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Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water — United States, 2003–2004

and

Surveillance for Waterborne Disease and Outbreaks Associated with Drinking Water and Water not Intended for Drinking — United States, 2003–2004




DEPARTMENT OF HEALTH AND HUMAN SERVICES
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On the cover: *Left to right*: Two children, wearing goggles, in a swimming pool. A man drinking water from a glass. Young girl on boogie board in water. Drinking fountain with water running.

Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water — United States, 2003–2004

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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 collaboratively maintained the Waterborne Disease and Outbreak Surveillance System for collecting and reporting waterborne disease and outbreak (WBDO)-related data. In 1978, WBDOs associated with recreational water (natural and treated water) were added. This system is the primary source of data regarding the scope and effects of WBDOs in the United States.

Reporting Period: Data presented summarize WBDOs associated with recreational water that occurred during January 2003–December 2004 and one previously unreported outbreak from 2002.

Description of the System: Public health departments in the states, territories, localities, and the Freely Associated States (i.e., 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) have primary responsibility for detecting, investigating, and voluntarily reporting WBDOs to CDC. Although the surveillance system includes data for WBDOs associated with drinking water, recreational water, and water not intended for drinking, only cases and outbreaks associated with recreational water are summarized in this report.

Results: During 2003–2004, a total 62 WBDOs associated with recreational water were reported by 26 states and Guam. Illness occurred in 2,698 persons, resulting in 58 hospitalizations and one death. The median outbreak size was 14 persons (range: 1–617 persons). Of the 62 WBDOs, 30 (48.4%) were outbreaks of gastroenteritis that resulted from infectious agents, chemicals, or toxins; 13 (21.0%) were outbreaks of dermatitis; and seven (11.3%) were outbreaks of acute respiratory illness (ARI). The remaining 12 WBDOs resulted in primary amebic meningoencephalitis (n = one), meningitis (n = one), leptospirosis (n = one), otitis externa (n = one), and mixed illnesses (n = eight). WBDOs associated with gastroenteritis resulted in 1,945 (72.1%) of 2,698 illnesses. Forty-three (69.4%) WBDOs occurred at treated water venues, resulting in 2,446 (90.7%) cases of illness. The etiologic agent was confirmed in 44 (71.0%) of the 62 WBDOs, suspected in 15 (24.2%), and unidentified in three (4.8%). Twenty (32.3%) WBDOs had a bacterial etiology; 15 (24.2%), parasitic; six (9.7%), viral; and three (4.8%), chemical or toxin. Among the 30 gastroenteritis outbreaks, *Cryptosporidium* was confirmed as the causal agent in 11 (36.7%), and all except one of these outbreaks occurred in treated water venues where *Cryptosporidium* caused 55.6% (10/18) of the gastroenteritis outbreaks.

In this report, 142 *Vibrio* illnesses (reported to the Cholera and Other *Vibrio* Illness Surveillance System) that were associated with recreational water exposure were analyzed separately. The most commonly reported species were

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Vibrio vulnificus, V. alginolyticus, and *V. parahaemolyticus. V. vulnificus* illnesses associated with recreational water exposure had the highest *Vibrio* illness hospitalization (87.2%) and mortality (12.8%) rates.

Interpretation: The number of WBDOs summarized in this report and the trends in recreational water-associated disease and outbreaks are consistent with previous years. Outbreaks, especially the largest ones, are most likely to be associated with summer months, treated water venues, and gastrointestinal illness. Approximately 60% of illnesses reported for 2003–2004 were associated with the seven largest outbreaks (>100 cases). Deficiencies leading to WBDOs included problems with water quality, venue design, usage, and maintenance.

Public Health Actions: CDC uses WBDO surveillance data to 1) identify the etiologic agents, types of aquatic venues, water-treatment systems, and deficiencies associated with outbreaks; 2) evaluate the adequacy of efforts (i.e., regulations and public awareness activities) to provide safe recreational water; and 3) establish public health prevention priorities that might lead to improved regulations and prevention measures at the local, state, and federal levels.

Introduction

During 1920–1970, statistical data regarding waterborne disease and outbreaks (WBDOs) in the United States 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 collaboratively maintained the Waterborne Disease and Outbreak Surveillance System (WBDOSS), a surveillance system that tracks the occurrences and causes of WBDOs associated with drinking water (*2–11*). In 1978, WBDOs associated with recreational water were added to the surveillance system. The types of outbreaks and diseases included in the surveillance summaries have expanded multiple times. Outbreaks of Pontiac fever (PF) were added in 1989 (*9*), outbreaks of Legionnaires' disease were added in 2001 (*2*), and single cases of *Vibrio* illness associated with recreational water but not limited to preexisting wounds have been added in this report. WBDOs associated with drinking water and water not intended for drinking are presented in a separate report (*12*).

WBDO surveillance activities are intended to 1) characterize the epidemiology of WBDOs; 2) identify changing trends in the etiologic agents and other risk factors associated with WBDOs; 3) identify major deficiencies in providing safe recreational water; 4) encourage public health personnel to detect and investigate WBDOs; and 5) foster collaboration among local, state, federal, and international agencies on initiatives to prevent waterborne disease. Data obtained through the WBDOSS are useful for identifying major deficiencies in providing safe recreational water, influencing research priorities, supporting public health recommendations, and encouraging improved water-quality policies and regulations. However, the WBDOs summarized in this report represent only a portion of the illness associated with water exposure. The surveillance information described in this report does not include endemic waterborne disease risks, although studies to measure the levels of endemic illness associated with recreational water use are needed. Reliable estimates of the number of unrecognized WBDOs are not available.

Background

Regulation of Recreational Water Quality

Recreational water use has involved a risk for disease for virtually all of human history. Evidence of schistosomiasis, a parasitic disease only contracted by having contact with contaminated water, can be found in Egyptian mummies approximately 3,000 years old (*13*). In the United States, state and local governments establish and enforce regulations for protecting recreational water from naturally occurring or human-made contaminants. For treated water venues (e.g., swimming and wading pools), no federal regulatory agency or national guidelines for standards of operation, disinfection, or filtration exist. Because these swimming pool codes are developed and enforced by state and local health departments, substantial variation is observed across the country in terms of policy, compliance, and enforcement (*14*). In 1986, EPA published bacterial water-quality criteria for untreated fresh and marine water sources (*15*) and made these criteria water-quality standards for the states and territories that did not adopt the criteria before 2004. For freshwater (e.g., lakes and rivers), EPA has recommended criteria that the monthly geometric mean water-quality indicator concentration be ≤33 CFU/100 mL for enterococci or ≤126 CFU/100 mL for *Escherichia coli*. For marine water, EPA has recommended criteria that the monthly geometric mean water-quality indicator concen-

tration be ≤35 CFU/100 mL for enterococci. However, state and local authorities have discretionary authority to determine which interventions should be used (e.g., posting signs to alert visitors of water contamination or closing the beach for swimming) when these limits have been exceeded. Natural processes to improve the quality of untreated recreational water might take days to months to occur. In contrast, disinfection, filtration, and pool drainage are examples of techniques that are used to restore a safe swimming environment in treated water venues. Whereas pools and other treated-water venues might need to be closed for a period of time and continued monitoring might be necessary, decontamination is usually feasible in hours to days.

EPA's Action Plan for Beaches and Recreational Waters (i.e., Beach Watch) was developed as part of the Clean Water Action Plan (available at http://www.cleanwater.gov). The intent of Beach Watch is to assist state, tribal, and local authorities in strengthening and extending existing programs to protect users of fresh and marine recreational waters. As part of the Beaches Act of 2000, the U.S. Congress directed EPA to create a new set of guidelines for recreational water based on novel water-quality indicators. As a result, EPA has been collaborating with CDC since 2002 on a series of epidemiologic studies at fresh and marine water recreational beaches in the United States. Information on the National Epidemiologic and Environmental Assessment of Recreational (NEEAR) Water Study is available at http://www.epa.gov/nerlcwww/neearnerl.htm. This study is being conducted to test rapid new water-quality methods that are able to produce results in <2 hours and to correlate these indicators with health effects among beachgoers. Preliminary results from two Great Lakes beaches have demonstrated an association between an increasing signal detected by a quantitative polymerase chain reaction–based test method for enterococci and human health effects (*16*).

Methods

Data Sources

Public health departments in individual states, territories, localities, and the Freely Associated States (FAS)* have the primary responsibility for detection and investigation of WBDOs. The outbreaks are voluntarily reported to CDC through a standard form (i.e., CDC form 52.12) available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf. The form solicits data on the WBDO, including characteristics of person, place, time, and results of epidemiologic studies, disease symptoms, microbiology, and water sampling. Information regarding the setting of the outbreak also is gathered, including water-supply descriptions, any sanitary measures in place, and possible factors contributing to the contamination of the water. Public health professionals in each state or locality are designated as WBDO surveillance coordinators, and CDC annually requests reports from each coordinator and conducts as much follow-up correspondence as needed to resolve unaddressed questions. Contact is made with all states or localities, including those without WBDO reports. Information is sometimes solicited from other CDC surveillance systems and confirmed with the state or locality for inclusion as a WBDO. Outbreaks or cases, where applicable, are assigned to a state, based on location of exposure rather than state of residence of ill persons. Numeric and text data from the CDC form and any supporting documentation are entered into a database for analysis. Although all WBDOs are collected through the same CDC reporting system, the recreational water-associated outbreaks are analyzed and published in this report separately from drinking water-associated outbreaks and other WBDOs (*12*). SAS programming is used for all statistical analyses.

Definitions†

The unit of analysis for the WBDOSS is typically an outbreak, not an individual case of a waterborne disease. To be defined as a WBDO associated with recreational water, an event must meet two criteria. First, two or more persons must be epidemiologically linked by location of exposure to water, time, and illness. This criterion is waived for 1) single cases of laboratory-confirmed primary amebic meningoencephalitis (PAM) associated with recreational water, 2) wound infections or other *Vibrio* infections associated with recreational water, and 3) single cases of chemical/toxin poisoning if water or air-quality data indicate contamination by the chemical/toxin. Second, the epidemiologic evidence must implicate water as the probable source of the illness. WBDOs associated with cruise ships are not summarized in this report. Recreational water settings include swimming pools, wading pools, spas, waterslides, interactive fountains, wet decks, and fresh and marine bodies of water. For this analysis, the WBDOs are separated by

* 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 have been defined (Appendix A, Glossary of Definitions).

venue as untreated (i.e., fresh and marine surface water) or treated (i.e., disinfected [e.g., chlorinated]) water.

Strength of Evidence Classification for Waterborne Disease and Outbreaks

WBDOs reported to the WBDOSS are classified according to the strength of evidence that implicates 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 WBDO report form. Although in certain instances WBDOs without water-quality data were included in this report, outbreaks that lacked epidemiologic data linking the outbreak to water were excluded.

Class I indicates that adequate epidemiologic and water-quality data were reported (Table 1). However, the classification does not necessarily imply that an investigation was optimally conducted 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 classifications of III or IV because of the limited sample size available for analysis.

Changes in the 2003–2004 *Surveillance Summary*

Names, definitions, classifications, and other parameters in this *Surveillance Summary* have been modified and expanded to better reflect the changing epidemiology of WBDOs and to capture the wide scope of water-related disease. This section highlights these changes.

Title

The title of this *Surveillance Summary* has been changed. Previously titled *Surveillance for Waterborne-Disease Outbreaks Associated with Recreational Water*, the title of the report has been changed to *Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water*. This subtle difference ("Disease *and* Outbreaks") emphasizes the public health importance of certain waterborne contaminants (e.g., *Naegleria*, *Vibrio*, or chemicals) that frequently cause single cases of illness, can be strongly linked to recreational water exposure, and are reported to the WBDOSS, despite not being associated with multiple cases in a traditional "outbreak" setting.

Etiologic Agents

Etiologic agents are identified through clinical specimens or occasionally by water testing. In previous summaries, the term "acute gastrointestinal illness (AGI)" was used to indicate WBDOs of unidentified etiology associated with gastrointestinal symptoms. Because AGI refers to a type of illness and not to an etiologic agent, the term "unidentified" is now used to describe WBDOs with unknown etiology. A classification of "unidentified" might occur for various reasons, including a lack of clinical specimens, lack of appropriate testing, or inadequate laboratory capacity. If more than one agent is implicated, only those that appear in $\geq$5% of positive clinical specimens are included in the tables and calculations as etiologic agents. When each agent is of the same agent type (e.g., bacteria, chemicals/toxins, parasites, and viruses), the outbreak is analyzed within that agent type (e.g., an outbreak with both *Cryptosporidium* and *Giardia* would be analyzed as a parasitic outbreak). When agents represent more than one agent type, the outbreak is analyzed as a mixed agent outbreak. All outbreaks

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

Class	Epidemiologic data	Water-Quality data
I	Adequate Data provided concerning exposed and unexposed persons, with relative risk or odds ratio $\geq$2 or $p \leq 0.05$	Provided and adequate Laboratory data or historical information (e.g., the history that a chlorinator or pH acid feed pump malfunctioned, resulting in no detectable free-chlorine residual, or a breakdown in a recirculation system)
II	Adequate	Not provided or inadequate (e.g., laboratory testing of water not conducted and no historical information)
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

in which the etiologic agent is not known or confirmed are listed as unidentified, and they constitute a separate analysis category from those outbreaks with identified etiologic agents, even when other data (e.g., clinical findings) are suggestive of a particular pathogen or chemical/toxin.

In previous *Surveillance Summaries,* outbreaks in which patients sought medical care for dermatologic symptoms consistent with *Pseudomonas aeruginosa* infection but in which *Pseudomonas* was not isolated from clinical specimens or water samples were still classified as *Pseudomonas* outbreaks. However, in this report, only those outbreaks in which clinical specimens or water samples test positive for *Pseudomonas* are classified as *Pseudomonas* outbreaks.

Predominant Illness, Case Counts, and Deaths

Whereas the illness associated with a WBDO generally includes only one category of symptoms (e.g., gastroenteritis), WBDOs do occur where the symptoms cluster into more than one category (e.g., gastroenteritis and dermatitis). Therefore, in this report, if any one illness category is reported by ≥50% of ill respondents, then multiple illnesses will be listed for that WBDO. These mixed-illness WBDOs constitute a separate analysis category from WBDOs involving a single illness. In addition, the number of deaths associated with each WBDO is now presented in this report. This change provides increased information on the severity of illness associated with each WBDO.

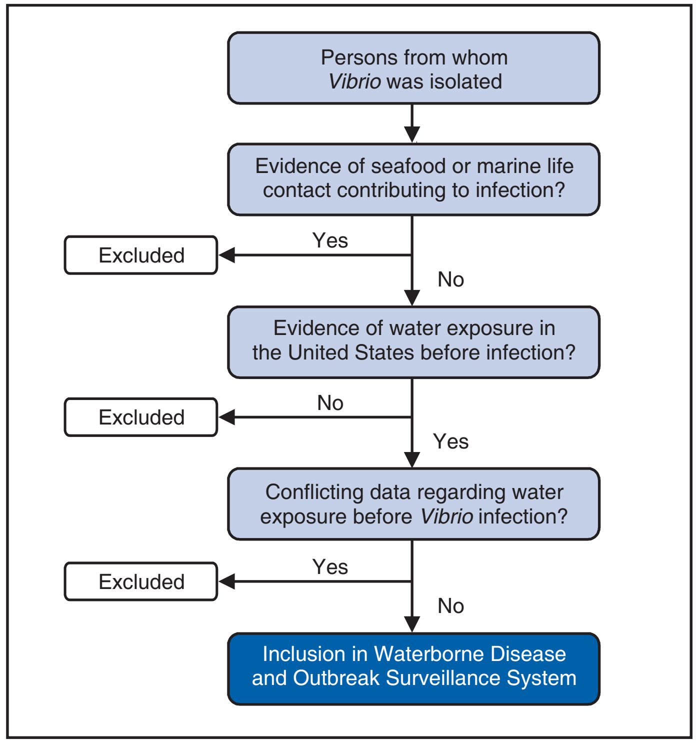
Strength of Evidence Classification for Waterborne Disease and Outbreaks

For the first time, the strength of evidence classification for WBDOs (Table 1) is used for nongastroenteritis outbreaks (e.g., dermatitis, PAM, and chemical/toxin poisonings). Classification of these WBDOs should provide a better understanding of the strength of each outbreak investigation.

Vibrio Cases

For the first time, single cases of recreational water-associated *Vibrio* illness were selected for inclusion in this *Surveillance Summary* by using an algorithm (Figure 1). The algorithm selected *Vibrio* cases for inclusion based on previous water exposure in the United States and the absence of seafood consumption or contact. All selected cases were verified by the state or local health departments. These infections frequently were associated with preexisting wounds but also were associated with other water-related exposure routes (e.g., wounds incurred while swimming or walking on the beach or unintentional inhalation of recreational water, resulting in a sinus infection). These cases

FIGURE 1. Algorithm for selection of illnesses associated with *Vibrio* isolation and recreational water — United States, 2003–2004*



* **Note:** *Vibrio*-related data are only presented in Figures 6–8 and in Tables 8 and 9.

are reported to the Cholera and Other *Vibrio* Illness Surveillance System on CDC form 52.79 (available at http://www.cdc.gov/foodborneoutbreaks/documents/cholera_vibrio_report.pdf). Staff operating the Cholera and Other *Vibrio* Illness Surveillance System collaborated with staff from the WBDOSS to gather all reported recreational water-associated *Vibrio* cases for inclusion in this report. These cases were analyzed separately from other recreational water illnesses to avoid substantially altering total WBDO numbers when compared with previous reports. Similarly, *Vibrio* cases are also discussed separately in this report.

Results

Excluding *Vibrio* cases, which are analyzed and discussed separately, a total of 62 outbreaks (28 in 2003 and 34 in 2004) associated with recreational water were reported to CDC (Tables 2–5). Of the 50 states and 10 territories, localities, and FAS participating in the WBDOSS, 27 (26 states and the territory of Guam) reported WBDOs (Figure 2). Descriptions of selected WBDOs have been presented (Appendix B, Selected Descriptions of Waterborne

TABLE 2. Waterborne-disease outbreaks (n = 18) associated with treated recreational water, by state — United States, 2003

State	Month	Class*	Etiologic agent	Predominant illness†	No. of cases (n = 1,141)	Type	Setting
Arkansas	Aug	IV	*Cryptosporidium*	AGI†	4	Pool	Large facility
Connecticut	Jul	I	Echovirus 9	Neuro†	36	Pool	RV§ campground
Connecticut	Aug	I	MRSA¶	Skin†	10	Spa	Athletic center
Georgia	Apr	IV	Unidentified	Skin	5	Spa	Hotel
Illinois	Jan	I	*Pseudomonas aeruginosa*	Skin	52	Spa	Hotel
Illinois	Dec	I	Unidentified**	AGI	12	Pool	Hotel
Iowa	Jun	IV	*Cryptosporidium* and *Giardia intestinalis*††	AGI	63	Wading pool	Day care center
Kansas	Jul	I	*C. hominis*§§	AGI	617	Pools, Wading pools	Community
Massachusetts	Jun	II	*G. intestinalis*	AGI	149	Pool	Membership club
Michigan	Feb	II	Unidentified¶¶	Skin	25	Spa	Hotel
New Mexico	Jun	III	*Legionella pneumophila* serogroup 1	ARI†	4	Spa	Hotel
New York	Mar	III	Muriatic (hydrochloric) acid	ARI	3	Pool	Membership club
New York	Nov	IV	Unidentified¶¶	Skin	7	Pool	Membership club
Ohio	Jan	I	*P. aeruginosa*	Skin	17	Pool, spa	Hotel
Oregon	Jul	I	*Shigella sonnei*	AGI	56	Interactive fountain	Community
South Carolina	Nov	II	Unidentified	Skin	64	Spa, pool	Hotel
Wisconsin	Feb	I	*L. pneumophila* serogroup 1	ARI	3	Spa	Hotel
Wisconsin	Jul	II	*Cryptosporidium*	AGI	14	Wading pool	Community

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12 (available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf).
† AGI: acute gastrointestinal illness; Neuro: neurologic condition or symptoms (e.g., meningoencephalitis or meningitis); Skin: illness, condition, or symptom related to skin; and ARI: acute respiratory illness.
§ RV: recreational vehicle.
¶ MRSA: Methicillin-resistant *Staphylococcus aureus*.
** Etiology unidentified; chemical contamination from pool disinfection by-products (e.g., chloramines) suspected.
†† Each pathogen was identified in ≥5% of positive clinical specimens; therefore, both are listed as etiologic agents.
§§ Species determined by using molecular technology and current taxonomic guidelines (**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).
¶¶ Etiology unidentified: *P. aeruginosa* suspected on the basis of clinical syndrome and setting.

Disease and Outbreaks [WBDOs] Associated with Recreational Water). These 62 outbreaks resulted in 2,698 ill persons, including one death (attributable to PAM; Table 4). The median outbreak size was 14 persons (range: 1–617 persons). The seven largest outbreaks each had more than 100 ill persons and accounted for 60.3% (n = 1,628) of the total cases. Illinois reported the highest number of WBDOs (10), Ohio reported six WBDOs, and Georgia and Wisconsin both reported five WBDOs.

During 2003–2004, treated water venues were associated with 43 (69.4%) of the recreational water outbreaks and 2,446 (90.7%) of the cases (Tables 2 and 3; Figure 3). Untreated venues were responsible for 19 (30.6%) of the WBDOs but only 252 (9.3%) of the cases (Tables 4 and 5). Similar proportions were identified by venue treatment type when gastroenteritis outbreaks were analyzed separately (Table 6).

Of the 62 WBDOs, 30 (48.4%) were outbreaks of gastroenteritis, 13 (21.0%) were outbreaks of dermatitis, and seven (11.3%) were outbreaks of acute respiratory illness (ARI). The remaining WBDOs resulted in PAM (n = one), meningitis (n = one), leptospirosis (n = one), otitis externa (n = one), and mixed illnesses (n = eight) (Table 6, Figure 3). Gastroenteritis accounted for 1,945 (72.1%) of the cases of illness. The route of entry implicated for each WBDO was ingestion for 30 WBDOs (48.4%), contact for 15 (24.2%), inhalation for seven (11.3%), combined routes for eight (12.9%), other for one (1.6% [*Naegleria*]), and unknown for one outbreak (1.6%) (Figure 3).

WBDOs occurred in every calendar month except October, but the summer months (June through August) accounted for 35 (56.5%) WBDOs and 1,888 (70.0%) cases (Figure 4). Gastroenteritis was particularly clustered during these months, in which 22 (73.3%) of 30 outbreaks and 1,631 (83.9%) of 1,945 cases (Figure 4) were reported. Treated venues were associated with WBDOs throughout the year, whereas untreated venue-associated WBDOs occurred almost exclusively from May through August (Tables 2–5). Increased reporting of WBDOs occurred during the summer, with a relative risk (RR) of 3.9 (95% confidence interval [CI] = 2.4–6.4). This risk increased for certain outbreak categories. Gastroenteritis outbreaks compared with other illnesses (RR = 8.2; 95% CI = 3.7–18.5) were especially frequent during the summer (Figure 4).

TABLE 3. Waterborne-disease outbreaks (n = 25) associated with treated recreational water, by state — United States, 2004

State	Month	Class*	Etiologic agent	Predominant illness†	No. of cases (n = 1,305)	Type	Setting
California	Aug	I	*Cryptosporidium*	AGI†	336	Pool	Water park
Colorado	Aug	III	*Cryptosporidium*	AGI	6	Pool	Hotel
Florida	May	III	Norovirus	AGI	42	Waterslide	School
Georgia	Jan	IV	Unidentified§	Skin†	17	Pool	Hotel
Georgia	Jun	IV	*Cryptosporidium*	AGI	14	Pool	Community
Idaho	Mar	II	Norovirus	AGI	140	Pool	Community
Illinois	Jan	I	Unidentified¶	Eye†, ARI†	45	Pool	Hotel
Illinois	Jan	I	Unidentified¶	Eye, ARI	22	Pool, spa	Hotel
Illinois	Feb	III	*Pseudomonas aeruginosa*	Skin, ARI	16	Pool, spa	Hotel
Illinois	Feb	I	*P. aeruginosa*	Skin	5	Spa	Hotel
Illinois	Mar	I	Unidentified¶	Eye, ARI	57	Pool, spa	Hotel
Illinois	Jul	IV	Unidentified**	AGI	9	Pool	Community
Illinois	Jul	I	*Cryptosporidium*	AGI	37	Pool, wading pool, interactive fountain	Community
Illinois	Sep	I	*Cryptosporidium*	AGI	8	Pool	Hotel
New Mexico	Aug	IV	Unidentified¶	ARI	16	Pool	Membership club
New York	Dec	IV	Unidentified¶	ARI	5	Pool	Military facility
North Carolina	Mar	II	*P. aeruginosa*	Skin	41	Spa	Hotel
Ohio	Jul	I	*C. hominis*††	AGI	160	Pool, wading pool	Community
Ohio	Jul	I	*P. aeruginosa*	Ear†, skin	119	Pool, spa	Resort
Ohio	Aug	I	*Legionella pneumophila* serogroup 1	ARI	3	Spa	Household
Oklahoma	Mar	I	*L. pneumophila* serogroup 1	ARI	107	Spa	Hotel
Oregon	Mar	III	*P. aeruginosa*	Skin	2	Spa	Motel
Vermont	Feb	I	Norovirus	AGI	70	Pool	Membership club
Wisconsin	Jun	I	*P. aeruginosa*	Skin, AGI	22	Pool, spa	Hotel
Wisconsin	Aug	IV	*Cryptosporidium*	AGI	6	Pool	Community

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12 (available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf).
† AGI: acute gastrointestinal illness; Skin: illness, condition, or symptom related to skin; Eye: illness, condition, or symptom related to eyes; ARI: acute respiratory illness; and Ear: illness, condition, or symptom related to ears.
§ Etiology unidentified; psychogenic factors and chemical contamination suspected.
¶ Etiology unidentified; chemical contamination from pool disinfection by-products (e.g., chloramines) suspected.
** Etiology unidentified; chemical contamination with pool algaecide suspected.
†† Although both *Cryptosporidium* oocysts and *Giardia* cysts were identified in the pool water, only *Cryptosporidium* oocysts were isolated from clinical specimens.

