10 (43.5%) were linked to consumption of untreated groundwater, six (26.1%) were associated with treatment deficiencies; four (17.4%) were linked to deficiencies in the distribution system; and three (13.0%) had unknown deficiencies (Table 8). Among the two outbreaks related to surface water systems, one (50.0%) was caused by a treatment deficiency and one (50.0%) by a distribution system deficiency.

Outbreaks Caused by *Legionella* species

Drinking Water *Legionella* Outbreaks

During 2001–2002, six *Legionella* outbreaks were related to water systems in which the primary water use at the outbreak site was for drinking (Table 5). These outbreaks caused illness in 80 persons and resulted in 41 hospitalizations and four deaths. The predominant clinical syndrome in all six outbreaks was Legionnaires disease, although in one outbreak involving a government building complex in Vermont (July 2002), six (21.4%) of the 28 ill persons had symptoms consistent with the case definition for Pontiac fever. All of these outbreaks occurred in large buildings or institutional settings and were related to multiplication of *Legionella* species in the respective distribution systems.

Other *Legionella* Outbreaks

One *Legionella* outbreak was related to a water system in which the primary water use at the outbreak site was recreational (Table 5); this outbreak is discussed elsewhere (*8*). One *Legionella* outbreak occurred in an occupational setting and is discussed in the following section. Another *Legionella* outbreak occurred in Tennessee in April 2002 (*32*) (Appendix) when patrons of a restaurant experienced Pontiac fever in association with sitting near a particular fountain in the restaurant. Cultures from the fountain were positive for *L. anisa*. No foods or other exposures were associated with illness, and the restaurant's air conditioning system was negative for *Legionella* species on laboratory testing. This outbreak caused illness in 117 persons and led to one hospitalization.

Outbreaks Associated with Occupational Exposure to Water

Two outbreaks associated with exposure to water in an occupational setting were reported during 2001–2002. In November 2002, a worker at a wastewater treatment plant in California fell into an equalization basin containing untreated wastewater and subsequently contracted giardiasis. A coworker subsequently experienced gastrointestinal symptoms, although his illness went undiagnosed. In March 2001, an outbreak of Legionnaires disease occurred at an automotive plant in Ohio (*33*) in which contact with the cleaning area of the plant (particularly one cleaning line) was associated with disease. As a result of this outbreak, 17 persons became ill, two of whom died.

Previously Unreported Outbreaks

Reports of three previously unreported drinking water outbreaks that occurred during 2000 were received during this reporting period (Table 9). An outbreak of cryptosporidiosis occurred in Florida in December 2000 when a groundwater system experienced a main break days before the first of a cluster of five cases of gastrointestinal illness. *Cryptosporidium* was subsequently identified in a stool specimen from one of these patients. Reports of outbreaks of norovirus (Kansas, June 2000) and cholera (Marshall Islands, December 2000) were also received during this reporting period (Appendix).

Outbreaks Not Classified as WBDOs

Epidemiologic evidence from four additional outbreaks that were reported as potentially associated with drinking water during 2001–2002 was insufficient to warrant counting these outbreaks as WBDOs. However, because of their potential links to drinking water, a brief description of these outbreaks follows.

In June 2002, an outbreak of diarrheal illness occurred among 38 climbers of Mt. Denali in Alaska; illness lasted a mean of 2 days (range: 1–5 days), and the attack rate of climbers was 27% during the 3-day study period. The hypothesized cause was use of fecally contaminated snow as a drinking water source, but this was not associated with illness in a cohort study that was performed during the outbreak.

TABLE 9. Waterborne-disease outbreaks (n = 3) associated with drinking water that were not included in previous surveillance summaries

State/territory	Month, year	Class	Etiologic agent	Predominant illness	No. of cases (n = 194)	Type of system*	Deficiency†	Source	Setting
Florida	December 2000	III	*Cryptosporidium* species	Gastroenteritis	5	Com	4	Well	Community
Kansas	June 2000	I	Norovirus	Gastroenteritis	86	Ncom	2	Well	Cabin
Republic of Marshall Islands	December 2000	II	*Vibrio cholerae*	Gastroenteritis	103	Ind	5	Unknown	Community

* 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 of the year, but not year-round (e.g., factories or schools), whereas transient systems provide water to places in which persons do not remain for long periods of time (e.g., restaurants, highway rest stations, or parks). Individual water systems are small systems not owned or operated by a water utility that 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 or storage container).

In June 2002, two persons in a Florida household supplied by an untreated well experienced recurring oral lesions and pharyngitis. A third person in the household who did not drink from this water source remained asymptomatic. Although the well water was positive for fecal coliforms, no other epidemiologic evidence linked the drinking water to illness.

In June 2002, ≥77 rafters on the Colorado River in Grand Canyon National Park in Arizona became ill with diarrhea and other gastrointestinal symptoms. Norovirus was isolated from stool specimens of seven (53.8%) of the 13 persons tested. Although norovirus was identified in samples of river water and water from a sewage treatment plant that emptied into the river, these were not the same strains identified in the stool samples. However, a weak association was identified between drinking river water and illness, and no other exposures (e.g., food contamination or asymptomatic carriers) were associated with illness.

In April 2000, an outbreak of cholera that sickened approximately 3,500 persons and caused 20 deaths began on Pohnpei Island in the Federated States of Micronesia. No information is available as to the cause of the outbreak or the risk factors for illness.