Etiologic Agents

Of the 62 WBDOs associated with recreational water, the etiologic agent was confirmed in 44 (71.0%), suspected in 15 (24.2%) and unidentified in three (4.8%) (Table 7). Twenty (32.3%) outbreaks were confirmed as bacterial; 15 (24.2%), as parasitic; six (9.7%) as viral; and three (4.8%) as chemical- or toxin-mediated (Figure 3).

Of the 43 outbreaks associated with treated water venues that had an identified etiologic agent, 14 (32.6%) involved bacteria; 12 (27.9%), parasites; four (9.3%), viruses; and one (2.3%), involved chemicals (Table 7). However, parasites were responsible for more than three times more cases than bacterial causes (1,414 versus 457). Of the 19 WBDOs associated with untreated water venues, six (31.6%) involved bacteria; three (15.8%) parasites; two (10.5%) viruses; and two (10.5%) toxins. Unlike treated water venues, bacteria were responsible for more than six times more cases in untreated water venues than parasites (96 versus 14).

Parasites

Of the 30 outbreaks of gastroenteritis, 14 (46.7%) were parasitic in origin, including 11 (78.6%) caused by *Cryptosporidium*, two (14.3%) caused by *Giardia intestinalis*, and one (7.1%) caused by both *Cryptosporidium* and *Giardia* (Tables 2–6; Figure 5). Of the 12 gastroenteritis outbreaks associated with untreated water venues, only two (16.6%) were caused by parasites. A single *Cryptosporidium* outbreak and a single *Giardia* outbreak each occurred in untreated lake water, causing four and nine cases of illness, respectively. In contrast, parasites were the most common causes of gastroenteritis outbreaks associated with treated water venues; *Cryptosporidium* was the most common parasitic agent, causing 10 (55.6%) of the 18 outbreaks. A total of 12 parasitic gastroenteritis outbreaks occurred in treated water venues that caused illness in 1,414 persons. Four of these outbreaks each caused over 100 (range: 149–617 persons) cases of illness. In June 2003, an

TABLE 4. Waterborne-disease outbreaks (n = 10) associated with untreated recreational water, by state — United States, 2003

State	Month	Class*	Etiologic agent	Predominant illness†	No. of cases (deaths) (n = 133)	Type	Setting
California	Jun	IV	Unidentified§	Skin†	9	Lake	Lake
Florida	Jul	II	Unidentified¶	AGI†	10	Lake	Lake
Florida	May	II	Unidentified¶	AGI	20	Lake	Camp
Georgia	May	I	*Shigella sonnei*	AGI	13	Lake	Park
Idaho	Jul	IV	*Cryptosporidium*	AGI	4	Lake	Lake
Maryland	Jul	III	*S. sonnei* & *Plesiomonas shigelloides***	AGI	65	Lake	Park
North Carolina	Jul	IV	*Naegleria fowleri*	Neuro†	1 (1)	Lake	Lake
Ohio	Jul	IV	*P. shigelloides*	AGI	3	Lake	Bathing beach
Ohio	Jun	IV	Unidentified§	Skin	6	Lake	Private beach
Wyoming	Jul	IV	*P. shigelloides*	AGI	2	Reservoir	Reservoir

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12 (available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf).
† Skin: illness, condition, or symptom related to skin; AGI: acute gastrointestinal illness; and Neuro: neurologic condition or symptoms (e.g., meningoencephalitis, meningitis).
§ Etiology unidentified; clinical diagnosis of cercarial dermatitis (caused by avian schistosomes).
¶ Etiology unidentified; illness was most consistent with norovirus infection.
** Each pathogen was identified in ≥5% of positive clinical specimens; therefore, both are listed as etiologic agents.

TABLE 5. Waterborne-disease outbreaks (n = nine) associated with untreated recreational water, by state/territory — United States, 2004

State/Territory	Month	Class*	Etiologic agent	Predominant illness†	No. of cases (n = 119)	Type	Setting
Arkansas	Jun	IV	*Shigella flexneri*	AGI†	10	Lake	Swimming beach
Georgia	Aug	IV	Unidentified	Ear†	9	Lake	Lake
Guam	Apr	IV	*Leptospira* species	Leptospirosis	3	River	Waterfalls
Minnesota	Jun	IV	Norovirus	AGI	9	Lake	Swimming beach
Missouri	Mar	IV	*Giardia intestinalis*	AGI	9	Lake	Lake
Nebraska	Jul	III	Microcystin toxin (blue-green algae)	AGI, Skin†	20	Lake	Lake
Nebraska	Jul	III	Microcystin toxin (blue-green algae)	AGI, Skin	2	Lake	Lake
Oregon	Jul	IV	Norovirus	AGI	39	Lake	Swimming beach
Wisconsin	Jul	IV	Unidentified§	AGI	18	Lake	State park

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12 (available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf).
† AGI: acute gastrointestinal illness; Ear: illness, condition, or symptom related to ears; and Skin: illness, condition, or symptom related to skin.
§ Etiology unidentified; Illness was most consistent with norovirus infection.

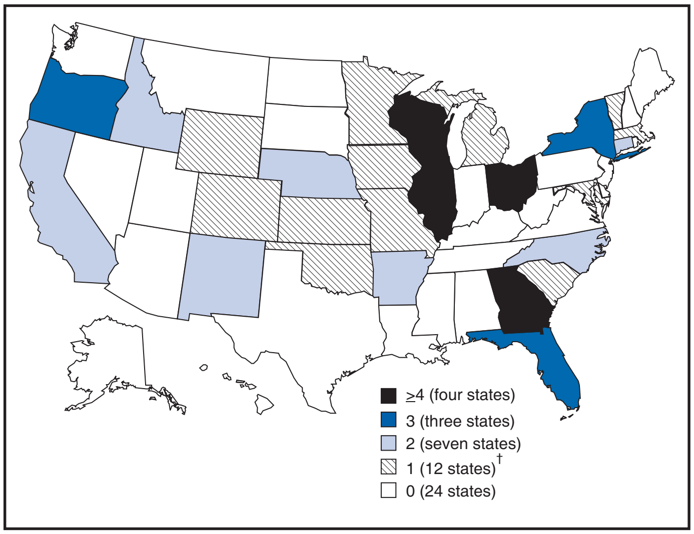
outbreak of *G. intestinalis* started at a Massachusetts membership club pool and resulted in 149 cases, including cases of secondary person-to-person transmission. In July 2003, a *C. hominis* outbreak spread in multiple Kansas pools and day care centers and resulted in 617 cases; this outbreak was the largest recreational water outbreak during 2003–2004. In July 2004, an outbreak of *Cryptosporidium* in a community pool in Ohio caused gastroenteritis in 160 persons from three counties. In August 2004, employees ill with gastroenteritis at a California water park continued working and swimming in the pools, resulting in a *Cryptosporidium* outbreak involving 336 persons.

Of the 15 WBDOs of all illness types confirmed to be of parasitic origin, only one (6.7%) did not involve gastroenteritis; a single fatal case of PAM caused by *Naegleria fowleri* occurred in July 2003 at a lake in North Carolina. This case was the only death reported among the 62 WBDOs during this reporting cycle (excluding *Vibrio* cases).

Bacteria

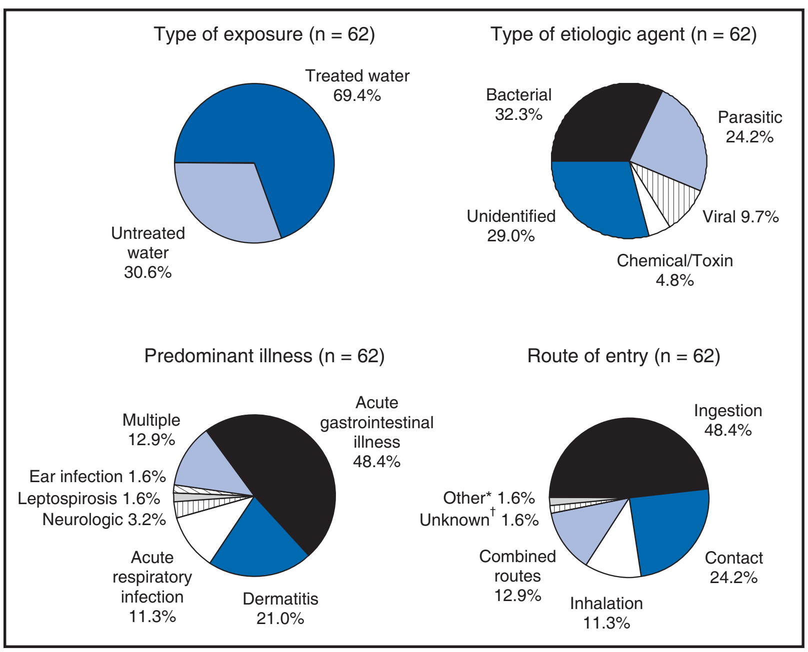
Six reported gastroenteritis outbreaks of confirmed bacterial origin were reported (Figure 5), one of which was at a treated water venue. This outbreak of *Shigella sonnei* occurred in an interactive fountain in Oregon in July 2003, resulting in 56 cases. Inadequate disinfection, poor monitoring of water chemistry, and heavy use of the fountain by young diaper-aged children were all cited as factors contributing to the outbreak. The other five bacterial outbreaks of gastroenteritis were associated with untreated bodies of water, including two additional outbreaks of *Shigella,* two outbreaks of *Plesiomonas shigelloides,* and one outbreak that involved both *Shigella* and *Plesiomonas* associated with the use of a lake in Maryland, resulting in illness in 65 persons. Fecal accidents and sewage contamination were implicated in this outbreak. The other four outbreaks were substantially smaller; illness occurred in 13 or fewer persons in each outbreak.

FIGURE 2. Number of recreational water-associated outbreaks (n = 62) — United States, 2003–2004*



* **Note:** These numbers are largely dependent on reporting and surveillance activities in individual states and do not necessarily indicate the true incidence in a given state.
† Guam also reported one recreational water-associated outbreak in 2004.

FIGURE 3. Recreational water-associated outbreaks, by type of exposure, type of etiologic agent, predominant illness, and route of entry — United States, 2003–2004



* Infection with *Naegleria* was categorized as other because of the nasal, noninhalational route of infection.
† Route of transmission for leptospirosis was unclear after investigation.

Nine of the bacterial outbreaks resulted in cases of dermatitis; for eight of these outbreaks, *Pseudomonas aeruginosa* was the confirmed etiologic agent. Three of the eight *Pseudomonas* outbreaks were associated with mixed illnesses. All eight *Pseudomonas* outbreaks occurred at treated water venues that involved heated spa water (some of these outbreaks also involved pools), and illness occurred in 274 persons. One outbreak in Ohio in July 2004 involving a spa and pool accounted for 119 of these cases, which is the largest bacterial outbreak summarized in this report. Potential exposure also occurred in this outbreak when the hotel spa water flowed directly into the swimming pool. The one bacterial dermatitis outbreak that did not involve *Pseudomonas* occurred in August 2003. Multiple members of a Connecticut college football team were diagnosed with methicillin-resistant *Staphylococcus aureus* (MRSA) skin infections. A spa at the team's athletic facility, which was disinfected with an unapproved disinfectant (i.e., povidone), was implicated in the outbreak.

Four outbreaks caused by *Legionella pneumophila* were associated with treated recreational water venues (i.e., spas) during 2003–2004. Three of these outbreaks each had fewer than five cases of Legionnaires' disease. The fourth outbreak, which occurred at a hotel in Oklahoma during a weeklong basketball tournament in March 2004, included six cases of Legionnaires' disease and 101 cases of PF. The bather load (i.e., maximum occupancy) of the hotel spa was exceeded, and the bromine concentrations in the spa were not adequately monitored.

An April 2004 outbreak of leptospirosis in Guam involved three U.S. military personnel who swam in a remote set of waterfalls. This was the only outbreak of leptospirosis reported and the only outbreak reported from outside the 50 states.

Viruses

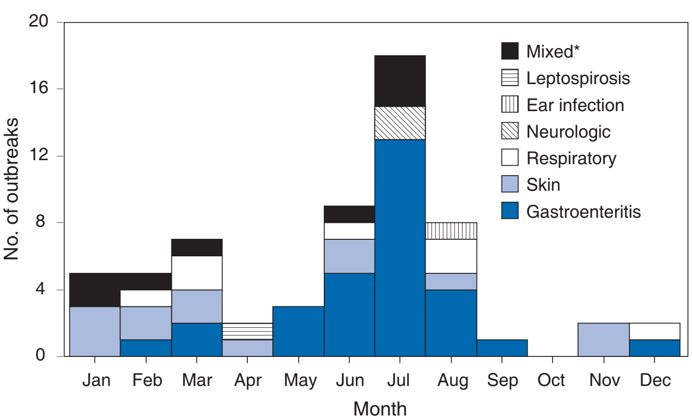
Six outbreaks of confirmed viral origin occurred, five of which caused gastroenteritis. In all five of these gastroenteritis outbreaks, norovirus was identified as the etiologic agent; two occurred at lake swimming beaches, and three occurred in treated water settings. These five norovirus outbreaks resulted in 300 cases of gastroenteritis. Three other outbreaks were suspected to have been caused by norovirus contamination. One outbreak (Idaho, March 2004) occurred during a swimming competition at a community pool and resulted in 140 cases. One outbreak (Florida,

TABLE 6. Number of waterborne-disease outbreaks (n = 62) associated with recreational water, by predominant illness and type of water — United States, 2003–2004

	Type of water					
	Treated		Untreated		Total	
Predominant illness*	No. of outbreaks	No. of cases	No. of outbreaks	No. of cases	No. of outbreaks (%)	No. of cases (%)
AGI	18	1,743	12	202	**30 (48.4)**	**1,945 (72.1)**
ARI	7	141	0	0	**7 (11.3)**	**141 (5.2)**
Ear	0	0	1	9	**1 (1.6)**	**9 (0.3)**
Ear and Skin	1	119	0	0	**1 (1.6)**	**119 (4.4)**
Eye and ARI	3	124	0	0	**3 (4.8)**	**124 (4.6)**
Leptospirosis	0	0	1	3	**1 (1.6)**	**3 (0.1)**
Neurologic	1	36	1	1	**2 (3.2)**	**37 (1.4)**
Skin	11	245	2	15	**13 (21.0)**	**260 (9.6)**
Skin and AGI	1	22	2	22	**3 (4.8)**	**44 (1.6)**
Skin and ARI	1	16	0	0	**1 (1.6)**	**16 (0.6)**
Total (%)	**43 (69.4)**	**2,446 (90.7)**	**19 (30.6)**	**252 (9.3)**	**62 (100.0)**	**2,698 (100.0)**

* AGI: acute gastrointestinal illness; ARI: acute respiratory illness; Ear: illness, condition, or symptom related to ears; Skin: illness, condition, or symptom related to skin; Eye: illness, condition, or symptom related to eyes; and Neuro: neurologic condition or symptoms (e.g., meningoencephalitis, meningitis).

FIGURE 4. Number of recreational water-associated outbreaks (n = 62), by predominant illness and month — United States, 2003–2004



* A combination of illnesses.

May 2004, norovirus etiology) involved an elementary school that used an outdoor hose to supply waterslides during outdoor play time. Children were infected after one ill child with diarrhea used one of the slides; secondary transmission to household contacts also occurred, resulting in 42 cases.

In July 2003, a viral outbreak of meningitis occurred in a pool at a Connecticut campground. Echovirus 9, an enterovirus, was isolated from patient cerebrospinal fluid samples. Although aseptic meningitis occurred in 12 of 36 persons, a wide range of other symptoms were reported by the other 24 ill persons, including headache and rash.

Chemicals/Toxins

During 2003–2004, three outbreaks involving chemicals or toxins resulted in 25 ill persons. One outbreak occurred in a treated water venue. In March 2003, muriatic (i.e., hydrochloric) acid, used for pH control in recreational water, spilled on the floor at an indoor pool in New York and resulted in exposure to toxic fumes, which led to respiratory distress in three persons who sought emergency department medical care.

During 2004, two toxin-associated outbreaks occurred in untreated water venues in Nebraska. These outbreaks were attributed to elevated levels of microcystin toxin (*17*) from blue-green algae (i.e., cyanobacteria) in lakes, causing 22 cases of illness. The predominant illnesses in both outbreaks involved dermatitis and gastroenteritis. Patients who sought medical care had a combination of rashes, diarrhea, cramps, nausea, vomiting, and fevers.

Unidentified Etiologic Agents

Eighteen outbreaks occurred in which no etiologic agent was confirmed; however, in 15 of these outbreaks, investigation reports described a suspected agent, based on symptoms, setting, and circumstances (Table 7). Of these 18 outbreaks, seven reported skin infections, five reported gastroenteritis, three reported mixed-eye and ARI, two reported ARI, and one reported ear infections. Eight of these 15 outbreaks were suspected to be related to chemical exposure. For one of these outbreaks (Georgia, January 2004), psychogenic factors also were suspected to play a role in the 17 cases of dermatitis because certain rashes resolved before first responders arrived to investigate. Another outbreak of gastroenteritis was suspected to be a result of the application of a pool algaecide before swimmers entered the pool. The six remaining outbreaks all were suspected to involve exposure to excess chloramines (i.e., disinfection by-products of chlorination) (*18–20*) in the indoor pools and surrounding areas (i.e., indoor pool air), which resulted

TABLE 7. Number of waterborne-disease outbreaks (n = 62) associated with recreational water, by etiologic agent(s) and type of water — United States, 2003–2004

	Type				Total	
	Treated		Untreated			
Etiologic agent	No. of outbreaks	No. of cases	No. of outbreaks	No. of cases	No. of outbreaks (%)	No. of cases (%)
Bacteria	**14**	**457**	**6**	**96**	**20 (32.3)**	**553 (20.5)**
Legionella pneumophila	4	117	0	0	**4**	**117**
Leptospira species	0	0	1	3	**1**	**3**
MRSA*	1	10	0	0	**1**	**10**
Plesiomonas shigelloides	0	0	2	5	**2**	**5**
Pseudomonas species	8	274	0	0	**8**	**274**
Shigella species	1	56	2	23	**3**	**79**
Shigella and *Plesiomonas* species	0	0	1	65	**1**	**65**
Parasites	**12**	**1,414**	**3**	**14**	**15 (24.2)**	**1,428 (52.9)**
Cryptosporidium species	10	1,202	1	4	**11**	**1,206**
Giardia species	1	149	1	9	**2**	**158**
Naegleria fowleri	0	0	1	1	**1**	**1**
Cryptosporidium and *Giardia* species	1	63	0	0	**1**	**63**
Viruses	**4**	**288**	**2**	**48**	**6 (9.7)**	**336 (12.5)**
Echovirus 9	1	36	0	0	**1**	**36**
Norovirus	3	252	2	48	**5**	**300**
Chemicals/toxins	**1**	**3**	**2**	**22**	**3 (4.8)**	**25 (0.9)**
Microcystin toxin (blue-green algae)	0	0	2	22	**2**	**22**
Muriatic acid	1	3	0	0	**1**	**3**
Unidentified agent	**12**	**284**	**6**	**72**	**18 (29.0)**	**356 (13.2)**
Suspected chemicals†	1	17	0	0	**1**	**17**
Suspected chloramines	6	157	0	0	**6**	**157**
Suspected algaecide	1	9	0	0	**1**	**9**
Suspected norovirus	0	0	3	48	**3**	**48**
Suspected *Pseudomonas* species	2	32	0	0	**2**	**32**
Suspected schistosomes	0	0	2	15	**2**	**15**
Other unidentified	2	69	1	9	**3**	**78**
Total (%)	**43 (69.4)**	**2,446 (90.7)**	**19 (30.6)**	**252 (9.3)**	**62 (100.0)**	**2,698 (100.0)**

* Methicillin-resistant *Staphylococcus aureus*.
† Suspected psychogenic factors and chemical exposure.

in ARI, eye irritation, and gastroenteritis. *P. aeruginosa* was the suspected pathogen in two dermatitis outbreaks in treated water venues. Norovirus was the suspected pathogen in three gastroenteritis outbreaks at lakes, based on epidemiologic and clinical evidence. Two outbreaks were suspected to be the result of contact with avian schistosomes, causing cercarial dermatitis.

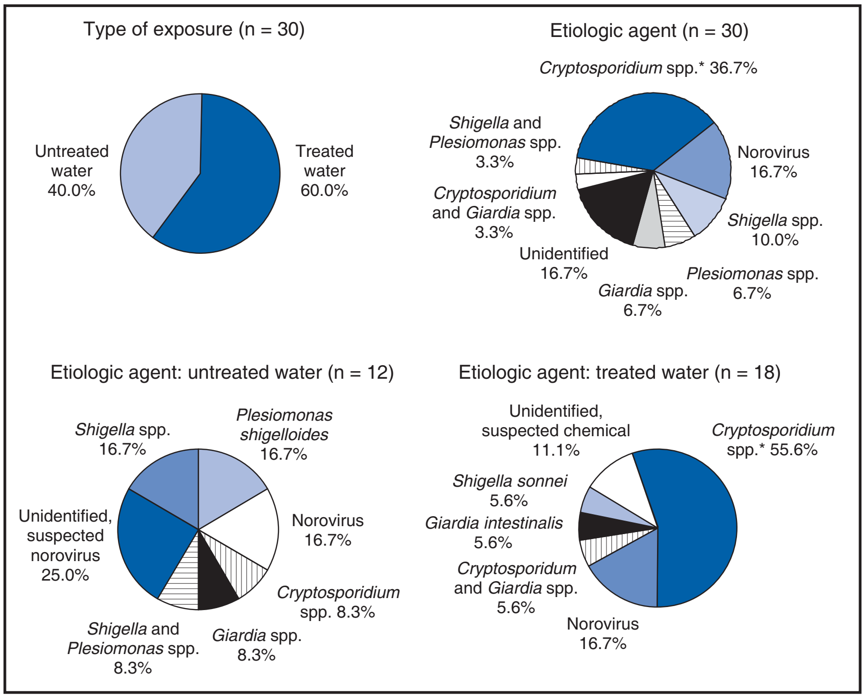
Information regarding the remaining three outbreaks of unidentified etiology was not sufficient to suggest an etiologic agent. Skin infections were reported as the predominant illness in two of these outbreaks, and ear infections were reported for the third one. Two outbreaks of skin infections were associated with spas. One resulted in 64 ill persons, but water sampling could not be conducted because the spa had been drained for routine maintenance before the investigation (South Carolina, November 2003). The third outbreak resulted in ear infections in nine children (Georgia, August 2004) who had been swimming and submerging their heads in a lake.

Vibrio Cases Associated with Recreational Water

During 2003–2004, a total of 142 *Vibrio* cases associated with recreational water were reported from 16 states. Recreational water-associated *Vibrio* cases were defined as those with recreational water exposure in the United States before infection and with no evidence that contact with seafood or marine life might have caused infection (Figure 1). Among patients for whom information was available, 70 (49.3%) of 142 were hospitalized, and nine (6.3%) of 142 died (Table 8).

The most frequently isolated *Vibrio* species was *V. vulnificus*, which was isolated from 47 (33.1%) persons; 41 (87.2%) were hospitalized, and six (12.8%) died. *V. alginolyticus* was isolated from 43 (30.2%) persons; eight (18.6%) were hospitalized, and one (2.3%) died. *V. parahaemolyticus* was isolated from 34 (23.9%) persons; 15 (44.1%) were hospitalized, and none died. Other *Vibrio* species (including noncholerigenic *V. cholerae*, *V. damsela*,

FIGURE 5. Recreational water-associated outbreaks of gastroenteritis, by type of exposure and etiologic agent — United States, 2003–2004



* For one of these outbreaks, cysts of *Giardia* species and oocysts of *Cryptosporidium* species were identified in pool water, but only *Cryptosporidium* was identified in the tested clinical samples.

V. fluvialis, nonspeciated *Vibrio*, and mixed *Vibrio* species) were identified in 18 (12.7%) persons; six (33.3%) were hospitalized, and two (11.1%) died. Six patients were reported to have had an amputation; five were infected with *V. vulnificus*; and one with *V. parahaemolyticus.*

Other bacterial species also were identified with *Vibrio*; 25 (25.3%) of 99 *Vibrio* isolates for which information was available yielded other bacterial species. These other species included *E. coli, Pseudomonas* species, *Staphylococcus marcescens*, *S. aureus,* and *Streptococcus*. Of the 149 *Vibrio* isolates taken from 142 patients, 85 (57%) were from wounds, 31 (20.8%) from blood, 27 (18.1 %) from ears, and six (4%) from other sites (i.e., chest abscess, eye, incision, sinus, sputum, stool, and urine).

Geographic location. Nearly all *Vibrio* patients reported that they were exposed to recreational water in a coastal state (Figure 6). The most frequently reported location was the Gulf Coast (62.7%); Pacific Coast states (19.7%); Atlantic Coast states, excluding Florida (16.9%); and inland states (0.7%) (Table 9). Florida, Hawaii, and Texas reported the highest number of cases, 51, 23, and 28 cases, respectively (Figure 6; Table 9).

Seasonality. In the temporal distribution of illness in patients from whom *Vibrio* species were isolated, a clear seasonal peak occurred during the summer (Figure 7). The greatest frequency of *Vibrio* cases occurred during July and August for all species.

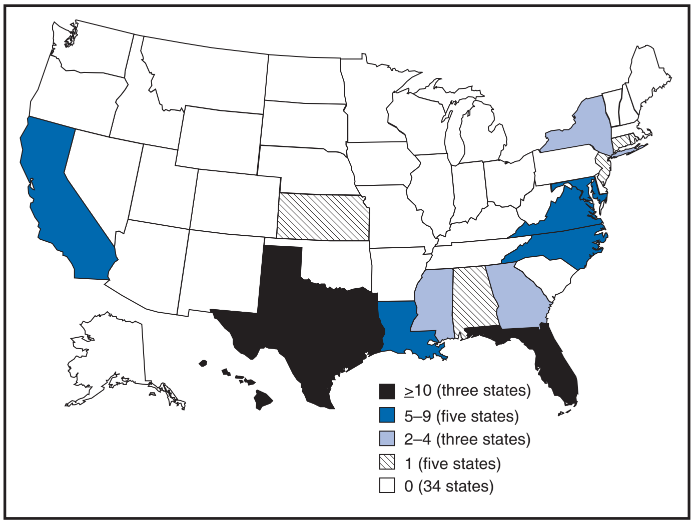
Exposures. Activities associated with *Vibrio* cases included swimming, diving, or wading in water (66.9%); walking or falling on the shore or rocks (32.3%); and boating, skiing, or surfing (21.8%). The majority of patients reported being exposed in the ocean (100 [70.4%]); 12 (8.5%) were exposed in a river, stream, or creek; seven (4.9%) were exposed in a lake or bay; eight (5.6%) were exposed to another water source; and 15 (10.6%) exposed a wound to an unknown water source.

TABLE 8. Number of illnesses associated with *Vibrio* isolation (n = 142) and recreational water exposure, by species and year — United States, 2003–2004

	Year								
	2003			2004			Total		
Species	Cases	Hospitalized	Deaths	Cases	Hospitalized	Deaths	Cases	Hospitalized	Deaths
Vibrio alginolyticus	24	4	1	19	4	0	**43**	**8**	**1**
V. cholerae non-O1, non-O139	3	0	0	4	2	1	**7**	**2**	**1**
V. cholerae, unknown type	0	0	0	1	0	0	**1**	**0**	**0**
V. damsela	1	0	0	1	1	0	**2**	**1**	**0**
V. fluvialis	1	1	0	0	0	0	**1**	**1**	**0**
V. parahaemolyticus	12	4	0	22	11	0	**34**	**15**	**0**
V. vulnificus	20	20	1	27	21	5	**47**	**41**	**6**
Multiple*	0	0	0	1	1	0	**1**	**1**	**0**
Vibrio, species not identified	2	0	0	4	1	1	**6**	**1**	**1**
Total (% of cases)	**63**	**29 (46.0%)**	**2 (3.2%)**	**79**	**41 (51.9%)**	**7 (8.9%)**	**142**	**70 (49.3%)**	**9 (6.3%)**
Percentage by year	**(44.4)**	**(41.4)**	**(22.2)**	**(55.6)**	**(58.6)**	**(77.8)**	**(100.0)**	**(100.0)**	**(100.0)**

* *V. alginolyticus/V. parahaemolyticus* coinfection.

FIGURE 6. Number of illnesses associated with *Vibrio* isolation and recreational water exposure (n = 142) — United States, 2003–2004*



* **Note:** These numbers are largely dependent on reporting and surveillance activities in individual states and do not necessarily indicate the true incidence in a given state.

Symptoms. Symptoms associated with *Vibrio* cases were cellulitis (54.9%), fever (41.5%), muscle pain (24.6%), ear infection (19.0%), nausea (18.3%), shock (12.7%), and bullae (12.0%) (Figure 8). *V. vulnificus* accounted for the majority of skin infections, including cellulitis, bullae, and other skin infections (56 [51.9%] of 108). *V. vulnificus* also accounted for the majority of severe illnesses, including those with fever (79.5%), bacteremia (80.6%), and shock (66.7%). *V. alginolyticus* accounted for the majority of ear infections (17 [63.0%] of 27). Other symptoms and infections were reported in low frequencies (e.g., bladder infections, hematuria, eye infections, respiratory symptoms, sinus infections, diarrhea, and vomiting).

Previously Unreported Outbreak

One previously unreported recreational water outbreak from 2002 was received. The outbreak is summarized but not analyzed in this *Surveillance Summary*. The outbreak occurred in Florida in December 2002 and involved two

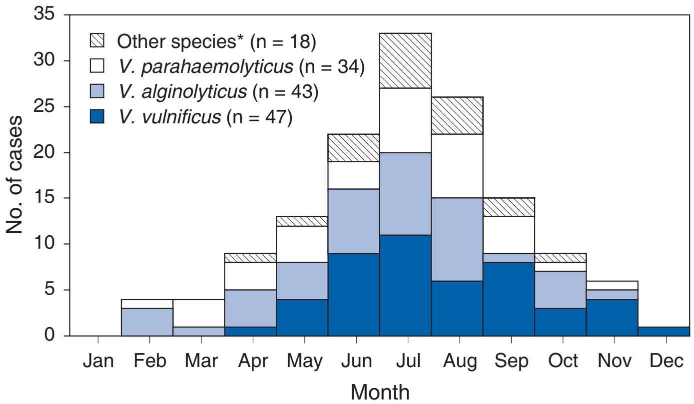
TABLE 9. Number of recreational water-associated *Vibrio* isolations and deaths, by region/state and species — United States, 2003–2004

	Species									
	V. alginolyticus		*V. parahaemolyticus*		*V. vulnificus*		Other/unknown species*		Total	
Region/State	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Atlantic										
Connecticut	0	0	1	0	0	0	0	0	**1**	**0**
Georgia	1	0	0	0	0	0	1	0	**2**	**0**
Maryland	2	1	1	0	2	0	0	0	**5**	**1**
North Carolina	2	0	2	0	1	0	2	0	**7**	**0**
New Jersey	0	0	1	0	0	0	0	0	**1**	**0**
New York	2	0	0	0	0	0	0	0	**2**	**0**
Rhode Island	1	0	0	0	0	0	0	0	**1**	**0**
Virginia	1	0	2	0	2	0	0	0	**5**	**0**
Total	**9**	**1**	**7**	**0**	**5**	**0**	**3**	**0**	**24**	**1**
Gulf Coast										
Alabama	0	0	0	0	1	0	0	0	**1**	**0**
Florida†	9	0	17	0	21	2	4	0	**51**	**2**
Louisiana	0	0	0	0	6	1	0	0	**6**	**1**
Mississippi	1	0	1	0	1	1	0	0	**3**	**1**
Texas	5	0	6	0	8	1	9	2	**28**	**3**
Total	**15**	**0**	**24**	**0**	**37**	**5**	**13**	**2**	**89**	**7**
Noncoastal										
Kansas	0	0	0	0	0	0	1	0	**1**	**0**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**
Pacific										
California	4	0	0	0	0	0	1	0	**5**	**0**
Hawaii	15	0	3	0	5	1	0	0	**23**	**1**
Total	**19**	**0**	**3**	**0**	**5**	**1**	**1**	**0**	**28**	**1**
Total	**43**	**1**	**34**	**0**	**47**	**6**	**18**	**2**	**142**	**9**
Percentage	**(30.3)**	**(11.1)**	**(23.9)**	**(0)**	**(33.1)**	**(66.7)**	**(12.7)**	**(22.2)**	**(100.0)**	**(100.0)**

* Includes *V. cholerae* (non-O1, non-O139, and unknown serotype), *V. damsela*, *V. fluvialis*, *V. alginolyticus*/*V. parahaemolyticus* coinfection, and *Vibrio* species not identified.

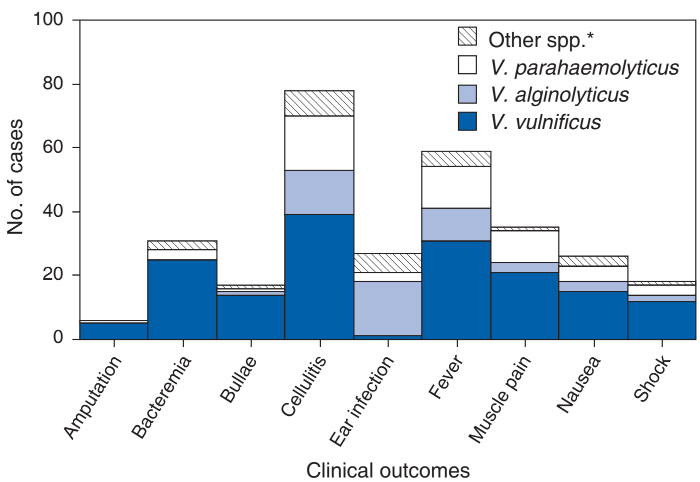
† Five reports from Florida indicate Atlantic coast exposure.

FIGURE 7. Number of illnesses associated with *Vibrio* isolation and recreational water (n = 142), by species and month — United States, 2003–2004



* Includes noncholeragenic *V. cholerae* (eight), *V. damsela* (two), *V. fluvialis* (one), *V. alginolyticus/V. parahaemolyticus* coinfection (one), and *Vibrio* species not identified (six).

FIGURE 8. Number of illnesses associated with *Vibrio* isolation and recreational water (n = 142), by selected clinical outcomes and species — United States, 2003–2004



* Includes noncholeragenic *V. cholerae, V. damsela, V. fluvialis, V. alginolyticus/V. parahaemolyticus* coinfection, and *Vibrio* species not identified.

laboratory-confirmed cases of Legionnaires' disease (i.e., *Legionella pneumophila* serogroup 1) linked to a hotel spa. Both persons were hospitalized and recovered. No *Legionellae* were recovered from the spa, but epidemiologic evidence (Class III) implicated the spa as the probable source for this cluster of cases. Bromine tablets were used to disinfect the spa, but the tablets did not dissolve properly, leading to low bromine concentrations in the water and conditions favorable for the growth of *Legionella*.

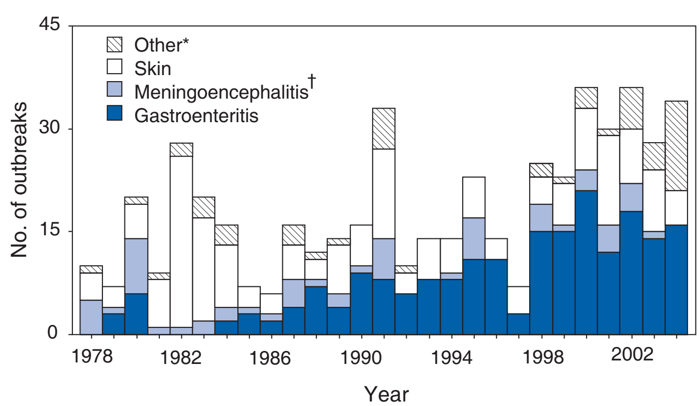
Discussion

Trends in Reporting Outbreaks

A total of 62 recreational water-associated WBDOs were reported to CDC during 2003–2004. This number is a slight decrease from the previous 2001–2002 *Surveillance Summary* in which a record number (65) of WBDOs were reported. Both the number of reported recreational water-associated WBDOs (Pearson's correlation = 0.59; p<0.01) and outbreaks of gastroenteritis (Pearson's correlation = 0.86; p<0.01) have increased significantly since 1978 when CDC first began receiving these reports (Figure 9). These increases are likely a result of a combination of factors such as the emergence of pathogens (e.g., *Cryptosporidium*), increased participation in aquatic activities, and increases in the number of aquatic venues. Increased recognition, investigation, and reporting of recreational water-associated outbreaks also might be contributing factors.

The number of reported WBDOs also differs substantially based on geographic location (Figure 2). This variation might be a result of several factors, including public awareness of the outbreak, availability of laboratory testing, requirements for reporting diseases, and resources available to local and state health departments for surveillance and investigation of probable outbreaks. Differences in the capacity of local and state public health agencies and laboratories to detect WBDOs probably result in reporting and surveillance bias. Therefore, the states with the majority of outbreaks reported for this period might not be the states in which the majority

FIGURE 9. Number of recreational water-associated outbreaks (n = 508), by year and illness — United States, 1978–2004



* Includes keratitis, conjunctivitis, otitis, bronchitis, meningitis, hepatitis, leptospirosis, Pontiac fever, acute respiratory illness, and combined illnesses.

† 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).

of outbreaks actually occurred. An increase or decrease in the number of WBDOs reported might reflect either an actual change in the incidence of outbreaks or a change in the sensitivity of surveillance practices.

Multiple other factors also might influence which WBDOs are reported. Larger outbreaks are more likely to be identified by public health authorities and to receive more rigorous investigations. Etiologic agents with shorter incubation periods might be more easily linked to water exposures, facilitating the recognition of outbreaks. In contrast, private residential pools and spas might experience problems that go undetected because they are not regulated or inspected by public health agencies. In addition, outbreaks of gastroenteritis at large venues that draw from a wide geographic range (e.g., the Great Lakes and ocean beaches) might be difficult to detect because potentially infected persons disperse widely from the site of exposure and, therefore, might be less likely to be identified as part of an outbreak. Such an effect is supported by data from EPA's NEEAR Water Study (*16*). This prospective study of large beaches on the Great Lakes has indicated that elevated rates of gastroenteritis have occurred in swimmers compared with nonswimmers on all four beaches studied, although outbreaks associated with the use of the beaches were not reported during this period. Consistent with this finding, WBDOs reported in *Surveillance Summaries* have not been ocean beach-associated outbreaks of gastroenteritis, and only one Great Lakes beach-associated outbreak of gastroenteritis has been reported since 1978 (*2*). Multiple other prospective studies of gastroenteritis associated with beach swimming have also indicated elevated rates of illness associated with swimming (*21*). This endemic recreational water-associated illness is not captured by the WBDOSS, supporting the need for more studies to be conducted to determine the magnitude of risk of illness for routine, nonoutbreak-associated exposures at recreational water venues.

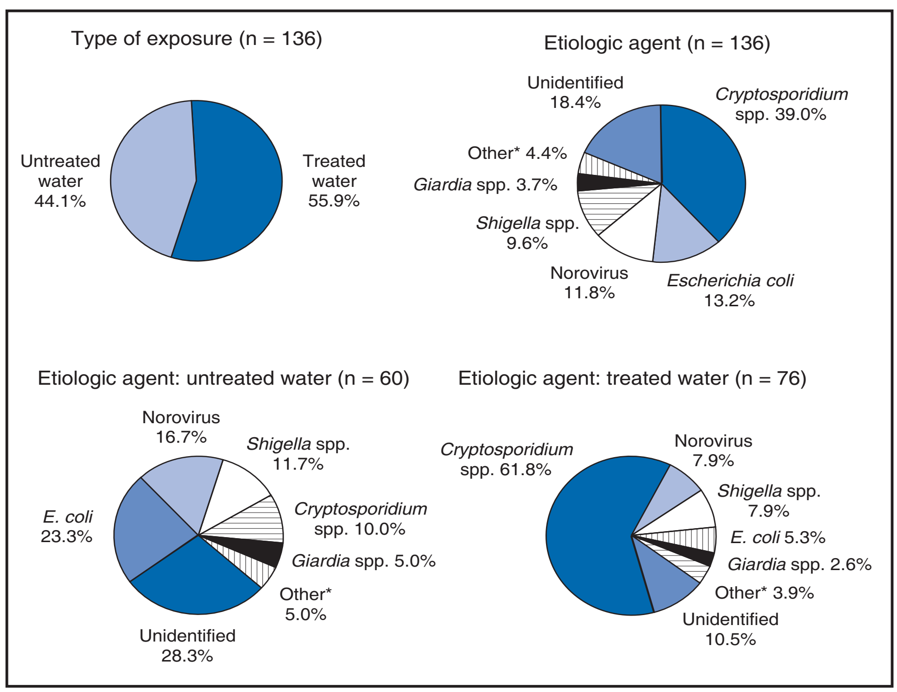
WBDOs associated with recreational water use occur year-round, but the number of reported WBDOs and cases are highest during the annual summer swim season (Figure 4). For public health professionals, these trends can help determine the allocation of resources so that health education messages are targeted to populations during times of the year when the highest risk for preventable illness occurs.

Swimming Pools

Infectious Gastroenteritis

During 2003–2004, *Cryptosporidium* caused the largest number of recreational water-associated outbreaks (n = 11). These outbreaks accounted for the largest number of ill persons included in this report (n = 1206); 99.7% of these cases were associated with treated water venues. During 1995–2004, *Cryptosporidium* was implicated in 39.0% of the recreational water-associated outbreaks of gastroenteritis and, although *Cryptosporidium* rarely was attributed to outbreaks in lakes and rivers (10% of outbreaks), it caused 61.8% of outbreaks associated with treated venues (Figure 10). This observation for treated venues is consistent with the finding that *Cryptosporidium* requires extended contact time with chlorine for inactivation; oocysts can survive for days in the chlorine levels that typically are recommended for swimming pools (1–3 ppm free chlorine; *22*). The continued reporting of cryptosporidiosis associated with the use of treated water venues underscores the importance of other prevention measures that reach beyond traditional pool chlorination, which is currently the primary barrier to infectious disease transmission. Cryptosporidiosis has stimulated the need for new technology to keep swimming venues safe (e.g., ultraviolet light irradiation, ozonation, chlorine dioxide use, or improved

FIGURE 10 . Recreational water-associated outbreaks of gastroenteritis, by type of exposure and etiologic agent — United States, 1995–2004



* These include outbreaks of *Salmonella, Campylobacter, Plesiomonas,* and mixed pathogens.

filtration). However, cryptosporidiosis outbreaks also highlight the need for improved operator training and continued education of the general public concerning appropriate healthy swimming practices to reduce the risk of future outbreaks.

Because *Cryptosporidium* is resistant to the chlorine levels used in pools, outbreaks can occur, even in facilities that are well-maintained. Therefore, a rapid public health response and increased community involvement is needed to prevent the expansion of these outbreaks (*23*). The *Cryptosporidium* outbreak (Ohio, July 2004) that occurred in a community swimming pool demonstrates that a rapid communitywide public health response during the early stages of an outbreak can help control the potential spread of illness into the community. In Ohio, detection and investigation started during the second week after exposure. The response included mitigating actions (e.g., hyperchlorination of all pools and providing instructions regarding proper water hygiene to pool staff and users, day care centers, restaurants, and other potentially affected facilities). In addition, the investigation indicated that no transmission had apparently occurred outside of the single community pool. In contrast, the outbreak in Kansas (July 2003) was not detected for multiple weeks. As a result, a full communitywide outbreak occurred when ill pool patrons and daycare center attendees continued their normal activities (despite their illness) exposing large numbers of persons to *Cryptosporidium*.

Approximately 60% of all cases of illness reported to this surveillance system during 2003–2004 were associated with infectious gastroenteritis outbreaks in treated pools. Several of these outbreaks (e.g., giardiasis, norovirus, and echovirus) could have been prevented or reduced in scale by using proper pool disinfectant procedures and by following existing operation, maintenance, and communication protocols because of the pathogens' chlorine sensitivities. The norovirus outbreak (Vermont, February 2004) demonstrated that when pool staff do not follow these protocols, outbreaks might occur. Despite complaints from patrons concerning water quality, on-duty staff failed to alert off-duty pool operation personnel. As a result, a malfunctioning chlorinator system was not detected for several days; norovirus transmission occurred for multiple days (which probably would have been hours or less with proper chlorination) before the breakdown was discovered and corrected (*24*). This outbreak emphasizes the need for both effective communication channels at aquatic facilities and trained personnel on site or accessible on weekends when pool use is highest.

Swimming behavior is also a critical component of pool operation. Because swimming is essentially communal bathing, when persons who are ill with infectious diarrhea continue to swim, a public health challenge is created that requires a focused public education effort. In addition, improved hygiene is essential to ensure the cleanliness of swimmers entering pools. Functioning and adequate hygiene facilities (i.e., toilets, diaper-changing areas, and showers) in adequate numbers should be located near pools and should provide hot water and handwashing access. Swimmers should be encouraged to shower thoroughly (i.e., washing the perianal surface in particular) before entering the pool. Diaper-changing facilities, with hand-washing stations, should be readily accessible to prevent diaper-changing at the poolside. These outbreaks demonstrate how pools can serve as ideal amplification venues for fecal-oral transmission of pathogens. As a result, facilities should be diligent about making patrons aware of these public health concerns and about making clear that "no diarrhea" policies apply to all pools. This policy is especially needed for young children visiting pools, particularly large groups (e.g., day care centers), which already have diarrhea exclusion policies but might not always enforce them (Kansas, July 2003). Diarrhea exclusion policies should apply to both pool employees when swimming and food workers when preparing food. For the waterpark-associated outbreak in California (August 2004), documentation revealed that employees were ill with diarrhea before the main outbreak, which involved patrons, and that employees admitted to swimming while symptomatic. All aquatic facilities need to establish standardized policies for keeping staff who are ill with diarrhea out of pools and should subsequently implement and enforce these policies.

Meningitis

Although gastroenteritis is the most common illness spread via pool outbreaks, it is not the only disease that can be contracted in this manner. In one outbreak, the transmission of an agent causing viral meningitis via a swimming pool at a recreational vehicle campground (Connecticut, July 2003) was reported. The implicated enterovirus, Echovirus 9, was the predominant enterovirus serotype circulating through the eastern United States during 2003 and is susceptible to chlorine if proper chlorine residuals are maintained (*25*). Properly monitored and maintained chlorination levels and pH control in pools should prevent this type of WBDO.

Chemical Toxicity

During 2003–2004, pool chemicals or disinfection by-products were confirmed (n = one) or suspected (n = eight) in nine pool-associated outbreaks. Chemicals are added to pool water to protect against microbial growth and improve the water quality and efficacy of the disinfection process (e.g., pH control). However, these same chemicals can become sources of illness if they are not properly handled or if water quality and ventilation are poor. One outbreak in New York (March 2003) involved an overflow and spill of muriatic (i.e., hydrochloric) acid, which is used for pH control of pool water. As a result, three persons developed ARI from exposure to fumes. Another outbreak (Illinois, July 2004) was suspected to be caused by ingestion of algaecide that was added to the pool before a swim meet, which resulted in nine persons becoming ill with gastroenteritis. These outbreaks underscore the need for safe chemical training (i.e., adding disinfectant, controlling pH levels, and using pool additives appropriately), handling, and safety practices at all aquatic facilities to protect the health of patrons and staff. These policies should include proper handling of chemicals in the pump room and application procedures for adding pool chemicals directly to the pool.

Six outbreaks of acute respiratory symptoms, eye irritation, and gastroenteritis were suspected to be a result of an accumulation of chloramines in the air and water of indoor pools. Chloramines are disinfection by-products that result from chlorine oxidation of nitrogenous waste compounds, commonly shed into pools by swimmers (e.g., perspiration, saliva, urine, and body oils) (*18*). These chemicals are produced in the water and volatilize in the air. In indoor pool settings, chloramines can also accumulate in the enclosed spaces if ventilation is inadequate (*19*). The resulting high levels of chloramines can cause respiratory tract and mucous membrane irritation (*20*); these high levels also are potentially linked to asthma in indoor pool settings (*26*).