Discussion

Considerations Regarding Reported Results

The WBDO surveillance system provides information concerning epidemiologic and etiologic trends in outbreaks related to drinking water. However, not all outbreaks are recognized, investigated, or reported to CDC or EPA, and studies have not been performed that assess the sensitivity of this system. Furthermore, outbreaks occurring in national parks, tribal lands, or military bases might not be reported to state or local authorities. For these reasons, the true incidence of WBDOs is probably greater than is reflected in surveillance system data. Multiple factors influence whether WBDOs are recognized and investigated by local or state public health agencies, including public awareness of the outbreak, availability of laboratory testing, requirements for reporting diseases, and resources available to local health departments for surveillance and investigation of probable outbreaks. In addition, because changes in the capacity of local and state public health agencies and laboratories to detect an outbreak might result in reporting and surveillance bias, the states with the majority of outbreaks reported during this period might not be the states in which the majority of outbreaks actually occurred. An increase or a decrease in the number of outbreaks reported might reflect either an actual increase or decrease in outbreaks or a change in sensitivity of surveillance practices. As with any passive surveillance system, accuracy of the data depends greatly on the reporting agencies (i.e., state, local, and territorial health departments). Thus, independent of the recognition or investigation of a given outbreak, reporting bias can also influence the final data.

Outbreaks most likely to be recognized and investigated are those involving acute illness characterized by a short incubation period, serious illness or symptoms requiring medical treatment, or recognized etiologies for which laboratory methods have become more sensitive or widely available. Increased reporting often occurs as etiologies become better recognized, water system deficiencies are identified, and state surveillance activities and laboratory capabilities increase (*34–36*). Recommendations for improving WBDO investigations include increased laboratory support for clinical and water analyses, enhanced surveillance activities, and assessment of sources of potential bias (*37–39*).

The identification of the etiologic agent of a WBDO depends on the timely recognition of the outbreak so appropriate clinical and environmental samples can be collected. Additionally, the laboratory involved must have the capability to test for an organism to detect it. For example, routine testing of stool specimens at laboratories include tests for the presence of enteric bacterial pathogens and might also include an ova and parasite examination. However, *Cryptosporidium* species, among the most commonly reported waterborne pathogens, are often not included in standard ova and parasite examinations and thus should be specifically requested (*40*). Additionally, although norovirus testing is being performed more commonly, testing for other viral agents is rarely done. Finally, 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.

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 rather than endemic 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 have recently completed a series of epidemiologic studies designed to assess the magnitude of endemic waterborne illness associated with consumption of municipal drinking water. A joint report on the results of these studies is forthcoming.

Drinking Water Outbreaks Caused by *Legionella* species

Of the 31 drinking water-associated outbreaks that occurred during 2001–2002, six (19.4%) were caused by *Legionella* species, which was the single most commonly identified etiologic agent. Because this is the first time that LD outbreaks have been included in the *MMWR Surveillance Summary* of WBDOs, no comparative data are available from previous reporting periods. LD outbreaks tended to result in higher morbidity and mortality than the majority of other outbreaks reported (as evidenced by the hospitalization and case-fatality rates) and differed epidemiologically from other drinking water outbreaks. They fit patterns usually seen with *Legionella* (i.e., they all occurred in large buildings or institutional settings, were related to amplification of *Legionella* species in the respective distribution systems, and were most likely spread by aerosolization of water from these systems). Contamination of source water is less likely to lead to outbreaks involving this organism. These outbreaks underscore the importance of remaining vigilant about the possibility of *Legionella* species in any building complex and the need to take measures that address this threat (e.g., maintaining hot water temperatures of ≥124°F [return temperature]/>140°F [storage temperature] and cold water storage and distribution temperatures <68°F, testing for this organism when outbreaks of respiratory disease or febrile illness occur in these settings, and maintaining adequate disinfectant levels as appropriate) (*41,42*).

Drinking Water Outbreaks (Excluding Those Caused by *Legionella* species)

Because of the different epidemiology of *Legionella* outbreaks and because LD outbreaks have not been included in previous summaries, they will not be discussed in the following sections, which address the remaining 25 drinking water outbreaks that occurred during 2001–2002. These 25 outbreaks represent a 35.9% decrease from the 39 outbreaks reported during 1999–2000 (*2*), which was the highest total reported in 8 years (*2–7*). Seasonality of drinking water outbreaks remained consistent with previous years, with the highest number of outbreaks reported during June–September.

The number of reported outbreaks began to decrease sharply beginning with the 1985–1986 reporting period; this was attributable primarily to fewer community and noncommunity outbreaks. With institution and enforcement of better regulations that chiefly affect these types of water systems (particularly community systems), a marked drop in the number of outbreaks was seen. In contrast, the increase in outbreaks reported during 1999–2000 was attributable primarily to individual water systems, which affect fewer persons, are less regulated, and are more subject to changes in surveillance and reporting. The relative proportion of community, noncommunity, and individual outbreaks during 2001–2002 was more consistent with historic norms, as was the total number of outbreaks.

During 2001–2002, Florida reported the highest number of outbreaks (eight), as was the case during 1999–2000, when 15 outbreaks were reported. The only other state to report >2 drinking water-associated outbreaks during 2001–2002 was Minnesota, with three outbreaks. Reports of these outbreaks might reflect enhanced surveillance activities rather than a true increase in WBDO incidence; six outbreaks in Florida during 2001–2002 and 14 during 1999–2000 occurred in a single county and were investigated by the same epidemiologist. Among the five most populous states (California, Florida, Illinois, New York, and Texas), only Florida reported >1 drinking water-associated outbreak; California and Texas reported none, and Illinois and New York each reported one. Similarly, in the 2001–2002 summary of recreational water-associated outbreaks (*8*), Florida and Minnesota reported more recreational water-associated outbreaks than any other state (seven and nine, respectively). This suggests that reporting and surveillance bias might be influencing the number of reports, resulting in considerable year-to-year and state-to-state variation.

Surface Water

Two (8.0%) of the 25 drinking water-associated outbreaks during 2001–2002 were associated with systems served by surface water (Figure 6), compared with seven (18.4%) during 1999–2000. Among the two surface water-related outbreaks, one was an outbreak of copper poisoning (Ohio, 2001) related to a distribution system deficiency, and one was an outbreak of giardiasis in a rural Colorado town during 2001 caused by the failure of a bag filtration system. The latter outbreak is the first associated with inadequate treatment of surface water to occur in a community system since 1997, when an outbreak of giardiasis associated with disinfected but unfiltered surface water occurred in New York (*3*). The last community system-associated outbreak related to inadequate filtration of surface water occurred during 1995, when a large outbreak of giardiasis was reported in New York (*4*). In contrast, during 1991–1994, eight outbreaks (including a substantial outbreak in Milwaukee) were reported in community systems that used treated surface water (*5,6*). The decrease in outbreaks associated with inadequate treatment of surface water sources is likely attributable to increasingly stringent regulations for treatment of surface water. However, even with the additional EPA regulations, outbreaks might still occur. For example, in addition to the giardiasis outbreak reported in Colorado during 2001, another limited outbreak of giardiasis was reported in a Colorado resort during 1999–2000 (*2*); this outbreak was attributed in part to defective cartridge filters. The Colorado outbreaks underscore the need for cartridge, bag, and other package filters to meet design specifications and be properly installed if they are to be effective. All filtered systems, no matter what type of filter is employed, should be adequately operated, maintained, and monitored to ensure reliable performance.

During 2001–2002, no outbreaks were associated with the direct ingestion of untreated surface water, compared with three outbreaks during 1999–2000. This is encouraging, because keeping the public aware that surface water, despite its clarity, is prone to contamination by pathogens and should not be directly consumed without being treated at the point of use or boiled, remains a priority. Manufacturers of point-of-use devices and the National Sanitation Foundation provide information (available at http://www.nsf.org) regarding different devices, instructions for use, and their ability to make water safe for human consumption.

Groundwater

Of the 25 outbreaks related to drinking water, 23 (92.0%) were associated with groundwater sources, compared with 28 (73.7%) during 1999–2000 (*2*). Of the 25 reported outbreaks, 10 (40.0%) were linked to consumption of contaminated, untreated groundwater. During 1999–2000, a total of 17 (44.7%) of 38 outbreaks were associated with contaminated, untreated groundwater sources. Although outbreaks caused by the use of untreated groundwater decreased during 2001–2002, the largest proportion of groundwater outbreaks during this period remained attributable to untreated water systems, and untreated groundwater remains a primary cause of outbreaks, especially in private, individual water systems that are not regulated by EPA. During both the current and pervious reporting periods, half of the outbreaks attributed to untreated groundwater were reported in individual water systems.

Treated groundwater systems can also lead to outbreaks; six (24.0%) of the 25 outbreaks during 2001–2002 were associated with treatment deficiencies of groundwater systems (including one outbreak in which treatment was bypassed), compared with eight (21.1%) during 1999–2000. Four (66.7%) of the six outbreaks associated with treated groundwater during 2001–2002 were reported in individual rather than public systems, compared with one outbreak (14.3%) during 1999–2000. To safeguard the quality of their well water, homeowners should purchase appropriately designed point-of-use devices and follow instructions for operating and maintaining these treatment devices. Public health agencies can help by providing educational materials about effective water treatment devices for private, individual water systems. Although individual groundwater systems are not regulated by EPA, and public groundwater systems (other than systems influenced by surface water) are not required to filter or disinfect drinking water, efforts should continue to identify and remove possible sources of contamination and provide adequate, continuous treatment for those systems that need treatment. Wells and springs must be protected from contamination even if disinfection is provided, as groundwater can become contaminated with pathogens that might overwhelm the disinfection process. EPA's proposed GWR (information available at http://www.epa.gov/safewater/gwr.html) is expected to establish multiple barriers in groundwater systems to protect against pathogens in drinking water from groundwater sources and should establish a targeted strategy to identify groundwater systems at high risk for fecal contamination. The multiple barrier approach should begin with protection of the wellhead, an assessment of potential sources of contamination, and periodic sanitary surveys to ensure that wells remain protected. Periodic monitoring of source water is necessary to identify water-quality deterioration, and adequate, continuous water treatment is needed for wells that are identified as being vulnerable.

Of the 22 well-related outbreaks that occurred during 2001–2002, a total of 13 (59.1%) were associated with community or noncommunity wells, compared with nine (40.9%) that were associated with individual wells not covered by EPA regulations. This distribution, similar to previous reporting periods, is notable because only public water systems will be directly affected by GWR, and thus protections offered by GWR might not extend to individual groundwater systems. The quality of water in private wells and springs used by private persons and nonpublic systems thus remains a public health concern; approximately 17 million persons in the United States rely on private household wells for drinking water each year, and >90,000 new wells are drilled annually throughout the United States (*43*). In addition, contamination of a private well is not only a health concern for the household served by the well but can have an impact on households using other nearby wells that draw from the same aquifer. EPA does not regulate private wells and will not do so as part of the proposed GWR. EPA recommendations for protecting private water supplies are available at http://www.epa.gov/safewater/pwells1.html. Additional efforts should be taken to educate 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.