Because of the shortage of laboratories that perform analyses for airborne chloramines and because of rapid shifts in indoor air quality over days, the investigators' ability to respond to reports of airborne chloramines and to quantitatively identify these chemicals is difficult. Investigators should always document the easily measured total chlorine concentration (i.e., free plus combined chlorine) and free chlorine levels of the pool water to obtain some indication of pool water quality and the potential for the presence of disinfection by-products, especially chloramines, which might be present in the water and air.

Multiple steps can be taken to address indoor pool problems, including swimmer behavior modification. Encouraging showering before entering any pool or spa and facilitating frequent bathroom breaks for swimmers, particularly young children (i.e., by instituting adult-only swim times and short closures for water-quality testing), might reduce the amount of 1) urine and other nitrogenous waste contaminating the water and 2) accumulation of chloramines. To encourage swimmers to refrain from urinating in public pools, they should be educated that stinging eyes from pool chemicals are actually caused by human waste (i.e., urine and sweat) in the pool water. Improved indoor pool ventilation is vital to increase air-turnover and to remove concentrated chloramines; however, new studies have suggested that installation of ultraviolet light treatment devices in pool water recirculation systems can reduce pool chloramine levels and inactivate chlorine-resistant pathogens (e.g., *Cryptosporidium*) (*27,28*).

Surveillance for recreational water-associated outbreaks of acute chemical poisonings is likely to have multiple barriers; therefore, the number of reported chemical/toxin WBDOs probably underestimates the true magnitude of the problem. Symptoms associated with chemical poisonings in recreational water settings might be substantially different from those associated with more familiar infectious microbes, which might lead to decreased chemical-related WBDO identification. By contrast, chemicals/toxins and infectious agents might cause similar symptoms (e.g., gastrointestinal illness), and investigators might fail to identify the etiologic agent because they do not suspect a chemical etiology. Multiple health departments use infectious disease epidemiologists for WBDO surveillance and investigation. However, chemical-related WBDOs and recreational WBDOs, in general, might be investigated by staff from different sections of the health department or by staff from different agencies. Because of the acute nature of certain chemical-related WBDOs, first responders will likely be called to the scene, and persons from these agencies might be less likely to report back through the traditional chain of health department infectious disease epidemiologists who report to the WBDOSS. Therefore, building strong and effective intra- and interagency communication networks between health departments and other groups (e.g., first responders and pool operators) to reduce the underreporting of recreational WBDOs is critical.

Spas

Spas are susceptible to contamination from persons infected with the same pathogens that cause gastroenteritis

in swimming and wading pools. However, the increased temperature of the water also makes these venues susceptible to contamination with and amplification of thermophilic pathogens (e.g., *Pseudomonas* and *Legionella*) that naturally occur in the environment (i.e., contamination does not necessarily occur via ill swimmers).

Skin Infections

Spa-associated outbreaks are commonly associated with dermatitis and folliculitis; *P. aeruginosa* is the most commonly reported agent implicated in these settings (*29*). In this report, eight confirmed *Pseudomonas* WBDOs and two suspected *Pseudomonas* WBDOs were documented; five of these outbreaks involved spas, one involved a pool, and four involved both spas and pools. Because of the frequent use of both spas and pools at the facilities, determining whether the spa, pool, or both are implicated in transmission of illness is epidemiologically difficult, although amplification of *Pseudomonas* is more likely to occur in the higher temperatures of spas. One outbreak report (Ohio, July 2004) concluded that *Pseudomonas* growing in a spa was transferred to a pool through combined water circulation and that infection occurred in both settings.

Spas are a challenge to maintain and operate because they typically have reduced bather capacity compared with swimming pools, so they can more easily be overloaded and rapidly lose disinfectant concentrations when bather loads exceed recommended numbers of persons. In addition, depletion of disinfectant levels is increased at higher temperatures. Large gatherings at hotels and motels with spas (e.g., cheerleading competitions [North Carolina, March 2004], dance competitions [Ohio, July 2004], and school class outings [Michigan, February 2003]) can rapidly overload the disinfection capacity and lead to bacterial amplification. In addition to overloading the spas and depleting the disinfectant, these groups frequently arrive on weekends when hotel staff trained in spa maintenance are off duty. Hotels and motels should consider that employees with appropriate pool and spa operation training are needed on weekends, when usage is typically highest. Enhanced monitoring and maintenance should be implemented when a large group or event at a hotel is scheduled.

Multiple aquatic facilities have transitioned to employing remote monitoring services to check pool chemistry (e.g., chlorine and pH) on a regular basis and to alert the facility of any problems that arise. Breakdowns in communication between these remote monitoring services and the aquatic facility seem to facilitate problems that occur for long periods, without correction, which was documented in a large outbreak of *Pseudomonas* dermatitis in Illinois (January 2003) and several previous outbreaks (*30*). Facilities should not rely on off-site monitoring companies as the sole overseers of their aquatic facilities. Although remote monitoring can be beneficial in detecting water-quality problems, the service should not take the place of routine water-quality checks, which are required in the majority of pool codes. To prevent adverse events, having 1) clear communication plans for relaying warnings concerning problems, 2) prompt alerts so corrections can be made, and 3) diligent staff who immediately respond to alerts are essential.

To prevent spa-associated outbreaks, understanding the risk factors and steps that can be taken is necessary to limit transmission of the bacteria. Proper chlorination or bromination is effective in killing *Pseudomonas* and other skin-infecting bacteria. However, sufficient chlorine and bromine levels must be maintained consistently along with adequate pH control to limit bacterial amplification. Poor maintenance of spas has been documented (*31*). Cycling between high and low disinfectant levels allows biofilms to proliferate on spa surfaces, creating an environment where *Pseudomonas* and other bacteria are protected from disinfection (*32*). A review of 18 *Pseudomonas* outbreaks has demonstrated that all spa-associated outbreaks had inadequate disinfection (*33*). The majority of *Pseudomonas* outbreaks can be prevented by properly maintaining spas and by ensuring that disinfectant levels remain >1 ppm and pH levels remain in a range of 7.2–7.8. In addition, elimination of potential sources of *Pseudomonas* (e.g., soil from potted plants in close proximity to the water) (Illinois, January 2003) is advisable.

Pseudomonas is not the only bacterium that can cause spa-related skin infections. MRSA was associated with an outbreak involving an athletic spa in Connecticut (August 2003; *34*). MRSA infections can have substantial consequences, as in this outbreak in which otherwise healthy young athletes were hospitalized. Factors contributing to this outbreak included the presence of skin abrasions on the athletes from "turf burns" and body shaving, and the communal use of an athletic spa that employed limited and unproven disinfection methods. Appropriate spa operation, maintenance, and cleaning should prevent outbreaks of this emerging infectious disease.

Legionellosis

Legionellae, which cause both Legionnaires' disease and PF, are ubiquitous in freshwater environments (*35*). However, certain environmental conditions in spas (e.g., high temperatures and water aerosolization) promote the amplification and transmission of the bacteria. Similar to outbreaks of *Pseudomonas* dermatitis associated with spas,

transmission of *Legionella* is more likely to occur in the absence of adequate levels of disinfectant, underscoring the importance of maintaining disinfectant levels and pH control. When lapses in preventive measures occur and *Legionella* outbreaks occur, morbidity can be reduced by rapid recognition of the outbreak, identification of its source, and immediate implementation of remediation. These methods include cleaning and disinfecting the spa to eliminate *Legionella* colonization and performing follow-up cultures of *Legionella* to ensure that regrowth does not occur (*36*). Of the four *Legionella* WBDOs associated with recreational water during 2003–2004 (as well as one from 2002 which was previously unreported), all except one were associated with hotel spas. These travel-associated WBDOs highlight the importance of timely reporting of individual cases of legionellosis, which was recently recommended in a 2005 CSTE position statement (http://www.cste.org/PS/2005pdf/final2005/05-ID-01final.pdf).

Interactive Fountains/Wet Decks and Waterslides

Infectious Gastroenteritis

Certain treated water venues (e.g., interactive fountains, which are also called wet decks) might be overlooked as potential sites for disease transmission or pool regulation because they do not have the standing water found in traditional swimming pools. Outbreaks in this report continue to demonstrate the possibility of infection occurring in these settings. The use of interactive fountains has previously been associated with outbreaks of gastroenteritis (*37*). In two WBDOs in this report, contaminated interactive fountains are implicated; one involved a *S. sonnei*–contaminated fountain (Oregon, July 2003), and the other involved a *Cryptosporidium*-contaminated (Illinois, July 2004) fountain and swimming pool. In certain states, interactive fountains are not regulated as other recreational water venues, and fountain designs that include recirculation of the bathing water make these venues vulnerable to contamination. New designs that improve water treatment for these interactive fountains are needed so that visitors can enjoy them without risk from waterborne diseases.

The traditional use of tap water to fill or operate temporary aquatic venues (e.g., wading pools and waterslides) used by young children also needs to be reconsidered, particularly in institutional settings (e.g., day care centers and schools). If the water is not treated with adequate levels of disinfectant, residual disinfectant in the water is rapidly depleted; users are then at higher risk of exposure to infectious microbes in the untreated water. Special consideration needs to be given to kiddie pools, some of which have had unfavorable water-quality test results and associations with previous outbreaks (*38*). In one *Cryptosporidium* outbreak (Iowa, June 2003), a kiddie pool at a day care facility was filled with potable municipal water that had not received additional treatment, expediting infection of children and eventual expansion into a communitywide outbreak. In Kansas (July 2003), the communitywide outbreak also involved use of kiddie wading pools and in-ground pools at local day care centers. Portable waterslides in which municipal water is used also might be overlooked as sources of disease transmission because they can be set up, used, and taken down in a matter of hours. The outbreak in Florida associated with a waterslide (May 2004) demonstrated that the use of these slides by a person infected with a fecal-oral transmissible microbe (in this case, norovirus) contaminated the waterslide, so it became an ideal venue for spreading disease. As with pools, spas, and fountains, appropriate treatment of recreational water venues and exclusion of persons with diarrhea is needed to prevent disease transmission. Furthermore, the use of temporary pools filled with municipal water that do not include routine disinfection and filtration should be considered carefully by the public and, based on documented outbreaks, should be eliminated from institutional settings (e.g., day care centers and schools).

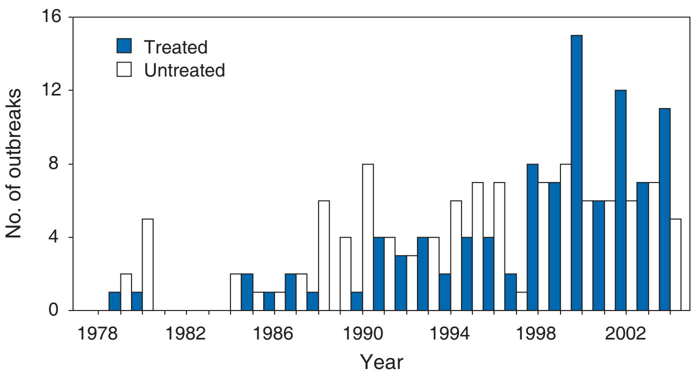
Lakes and Rivers

Infectious Gastroenteritis

Since the WBDOSS began collecting data on recreational water outbreaks, reports have implicated both treated and untreated venues. Since 1998, the numbers of reported outbreaks from treated water venues have surpassed those from untreated venues (Figure 11). For 2003–2004, a total of 12 outbreaks of gastroenteritis associated with untreated freshwater venues were reported; 11 of these outbreaks involved lakes, and one involved a reservoir. Freshwater outbreaks were more likely to be of a bacterial or viral origin than treated water outbreaks (Figure 5).

As with treated venues, human behavior plays a role in the spread of pathogens in untreated bodies of water. For example, in an outbreak in Maryland (July 2003), 5–10 diapers were reportedly retrieved from the lake each week. Modification of swimmer behavior might be a more critical factor because these natural water venues do not have the benefit of disinfection and filtration barriers. Recommendations for swimmer hygiene are the same for lakes, as

FIGURE 11. Number of recreational water associated outbreaks of gastroenteritis (n = 206), by water type and year — United States, 1978–2004



previously discussed regarding treated pools. In addition, beach managers and swimmers should be informed that shallow swimming areas with poor water circulation, although desirable to many swimmers, might pose a higher risk if a swimmer contaminates the water. Use of methods to improve circulation of water through these beach areas should be explored for the potential to reduce the risk for waterborne disease transmission. Additional reduction of risk might be accomplished by avoiding swimming immediately after a heavy rainfall when the water is at higher risk for transient contamination, and by avoiding swimming near storm drains or pipes that might release sewage into bodies of water. The use of water-quality monitoring (e.g., fecal indicator testing) by beach managers might also reduce risk (*15*), particularly when more rapid testing methods are implemented by EPA (*16*).

Primary Amebic Meningoencephalitis

Whereas infection with *Naegleria fowleri*, the cause of primary meningoencephalitis (PAM), is a rare occurrence in the United States (*39*), this disease has public health importance because of its high fatality rate. This free-living ameba proliferates in warm freshwater and hot springs. PAM is caused when the ameba coincidentally enters the nasal passages, travels to the olfactory lobe of the brain, and infects brain tissue. Only one fatality (North Carolina, July 2003) was reported for this 2003–2004 surveillance cycle (excluding *Vibrio* illnesses). During the summer, a young child was exposed to infection through warm lake water, similar to cases of PAM during previous years. PAM is difficult to predict, and prevention strategies might not prevent these tragic events. However, swimmers potentially can reduce their risk of PAM by wearing nose plugs, holding their nose while diving or jumping into the water, refraining from digging in sediment, and avoiding swimming in shallow waters during the warmest times of the year. Additional resources are needed to develop more evidence-based prevention measures.

Leptospirosis

Leptospirosis infection occurs worldwide, except in polar regions, and particularly in tropical and semitropical areas of the world, including several of the Pacific islands that report to this surveillance system (*40*). *Leptospira* can be found in the urine of infected wild and domesticated animals. Human infection can occur when contaminated water is ingested, aerosolized droplets are inhaled, or water enters the body through skin abrasions. One outbreak of leptospirosis was reported for 2003–2004 and involved three cases, which resulted from exposure to a river and waterfalls in Guam (April 2004). This outbreak occurred among U.S. military personnel in a remote area, and water buffalo moving through that region were suspected to have been the possible sources of contamination.

Blue-Green Algae Toxicity

Toxin or chemical-associated outbreaks can occur by natural mechanisms. Blue-green algae that bloom in freshwater lakes have been identified as sources of outbreaks of human waterborne diseases in multiple countries (*41*). The toxins involved include anatoxin (i.e., a potent neurotoxin) and microcystins (i.e., potent liver toxins), and poisonings can cause various symptoms. These symptoms were observed in two outbreaks (Nebraska, 2004) in which 22 persons became ill with ARI and dermatologic symptoms. The actual number of persons who become ill after exposure to blue-green algal toxins in drinking and recreational waters is not known; substantial research is needed to identify the actual extent of this public health threat. Toxin levels can be measured in samples collected from lakes where blooms occur. Currently no regulations exist that establish acceptable toxin levels in drinking or recreational water.

Cercarial Dermatitis

During the 2003–2004 surveillance period, two WBDOs of suspected cercarial dermatitis caused by avian schistosomes were reported (California, June 2003; Ohio, June 2003). Although the diagnosis was not confirmed, this self-limited disease is known to occur in lakes across America where the intermediate host snail species are found and a population of suitable bird hosts are present (*42*). Cases of cercarial dermatitis might be reduced by posting warning signs at lakes known to be infested, avoiding shallow swimming areas where infected snails reside, instituting a snail-control program, and by not attracting birds to swimming areas (e.g., by feeding them).

Marine Water

Vibrio Illness

A limited number of outbreaks at marine venues have been reported to the WBDOSS. Outbreaks in these settings can be difficult to detect because persons affected frequently travel from distant locations to visit these venues and might disperse before a health problem is recognized. However, single cases of *Vibrio* infections from recreational water exposure are captured through the Cholera and Other *Vibrio* Illness Surveillance System (http://www.cdc.gov/foodborneoutbreaks/vibrio_sum/cstevibrio2004.pdf) and represent an essential aspect of waterborne morbidity and mortality in the United States. As a result, recreational water-associated *Vibrio* illnesses will now be included in the WBDOSS to report the scope of waterborne disease in the United States in a more comprehensive manner.

During 2003–2004, the most commonly reported species were *V. vulnificus, V. alginolyticus,* and *V. parahaemolyticus.* Of these species, *V. vulnificus* illnesses had the highest hospitalization rate (87.2%) and mortality rate (i.e., 12.8% of infected patients with recreational water exposure). The predominant syndrome associated with *Vibrio* illness caused by recreational water was wound infection. *Vibrio* wound infections were characterized by cellulitis, muscle pain, and especially with *V. vulnificus*, bullae, and septicemia.

Vibrio illness caused by recreational water exposures occurs in all regions of the United States but most frequently occur along the Gulf Coast. However, the majority of *V. alginolyticus* cases occur in the Pacific coast states, where the most common exposures occur through surfing and swimming. Improved surveillance and analysis is needed to 1) assess the actual magnitude of *Vibrio* illness and other WBDOs at marine water venues, 2) better characterize the risk, and 3) educate the public concerning appropriate prevention measures (e.g., not swimming in warm water when a person has an open wound).

Prevention

Prevention of recreational water illnesses is likely to be accomplished only through a concerted team effort by public health professionals and swimming venue operators to educate all persons involved in recreational water activities, including the general public, concerning appropriate prevention measures. Operators at treated water venues are equipped with various methods that should be employed to prevent outbreaks. The traditional reliance on two water-treatment barriers at treated water venues, chlorination and filtration, might need to be expanded to include in-line (i.e., usually installed after filtration and before chlorination) supplemental disinfection (e.g., ultraviolet light irradiation, ozonation, or chlorine dioxide use). In-line supplemental disinfection can be used to improve the level of protection against pathogens, particularly *Cryptosporidium*. Improved monitoring of water-quality and facility maintenance programs and improved policies to educate the public and decrease body waste contamination of aquatic facilities should also reduce the risk for waterborne diseases. Because of the lack of protective barriers at swimming beaches, beach managers and public health officials should implement water-quality testing programs and educate swimmers concerning appropriate prevention measures, particularly measures addressing environmental pathogens unlikely to be prevented by current water-quality guidelines (e.g., illnesses caused by *Vibrio* and otitis media infections).

Public health professionals should 1) improve training for pool inspectors, 2) update and improve pool codes to stay current with changing designs and needs demonstrated by outbreaks summarized in this report, and 3) lead the educational efforts with aquatic staff and the general public. Safe handling and use of chemicals at aquatic facilities needs to be taught and reinforced. In addition, to improve overall indoor air quality, public health professionals and pool managers need to understand the importance of indoor air quality so that improvements in pool water quality, swimmer hygiene, air-turnover rates, and ventilation will be implemented.

Educating swimmers can play a vital role in reducing recreational water illness by instructing them to follow basic guidelines for healthy swimming. Fecal shedding of pathogens is common (*43*), so reducing the risk of water-related infection is best achieved by implementing diarrhea exclusion policies, using appropriate hygiene measures, and advising the public to minimize the swallowing of recreational water.

Conclusion

Data collected by the WBDOSS are used to characterize the epidemiology of waterborne disease and outbreaks associated with both drinking and recreational water. Swimming is a common activity in the United States (*44*). Certain disease-causing agents are spread through shared bodies of water, and new waterborne pathogens that infect humans (e.g., *Cryptosporidium* and toxigenic *E. coli*) have emerged in the previous three decades. Recreational water illness and outbreaks are associated with both treated and

untreated water and with every type of aquatic venue. Common themes derived from the outbreaks in this report include 1) low disinfectant levels, 2) inadequate water-quality monitoring, 3) high bather loads during large events, 4) breakdowns of equipment and lengthy detection times, 5) lack of essential cleaning of spas to minimize biofilm buildup, 6) accumulation of combined chlorines in pools accompanied by inadequate indoor air ventilation, 7) inadequately trained aquatic staff, 8) unclear communication chains for resolving problems, 9) outbreaks occurring on weekends when trained staff might be off duty, and 10) a lack of awareness by the general public of appropriate healthy swimming behaviors.

Whereas no easy solution exists for reducing recreational water WBDOs, a sustained effort by the swimming public, the pool sector, and public health agencies can reduce the associated risk. The millions of persons in the United States who use recreational water every year can best reduce their risk by staying informed regarding the health and safety concerns associated with swimming. Public health officials should lead this educational effort to promote healthy swimming behaviors. Prevention methods discussed in this report should help make swimming experiences both safe and enjoyable. The aquatic sector also can benefit from the recommendations, which address changes that are needed in operation, maintenance, and chemical handling procedures. Large numbers of violations of state pool codes occur each year (*14,31*), indicating that improved pool operation, disinfection policies, and enforcement are needed to prevent recreational water illness (*45*). In addition, improvements in indoor air quality monitoring and widespread dissemination of validated testing protocols are needed to support improved air quality in indoor swimming pool settings.

Public health professionals at all levels of government should lead a multidisciplinary approach to prevent recreational water illness that includes surveillance, health education, epidemiologic studies, laboratory support, and environmental health research. Educational resources and campaigns are needed for swimmers, parents, aquatic venue operators, and public health staff. Improved communications, particularly during outbreak investigations, between all levels of the public health system (e.g., infectious disease, environmental health, and surveillance staff) and between agencies in neighboring jurisdictions can 1) enhance awareness concerning ongoing occurrences of recreational water illness, 2) facilitate reporting to the WBDOSS in a more timely manner, and 3) strengthen WBDO investigations and responses to protect the public. The timely collection of clinical specimens and water samples for testing during a WBDO investigation and the initiation of an environmental investigation will result in more rapid identifications of the etiologic agent and determination of the conditions leading to the outbreak. However, the capacity of public health departments and laboratories to detect and investigate potential WBDOs varies and needs to be strengthened to meet these challenges. WBDO investigations typically require input from a variety of disciplines, including infectious disease epidemiology, environmental health, clinical medicine, water and sanitation engineering, and microbiology. Additional cross-training of existing personnel in these areas or additional staffing and resources are needed to improve WBDO detection, investigation, and reporting.

CSTE passed a position statement at its 2006 annual meeting making waterborne disease outbreaks, as a unit of reporting, nationally notifiable and reportable to CDC starting in 2007. Adoption of this CSTE recommendation at the state level through state-specific legislative action might improve reporting of waterborne outbreaks at the state and local levels. CDC and EPA were also asked to develop training resources for WBDO investigations that are targeted to local and state/territorial public and environmental health workers responsible for WBDO detection, investigation, and reporting. In addition, CDC and EPA should collaborate with CSTE and developed national WBDO investigation and surveillance guidelines. The position statement is available at http://www.cste.org/PS/2006pdfs/PSFINAL2006/06-ID-12FINAL.pdf (Box).

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BOX. Organizations that provide assistance in investigations of waterborne disease and outbreaks (WBDOs) associated with recreational water exposure

State health departments can request epidemiologic assistance and laboratory testing from CDC to investigate WBDOs. CDC and the U.S. Environmental Protection Agency (EPA) can be consulted regarding engineering and environmental aspects of recreational water treatment and collection of proper water samples to identify pathogenic viruses, bacteria, and parasites, which require special protocols for their recovery.

National WBDO Investigation and Surveillance Guidelines
CDC, EPA, and CSTE Position Statement
Internet: http://www.cste.org/PS/2006pdfs/PSFINAL2006/06-ID-12FINAL.pdf

How to Report WBDOs
Waterborne Disease Outbreak Coordinator
Division of Parasitic Diseases
National Center for Zoonotic, Vector-Borne, and Enteric Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC
Telephone: 770-488-7775
Fax: 770-488-7761
CDC Reporting Form (CDC 52.12, rev.01/2003)
Internet: http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf

Requests for Testing for Viral Organisms
Division of Viral Diseases
National Center for Immunization and Respiratory Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC
Telephone: 404-639-3607

Requests for Testing for Bacterial Enteric Organisms
Division of Foodborne, Bacterial, and Mycotic Diseases
National Center for Zoonotic, Vector-Borne, and Enteric Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC
Telephone: 404-639-1798

Requests for Testing for Parasites
Division of Parasitic Diseases
National Center for Zoonotic, Vector-borne, and Enteric Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC
Telephone: 770-488-7775

Requests for Information or Testing for *Legionella*
Division of Bacterial Diseases
National Center for Immunization and Respiratory Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC
Telephone: 404-639-2215
Internet: http://www.cdc.gov/legionella

Information Regarding Legionellosis
Internet: http://www.cdc.gov/legionella

CDC provides public health professionals, clinicians, laboratorians, and persons in other allied health fields with background and clinical information, guidance on investigations, and resources concerning Legionnaires' disease and Pontiac fever cases or potential outbreaks. Resources include outbreak investigative tools, environmental sampling protocols, fact sheets, clinical evaluation and management guides, and laboratory testing protocols.