Deficiencies

During 2001–2002, the number of outbreaks associated with each different type of deficiency (untreated surface water, untreated groundwater, treatment deficiency, distribution system deficiency, and unknown/miscellaneous deficiency) decreased from levels reported during 1999–2000. In addition, each deficiency type represented a similar proportion of the total number of drinking water outbreaks reported during 1999–2000.

Water Systems

During 2001–2002, the number of outbreaks associated with each of the three different types of water systems also decreased compared with 1999–2000 (Figure 6), whereas the proportion associated with each type remained relatively consistent. The number of outbreaks associated with individual systems decreased from 17 during 1999–2000 to 10 during 2001–2002, but still remained the most common of the three. Of the eight outbreaks reported from Florida (the state with the most reported outbreaks, possibly reflecting enhanced surveillance in that state), seven involved individual groundwater systems (the eighth involved a community well system), which might have biased the results toward more individual (as well as more groundwater) outbreaks; this again potentially demonstrates that outbreaks involving individual water systems are the most susceptible to detection bias, given the limited number of persons involved, the different levels of resources available to investigate these outbreaks, and the limited number of regulations that govern these systems. The number and proportion of outbreaks attributed to individual systems during 1999–2000 was at a 15-year high and accounted for much of the overall increase in the number of outbreaks reported during 1999–2000. The decline in outbreaks attributed to individual systems makes the number and proportion of outbreaks associated with each type of water system more comparable with reporting periods during the 1990s.

Etiologic Agent

The etiologic agent was not identified in seven (22.6%) of the 31 outbreaks reported during 2001–2002 (Figure 6). Although these seven outbreaks comprised the largest group of outbreaks, this was a marked decrease from the number (17) and percentage (43.6%) of outbreaks of unknown etiology during 1999–2000. This likely reflects both the improved diagnostic capability of laboratories and better outbreak investigations, resulting in more rapid and more appropriate specimen collection. Viral outbreaks (five) comprised 16.1% of the total, an increase from the previous reporting period. This likely reflects rapidly improving diagnostic capability for detecting norovirus in stool samples, a hypothesis supported by the fact that all five viral outbreaks were caused by this agent. The five norovirus outbreaks affected by far the most persons (727) of any single etiologic agent and caused more illness than all other agents combined. Parasitic outbreaks (five) also comprised 16.1% of the total, similar to previous years. Among the parasitic outbreaks, two linked cases of *N. fowleri* infection occurred in Arizona during October 2002, resulting in two deaths; this was the first report of an outbreak of *N. fowleri* in the United States related to a drinking water system (Appendix). This outbreak further underscores the need for treatment of groundwater, particularly in geothermal areas in which these thermophilic amebae are likely to be amplified. Chemical outbreaks (five) also comprised 16.1% of the total, an increase from the previous reporting period; these outbreaks highlight the importance of proper maintenance of water systems, because four of the five resulted directly from errors related to either recent maintenance work or to an improperly installed device. Bacterial outbreaks (three) comprised 9.7% of the total, a decrease compared with the previous reporting period and the lowest number reported since 1991–1992.

Conclusion

Data collected as part of the national WBDO surveillance system are used to describe the epidemiology of waterborne diseases in the United States. Trends 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 authorities should be able to detect and recognize drinking water-associated outbreaks 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 might 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).

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 information or testing for *Legionella* should be made to CDC's Respiratory Diseases Branch, Division of Bacterial and Mycotic Diseases, at 404-639-2215. Requests for tests for parasites should be made to CDC's Division of Parasitic Diseases, NCID, at 770-488-7756.

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 DPD drinking water website at http://www.cdc.gov/ncidod/dpd/healthywater/index.htm;
- CDC's Cryptosporidiosis Information Line of the Parasitic Disease Information Line at 888-232-3228 (voice system) or 888-232-3299 (fax system); and
- for reporting WBDOs, CDC's Division of Parasitic Diseases, NCID, at 770-488-7756 or by fax at 770-488-7761; an electronic version of CDC's reporting form (CDC 52.12, rev. 01/2003) is available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf.

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References

1. Craun GF, ed. Waterborne diseases in the United States. Boca Raton, FL: CRC Press, Inc., 1986.
2. Lee SH, Levy DA, Craun GF, Beach MJ, Calderon RL. Surveillance for waterborne disease outbreaks—United States, 1999–2000. In: CDC Surveillance Summaries, November 22, 2002. MMWR 2002;51 (No. SS-8):1–47.
3. Barwick RS, Levy DA, Craun GF, Beach MJ, Calderon RL. Surveillance for waterborne disease outbreaks—United States, 1997–1998. In: CDC Surveillance Summaries, May 26, 2000. MMWR 2000;49(No. SS-4):1–34.
4. Levy DA, Bens MS, Craun GF, Calderon RL, Herwaldt BL. Surveillance for waterborne-disease outbreaks—United States, 1995–1996. In: CDC Surveillance Summaries, December 11, 1998. MMWR 1998;47(No. SS-5):1–34.
5. Kramer MH, Herwaldt BL, Craun GF, Calderon RL, Juranek DD. Surveillance for waterborne-disease outbreaks—United States, 1993–1994. In: CDC Surveillance Summaries, April 12, 1996. MMWR 1996;45(No. SS-1):1–33.
6. Moore AC, Herwaldt BL, Craun GF, Calderon RL, Highsmith AK, Juranek DD. Surveillance for waterborne disease outbreaks—United States, 1991–1992. In: CDC Surveillance Summaries, November 19, 1993. MMWR 1993:42(No. SS-5):1–22.
7. Herwaldt BL, Craun GF, Stokes SL, Juranek DD. Waterborne-disease outbreaks, 1989–1990. In: CDC Surveillance Summaries, December 1991. MMWR 1991;40(No. SS-3):1–21.
8. Yoder JS, Blackburn BG, Craun GF, et al. Surveillance for recreational water-associated outbreaks—United States, 2001–2002. In: Surveillance Summaries, October 22, 2004. MMWR 2004;53(No. SS-8):1–21.
9. Environmental Protection Agency. 40 CFR Part 141. Water programs: national interim primary drinking water regulations. Federal Register 1975;40:59566–74.
10. Pontius FW, Roberson JA. Current regulatory agenda: an update. Journal of the American Water Works Association 1994;86:54–63.

11. Pontius FW. Implementing the 1996 SDWA amendments. JAWWA 1997;89:18–36.
12. Environmental Protection Agency, 40 CFR Parts 9, 141, and 142. National primary drinking water regulations; arsenic and clarifications to compliance and new source contaminants monitoring. Federal Register 2001;66:1–92.
13. Environmental Protection Agency, 40 CFR Parts 9, 141, and 142. National primary drinking water regulations for lead and copper; final rule. Federal Register 2000;65:1949–2015.
14. Environmental Protection Agency. 40 CFR Parts 141 and 142. Drinking water; national primary drinking water regulations; total coliforms (including fecal coliforms and *E. coli*); final rule. Federal Register 1989;54:27544–68.
15. Environmental Protection Agency. 40 CFR Parts 141 and 142. Drinking water; national primary drinking water regulations; total coliforms; corrections and technical amendments; final rule. Federal Register 1990;55:25064–5.
16. Environmental Protection Agency. 40 CFR Parts 141 and 142. Drinking water; national primary drinking water regulations; filtration, disinfection; turbidity, *Giardia lamblia*, viruses, *Legionella*, and heterotrophic bacteria; final rule. Federal Register 1989;54:27486–541.
17. Environmental Protection Agency. 40 CFR Parts 9, 141, and 142. National primary drinking water regulations: interim enhanced surface water treatment; final rule. Federal Register 1998;63:69478–521.
18. Environmental Protection Agency. 40 CFR Parts 9, 141, and 142. National primary drinking water regulations: long term 1 enhanced surface water treatment rule; final rule. Federal Register 2002;67:1812–44.
19. Environmental Protection Agency. 40 CFR Parts 9, 141, and 142. National primary drinking water regulations: long term 1 enhanced surface water treatment and filter backwash rule; proposed rule. Federal Register 2000;67:19046–150.
20. Environmental Protection Agency. 40 CFR Parts 9, 141, and 142, National primary drinking water regulations: filter backwash recycling rule; final rule. Federal Register 2001;66:31086–105.
21. Environmental Protection Agency. 40 CFR Part 141. National primary drinking water regulations: monitoring requirements for public drinking water supplies; final rule. Federal Register 1996;61:24353–88.
22. Environmental Protection Agency. 40 CFR Parts 141 and 142. National primary drinking water regulations: long term 2 enhanced surface water treatment rule; proposed rule. Federal Register 2003;68:47640–795.
23. Environmental Protection Agency. 40 CFR Parts 141 and 142. National primary drinking water regulations: long term 2 enhanced surface water treatment rule; extension of comment period. Federal Register 2003;68:47640–795.
24. Environmental Protection Agency. 40 CFR Parts 141, 142 and 143. National primary drinking water regulations: stage 2 disinfectants and disinfection byproducts rule; national primary and secondary drinking water regulations: Approval of analytical methods for chemical contaminants. Federal Register 2003;68:49548–681.
25. Environmental Protection Agency. 40 CFR Parts 141 and 142. National primary drinking water regulations: ground water rule; proposed rules. Federal Register 2000;65:30194–274.
26. Environmental Protection Agency. 40 CFR Parts 9, 144, 145, and 146. Underground injection control regulations for class V injection wells, revision; final rule. Federal Register 1999;64:68546–73.
27. Environmental Protection Agency. Announcement of the drinking water contaminant candidate list; notice. Federal Register 1998;63:10274–87.
28. Environmental Protection Agency. 40 CFR Part 141. Unregulated contaminant monitoring regulation for public water systems; analytical method for list 2 contaminants; clarifications to the unregulated contaminant monitoring regulation. Federal Register 2001;66:2273–308.
29. Environmental Protection Agency. 40 CFR Part 141. Unregulated contaminant monitoring regulation for public water systems; amendment to the list 2 rule and partial delay of reporting of monitoring results. Federal Register 2001;66:46221–4.
30. Environmental Protection Agency. 40 CFR Part 141. Unregulated contaminant monitoring regulation for public water systems; establishment of reporting date. Federal Register 2002;67:11043–6.
31. Environmental Protection Agency, Office of Water. Factoids: drinking water and ground water statistics for 2003. Washington, DC: Environmental Protection Agency, Office of Water, 2003. EPA publication no. 816K03001. Available at http://www.epa.gov/safewater/data/pdfs/factoids_2003.pdf.
32. Jones TF, Benson RF, Brown EW, Rowland JR, Crosier SC, Schaffner W. Epidemiologic investigation of a restaurant-associated outbreak of Pontiac fever. Clin Infect Dis 2003;37:1292–7.
33. Fry AM, Rutman M, Allan T, et al. Legionnaires' disease outbreak in an automobile manufacturing plant. J Infect Dis 2003;187:1015–8.
34. Frost FJ, Calderon RL, Craun GF. Waterborne disease surveillance: findings of a survey of state and territorial epidemiology programs. J Environ Health 1995;58:6–11.
35. Frost FJ, Craun GF, and Calderon RL. Waterborne disease surveillance. Journal of the American Water Works Association 1996;88:66–75.
36. Hopkins RS, Shillam P, Gaspard B, Eisnack L, Karlin RJ. Waterborne disease in Colorado: three years' surveillance and 18 outbreaks. Am J Public Health 1985;75:254–7.
37. Craun GF, Frost FJ, Calderon RL, et al. Improving waterborne disease outbreak investigations. Int J Environ Health Res 2001;11:229–43.
38. Frost FJ, Calderon RL, Craun GF. Improving waterborne disease surveillance. In: Pontius FW, ed. Drinking water regulation and health. 2003. New York, NY: John Wiley & Sons, 25–44.
39. Hunter PR, Waite M, Ronchi E, eds. Drinking water and infectious disease—establishing the links. Boca Raton, FL: CRC Press, 2003:221.
40. Jones JL, Lopez A, Wahlquist SP, Nadle J, Wilson M. Survey of clinical laboratory practices for parasitic diseases. Clin Infect Dis 2004;38:S198–S202.
41. CDC. Guidelines for preventing health-care–associated pneumonia, 2003. MMWR 2004;53(RR No.-03):1–36.
42. American Society of Heating, Refrigeration and Air-Conditioning Engineers. ASHRAE standard: minimizing the risk of legionellosis associated with building water systems. Atlanta, GA: ASHRAE Guideline 12-2000.
43. US General Accounting Office. Drinking water: information on the quality of water found at community water systems and private wells. Washington, DC: US General Accounting Office, 1997. GAO publication no. GAO/RCED-97-123.