Information Regarding Healthy Swimming
CDC Internet: http://www.cdc.gov/healthyswimming
- Recreational water health communication and education resources for the general public and aquatic staff
- Pool and spa operation guidelines, including disinfection and fecal accident response
- Outbreak investigation toolkit and technical information concerning laboratory diagnostics

Information Regarding Beaches
EPA Internet: http://www.epa.gov/OST/beaches

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Appendix A

Glossary of Definitions

bather load	The maximum number of bathers who may use a swimming pool or spa at any one time. This limit is usually determined by state or local pool code, based on surface area and depth of the pool or spa.
biofilm	Microbial cells that adhere to a surface through a matrix of primarily polysaccharide materials in which they are encapsulated. These can grow on piping and surfaces of aquatic venues and can be notoriously difficult to remove. They offer protection to microbes from disinfectants (e.g., chlorine) in the water.
cercarial dermatitis	Dermatitis caused by contact/skin perforation by the cercariae (larval stage) of certain species of schistosomes, a type of parasite, for which the 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 and outbreaks are classified according to the strength of the epidemiologic and water-quality data implicating recreational water as the source of the disease or outbreak (see Table 1).
chloramines	A group of disinfection by-products or weak disinfectants formed when free chlorine combines with nitrogen-containing compounds in the water (e.g., urine or perspiration). Tri- and di-chloramine can cause eye, skin, lung, and throat irritation and can accumulate in the water and air over treated-water pools. In drinking water treatment, monochloramine is used for disinfection to reduce formation of disinfection by-products created when using chlorine as a disinfectant.
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. Chlorine that has combined with organic compounds in the water and is no longer an effective disinfectant for recreational water. This value is derived by subtracting the free chlorine test level from total chlorine test level.
contact time	The length of time water (and pathogens) is exposed to a disinfectant; usually measured in minutes (e.g., chlorine contact time).
Cryptosporidium	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, primates, and monkeys. Both species were referred to previously as *C. parvum*.
dermatitis	Inflammation of the skin. In this surveillance summary, the term dermatitis is used to denote a broad category of skin-related symptoms (e.g., folliculitis, cellulitis, burns, or rash).
disinfection by-products	Chemicals formed in water through reactions between organic matter and disinfectants. Includes chloramines.
etiologic agent	The pathogen, chemical, or toxin causing a waterborne disease or outbreak. Infectious etiologic agents include bacteria, parasites, and viruses.

fecal coliforms	Coliforms that grow and ferment lactose to 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 pore 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 chlorine	The chlorine in water not combined with other constituents; therefore, it is able to serve as an effective disinfectant (also referred to as free available chlorine or residual chlorine). A common water-quality test.
freshwater (untreated water)	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 or water/spray feature intended for (or accessible to) recreational use. They usually do not have standing water as part of the design. These are sometimes called spray pads, splash pads, wet decks, or spray grounds. 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 or estuarine setting.
microcystin toxin	A secondary metabolite of blue-green algae (cyanobacteria) that can have toxic effects on humans and animals, potentially causing a wide range of illness or even death when exposure to accumulated toxins in fresh or marine water occurs.
mixed agent outbreak	More than one type of etiologic agent is identified in clinical specimens from affected persons and each etiologic agent is found in ≥5% of positive clinical specimens (e.g., an outbreak with *Giardia* spp. [parasites] and *Salmonella* spp. [bacteria] with each agent identified in ≥5% of stool specimens).
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.
predominant illness	The category of symptoms most commonly expressed in a substantial proportion (≥50%) of patients (e.g., gastroenteritis, dermatitis, acute respiratory illness). When more than one illness category seems to define the character of the waterborne disease and outbreak, they are listed together as predominant illnesses.
recreational water venue	A body of water used for the purpose of recreation (e.g., swimming, soaking, or athletics) including any structure that encloses this water. It can include lakes and ponds, rivers, springs, the ocean, and man-made venues (e.g., swimming pools, spas, and waterparks) that do not necessarily include standing water (e.g., interactive fountains).
reservoir, impoundment	An artificially maintained lake or other body of water created for the collection and storage of water. This body of water may be available for recreational use.
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 purposes 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.

total chlorine	The chlorine in water that is free for disinfection (free chlorine) plus that combined with other organic materials (combined chlorine). A common water quality test. The combined chlorine level is derived by subtracting the free chlorine test result from the total chlorine test result.
total coliforms	Nonfecal and fecal coliforms that are detected by using a standard test.
treated water	Water that has undergone a disinfection or treatment process (e.g., chlorination and filtration) for the purpose of making it safe for recreation. Typically, this refers to any recreational water in an enclosed, manufactured structure but may include swimming or wading pools, fountains, or spas filled with treated tap water (e.g., small wading “kiddie” pool) or untreated water (e.g., mineral spring water) that receives no further treatment.
untreated water	Surface water that has not been treated in any way (i.e., lakes, rivers, and reservoirs).
Vibrio species	A genus of comma-shaped, gram-negative Proteobacteria that include a variety of human pathogens. Some of these species are found in salty or brackish water and can cause illness by contamination of a wound or epithelial site (e.g., eardrums or sinus cavities). Sequelae can include sepsis and death.
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 with a density or concentration that correlates best with health effects associated with a type of hazard or pollution (e.g., turbidity, coliforms, fecal coliforms, *Escherichia coli*, enterococci, free chlorine level).

Appendix B

Selected Descriptions of Waterborne Disease and Outbreaks (WBDOs) Associated with Recreational Water

Date of WBDO	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
Parasites				
June 2003	Massachusetts	*Giardia intestinalis*	149	A community outbreak of giardiasis was traced to a membership club. The investigation demonstrated an association with use of a kiddie pool at the facility, where at least 30 persons had primary exposures. Another 105 cases had links to those primary cases, indicating secondary person-to-person transmission. No violations of water or safety regulations were found by inspection of the membership club, although the pool closed for the season before the investigation was conducted.
June 2003	Iowa	*Cryptosporidium* and *Giardia* spp.	63	A kiddie wading pool at a child care center, filled with the municipal water supply, was implicated as the original source of this outbreak. This was followed by expansion into a communitywide outbreak via secondary transmission. An estimated 100 persons became ill, although the reported number of confirmed cases was 63; 20 persons had *Giardia*, 35 had *Cryptosporidium*, and eight had coinfections.
July 2003	Kansas	*C. hominis*	617	An increased incidence of laboratory-confirmed cryptosporidiosis alerted a local health department, and the subsequent inquiry revealed an ongoing communitywide outbreak with multiple clusters identified. Although the initial point of transmission could not be identified, transmission was associated with swimming pools (different swim teams, day camps), and multiple day care facilities where water activities were prevalent. Children who continued to swim while ill with diarrhea likely contributed to the continued spread of disease.
July 2003	North Carolina	*Naegleria fowleri*	1 (1)	A child aged 12 years swam at a popular recreational freshwater lake with frequent splashing, diving, and swimming underwater giving ample opportunity for the ameba to enter the nasal cavities. The child had a headache 2 days later, was hospitalized 4 days after the headache, and died 3 days later.
July 2004	Ohio	*C. hominis*	160	A health-care professional alerted the health department about a cluster of cryptosporidiosis cases. The health department responded rapidly through community health alerts, hyperchlorination of the community pool, and expanded public health activity at a county festival. An estimated 85% of patients swam at a community pool in the 2 weeks leading up to their onset of illness. Two peak days of attendance in August 2004 were identified as the likely time of exposure for the majority of cases, which was only 1 week before the initial health department response. Although ill persons resided in three different Ohio counties, the investigation indicated a low rate of transmission in any of the affected counties and that little transmission occurred beyond the municipal pool. Hyperchlorination of the pool appeared to be effective in stopping transmission, and a rapid response and containment of the outbreak were likely responsible for preventing further spread.
August 2004	California	*Cryptosporidium* spp.	336	A recreational waterpark was implicated as the source of this outbreak. Approximately 80% of persons calling the county health department to report illness had visited the park before their onset of symptoms. Many of the employees of the waterpark were ill with a median onset date that preceded that for ill members of the public. Park policy required employees to be in the water regularly, and no policy was in place for reassigning employees who were ill with diarrhea.
Bacteria				
December 2002	Florida	*Legionella pneumophila* serogroup 1	2	Two non-Florida residents had Legionnaires' disease and were epidemiologically linked to a Florida hotel at which they had both stayed during their incubation periods. In addition, the spa was the only common location identified at the hotel in which transmission could have occurred. Both patients had spent several hours each day in the spa. Though no *Legionella* species were recovered from the spa, the levels of bromine disinfectant were low and resulted in an environment where the pathogen was more likely to grow.
January 2003	Illinois	*Pseudomonas aeruginosa*	52	Multiple guests of a large hotel contracted dermatitis and/or ear infections and an investigation associated spa usage with illness. Records from an off-site monitoring company demonstrated that chlorine (oxidation reduction potential was actually measured) and pH levels were well below recommended levels. Communication between the monitoring company and hotel did not result in prompt maintenance of the spa. The hotel eventually discovered that the chlorinator pump switch had been turned off. A potted plant and soil near the spa might have contributed to contamination, and *Pseudomonas* was detected in multiple environmental samples from the spa.
February 2003	Wisconsin	*L. pneumophila* serogroup 1	3	Three cases of Legionnaires' disease were linked to a hotel spa. *Legionella* was isolated from the spa water that had insufficient disinfectant concentrations. Active case-finding also identified persons with potential signs and symptoms of Pontiac fever, each of whom was exposed to the implicated spa.

Date of WBDO	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
May 2003	Georgia	*Shigella sonnei*	13	Contact with or having water from a freshwater lake in the mouth was associated with increased risk for shigellosis. Attack rates ranged from 38%–58% and increased with prolonged exposure. Fecal coliform measurements exceeded recommended standards. The man-made lake had no outlets, and septic systems were adequate. Investigators concluded that contamination was likely caused by fellow bathers.
July 2003	Maryland	*S. sonnei* and *Plesiomonas shigelloides*	65	Visitors from four different states swam in a state park lake and became ill with gastroenteritis. Fecal coliform and *Escherichia coli* levels exceeded standards on at least one sample collection time. Lifeguards at the lake reported that 5–10 diapers were pulled from the lake each week, and on one occasion, a camper was observed dumping waste into a drain that flowed into the lake instead of into the dump station. Both behaviors were suggested as contributing to contamination of the lake. The bathing beach permit was temporarily suspended during the investigation and partially obstructed sewer lines repaired.
July 2003	Oregon	*S. sonnei*	56	After a physician reported seeing five unrelated children with diarrhea, an investigation linked transmission to a local interactive fountain commonly visited by community children. A case-control study indicated that 39% of children who played in the fountain subsequently experienced diarrhea, compared with 3% of those who did not visit the fountain. Fecal coliforms and *E. coli* were detected in the water, and zero chlorine residual could be measured. This particular fountain was subsequently redesigned to include an automated chlorinator and was required to be licensed and regulated as a public wading pool.
August 2003	Connecticut	Methicillin-resistant *Staphylococcus aureus*	10	In an investigation of a MRSA outbreak within a college football team of 100 players, 10 cases were detected, two needing hospitalization. Risk factors included abrasions from artificial grass ("turf burns"), player positions with more frequent body-to-body contact (cornerbacks and wide receivers), and body shaving (particularly groin/genital shaving). Infection also was associated with sharing the whirlpool spa at the team's athletic training center. The water in this spa used a single daily addition of povidone for disinfection. This practice of adding disinfectant did not meet Connecticut pool code regulations nor was the disinfectant approved for this use.
March 2004	Oklahoma	*L. pneumophila* serogroup 1	107	A hotel hosted participants of a youth basketball tournament over several days. Many of the guests were using the hotel spa throughout this period, leading to occasional bather overload. Disinfectant levels in the water were not being consistently monitored or maintained during this time. Four cases required hospitalization; however, the majority of ill persons had symptoms of Pontiac fever. Urine antigen testing and serology were used for laboratory confirmation. Environmental testing of the spa and its surroundings, which was performed after extensive decontamination measures took place, did not reveal evidence of *Legionella* growth.
July 2004	Ohio	*P. aeruginosa*	119	Two pools and a spa at a resort hosting an interstate dance competition were all associated with this large *Pseudomonas* outbreak. Symptoms included rash, eye and ear infections, fever, nausea, vomiting, and diarrhea. The water from an indoor pool and the spa could co-mingle because of specific design features (e.g., waterfalls) connecting the features, and water samples from both were positive for the *Pseudomonas*. This contamination, along with the high bather load resulting from the dance competition, provided the opportunity for widespread transmission.
Viruses				
July 2003	Connecticut	Echovirus 9	36	An outbreak of meningitis was associated with swimming at an RV campground pool. The investigation identified 36 cases; 12 of which were categorized as aseptic meningitis and 24 that had enterovirus-like illness (acute illness with any of several meningitis-like symptoms). Pool disinfectant levels were inadequate to support a high bather load. Chlorine testing was only performed in the early morning and evening after heavy bather use.
February 2004	Vermont	Norovirus	70	The state health department was notified of a group of children with gastroenteritis who had all attended the same swimming club during the previous weekend. The investigation revealed several more cases, including an adult who was hospitalized for severe vomiting. Multiple lapses in pool staff training and maintenance contributed to the outbreak. Staff lacked formal training in pool operation, disinfectant levels and monitoring were inadequate, the pool operator was off for the weekend, and the pool staff did not call for maintenance when patrons complained about the water quality. This led to a delay in identifying a chlorinator pump tube malfunction. As a result, norovirus was transmitted via the pool water for much longer (multiple days) than would have occurred if disinfectant levels were appropriately maintained.
March 2004	Idaho	Norovirus	140	A regional swim meet at a community pool facility was associated with this outbreak of gastroenteritis. Although cases occurred amongst swimmers (approximately 450) and nonswimmers (approximately 550) at the event, swimming in the pools was a significant risk factor. Certain proper hygiene measures, such as showering before entering the pool and having functional hand washing sinks in the restrooms, were not being consistently followed and could have amplified spread of the disease. Both pools were found to be within normal operating limits for free chlorine (1.0–3.0 ppm) and pH (7.2–7.8) before and during the meet, although this would be unlikely to prevent short-term transmission.
May 2004	Florida	Norovirus	42	An elementary school "game day" included two water slides that were wet down with municipal tap water so that the water was likely to be disinfectant free in a short period. After one of the slides was used by a child with diarrhea, several classmates continued to use the slide, as students from another class did while the original class ate lunch. Students from both classes, as well as household contacts, became ill.

Date of WBDO	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
July 2004	Oregon	Norovirus	39	Swimming beaches at a lake were closed after initial reports of several cases of gastroenteritis were received. This popular recreational lake had been receiving routine bacterial water quality testing since 1991, when it was the site of a 59-case outbreak of *E. coli* O157:H7 and *Shigella sonnei* (**Source:** Keene WE, McAnulty JM, Hoesly FC, Williams LP Jr, Hedberg K, Oxman GL, Barrett TJ, Pfaller MA, Fleming DW. A swimming-associated outbreak of hemorrhagic colitis caused by *Escherichia coli* O157:H7 and *Shigella sonnei*. N Engl J Med 1994;331:579–84).
Chemicals/Toxins				
March 2003	New York	Muriatic (hydrochloric) acid	3	Acid, used to adjust pool water pH, was spilled on the floor of an indoor swimming pool/ membership club. The resulting fumes caused respiratory symptoms among three persons in the vicinity, all of whom were taken to an emergency department for treatment and were subsequently released.
July 2004	Nebraska	Microcystin toxin (blue-green algae)	20	All affected persons were swimming in a lake that was experiencing a blue-green algae bloom, a common occurrence in Nebraska lakes during late summer months. Symptoms included rashes, diarrhea, cramps, nausea, vomiting, and fevers. The lake was found to have >15 ppb of microcystin toxin. The lake was closed to public use while the toxin levels remained high. A nearby lake in the same county reported a similar outbreak during July, with two ill persons involved.
Unidentified				
March 2004	Illinois	Suspected chloramines	57	A physician reported six members of a family experienced respiratory illness after a visit to a local hotel's indoor pool area. The subsequent investigation uncovered 51 additional cases related to this pool. Symptoms included burning eyes (77%), cough (47%), and fatigue (25%), among others. Exposure to pool water was a risk factor for illness. One child with asthma was hospitalized after the exposure. Chloramines were suspected as the source of the "strong chlorine-like odor" that visitors noticed in the pool area. A similar outbreak at another Illinois hotel in January 2004, with 22 cases, also was attributed to chloramines in the indoor pool area underscoring the importance of air quality at indoor recreational water facilities.
August 2004	New Mexico	Suspected chloramines	16	A chlorinated, indoor pool at a membership club was the site of an outbreak suspected to involve inhaled chloramines. Inadequate ventilation in the pool area was believed to be a contributing factor. Symptoms included both acute respiratory and gastrointestinal complaints, reinforcing the concept that diarrhea and vomiting associated with recreational water can have chemical etiologies as well as infectious ones. Five other outbreaks described in this report have similar characteristics to this one, including illness suspected to be caused by chemicals in the indoor pool area's air and water. Because of the difficulty of measuring transient airborne chloramine levels exact etiologies were not confirmed. All these outbreaks (with a total of 104 cases) demonstrate the need for good disinfection and maintenance of water quality along with adequate ventilation of indoor recreational water venues.
***Vibrio* infections**				
July 2004	Mississippi	*Vibrio vulnificus*	1 (1)	An adult male with a history of hepatitis C and cirrhosis of the liver sustained an injury to his chest wall from a bottle rocket while at a marine beach with a group of friends. He used ocean water to clean the wound and was hospitalized 2 days later with infection of the injured site. The *Vibrio* was cultured from his blood. After 2 days in the hospital, the patient died from complications of the infection; this was the only reported death from Vibrio site infection during 2003–2004 in Mississippi.
August 2004	North Carolina	*V. alginolyticus* and *V. parahaemolyticus*	1	A teenaged female was surfing at a coastal beach and cut her left calf on the fin of her surfboard while in the water. The wound was sutured at a local emergency department. After a 3-day incubation period, the patient reported to a Maryland hospital with cellulitis at the injury site. Incision and drainage was performed, and the surfer was treated with antibiotics and hospitalized for 5 days. Both species of *Vibrio* were cultured from the wound exudate (this was the only reported recreational water case during 2003–2004 to have two separate *Vibrio* species identified).
August 2004	Virginia	*V. parahaemolyticus*	1	An adult male was fishing at a coastal salt water site, when he was accidentally hit in the eye with his fishing hook while cutting his line. The eye became watery and irritated and days later he saw a physician for treatment. Antibiotics were successfully administered and the patient fully recovered without the need to be hospitalized.
September 2004	Florida	*V. parahaemolyticus*	1	An elderly man was found in the water of a brackish lagoon in the aftermath of Hurricane Ivan. He had sustained an injury on his left leg from the debris. Incision, drainage, and a skin graft were all eventually needed. His infection, which was confirmed by culturing the wound exudate, was probably exacerbated by additional risk factors: diabetes and use of prednisone for arthritis, both of which can lead to an immunocompromised state.

Surveillance for Waterborne Disease and Outbreaks Associated with Drinking Water and Water not Intended for Drinking — United States, 2003–2004

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Abstract

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

Reporting Period: Data presented summarize 36 WBDOs that occurred during January 2003–December 2004 and nine previously unreported WBDOs that occurred during 1982–2002.

Description of System: The surveillance system includes data on WBDOs associated with drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent. Public health departments in the states, territories, localities, and Freely Associated States (i.e., 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) are primarily responsible for detecting and investigating WBDOs and voluntarily reporting them to CDC by using a standard form.

Results: During 2003–2004, a total of 36 WBDOs were reported by 19 states; 30 were associated with drinking water, three were associated with water not intended for drinking, and three were associated with water of unknown intent. The 30 drinking water-associated WBDOs caused illness among an estimated 2,760 persons and were linked to four deaths. Etiologic agents were identified in 25 (83.3%) of these WBDOs: 17 (68.0%) involved pathogens (i.e., 13 bacterial, one parasitic, one viral, one mixed bacterial/parasitic, and one mixed bacterial/parasitic/viral), and eight (32.0%) involved chemical/toxin poisonings. Gastroenteritis represented 67.7% of the illness related to drinking water-associated WBDOs; acute respiratory illness represented 25.8%, and dermatitis represented 6.5%.

The classification of deficiencies contributing to WBDOs has been revised to reflect the categories of concerns associated with contamination at or in the source water, treatment facility, or distribution system (SWTD) that are under the jurisdiction of water utilities, versus those at points not under the jurisdiction of a water utility or at the point of water use (NWU/POU), which includes commercially bottled water. A total of 33 deficiencies were cited in the 30 WBDOs associated with drinking water: 17 (51.5%) NWU/POU, 14 (42.4%) SWTD, and two (6.1%) unknown. The most frequently cited NWU/POU deficiencies involved *Legionella* spp. in the

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drinking water system (n = eight [47.1%]). The most frequently cited SWTD deficiencies were associated with distribution system contamination (n = six [42.9%]). Contaminated ground water was a contributing factor in seven times as many WBDOs (n = seven) as contaminated surface water (n = one).

Interpretation: Approximately half (51.5%) of the drinking water deficiencies occurred outside the jurisdiction of a water utility in situations not currently regulated by EPA. The majority of the WBDOs in which deficiencies were not regulated by EPA were associated with *Legionella* spp. or chemicals/toxins. Problems in the distribution system were the most commonly identified deficiencies under the jurisdiction of a water utility, underscoring the importance of preventing contamination after water treatment. The substantial proportion of WBDOs involving contaminated ground water provides support for the Ground Water Rule (finalized in October 2006), which specifies when corrective action is required for public ground water systems.

Public Health Actions: CDC and EPA use surveillance data to identify the types of water systems, deficiencies, and etiologic agents associated with WBDOs and to evaluate the adequacy of current technologies and practices for providing safe drinking water. Surveillance data also are used to establish research priorities, which can lead to improved water-quality regulation development. The growing proportion of drinking water deficiencies that are not addressed by current EPA rules emphasizes the need to address risk factors for water contamination in the distribution system and at points not under the jurisdiction of water utilities.

Introduction

During 1920–1970, statistical data regarding U.S. waterborne-disease outbreaks were collected by 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 Waterborne Disease and Outbreak Surveillance System (WBDOSS) that tracks the occurrences and causes of waterborne disease and outbreaks (WBDOs) associated with drinking water. WBDOs associated with recreational water were added to the surveillance system in 1978 (*2*); WBDOs associated with occupational settings, water not intended for drinking (WNID)* and commercially bottled water were added in 1999 (*3*); and WBDOs associated with drinking water contaminated at the point of use, contaminated ice and beverages made with contaminated water, and beverages contaminated as a result of plumbing failures in drink mix/soda machines have been added to this report. This *Surveillance Summary* includes data from 30 WBDOs related to drinking water, three WBDOs related to WNID, and three WBDOs related to water of unknown intent (WUI). Nine previously unreported outbreaks also have been included in this report. Recreational water-associated disease and outbreaks have been presented in a separate report (*4*). This *Surveillance Summary* also introduces multiple changes in the WBDOSS to better characterize the breadth of waterborne-disease challenges in the United States.

* Additional terms have been defined (Appendix A, Glossary of Definitions).

Waterborne disease and outbreak surveillance activities 1) characterize the epidemiology of WBDOs; 2) identify changing trends in the etiologic agents and other risk factors associated with WBDOs; 3) identify major deficiencies in providing safe drinking water; 4) encourage public health personnel to detect and investigate WBDOs; and 5) foster collaboration among local, state, federal, and international agencies on initiatives to prevent waterborne disease. Data from this surveillance system are useful for identifying major deficiencies in providing safe drinking water, can influence research priorities, and can lead to improved focus in water-quality regulation development. However, the statistics reported in this report represent only a portion of the burden of illness associated with water exposure. In general, the surveillance information does not include endemic, nonoutbreak-related waterborne-disease risks, and reliable estimates of the number of unrecognized WBDOs are not available.

Background

U.S. Environmental Protection Agency 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) (*5–7*). SDWA authorizes EPA to set national standards to protect public drinking water and its sources against naturally occurring or man-made contaminants. Previously set standards by which

TABLE 1. U.S. Environmental Protection Agency regulations regarding drinking water, by year enacted — United States, 1974–2006

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
Ground Water Rule (proposed)	2000
Lead and Copper Rule — action levels	2000
Filter Backwash Recycling Rule	2001
Long Term 1 Enhanced SWTR	2002
Unregulated Contaminant Monitoring Regulations	2002
Drinking Water Contaminant Candidate List 2	2005
Long Term 2 Enhanced SWTR	2006
Stage 2 D-DBP Rule	2006
Ground Water Rule finalized	2006

microbial contamination is regulated include 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 (*8,9*). These rules have been described in more detail in a previous report (*3*).