Appendix

Selected Case Descriptions of Outbreaks Associated with Drinking Water

Outbreak date	State in which outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
Parasites				
October 2002	Arizona	*Naegleria fowleri*	2	Two previously healthy children from the same neighborhood died of meningoencephalitis within 1 day of each other; *N. fowleri* was identified at autopsy in brain tissue of both children. Neither child had any contact with recreational water during the incubation period except at their own or family members' private homes (untreated water in a bathtub and a swimming pool), and the two families did not associate with each other. Drinking water for the respective families came from the same untreated community well water system, and testing revealed *N. fowleri* in both a storage tank connected to one of the wells, and from the refrigerator filter of the house in which one of the children was exposed. The water was also positive for total coliforms. *N. fowleri* contaminating the aquifer, well, or distribution system might have been delivered to each home during the exposure period. This is the first association of a drinking water system with *N. fowleri* infection in the United States.
August 2001	Indiana	*Cryptosporidium* species	10	A reverse osmosis filtration system that was normally used to treat well water was intentionally bypassed when attendees of a party ran low on purified water. Attendees of the party who drank the untreated water subsequently experienced illness. The well was in a high-density septic tank area.
April 2002	New York	*Giardia intestinalis*	6	Water became contaminated at a trailer park, causing residents to become ill. Contamination was attributed to a power outage, which created a negative pressure condition in the distribution system. This allowed contaminated water to enter the system through either a cross connection inside a mobile home or a leaking underground pipe that was near sewer crossings.
Bacteria				
June 2001	Alaska	*Campylobacter jejuni* and *Yersinia enterocolitica*	12	Cannery workers who lived at a bunkhouse became ill when a well that supplied the bunkhouse became contaminated with surface water. This drinking water had become yellow tinged and malodorous just before the outbreak, and illness was associated with living in the bunkhouse and drinking water there. Well water tested positive for fecal coliforms; no chemical disinfectant had been used, and a filter of unknown efficacy against common pathogens had been used. Stool samples from six persons tested positive for *C. jejuni,* and those from one person tested positive for *Y. enterocolitica.*
December 2000	Republic of Marshall Islands*	*Vibrio cholerae*	103	Local residents of a small island became ill because of problems with the handling, transport, and storage of water from one of their primary drinking water sources (i.e., chlorinated water from a U.S. military base on a neighboring island). Residents collected and transported this water themselves to their island; illness was associated with drinking this water, whereas consuming bottled water or drinking water that was boiled or treated with flavored citric acid drink mixes (pH 3.4–3.9) was protective. Also protective was the use of vessels that could be tightly sealed and from which water could be poured without opening the vessel. No foods were associated with illness. Three of thirty stool specimens tested among persons with diarrhea were positive for *V. cholerae*, and 69% of case-patients tested positive for antibodies to this pathogen. Six persons died. Water from the base was not tested for *V. cholerae* but was determined to have adequate chlorine levels. Contamination likely occurred because of the use of loosely sealed vessels during storage, unsafe handling, and transport of the water

Outbreak date	State in which outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
				from one island to the other. (**Source:** Beatty ME, Jack T, Sivapalasingam S, et al. An outbreak of *Vibrio cholerae* O1 infections on Ebeye Island, Republic of the Marshall Islands, associated with use of an adequately chlorinated water source. Clin Infect Dis 2004;38:1–9.)
January 2001	Wisconsin	*C. jejuni*	13	Members of a book group attended lunch at a private home as part of a tour. Thirteen persons subsequently experienced gastrointestinal symptoms; all of six stools tested for bacteria were positive for *C. jejuni*. Exposure to well water was associated with illness, and on laboratory testing the water was positive for *C. jejuni*. Surface water contamination of a shallow, untreated well was thought to be the likely cause of the outbreak; the well was located next to a chicken coop.
June 2002	Massachusetts	*Legionella* species	16	Residents and an employee of a nursing facility contracted Legionnaires disease over a 2-week period. Laboratory testing for *Legionella* was positive in samples from the water distribution system. A watermain break was reported near the facility 1 month before the outbreak and might have allowed introduction of *Legionella* into the system.
February 2001	Minnesota	*Legionella* species	2	One hospital employee and a patient became ill with Legionnaires disease; in the previous two years, three other infections had occurred. An environmental investigation found *L. pneumophila* in potable water from showers and sinks in a hospital room and recovery room. Possible multiplication of *L. pneumophila* occurred in dead ends of the plumbing system.
February 2001	Nevada	*L. pneumophila*	20	Cases of Legionnaires disease occurred among hotel guests during an 8-month period; one person died. Illness was associated with residing in a particular tower of the hotel. Showering for longer times during the day was also associated with illness. An *L. pneumophila* isolate identical to the clinical isolates was found in potable water throughout the implicated hotel tower, and *L. pneumophila* isolates that differed from the clinical isolates were identified in all cooling towers at the hotel.
March 2001	Ohio†	*Legionella* species	17	Workers at an automotive engine manufacturing plant experienced Legionnaires disease during a 1-month period; two persons died. Contact with the cleaning area of the plant was a risk factor for disease, and one cleaning line in particular was associated with the highest risk. *Legionella* species were recovered from multiple environmental samples, although the subtype present in the patients was not recovered from the environmental samples. (**Source:** Fry AM, Rutman M, Allan T, et al. Legionnaires' disease outbreak in an automobile manufacturing plant. J Infect Dis 2003;187:1015–8.)
June 2002	Pennsylvania	*Legionella* species	12	Residents and an employee of a nursing facility contracted Legionnaires disease during a 1-month period; two persons died. Residence in a particular wing of the facility was associated with illness, as was frequent bathing or bathing during 2 particular days. Testing of potable water samples revealed no chlorine residual, and *Legionella* species were cultured from multiple water distribution sites, including a hot water holding tank, showers, sinks, and bathtubs; *Legionella* was not recovered from the cooling tower associated with the facility. Before the outbreak, water was shut off to part of the facility, causing a temporary decrease in water pressure.

Outbreak date	State in which outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
April 2002	Tennessee[§]	*L. anisa*	117	Patrons of a restaurant experienced Pontiac fever during a 1-week period. Illness was associated with sitting near a particular fountain, and cultures from that fountain were positive for *L. anisa.* Water in the fountains is recirculated for filtration and disinfection with bromine; environmental investigation identified areas in fountain pools where water may not have been recirculated. No foods or other exposures were associated with illness. The restaurant's air-conditioning system was negative for *Legionella* species on laboratory testing. One person was hospitalized, and no deaths occurred. (**Source:** Jones TF, Benson RF, Brown EW, Rowland JR, Crosier SC, Schaffner W. Epidemiologic investigation of a restaurant-associated outbreak of Pontiac fever. Clin Infect Dis 2003;37:1292–7.)
Viruses				
July 2002	Arizona	Norovirus	71	The outbreak occurred among users and employees of a golf course. Exposure to golf course drinking water was significantly associated with illness. Ice and water dispensers and ice-making facilities were not safely maintained and not properly cleaned and sanitized. One death occurred because of aspiration of vomitus. Norovirus was detected by polymerase chain reaction (PCR) in stool specimens from three of nine persons.
June 2002	Connecticut	Norovirus	142	Attendees of a camp became ill when a large well system likely became contaminated after heavy rains; well water samples were positive for total coliforms and *Escherichia coli.* The outbreak ended within 2 days of chlorinating the water supply and provision of alternate water, although some person-to-person spread was noted.
June 2000	Kansas*	Norovirus	86	Untreated well water caused a large outbreak of gastrointestinal illness among attendees of two separate social events during a 2-day period at a rented reception hall. Consumption of water or iced tea (made with ice from same faucet) were the only risk factors associated with illness. Well water was positive for fecal coliforms, indicating that it was subject to contamination. Stool samples from seven of the 17 ill attendees tested were positive for norovirus.
January 2001	Wyoming	Norovirus	230	Visitors to a snowmobile lodge experienced gastrointestinal illness during a 2-month period, resulting in one hospitalization. Closure of the lodge stopped the outbreak. Illness was associated only with consumption of water in the lodge, and stool samples from eight (61.5%) of 13 ill persons tested positive for norovirus by PCR. The lodge was served by three wells, which were all located in proximity to a septic tank or outhouse. Water samples also tested positive for norovirus by PCR and contained fecal coliforms. The wells were drilled in fractured granite, and sandy, porous soil existed above this. The cause of the outbreak was attributed to increased sewage load (which the septic tanks were unable to accommodate) combined with the geologic conditions in which the wells resided, which allowed rapid water percolation and thus decreased filtering. This outbreak and the following one also highlight the usefulness of PCR in detecting limited numbers of norovirus in water samples, because substantial volumes can be concentrated and tested in this manner. (**Source:** Anderson AD, Haryford AG, Sarisky JP, et al. A waterborne outbreak of Norwalk-like virus among snowmobilers—Wyoming, 2001. J Infect Dis 2003;187:303–6.)