All public water systems are required by TCR to monitor for total coliforms at a prescribed frequency (*10,11*). SWTR (*12*) and IESWTR (*13*) apply to public systems that serve ≥10,000 persons and surface water or ground water under the direct influence of surface water. These two rules are intended to protect the public against exposure to *Giardia intestinalis*, *Cryptosporidium* spp., viruses, *Legionella* spp., and other selected pathogens. LT1ESWTR applies to public systems that serve <10,000 persons and is intended to improve the control of microbial pathogens, especially *Cryptosporidium* spp. (*14*). An additional regulation, the Filter Backwash Recycling Rule, requires the return of recycle flows to the water treatment process so that microbial contaminant removal is not compromised (*15*).

Recently finalized microbial and disinfection by-products regulations include the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) and the Stage 2 Disinfectants and Disinfection By-products Rule (DBPR2). These regulations were developed simultaneously to address risk tradeoffs between the control of pathogens and limiting exposure to disinfection by-products (DBPs) that can form in water from the disinfection process used to control microbial pathogens (*16*).

LT2ESWTR (*17,18*) requires the use of treatment techniques and monitoring, reporting, and public notification for all public water systems that use surface water sources. Key provisions include the following: source water monitoring for *Cryptosporidium* spp.; additional treatment for filtered systems on the basis of source-water *Cryptosporidium* 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.

DBPR2 applies to all community and all nontransient, noncommunity water systems that use a disinfectant other than ultraviolet light (*17*). DBPR2 requires systems to meet maximum contaminant levels for total trihalomethanes and five haloacetic acids 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 customers are exposed to high DBP levels.

The 1996 SDWA amendments require EPA to develop regulations that mandate disinfection of public ground water systems, as necessary, to protect the public health. The Ground Water Rule (GWR) (finalized by EPA in October 2006) specifies when corrective action, including disinfection, is required to protect consumers from bacteria and viruses (*19*). Additional information is available at http://www.epa.gov/safewater/gwr.html. Requirements include periodic sanitary surveys to identify deficiencies, hydrogeologic sensitivity assessments for nondisinfected systems, source-water microbial monitoring from certain systems, and compliance monitoring for systems that disinfect to ensure adequate inactivation or removal of viruses. SDWA Wellhead Protection Program requires every state to develop a program to delineate wellhead protection areas in which sources of contamination are managed to minimize ground water contamination (*19*).

Every 5 years, EPA is 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 (CCL1) was issued in 1998 and included 50 chemical and 10 microbial contaminants (*20*). However, EPA decided not to regulate *Acanthamoeba*, which was on the first list. The second Contaminant Candidate List 2 (CCL2) carried forward nine microbiologic contaminants from CCLl, excluding *Acanthamoeba* (*21*). EPA also must establish criteria for a program to monitor unregulated contaminants and

publish a list of contaminants to be monitored (*22–25*). Microorganisms on this list include those for which analytical methods are available (*Aeromonas*) and those for which analytical methods are being developed (i.e., *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 for or excluded from regulation.

Methods

Data Sources

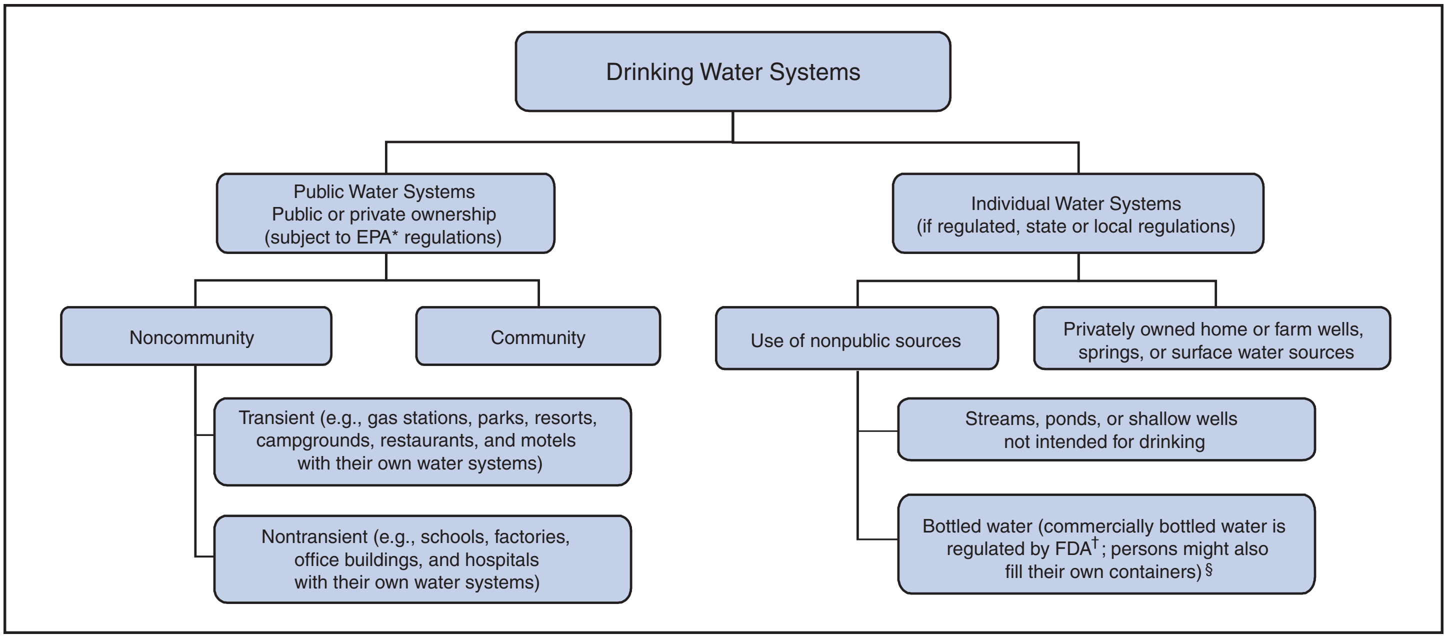
Public health departments in the states, territories, localities, and Freely Associated States (FAS) (i.e., the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau, formerly parts of the U.S.-administered Trust Territory of the Pacific Islands) have primary 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 WBDO (e.g., cases, time, and location); results from epidemiologic studies; results from clinical specimen and water sample testing; and other factors potentially contributing to the WBDO (e.g., environmental concerns, disinfection deficiencies, and filtration problems). 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 water treatment as needed. Information also can be solicited from other CDC surveillance systems and confirmed with the state, territory, locality, or FAS for inclusion as a WBDO. Numerical and text data are abstracted from the WBDO report form and supporting documents and entered into a database for analysis. Although reports of WBDOs are collected through the WBDOSS, the cases and outbreaks associated with drinking water, WNID, and WUI are analyzed and published separately from the cases and outbreaks associated with recreational water (*4*).

Definitions

The unit of analysis for the WBDOSS is typically an outbreak, not an individual case of a waterborne disease. Two criteria must be met for an event to be defined as a waterborne outbreak associated with drinking water, WNID (excluding recreational water) or WUI. First, two or more persons must be epidemiologically linked by location of exposure to water, time, and illness. This criterion is waived for single cases of laboratory-confirmed primary amebic meningoencephalitis (PAM) and for single cases of chemical/toxin poisoning if water-quality data indicate contamination by the chemical/toxin. Second, the epidemiologic evidence must implicate water as the probable source of illness. Reported cases and outbreaks associated with contaminated drinking water; contaminated commercially bottled water, ice, or beverages made with contaminated water; and deficiencies of equipment/devices for which water is used or distributed (e.g., beverages contaminated by plumbing failures in drink mix/soda machines) are classified as WBDOs. WBDOs associated with cruise ships are not summarized in this report. Tabulation of WBDOs and associated cases is based on location of water exposure, not on state of residence of the ill persons.

Numerous types of drinking water systems exist and have been outlined (Figure 1). Public water systems, which are classified as either community or noncommunity , are regulated under SDWA. Of the approximately 167,012 public water systems in the United States, 112,948 (67.6%) are noncommunity systems, including 93,210 transient systems and 19,738 nontransient systems; 54,064 (32.4%) are community systems. Despite representing a minority of water systems, community systems serve 264 million persons (approximately 93.9% of the U.S. population) (*26*). Furthermore, a limited number of community systems (15%) provide water to 90% of the community system population (*26*). Noncommunity, nontransient systems provide water to 6.9 million persons, and noncommunity, transient systems provide water to 12.9 million persons (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) (*26*). Although the majority of public water systems (91.6%) are supplied by ground water, more persons (63.4%) drink from public systems served by surface water (*26*). Approximately 15.0% of the U.S. population relies on individual water systems that are privately owned (*27*). In previous *Surveillance Summaries*, commercially bottled water, when linked with a WBDO, was classified as an individual water system; these WBDOs are now classified as bottled water. WNID is defined as water used in occupational settings; lakes, springs, and creeks used as drinking water by campers and boaters; irrigation water; and other nonpotable water sources with or without taps. WNID does not include recreational water, which is dis-

FIGURE 1. Types of drinking water systems



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

cussed in a separate *Surveillance Summary* (*4*). WBDOs with more than one implicated water system type are tabulated and analyzed as mixed water systems (e.g., noncommunity and individual).

Source water is defined as the untreated water (i.e., raw water) used to produce drinking water. WBDOs with more than one implicated water source are tabulated and analyzed as mixed water sources (e.g., lake and well). For WNID or WUI, primary water exposure is defined as the source of contaminated water.

Water setting is defined as the location of ill person's exposure to the contaminated water. The setting applies to drinking water, WNID, and WUI.

The purpose of this surveillance system is not only to evaluate the relation between water and reported outbreaks and disease, but also to identify system breakdowns, operator errors, and other engineering-related activities that lead to outbreaks. To understand the circumstances and system breakdowns that lead to illness, each WBDO is classified as having one or more deficiencies (Table 2).

Waterborne Disease and Outbreak Strength of Evidence Classification

All WBDOs reported to the surveillance system have been classified according to the strength of the evidence implicating water as the vehicle of transmission (Table 3). The classification scheme (i.e., Classes I–IV) is based on the epidemiologic and water-quality data provided with the WBDO report form. Although WBDOs without water-quality data might have been included in this report, reports that lacked epidemiologic data, linking the outbreak to water, have been excluded.

A classification of I indicates that adequate epidemiologic and water-quality data were reported. However, this classification does not necessarily imply that the investigation was optimally conducted nor does a classification of II, III, or IV imply that the investigation was inadequate or incomplete. WBDOs and their resulting investigations occur under different circumstances, and not all WBDOs can or should be rigorously investigated. In addition, WBDOs that affect few persons are more likely to receive a classification of III or IV because of the limited sample size available for analysis.

Changes in the 2003–2004 *Surveillance Summary*

Names, definitions, and other parameters in this report have been modified and expanded to better reflect the changing epidemiology of WBDOs and capture the wide scope of water-related disease. This section highlights those changes.

TABLE 2. Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent

Deficiency
Contamination of water at/in the water source, treatment facility, or distribution system (SWTD)*
1: Untreated surface water intended for drinking
2: Untreated ground water intended for drinking
3: Treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, or inadequate or no filtration)
4: Distribution system deficiency, including storage (e.g., cross-connection, backflow, contamination of water mains during construction or repair)
Contamination of water at points not under the jurisdiction of a water utility or at the point of use (NWU/POU)†
5: *Legionella* spp. in water system
A: Water intended for drinking
B: Water not intended for drinking (excluding recreational water)
C: Water of unknown intent
6: Plumbing system deficiency after the water meter or property line (e.g., cross-connection, backflow, or corrosion of pipes)
7: Deficiency in building/home-specific water treatment after the water meter or property line
8: Deficiency or contamination of equipment/devices using or distributing water (e.g., drink-mix machines)
9: Contamination during commercial bottling
10: Contamination during shipping, hauling, or storage
A: Water intended for drinking – Tap water
B: Water intended for drinking – Commercially bottled water
11: Contamination at point of use
A: Tap
B: Hose
C: Commercially bottled water
D: Container, bottle, or pitcher
E: Unknown
12: Drinking or contact with water not intended for drinking (excluding recreational water)
Unknown/Insufficient information
99: Unknown/Insufficient information
A: Water intended for drinking – Tap water
B: Water intended for drinking – Commercially bottled water
C: Water not intended for drinking (excluding recreational water)
D: Water of unknown intent

*Contamination of water and deficiencies occurring in the drinking water system at/in the water source, treatment facility, or distribution system of pipes and storage facilities. For a community water system, the distribution system refers to the pipes and storage infrastructure under the jurisdiction of the water utility before the water meter or property line (if the system is not metered). For noncommunity and nonpublic individual water systems, the distribution system refers to the pipes and storage infrastructure before entry into a building or house.

† Contamination of drinking water and deficiencies occurring after the water meter or outside the jurisdiction of a water utility (e.g., in a service line leading to a house or building, in the plumbing inside a house or building, during shipping or hauling, during storage other than in the distribution system, or at point of use).

TABLE 3. Classification of investigations of waterborne disease and outbreaks — United States

Class	Epidemiologic data	Water-Quality data
I	Adequate Data provided concerning exposed and unexposed persons, with relative risk or odds ratio ≥2 or p≤0.05	Provided and adequate Laboratory data or historical information (e.g., reports of a chlorinator malfunction, a water main break, 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 and no historical information)
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

Title

The title of this *Surveillance Summary* has been changed. The change in the title of this report emphasizes and better represents the public health importance of single cases of waterborne disease and disease associated with water exposures other than drinking water and recreational water.

Etiologic Agents

Etiologic agents are typically identified through clinical specimen testing. If more than one agent is identified, only those agents that individually represent ≥5% of positive clinical specimens appear in the tables and calculations as etiologic agents for that WBDO. Occasionally, clinical specimen data are unavailable, but water sample testing implicates a particular etiologic agent that is consistent with the presenting illness. In these situations, the agent identified by water testing is listed as the etiologic agent for that WBDO. WBDOs in which the etiologic agent is unconfirmed or unknown are listed as unidentified, even when other data (e.g., clinical findings) are suggestive of a particular pathogen or chemical/toxin. In previous reports, the term "acute gastrointestinal illness (AGI)" was used to indicate WBDOs of unidentified etiology associated with gastrointestinal symptoms. Because AGI refers to a type of illness and not to an etiologic agent, the term "unidentified" is now used to describe WBDOs with unknown etiology.

When each etiologic agent is of the same agent type (i.e., bacterial, chemical/toxin, parasitic, or viral), the WBDO is analyzed within that category (e.g., an outbreak with both *Cryptosporidium* spp. and *Giardia* spp. will be analyzed as a parasitic outbreak). When agents represent more than one type, the WBDO is analyzed as a mixed-agent WBDO (e.g., an outbreak with both *Giardia* spp. and *Salmonella* spp. will be analyzed as a mixed parasitic and bacterial outbreak).

Predominant Illness

All WBDOs are categorized according to predominant illness. Whereas the illness associated with a WBDO generally includes only one category of symptoms (e.g., gastroenteritis), WBDOs do occur where the symptoms cluster into more than one category (e.g., gastroenteritis and dermatitis). Therefore, in this report, any illness symptom reported by ≥50% of patients will be listed; multiple illnesses will be listed for a single WBDO, if applicable. Mixed illness WBDOs are analyzed separately from single illness WBDOs.

Case Counts and Deaths

The number of deaths associated with each WBDO has been added to the case counts. No deaths occurred unless noted. This change provides greater information on the severity of illness associated with each WBDO.

Deficiencies

Water utilities manage the drinking water in public systems before the water reaches the water meter (or before the property line if the distribution system is not metered). These public drinking water systems are subject to EPA regulations. Drinking water concerns arising after the meter or property line (e.g., *Legionella* colonization in plumbing, plumbing contamination and cross-connections within buildings and homes, and drink mix/soda machine deficiencies) might not be under the jurisdiction of water utilities and might not be regulated under current EPA drinking water rules. To characterize drinking water concerns that might have different oversight, the classification of deficiencies leading to WBDOs has been modified in this report. The new deficiency classification (Table 2) provides greater detail concerning the circumstances and risk factors that led to illness and clarifies deficiencies that might require different types of public health responses.

In the old deficiency classification (formerly deficiencies 1–5), antecedent circumstances related to WBDOs that occurred outside the jurisdiction of a water utility were 1) classified with water distribution system deficiencies that were within the jurisdiction of a water utility (formerly deficiency 4); 2) classified as miscellaneous deficiencies (formerly deficiency 5); or 3) not classified at all (e.g., *Legionella* colonization in plumbing). In the new deficiency classification, a clear distinction is made between contamination occurring at or in the source water, treatment facility, or distribution system (SWTD) (deficiencies 1–4), which are under the jurisdiction of a water utility if a public water system is involved versus contamination at points not under the jurisdiction of a water utility or at the point of use (NWU/POU) (i.e., deficiencies 5A, 6–11, and 99A and 99B). The NWU/POU deficiencies include WBDOs associated with drinking water contaminated during shipping, hauling, storing, or use; commercially bottled water; ice or beverages made with contaminated water; and deficiencies of equipment/devices in which water is used or distributed (e.g., beverages contaminated by plumbing failures in drink mix/soda machines). For WBDOs involving consumption or contact with WNID and WUI, separate deficiency classifications (i.e., deficiencies 5B, 5C, 12, 99C, and 99D) are used.

The reporting and analysis of deficiencies also have changed to emphasize that individual WBDOs might be associated with more than one deficiency. Instead of reporting and analyzing only the primary deficiency when multiple deficien-

cies have been identified, all deficiencies are now considered. Identifying only the primary deficiency might be difficult because more than one deficiency might have resulted in contamination of water that would result in illness. To reflect this complexity, tables and figures that report deficiency information report all deficiencies that have likely contributed to the WBDO. Therefore, the total number of deficiencies is greater than the total number of WBDOs.

Water System Type

Drinking water systems remain categorized as community, noncommunity, or individual systems. For the 1999–2000 and 2001–2002 *Surveillance Summaries,* WBDOs linked to commercially bottled water and WNID were classified as individual water systems for analysis purposes (*3,28*). For 2003–2004, to distinguish between piped and nonpiped drinking water, the definition of an individual drinking water system no longer includes commercially bottled water and WNID. WBDOs associated with commercially bottled water are now classified separately (i.e., bottled). Separating piped from nonpiped water also distinguishes between drinking water systems regulated by EPA (community and noncommunity) and the FDA (i.e., bottled). WBDOs associated with WNID no longer have a water system type designation because the risk factors associated with these WBDOs are not relevant to drinking water systems.

Analyses involving water system types have also changed. If a WBDO involving more than one water system type occurs, the WBDO is classified and analyzed as a mixed water system. Furthermore, all analyses that involve water system types are limited to WBDOs with deficiencies 1–4 and deficiency 99 when a water system can be identified but insufficient information concerning the deficiency is available. Under the revised deficiency classification, the only deficiencies relevant to the type of drinking water system associated with the WBDO are deficiencies 1–4 (i.e., surface water contamination, ground water contamination, water treatment deficiencies, and distribution system contamination).

Water Source

The only deficiencies relevant to the type of drinking water source involved in the WBDO are deficiencies 1–3 (i.e., surface water contamination, ground water contamination, and water treatment deficiencies). Therefore, all analyses presented in this report that involve source water type are limited to WBDOs with deficiencies 1–3. If a WBDO involves more than one source water type, the WBDO is classified and analyzed as a mixed source WBDO.

Legionella

Although outbreaks of Pontiac fever (PF) have been included in the WBDOSS since 1981, outbreaks of Legionnaires' disease (LD) only have been included since the 2001–2002 surveillance period (*28*). During this period, all PF and LD outbreaks were listed in the drinking water *Surveillance Summary* in a table separate from the tables listing other drinking water-associated WBDOs; the single PF outbreak associated with recreational water was discussed in the recreational water *Surveillance Summary* (*29*). Beginning with the 2003–2004 *Surveillance Summary*, PF and LD outbreaks associated with drinking water are included in the same line lists with other drinking water-associated WBDOs. Similarly, PF and LD outbreaks associated with recreational water are listed and discussed in the 2003–2004 *Surveillance Summary* of recreational water-associated WBDOs (*4*). Inclusion and analysis of PF and LD outbreaks with other drinking water-associated WBDOs is a reflection of the changing epidemiology of WBDOs. *Legionella* outbreaks that occur in association with WNID or WUI also are listed and discussed in this report.

Water Not Intended for Drinking and Water of Unknown Intent

In previous *Surveillance Summaries*, WBDOs (excluding *Legionella* outbreaks) associated with WNID or with WUI were integrated into the drinking water WBDO line lists. Beginning with this report, WBDOs (including *Legionella* outbreaks) associated with WNID or with WUI are listed in separate tables to distinguish the different water types.

Strength of Evidence Classification for Waterborne Disease and Outbreaks

Single cases of PAM or chemical/toxin poisoning are now given strength of evidence classifications (Table 3) along with the other WBDOs. These single cases do not receive rankings higher than III because relative risks, odds ratios, and p values are not calculated from single cases.

Results

During 2003–2004, 19 states reported 36 WBDOs (i.e., 14 for 2003 and 22 for 2004). These WBDOs were associated with water intended for drinking (n = 30), WNID (n = three), and WUI (n = three) and are tabulated by year and state (Tables 4–6).

TABLE 4. Waterborne-disease outbreaks associated with drinking water (n = 12), by state — United States, 2003

State	Month	Class	Etiologic agent	Predominant illness	No. of cases* (n = 819)	Type of system†	Deficiency§	Water source	Setting
Florida	Jan	II	Unidentified¶	Gastroenteritis	419	Bottle	11C	Spring	Sports complex
Florida	Nov	III	Bromate and other byproducts of disinfection	Gastroenteritis	2	Bottle	9	Unknown	Private residence
Illinois	Jul	I	Unidentified	Gastroenteritis	180	Ncom	99A	Well	Water park
Maine	Dec	III	Cleaning product	Gastroenteritis	2	Bottle	10B	Spring	Unknown
Maryland**	Oct	III	*Legionella pneumophila* serogroup 1	Acute respiratory	7	Com	5A	Well	Hotel
Michigan	Sep	I	Unidentified	Gastroenteritis	4	Com	11D	Well	Worksite
Minnesota	Jun	I	Copper	Gastroenteritis	4	Com	8	River, stream	Restaurant
Minnesota	Nov	I	Copper	Gastroenteritis	5	Com	8	Lake	Restaurant
New York	Mar	III	Sodium hydroxide	Dermatitis	4	Com	3	Well	Community
Ohio	Nov	I	*Campylobacter jejuni* and *Shigella* spp.††	Gastroenteritis	57	Ind	1	Pond	Worksite
Utah	Jul	III	Unidentified	Gastroenteritis	25	Ncom	99A	Unknown	Camp
Washington	May	III	*Campylobacter* spp.§§	Gastroenteritis	110	Ind	2, 4	Well	Farm

* No deaths were reported.
† Com: community; Ncom: noncommunity; Ind: individual; Bottle: commercially bottled water. Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and schools), whereas transient systems provide water to places in which persons do not remain for long periods (e.g., restaurants, highway rest stations, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
§ Refer to Table 2 - Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent.
¶ Etiology unidentified; norovirus suspected based on incubation period, symptoms, and duration of illness.
** **Source:** CDC. Legionnaires' disease associated with potable water in a hotel—Ocean City, Maryland, October 2003–February 2004. MMWR 2005;54:165–8.
†† Sixteen persons had stool specimens that tested positive for *C. jejuni*, and two persons had stool specimens that tested positive for *Shigella* spp.
§§ Nine persons had stool specimens that tested positive for *Campylobacter* spp., and three persons had stool specimens that tested positive for *C. jejuni*.

Waterborne Disease and Outbreaks Associated with Water Intended for Drinking

The 30 drinking water-associated WBDOs (i.e., 12 during 2003 and 18 during 2004) were reported by 18 states (Figure 2). The number of drinking water-associated WBDOs reported for 2003–2004 is similar to that reported for 2001–2002 (n = 36, including the five previously unreported outbreaks for 2002 [Table 7; Figure 3]). WBDOs associated with drinking water occurred throughout the year (Figure 4). Five states (Florida, New Jersey, New York, Ohio, and Pennsylvania) reported the highest number of drinking water-associated WBDOs (three each) for 2003–2004. Selected WBDO descriptions have been reported (Appendix B, Descriptions of Selected Waterborne Disease and Outbreaks (WBDOs) Associated with Drinking Water, Water Not Intended for Drinking, and Water of Unknown Intent).

The 30 drinking water-associated WBDOs reported for 2003–2004 caused illness among approximately 2,760 persons and resulted in four deaths. The median number of persons affected in a WBDO was seven (range: 1–1,450). Twenty-nine WBDOs were associated with either acute respiratory illness (ARI) or AGI, and one WBDO was associated with both ARI and AGI. All ARI outbreaks were associated with exposure to *Legionella* spp. (Figure 5).

Seven (23.3%) of the 30 drinking water-associated WBDOs were given a strength of evidence Class I ranking on the basis of epidemiologic and water-quality data; one (3.3%) was ranked as Class II; 20 (66.7%) were ranked as Class III; and two (6.7%) were ranked as Class IV. Drinking water-associated WBDOs are tabulated by etiologic agent and type of water system (Table 8), etiologic agent and type of water source (Table 9), type of deficiency and type of water system (Table 10), type of deficiency and type of water source (Table 11), predominant illness and type of water system (Table 12), and predominant illness and type of water source (Table 13). WBDOs were included (Tables 8–13) only if the type of deficiency involved in each WBDO was associated with the summarized variable. WBDOs were not included if the type of deficiency did

TABLE 5. Waterborne-disease outbreaks associated with drinking water (n = 18), by state — United States, 2004

State	Month	Class	Etiologic agent	Predominant illness	No. of cases (deaths)* (n = 1,941)	Type of system†	Deficiency§	Water source	Setting
Florida	Oct	III	Gasoline byproducts	Gastroenteritis	1	Bottle	99B	Unknown	Private residence
Maryland	Dec	III	*Legionella pneumophila* serogroup 1	Acute respiratory	6 (2)	Com	5A	Well	Condominium
Montana	Aug	III	*Salmonella typhimurium*	Gastroenteritis	70	Ncom	3, 4	Well	Restaurant
New Jersey	Apr	III	Sodium hydroxide	Dermatitis	2	Com	3	Well	Community
New Jersey	Jun	III	*L. pneumophila* serogroup 1	Acute respiratory	2	Com	5A	River	Apartment
New Jersey	Jul	III	*L. pneumophila* serogroup 1	Acute respiratory, Gastroenteritis¶	2 (1)	Com	5A	River	Senior housing center
New York	Jan	III	*L. micdadei*	Acute respiratory	2	Com	5A	Reservoir	Hospital
New York	May	III	*L. pneumophila* serogroup 1	Acute respiratory	2	Com	5A	Reservoir	Hospital
Ohio	Jan	III	*Campylobacter jejuni*, *Campylobacter lari*, *Cryptosporidium* spp., and *Helicobacter canadensis***	Gastroenteritis	82	Com	4	Well	Factory
Ohio	Jul	I	*C. jejuni,* norovirus, and *Giardia intestinalis*††	Gastroenteritis	1450	Ncom/Ind	2, 4	Well	Restaurant, bar camp, and tourist attraction
Pennsylvania	Jan	I	Norovirus	Gastroenteritis	70	Ncom	6	Pond	Ski resort
Pennsylvania	Jun	III	Unidentified	Gastroenteritis	174	Ncom	3	Well	Camp
Pennsylvania	Apr	III	*L. pneumophila* serogroup 1	Acute respiratory§§	3 (1)	Com	5A	Well, lake, and creek	Nursing home
South Carolina	Jul	III	Copper	Gastroenteritis	7	Com	8	Lake	Restaurant
Texas	Sep	IV	*L. pneumophila* serogroup 1	Acute respiratory	3	Com	5A	Well	Hospital
Virginia	Aug	IV	*Campylobacter* spp.	Gastroenteritis	34	Com	4	Well	Community
Vermont	Jun	III	*G. intestinalis*	Gastroenteritis	11	Ncom	4	Well	Camp
Wisconsin	Dec	III	*C. jejuni*	Gastroenteritis	20	Ncom	2	Well	Restaurant

* Deaths are indicated in parentheses if they occurred.
† Com: community; Ncom: noncommunity; Ind: individual; Bottle: commercially bottled water. Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and schools), whereas transient systems provide water to places in which persons do not remain for long periods (e.g., restaurants, highway rest stations, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
§ Refer to Table 2 - Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent.
¶ Two persons had cough, fever, and diarrhea.
** Seven persons had stool specimens that tested positive for *C. jejuni,* one person had a stool specimen that tested positive for *C. lari*, one person had a stool specimen that tested positive for *Cryptosporidium* spp., and one person had a stool specimen that tested positive for *H. canadensis*.
†† Sixteen persons had stool specimens that tested positive for *C. jejuni*, nine persons had stool specimens that tested positive for norovirus, and three persons had stool specimens that tested positive for *G. intestinalis*. Only one person (<5%) had a stool specimen that tested positive for *S. typhimurium* — this pathogen is not included in the table.
§§ Legionnaires' disease was diagnosed in two persons, and Pontiac fever was diagnosed in one person.

not reflect the summarized variable (e.g., the source of raw untreated water would unlikely be relevant for a *Legionella* outbreak associated with a building plumbing system).

Etiologic Agents

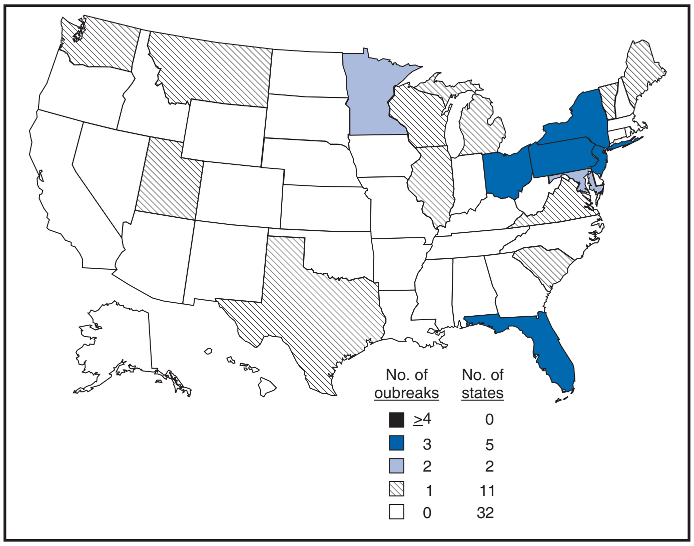
Twenty-five (83.3%) of the 30 drinking water-associated WBDOs were of known etiology; 17 (68.0%) were attributed to an infectious etiology, and eight (32.0%) were attributed to chemical/toxin poisoning. Of the 17 WBDOs with known infectious etiology, 13 (76.5%) were caused by bacteria (eight [61.5%] of which were caused by *Legionella* spp.), two (11.8%) were caused by more than one etiologic agent type, one (5.9%) was caused by a parasite, and one (5.9%) was caused by a virus. Five (16.7%) of the 30 drinking water-associated WBDOs were of unknown etiology. The distribution of etiologic agents for

TABLE 6. Waterborne-disease outbreaks associated with water not intended for drinking (excluding recreational water) and water of unknown intent (n = six), by state — United States, 2003–2004

State	Month/ Year	Class	Etiologic agent	Predominant illness	No. of cases (deaths)* (n = 36)	Deficiency†	Primary water exposure	Setting
New York	Jul 2003	IV	*Legionella pneumophila* serogroup 1	Acute respiratory	2	5C	Unknown	Nursing home
New York	Jul 2004	III	*L. pneumophila* serogroup 1	Acute respiratory	2 (1)	5B	Cooling tower	Nursing home
North Carolina	Sep 2004	I	*L. pneumophila* serogroup 1	Acute respiratory	7 (3)	5B	Cooling tower	Nursing home, hospital, and factory
Ohio	Jul 2004	I	*L. pneumophila* serogroup 1	Acute respiratory§	13	5C	Unknown	Worksite
Texas	Oct 2004	IV	*L. pneumophila* serogroup 1	Acute respiratory	2	5C	Unknown	Hotel
Wisconsin	Jul 2003	IV	*Escherichia coli* O157:H7	Gastroenteritis	10	12	Broken septic line	Camp

* Deaths are indicated in parentheses if they occurred.
† Refer to Table 2 - Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent.
§ Two confirmed cases of Legionnaires' disease and 11 probable cases with symptoms consistent with Pontiac fever.

FIGURE 2. Number* of waterborne-disease outbreaks associated with drinking water — United States, 2003–2004



* n = 30; numbers are dependent on reporting and surveillance activities in individual states and do not necessarily indicate that more outbreaks occurred in a given state.

the 30 drinking water-associated WBDOs has been reported (Figure 6).

Bacteria. Thirteen WBDOs affecting 318 persons were attributed to bacterial infections: eight *Legionella* spp. outbreaks, three *Campylobacter* spp. outbreaks, one *Salmonella typhimurium* outbreak, and one outbreak involving two different bacteria (16 persons had stool specimens that tested positive for *C. jejuni,* and two persons had stool specimens that tested positive for *Shigella* spp.). Illnesses from these 13 WBDOs resulted in four deaths, all of which were associated with *Legionella* spp.

Chemicals/Toxins. Eight WBDOs affecting 27 persons were attributed to chemical/toxin poisoning; no deaths were reported. Three WBDOs involved high levels of copper associated with drink mix/soda machines; three WBDOs were a result of contamination of commercially bottled water with bromate and other by-products of disinfection, cleaning products, and gasoline by-products; two WBDOs were a result of large volumes of sodium hydroxide discharged into community water supplies.

Mixed agents. Two WBDOs were attributed to more than one type of etiologic agent; no deaths were reported. The largest reported outbreak affected 1,450 persons and involved at least one bacterium (i.e., *C. jejuni*, although one clinical specimen with *S. typhimurium* also was reported), one virus (norovirus), and one parasite (*Giardia intestinalis*). The second mixed-agent outbreak affected 82 persons and involved infection with three different bacteria (i.e., *C. jejuni*, *C. lari*, and *Helicobacter canadensis*) and one parasite (*Cryptosporidium* spp.).

Parasites. One WBDO attributed to *G. intestinalis,* affected 11 persons. No deaths were reported.

Viruses. One WBDO attributed to norovirus affected 70 persons. No deaths were reported.

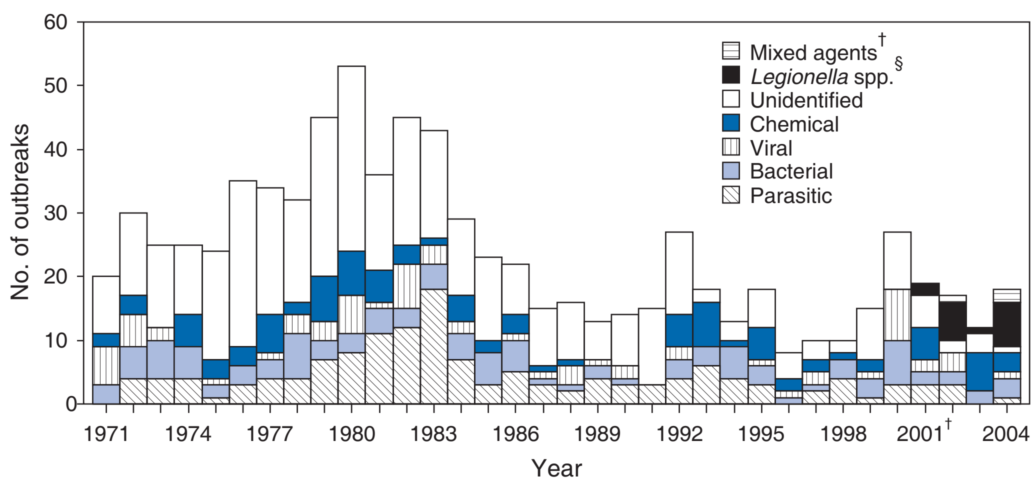
Unidentified etiologic agents. Five WBDOs involving AGI of unidentified etiology affected 802 persons; no deaths were reported. Stool testing to identify a causative agent was attempted in four of the five outbreaks. In one outbreak at a volleyball tournament, norovirus was suspected on the basis of incubation period, symptoms, and duration of illness (Florida, January 2003). However, the implicated water tested negative for norovirus, and patient samples were not collected for confirmatory testing.

TABLE 7. Waterborne-disease outbreaks that were not included in previous surveillance summaries (n = nine), by state/territory — United States, 1982–2002

State/Territory	Month/ Year	Class	Etiologic agent	Predominant illness	No. of cases* (n = 217)	Type of system†	Deficiency§	Water source	Setting
Maryland	Nov 2002	III	*Legionella pneumophila* serogroup 1	Acute respiratory	3	Com	5A	Reservoir	Club
New York	May 1982	III	Unidentified	Gastroenteritis	16	Ncom	3	Well	Restaurant
New York	May 1984	II	Copper	Gastroenteritis	15	Com	4	Reservoir	Restaurant
New York	Aug 1995	I	Unidentified¶	Gastroenteritis	30	Ncom	2, 11E	Well	Motel
New York	Aug 1996	I	Unidentified**	Gastroenteritis	58	Ncom	2	Well	Camp
New York	Jul 2002	III	*Escherichia coli* O157:H7	Gastroenteritis	6	Ind	2	Well	Private residence
New York	Dec 2002	I	*Campylobacter jejuni*, *Entamoeba* spp., and *Giardia* spp.††	Gastroenteritis	27	Com	2	Well	Apartment
Palau	Apr 2002	III	*Entamoeba histolytica*	Gastroenteritis	59	Ncom	99A	Stream	Unknown
Virgin Islands§§	Nov 2002	III	*L. pneumophila* serogroup 1	Acute respiratory	3	Ncom	5A	Reservoir, cistern¶¶	Hotel

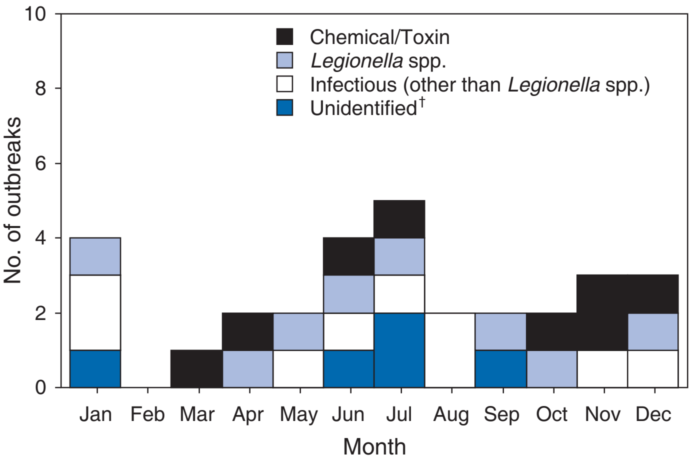
* No deaths were reported.
† Com: community; Ncom: noncommunity; Ind: individual; Bottle: commercially bottled water. Community and noncommunity water systems are public water systems that have ≥15 service connections or serve an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
§ Refer to Table 2 - Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent.
¶ Etiology unidentified; Norwalk-like virus suspected based on incubation period, symptoms, and duration of illness.
** Etiology unidentified; viral etiology suspected based on incubation period, symptoms, and duration of illness.
†† Three persons had stool specimens that tested positive for *C. jejuni*; two persons had stool specimens that tested positive for *Entamoeba* spp., and one person had a stool specimen that tested positive for *Giardia* spp.
§§ **Source:** Cowgill KD, Lucas CE, Benson RF, et al. Recurrence of Legionnaires' disease at a hotel in the United States Virgin Islands over a 20-year period. Clin Infect Dis 2005;40:1205–7.
¶¶ Rainwater cistern sometimes was supplemented with community water.

FIGURE 3. Number* of waterborne-disease outbreaks associated with drinking water, by year and etiologic agent — United States, 1971–2004



* n = 803.
† Beginning in 2003, mixed agents of more than one etiologic agent type were included in the surveillance system. However, the first observation is a previously unreported outbreak in 2002.
§ Beginning in 2001, Legionnaires' disease was added to the surveillance system, and *Legionella* spp. were classified separately in this figure.

FIGURE 4. Number* of waterborne-disease outbreaks associated with drinking water, by etiologic agent and month — United States, 2003–2004



* n = 30.
† Unidentified etiology includes suspected etiologies not confirmed during the outbreak investigation.

Reports for the other four WBDOs did not note a suspected etiologic agent.

Deficiencies

Thirty-three deficiencies were cited in the 30 drinking water-associated WBDOs. Fourteen (42.4%) deficiencies involved the source water, treatment facility, or distribution system (SWTD); 17 (51.5%) deficiencies occurred at points not under the jurisdiction of a water utility or at the point of use (NWU/POU); and two (6.1%) were unknown deficiencies (Figure 7; Table 14).

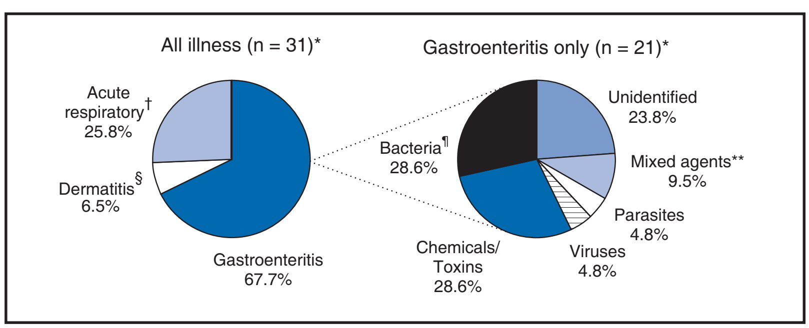
Deficiencies 1-4: Contamination of Water at/in the Water Source, Treatment Facility, or Distribution System

Water-quality data. Water-quality data (e.g., data regarding the presence of coliform bacteria, pathogens, or chemical/toxin contaminants; or data regarding levels of disinfectants, such as chlorine) were available for all 11 WBDOs given a deficiency classification of 1-4. Bacterial water-quality data were available for the eight WBDOs with confirmed infectious etiologies, and positive total or fecal coliform results from the implicated water were reported for seven (87.5%). The implicated water was tested for specific pathogens in two (25.0%) of the eight WBDOs with confirmed infectious etiologies. However, a pathogen was isolated from water in only one of these outbreaks; in this mixed-agent outbreak, the implicated water tested positive for *Cryptosporidium* spp., but the other three implicated infectious agents (*C. lari, C. jejuni,* and *H. canadensis*) were not recovered from the water samples.

Two (18.2%) of the 11 WBDOs with water-quality data were attributed to chemical/toxin poisoning. In both WBDOs, sodium hydroxide was the implicated agent and the water had a high pH level. One (9.1%) of the 11 outbreaks did not have an etiologic agent identified. However, the implicated water tested positive for both total and fecal coliforms.

Water systems. Four (36.4%) of 11 WBDOs with deficiencies 1-4 involved community water systems, four (36.4%) involved noncommunity water systems, two (18.2%) involved individual water systems, and one (9.1%) involved both noncommunity and individual water systems (Tables 8, 10, and 12; Figure 6). Among the four outbreaks involving community water systems, two (50.0%) were associated with a treatment deficiency, and two (50.0%) were associated with problems with the water distribution system or water storage. Among the four outbreaks involving noncommunity water systems, one (25.0%) was associated with contaminated untreated ground water intended for drinking; one (25.0%) was associated with a treatment deficiency; one (25.0%) was associated with a deficiency in the water distribution system; and one was associated with both a treatment and a distribution system deficiency. Among the two outbreaks involving individual water systems, one (50.0%) was associated with contaminated untreated surface water intended for drinking; and one (50.0%) was associated with both contaminated untreated ground water intended for drinking and deficiencies in the water distribution system. The single outbreak involving

FIGURE 5. Percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water, by illness and etiology — United States, 2003–2004



* One of the WBDOs had two predominant illnesses: acute respiratory illness and gastroenteritis.
† All acute respiratory illness was attributed to *Legionella* spp.
§ All dermatitis was attributed to chemicals/toxins.
¶ Including one *Legionella* spp. outbreak that involved both acute respiratory and gastrointestinal illnesses.
** Each outbreak involves more than one etiologic agent.

TABLE 8. Number of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = 11),* by etiologic agent and type of water system — United States, 2003–2004

	Type of water system†									
	Community		Noncommunity		Individual§		Mixed system		Total	
Etiologic agent	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases
Bacteria	**1**	**34**	**2**	**90**	**2**	**167**	**0**	**0**	**5**	**291**
Campylobacter spp.	1	34	1	20	1	110	0	0	**3**	**164**
C. jejuni and *Shigella* spp.	0	0	0	0	1	57	0	0	**1**	**57**
Salmonella typhimurium	0	0	1	70	0	0	0	0	**1**	**70**
Parasites	**0**	**0**	**1**	**11**	**0**	**0**	**0**	**0**	**1**	**11**
Giardia intestinalis	0	0	1	11	0	0	0	0	**1**	**11**
Chemicals/Toxins	**2**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**6**
Sodium hydroxide	2	6	0	0	0	0	0	0	**2**	**6**
Mixed agents¶	**1**	**82**	**0**	**0**	**0**	**0**	**1**	**1,450**	**2**	**1,532**
C. jejuni, *C. lani*, *Cryptosporidium* spp., and *Helicobacter canadensis*	1	82	0	0	0	0	0	0	**1**	**82**
C. jejuni, norovirus, and *G. intestinalis*	0	0	0	0	0	0	1**	1,450	**1**	**1,450**
Unidentified	**0**	**0**	**1**	**174**	**0**	**0**	**0**	**0**	**1**	**174**
Unidentified	0	0	1	174	0	0	0	0	1	174
Total	**4**	**122**	**4**	**275**	**2**	**167**	**1**	**1,450**	**11**	**2,014**
Percentage	**(36)**	**(6)**	**(36)**	**(14)**	**(18)**	**(8)**	**(9)**	**(72)**	**(100)**	**(100)**

* WBDOs with deficiencies 1–4 (i.e., surface water contamination, ground water contamination, water treatment deficiency, and distribution system contamination) were used for analysis.

† Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.

§ Excludes commercially bottled water, therefore not comparable to previous summaries.

¶ Multiple etiologic agent types (e.g., bacteria, parasite, virus, and/or chemical/toxin) identified.

** Noncommunity and individual water systems.

TABLE 9. Number of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = eight),* by etiologic agent and water source — United States, 2003–2004

	Water source									
	Ground water		Surface water		Unknown		Mixed source		Total	
Etiologic agent	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases
Bacteria	**3**	**200**	**1**	**57**	**0**	**0**	**0**	**0**	**4**	**257**
Campylobacter spp.	2	130	0	0	0	0	0	0	**2**	**130**
C. jejuni and *Shigella* spp.	0	0	1	57	0	0	0	0	**1**	**57**
Salmonella typhimurium	1	70	0	0	0	0	0	0	**1**	**70**
Chemicals/Toxins	**2**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**6**
Sodium hydroxide	2	6	0	0	0	0	0	0	**2**	**6**
Mixed agents†	**1**	**1,450**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1,450**
C. jejuni, norovirus, and *Giardia intestinalis*	1	1,450	0	0	0	0	0	0	**1**	**1,450**
Unidentified	**1**	**174**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**174**
Unidentified	1	174	0	0	0	0	0	0	1	174
Total	**7**	**1,830**	**1**	**57**	**0**	**0**	**0**	**0**	**8**	**1,887**
Percentage	**(88)**	**(97)**	**(13)**	**(3)**	**0**	**0**	**0**	**0**	**(100)**	**(100)**

* WBDOs with deficiencies 1–3 (i.e., surface water contamination, ground water contamination, and water treatment deficiency) were used for analysis.

† Multiple etiologic agent types (e.g., bacteria, parasite, virus, and/or chemical/toxin) identified.

TABLE 10. Number and percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = 11),* by type of deficiency (n = 14)† and type of water system — United States, 2003–2004

	Type of water system§									
	Community		Noncommunity		Individual¶		Mixed system		Total	
Type of deficiency	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1: Untreated surface water intended for drinking	0	(0)	0	(0)	1	(33.3)	0	(0)	**1**	**(7.1)**
2: Untreated ground water intended for drinking	0	(0)	1	(20.0)	1	(33.3)	1**	(50.0)	**3**	**(21.4)**
3: Treatment deficiency	2	(50.0)	2	(40.0)	0	(0)	0	(0)	**4**	**(28.6)**
4: Distribution system deficiency, including storage	2	(50.0)	2	(40.0)	1	(33.3)	1**	(50.0)	**6**	**(42.9)**
Total	**4**	**(100.0)**	**5**	**(100.0)**	**3**	**(100.0)**	**2**	**(100.0)**	**14**	**(100.0)**

* WBDOs with deficiencies 1–4 (i.e., surface water contamination, ground water contamination, water treatment deficiency, and distribution system contamination) were used for analysis.
† Some WBDOs have multiple deficiencies that are tabulated separately. This table reports 14 deficiencies from 11 WBDOs.
§ Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
¶ Excludes commercially bottled water, therefore, not comparable to previous summaries.
** Noncommunity and individual water systems.