Outbreak date	State in which outbreak occurred	Suspected or confirmed etiologic agent	Number of persons affected	Case description
September 2001	Wyoming	Norovirus	83	Patrons of a bar experienced gastrointestinal illness, which was significantly associated only with consumption of water or ice from the bar. Stool samples from three ill persons tested positive for norovirus by PCR. The bar was served by a well, and water samples also tested positive for norovirus and contained fecal coliforms. The wells were drilled in fractured basalt and had perforations in the screens that covered the well casing. The cause of the outbreak was attributed to the close location of the well to a septic tank and septic tank leach field combined with the underlying geologic conditions. In addition, a pellet chlorinator installed on the wellhead failed because of pellet dust blockage of the drop hole. (**Source:** Parshionikar SU, Willian-True S, Fout GS, et al. Waterborne outbreak of gastroenteritis associated with a norovirus. Appl Environ Microbiol 2003;69:5263–8.)
Chemicals				
August 2001	Florida	Ethylene glycol	3	The water supply at a middle school became contaminated by ethylene glycol when a maintenance worker created a cross-connection between the air conditioning unit and the potable water supply. The worker used the potable water system to dilute the ethylene glycol solution in the chiller unit. The higher water pressure in the chiller unit forced the diluted ethylene glycol into the school's water supply. Shortly thereafter, pink-colored water was noted in school bathrooms. Three students became ill with gastrointestinal symptoms as a result.
September 2001	Florida	Ethyl benzene, toluene, xylene	2	Bottled water purchased at a retail store caused gastrointestinal illness in two persons who consumed it. The water smelled like gasoline, and testing of sealed bottles revealed low levels of ethyl benzene, toluene, and xylene.
September 2001	Minnesota	Copper and other minerals	4	Children who consumed a soft drink consisting of well water and powdered drink mix at a church experienced gastrointestinal symptoms minutes later. Testing of the water revealed extremely high levels of copper and high levels of lead and zinc. Aluminum, antimony, arsenic, cadmium, and thallium were also detected. Investigation revealed that the well pump and pressure tank had been replaced 9 days before the outbreak. A high level of calcium hypochlorite (chlorine) was added to disinfect the system after this work. The system was then flushed, but the flushing did not include the line to the faucet that was used to make the drink. The high chlorine levels probably resulted in the leaching of metals from the interior of the water pipes and plumbing.
November 2001	Minnesota	Copper	28	Children experienced gastrointestinal symptoms within minutes of drinking water at their elementary school. Water samples were identified as having extremely high levels of copper, and patients reported the water appeared blue. An improperly installed anti-scaling device was thought to be responsible.
September 2001	Ohio	Copper	2	Workers at a steel plant experienced gastrointestinal symptoms within minutes of consuming water from a drinking fountain at the plant. The water contained blue-green sediment, and had high levels of copper upon laboratory testing. A copper pipe had been bumped, causing a kink, and this was replaced 1 day before the outbreak. Copper-containing sediment dislodged from this pipe was believed to be the cause of the outbreak.
Unidentified etiologic aggents				
June 2001	Pennsylvania	AGI[¶]	19	Illness was significantly associated with drinking water from one of four wells at a church camp. Water from this well was found to have no chlorine residual when tested in response to the outbreak.

[*] Occurred during 1999–2000 reporting period (previously unreported).
[†] Occupational exposure.
[§] Ornamental fountain exposure.
[¶] Acute gastrointestinal illness of unknown etiology.

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.
aquifer	An underground bed or layer of earth, gravel, or porous stone that yields water.
boil-water advisory	A statement to the public advising that tap water must be boiled before drinking it.
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 2).
coliforms	All aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas formation $\leq$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 $\geq$15 service connections or an average of $\geq$25 residents for $\geq$60 days/year.
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).
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.
equalization basin	A holding basin in which variations in flow and composition of a liquid stream are averaged, allowing storage and controlled release of wastewater to treatment processes.
fecal coliforms	Coliforms that grow and produce gas at 112.1°F (44.5°C) in $\leq$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.
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 influence of surface water	Any water beneath the surface of the ground with substantial occurrence of insects or direct other macrooganisms, algae, or large-diameter pathogens (e.g., *Giardia intestinalis* or *Cryptosporidium*) or substantial and relatively rapid shifts in water characteristics (e.g., turbidity, temperature, conductivity, or pH) that closely correlate with climatologic or surface water conditions. Direct influence must be determined for individual sources in accordance with criteria established by the state.
hydrogeology	The branch of geology that deals with the occurrence, distribution, and effect of ground water.

Individual (or private) water system	A water system that is not owned or operated by a water utility and that serves <15 residences or farms not having access to a public water system.
interactive fountain	A fountain intended for (or accessible to) recreational use, often located at waterparks. In contrast, noninteractive (ornamental) fountains are intended for public display rather than recreational use and are often located in front of buildings and monuments.
maximum contaminant level	The maximum permissible concentration (i.e., level) of a contaminant in water supplied to any user of a public water system.
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 but not year-round; 2) has ≥15 service connections or serves an average of ≥25 persons; and 3) is not a community water system.
nontransient noncommunity water system	Public water system that serves ≥25 of the same persons for ≥6 months/year (e.g., a factory or school) but not year-round.
norovirus	A group of related, single-stranded RNA, nonenveloped viruses (genus Norovirus, family *Caliciviridae*) that cause acute gastroenteritis in humans. Norovirus was recently approved as the official genus name for the group of viruses provisionally described as Norwalk-like viruses.
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.
transient noncommunity water system	Public water system that provides water to places where persons do not remain for long periods of time (e.g., restaurants, highway rest stations, or 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.
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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