TABLE 11. Number and percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = eight),* by type of deficiency (n = eight)† and source of water — United States, 2003–2004

	Water source									
	Ground water		Surface water		Unknown		Mixed system		Total	
Type of deficiency	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1: Untreated surface water intended for drinking	0	(0)	1	(100.0)	0	(0)	0	(0)	**1**	**(12.5)**
2: Untreated ground water intended for drinking	3	(42.9)	0	(0)	0	(0)	0	(0)	**3**	**(37.5)**
3: Treatment deficiency	4	(57.1)	0	(0)	0	(0)	0	(0)	**4**	**(50.0)**
Total	**7**	**(100.0)**	**1**	**(100.0)**	**0**	**(0)**	**0**	**(0)**	**8**	**(100.0)**

* WBDOs with deficiencies 1–3 (i.e., surface water contamination, ground water contamination, and water treatment deficiency) were used for analysis.
† Each of these WBDOs is associated with a single deficiency.

TABLE 12. Number and percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = 11),* by predominant illness and type of water system — United States, 2003–2004

	Type of water system†														
Predominant	Community			Noncommunity			Individual§			Mixed system			Total		
illness	WBDOs	Cases	(%)	WBDOs	Cases	(%)	WBDOs	Cases	(%)	WBDOs	Cases	(%)	WBDOs	Cases	(%)
Acute respiratory	0	0	(0)	0	0	(0)	0	0	(0)	0	0	(0)	**0**	**0**	**(0)**
Dermatitis	2	6	(4.9)	0	0	(0)	0	0	(0)	0	0	(0)	**2**	**6**	**(0.3)**
Gastroenteritis	2	116	(95.1)	4	275	(100.0)	2	167	(100.0)	1¶	1,450	(100.0)	**9**	**2,008**	**(99.7)**
Total	**4**	**122**	**(100.0)**	**4**	**275**	**(100.0)**	**2**	**167**	**(100.0)**	**1**	**1,450**	**(100.0)**	**11**	**2,014**	**(100.0)**

* WBDOs with deficiencies 1–4 (i.e., surface water contamination, ground water contamination, water treatment deficiency, and distribution system contamination) were used for analysis.
† Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
§ Excludes commercially bottled water, therefore, not comparable to previous summaries.
¶ Noncommunity and individual water systems.

TABLE 13. Number and percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = eight),* by predominant illness and water source — United States, 2003–2004

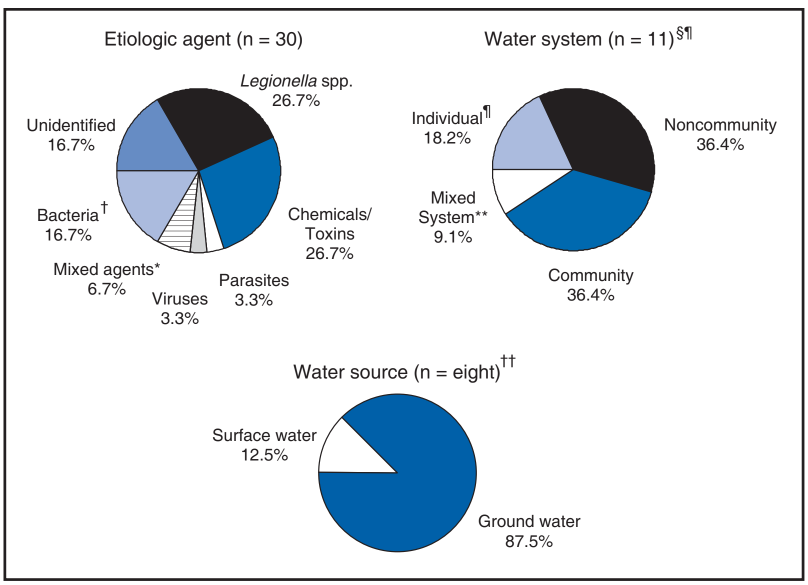
Predominant illness	Water source: Ground water WBDOs	Cases	(%)	Surface water WBDOs	Cases	(%)	Unknown WBDOs	Cases	(%)	Mixed source WBDOs	Cases	(%)	Total WBDOs	Cases	(%)
Acute respiratory	0	0	(0)	0	0	(0)	0	0	(0)	0	0	(0)	**0**	**0**	**(0)**
Dermatitis	2	6	(0.3)	0	0	(0)	0	0	(0)	0	0	(0)	**2**	**6**	**(0.3)**
Gastroenteritis	5	1,824	(99.7)	1	57	(100.0)	0	0	(0)	0	0	(0)	**6**	**1,881**	**(99.7)**
Total	**7**	**1,830**	**(100.0)**	**1**	**57**	**(100.0)**	**0**	**0**	**(0)**	**0**	**0**	**(0)**	**8**	**1,887**	**(100.0)**

* WBDOs with deficiencies 1–3 (i.e., surface water contamination, ground water contamination, and water treatment deficiency) were used for analysis.

both noncommunity and individual water systems was associated with both contaminated untreated ground water intended for drinking and deficiencies in the water distribution system.

Water sources. Seven (87.5%) of the eight WBDOs with deficiencies 1-3 were associated with ground water sources involving wells, and one (12.5%) WBDO was associated with surface water derived from a spring-fed pond. Among the seven outbreaks related to ground water sources, three (42.9%) were associated with consumption of untreated ground water, and four (57.1%) were associated with treatment deficiencies (Tables 9, 11, and 13; Figure 6).

FIGURE 6. Percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water, by etiologic agent, water system, and water source — United States, 2003–2004



* Each WBDO involves more than one etiologic agent.
† Other than *Legionella* spp.
§ Deficiencies 1–4. See Table 10.
¶ Does not include commercially bottled water, therefore, not comparable to previous summaries.
** Noncommunity and individual systems.
†† Deficiencies 1–3. See Table 11.

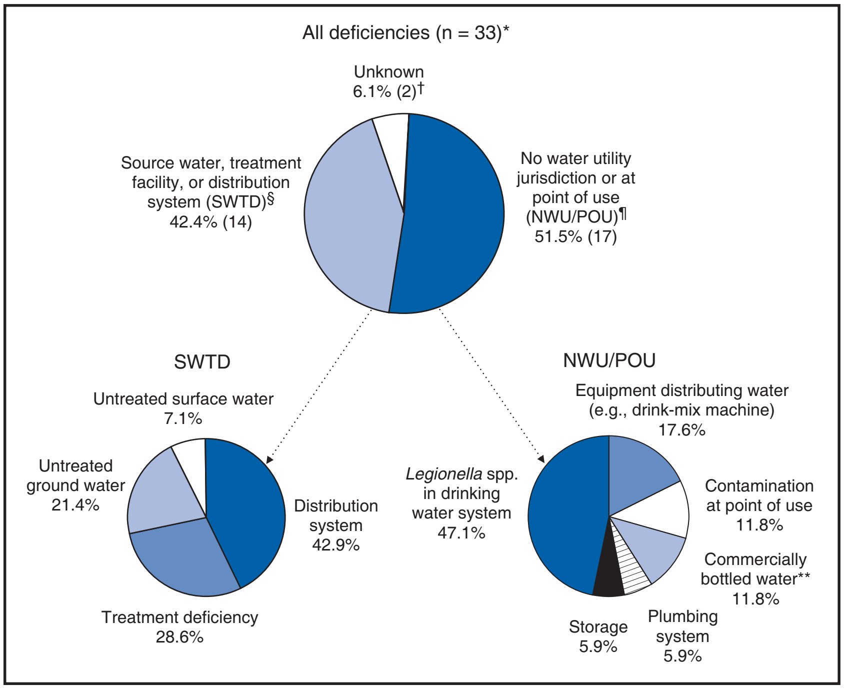
Deficiencies 5A, 6-11, and 99B: Contamination of Water at Points Not Under the Jurisdiction of a Water Utility or at the Point of Use

Water-quality data. Water-quality data indicating a problem with the water were available for 16 (94.1%) of 17 WBDOs with an NWU/POU deficiency. Among the nine WBDOs with an infectious etiology, eight (88.9%) were associated with *Legionella* spp., and one (11.1%) was associated with norovirus (Pennsylvania, January 2004). *Legionella* spp. were isolated from the implicated water sampled in all of the *Legionella* outbreaks. The implicated water in the norovirus outbreak tested positive for fecal coliforms.

Water-quality data were provided with the reports from all six WBDOs with chemical etiologies. In all six WBDOs, the contaminants causing the WBDO were recovered from the implicated water: copper in three WBDOs (Minnesota, June and November 2003; and South Carolina, July 2004); bromate and other by-products of disinfection in one WBDO (Florida, November 2003); a multiple-chemical cleaning product in one WBDO (Maine, December 2003); and gasoline by-products in one WBDO (Florida, October 2004). In the latter, the mechanism by which gasoline by-products got into the commercially bottled water was unknown, and this WBDO was given a deficiency of 99B. This WBDO is included with the other NWU/POU WBDOs for analysis purposes because commercially bottled water was involved.

Water-quality data also were provided with the reports from two WBDOs with unidentified etiologies. In one outbreak, the implicated water tested positive for total coliforms. In the other outbreak, the implicated water was tested specifically for norovirus, but it was not isolated.

FIGURE 7. Percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water, by deficiency* — United States, 2003–2004



* A total of 30 WBDOs but 33 deficiencies.
† Deficiency 99A. See Table 14.
§ Deficiencies 1–4. See Table 14.
¶ Deficiencies 5A, 6–11, 99B. See Table 14.
** Two WBDOs, one with contamination during bottling and one with unknown location or mechanism of contamination.

Deficiency 5A: *Legionella* in water intended for drinking. All eight of the drinking water-associated *Legionella* WBDOs occurred in large buildings or in institutional settings and were related to the multiplication of *Legionella* spp. in the plumbing. Among the 27 cases attributed to these *Legionella* outbreaks, one case was reported to have symptoms consistent with PF. The majority of cases of legionellosis were diagnosed by urinary antigen testing, which is specific for *L. pneumophila* serogroup 1 (*30*).

Deficiencies 6-11. Of the eight WBDOs associated with deficiencies 6-11, three (37.5%) were associated with drink mix/soda machine deficiencies resulting in copper intoxication; three (37.5%) were associated with commercially bottled water; one (12.5%) was associated with a cross-connection in the plumbing inside a building; and one (12.5%) was associated with point-of-use contamination of a communal water jug at a worksite. All of these WBDOs have been described (Appendix B).

Deficiency 99A: Unknown/ Insufficient Information Concerning Contamination of Water Intended for Drinking Tap Water

The deficiencies involved in two (6.7%) of the 30 WBDOs could not be identified because of insufficient information or unknown cause of contamination. Water samples from both of these noncommunity water systems and tap-water–associated WBDOs tested positive for *E. coli* and total coliforms, but etiologic agents were not identified. One outbreak involved ground water (i.e., well water), and one involved tap water from an unknown water source. However, because the mechanism of contamination was unknown and the point of contamination might not have been under the jurisdiction of a water utility, these two WBDOs are analyzed separately from the SWTD and NWU/POU deficiencies.

Waterborne Disease and Outbreaks Associated with Water Not Intended for Drinking and Water of Unknown Intent

Six WBDOs were associated with either WNID (n = three) or WUI (n = three) (Table 6). More WNID/WUI outbreaks were reported for 2003–2004 (n = six) than during 2001–2002 (n = one). The six WNID/WUI outbreaks caused illness among approximately 36 persons and resulted in four deaths. One (16.7%) WNID/WUI outbreak involved AGI, and five (83.3%) involved ARI. Two (33.3%) of the six WNID/WUI outbreaks were categorized as a strength of evidence Class I ranking; one (16.7%) was ranked as Class III; and three (50.0%) were ranked as Class IV.

Etiologic Agents

Five (83.3%) of the six WNID/WUI outbreaks were attributed to *L. pneumophila* serogroup 1, affected 26 persons, and resulted in four deaths. Fifteen of the cases were associated with LD, and 11 were associated with PF. The other WNID/WUI outbreak was attributed to *E. coli* O157:H7; 10 persons were reported ill.

TABLE 14. Waterborne-disease and outbreaks associated with drinking water (n = 30), by deficiency (n = 33)* — United States, 2003–2004

Deficiency	No.
Contamination of water at/in the water source, treatment facility, or distribution system (SWTD)†	**14**
1: Untreated surface water intended for drinking	1
2: Untreated ground water intended for drinking	3
3: Treatment deficiency	4
4: Distribution system deficiency, including storage	6
Contamination of water at points not under the jurisdiction of a water utility or at the point of use (NWU/POU)§	**16**
5: *Legionella* spp. in water system	
A: Water intended for drinking	8
B: Water not intended for drinking (excluding recreational water)	0
C: Water of unknown intent	0
6: Plumbing system deficiency after the water meter or property line	1
7: Deficiency in building/home-specific water treatment after the water meter or property line	0
8: Deficiency or contamination of equipment/devices using or distributing water	3
9: Contamination during commercial bottling	1
10: Contamination during shipping, hauling, or storage	
A: Water intended for drinking – Tap water	0
B: Water intended for drinking – Commercially bottled water	1
11: Contamination at point of use	
A: Tap	0
B: Hose	0
C: Commercially bottled water	1
D: Container, bottle, or pitcher	1
E: Unknown	0
Unknown/Insufficient Information	**3**
99: Unknown/Insufficient information	
A: Water intended for drinking – Tap water	2
B: Water intended for drinking – Commercially bottled water	1
C: Water not intended for drinking (excluding recreational water)	0
D: Water of unknown intent	0
Total no. of deficiencies*	**33**

* More than one deficiency might have been identified during the investigation of a single waterborne disease or outbreak.

† Contamination of water and deficiencies occurring in the drinking water system at/in the water source, treatment facility, or distribution system of pipes and storage facilities. For a community water system, the distribution system refers to the pipes and storage infrastructure under the jurisdiction of the water utility before the water meter or property line (if the system is not metered). For noncommunity and nonpublic water systems, the distribution system refers to the pipes and storage infrastructure before entry into a building or house.

§ Contamination of drinking water and deficiencies occurring after the water meter or outside the jurisdiction of a water utility (e.g., in a service line leading to a house or building, in the plumbing inside a house or building, during shipping or hauling, during storage other than in the distribution system, at point of use).

Deficiencies 5B, 5C, 12, 99C, and 99D

The six WNID/WUI outbreaks each had one known deficiency: five (83.3%) involved *Legionella* spp. in the water system (deficiencies 5B and 5C), and one (16.7%) involved WNID unrelated to *Legionella* (deficiency 12). Two (40.0%) of the five *Legionella* outbeaks involved WNID (deficiency 5B). In these outbreaks, the aerosolized water from cooling towers was tested and identified as the source of *Legionella* spp. Three *Legionella* outbreaks (60.0%) involved WUI (deficiency 5C). In these outbreaks, environmental water testing failed to determine the source of *Legionella* spp. The one outbreak unrelated to *Legionella* involved *E. coli* O157:H7 infection after exposure to sewage from a broken septic line at a camp. Campers might have been exposed in a wash house in which a septic backup occurred or might have been exposed to surface sewage seepage near the housing area. Campers were observed playing in a wet area near the sewage seepage. No water testing was performed in this outbreak. However, soil from the area of the sewage leakage tested negative for the pathogen.

Previously Unreported Outbreaks

Reports of nine previously unreported drinking water-associated WBDOs that occurred during 1982–2002 were received for this surveillance period (Table 7). An outbreak of diarrheal illness occurred among six attendants of a graduation party (New York, July 2002); two had laboratory-confirmed *E. coli* O157:H7 infections. This pathogen was isolated from a private well that provided drinking water and matched the two laboratory-confirmed cases by pulsed-field gel electrophoresis pattern. The well water supply was reportedly not disinfected.

An outbreak of gastroenteritis occurred among 15 students on a class trip (New York, May 1984). During the trip, 15 (30.6%) of 49 students became ill and experienced nausea and vomiting within 1–2 hours of eating at a restaurant. The ill students had ingested soda from a soda fountain that was described as having a metallic taste. Samples from the soda fountain machine were analyzed for copper, iron, and other metals and were within the normal range. However, testing of urine samples collected 2 days after illness onset demonstrated elevated levels of copper in some students' urine samples. Heavy use of fire hydrants nearby caused pressure problems in the community water main while students were being served at the restaurant. These pressure fluctuations might have stirred up sediment in the distribution system, resulting in excess copper being delivered to the restaurant water supply.

During April 2002, an outbreak of gastroenteritis in 59 persons occurred in Palau. *Entamoeba histolytica* was isolated from nine (30.0%) of 30 stool specimens. All ill persons reported consuming untreated drinking water from the same portable water catchment tank that collected water from a stream. Water sampled from the tank tested positive for total and fecal coliform bacteria.

Three outbreaks of gastroenteritis (New York, May 1982, August 1995, and August 1996) involved unidentified etiologic agents. During the 1982 outbreak, drinking water at a restaurant was linked to illness. Samples of water and ice were negative for pathogens, but the raw well water tested positive for fecal coliform bacteria. In addition, although the well water received ultraviolet light treatment before entering the restaurant plumbing system, fecal and total coliforms were found in water samples after treatment. The 1995 outbreak report implicated water and ice served at a hotel restaurant. An untreated well was the source of drinking water and water used to make ice. Water samples from the kitchen faucet were positive for both total coliforms and *E. coli*. On the basis of the incubation period, symptoms, and duration of illness, norovirus was suspected. Investigators speculated that the well water might have been contaminated or that an ill person might have contaminated the ice after production. During the 1996 outbreak among campers, a viral etiology was suspected based on incubation period, symptoms, and duration of illness. The source of illness was unconfirmed, but a fecally contaminated unchlorinated water supply (i.e., well water) was suspected. Water samples from the untreated well tested positive for *E. coli*. The well had tested positive the previous year for *E. coli* after a gastroenteritis outbreak.

Reports of two *Legionella* outbreaks (Maryland and the U.S. Virgin Islands, November 2002) and one mixed-agent outbreak (New York, December 2002) were also received for this surveillance period. These WBDOs have been described (Appendix B).

Surveillance Reports Not Classified as Waterborne Disease and Outbreaks

Three surveillance reports potentially implicating drinking water were submitted during 2003–2004 but had insufficient epidemiologic or laboratory evidence to warrant inclusion in this report as WBDOs. One surveillance report included only one confirmed case of *Legionella* infection; the second suspected case was not laboratory confirmed. Regarding the second report, the investigation did not reveal a common point source of *Legionella* transmission. However, because of the potential link to drinking water, a brief description of the third report has been provided. In July 2003, multiple persons attending a family reunion developed AGI. *E. coli* O157:H7 was isolated from the stool of four attendees. Lemonade made with untreated water was cited, but other common food and water sources were identified. No epidemiologic studies were conducted.

Discussion

Considerations Regarding Reported Results

WBDOSS provides information concerning epidemiologic and etiologic trends in outbreaks related to drinking water. However, not all outbreaks are recognized, investigated, or reported to CDC, and studies have not been conducted 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 and state health departments for surveillance and investigation of probable outbreaks. In addition, because differences in the capacity of local and state public health agencies and laboratories to detect WBDOs might result in reporting and surveillance bias, the states with the majority of outbreaks reported for this period might not be the states in which the majority of outbreaks actu-

ally occurred. An increase or a decrease in the number of WBDOs reported might reflect either an actual change in the incidence of outbreaks or a change in the sensitivity of surveillance practices. As with any passive surveillance system, the accuracy of the data depends substantially on the reporting agencies (i.e., state, local, and territorial health departments). Therefore, independent of the recognition or investigation of a given outbreak, reporting bias also can influence the final data.

The outbreaks most likely to be recognized and investigated are those involving acute illness characterized by short incubation periods, serious illness or symptoms requiring medical treatment, or recognized etiologies for which laboratory methods have become more sensitive or widely available. Increased reporting frequently occurs as etiologies become better recognized, water system deficiencies are identified, and state surveillance activities and laboratory capabilities increase (*31–33*). Consequently, recommendations for improving WBDO investigations include enhancing surveillance activities, increasing laboratory support for clinical specimen and water sample testing, and assessing sources of potential bias (*34–36*).

The identification of WBDO etiologic agents depends on multiple factors. Investigators must recognize the WBDO in a timely manner so that appropriate clinical specimens and environmental samples can be collected. Collection of water samples further depends on local and state statutory requirements and the availability of investigators. Methods for concentrating large volumes of water for testing are being developed and disseminated to multiple sites in the United States as standard protocols (*37*). The laboratories involved must have the capacity to concentrate large volumes of water for testing, in addition to the ability to test for the organism, chemical, or toxin in the clinical specimens and environmental samples. For example, routine testing of stool specimens at laboratories includes tests for the presence of enteric bacterial pathogens and also might include ova and parasite examination. However, testing for viral agents is rarely conducted, although norovirus testing is now being performed more commonly. In addition, clinicians and public health officials must know the correct tests to order. For example, testing for *Cryptosporidium* spp., one of the most commonly reported waterborne pathogens, is frequently not included in standard ova and parasite examinations and therefore must be specifically requested (*38*).

One key limitation of the data collected by the WBDOSS is that the information pertains only to outbreaks of waterborne illness and not to 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. In response to the Congressional Safe Drinking Water Act Amendments of 1996, in 2005, EPA and CDC completed a series of epidemiologic studies and a national workshop designed to assess the magnitude of endemic waterborne AGI associated with consumption of public drinking water. A joint report on the results of these studies is available at http://www.epa.gov/nheerl/articles/2006/waterborne_disease.html. The report includes multiple documents that discuss various methods for estimating the number of endemic waterborne AGI cases associated with public drinking water systems in the United States. In particular, the authors of two reports used current data and made various assumptions for missing data to derive two different but overlapping estimates of 1) 4.3–11.7 million annual AGI cases (confidence interval unknown) (*39*) and 2) 16.4 million annual AGI cases (range: 5.5–32.8) (*40*). These estimates should be interpreted with an understanding that information concerning endemic waterborne-disease risks is imprecise and uncertain and that substantial data gaps remain. The wide range in the number of estimated cases suggests a high level of uncertainty. Nonetheless, workshop participants agreed that enough data were available for rough estimates and that these estimates should be made at this time, with all assumptions and limitations fully described so the approaches can be evaluated.

These estimates, however, only describe a portion of the annual incidence of endemic waterborne-disease cases. To describe the overall incidence, estimates also would need to include the number of cases of waterborne disease other than AGI and the number of cases associated with nonpublic drinking water systems, commercially bottled water, recreational water, WNID, and WUI. If these other types and sources of waterborne disease were considered, the estimated number of cases of endemic waterborne disease would be higher than the figures previously presented in this report.

WBDOs Associated with Water Intended for Drinking

Etiologic agents

Legionella spp. and chemicals were the most commonly reported etiologic agents in drinking water-associated WBDOs. During 2003–2004, eight reported drinking water-associated WBDOs involved *Legionella* spp. and comprised 26.7% of the total, which is only the second time that data concerning *Legionella* outbreaks have been included in a *Surveillance Summary*.

Chemical/toxin drinking water-associated WBDOs (n = eight) comprised 26.7% of the total, an increase from the previous surveillance period and the largest number of chemical/toxin-related drinking water WBDOs since the 1993–1994 surveillance period. Of the eight chemical/toxin WBDOs, three (37.5%) resulted from deficiencies related to drink mix/soda machines, and two (25.0%) resulted from deficiencies related to recent maintenance work. These outbreaks stress the importance of proper installation and maintenance of water systems and equipment. The increased number of chemical/toxin-related outbreaks also emphasizes the need for increased awareness among the public and public health officials concerning the role that chemicals and toxins play in WBDOs.

During the 2003–2004 surveillance period, five drinking water-associated WBDOs involved only bacteria (other than *Legionella* spp.), an increase in the number of reported non-*Legionella* bacterial drinking water outbreaks compared with the 2001–2002 surveillance period (n = three). The ongoing occurrence of bacterial WBDOs, despite available and efficacious treatment practices, underscores the continuing need for protection and treatment of drinking water (*41*).

In addition, two mixed-agent outbreaks occurred during the 2003–2004 surveillance period, which included bacteria (one bacterial/parasitic outbreak and one bacterial/parasitic/viral outbreak). The occurrence of mixed-agent outbreaks emphasizes the importance of considering more than one etiologic agent in outbreak investigations, collecting appropriate specimens for each agent type, and requesting appropriate diagnostic testing for each agent type. In addition, both outbreaks were associated with sewage contamination of wells, underscoring the importance of proper waste management and proper drinking water system and waste water system designs.

One viral outbreak involving norovirus was reported for the 2003–2004 surveillance period (Pennsylvania, January 2004). Norovirus was also one of the etiologic agents identified in one of the mixed-agent outbreaks (Ohio, July 2004) and was the suspected etiologic agent in one of the outbreaks of unknown etiology (Florida, January 2003), based on incubation period, symptoms, and duration of illness. Sewage contamination was suspected in both outbreaks in which norovirus was identified. Point-of-use contamination of a water dispenser was a contributing factor in the suspected norovirus outbreak. These three outbreaks represent a decrease in viral drinking water-associated WBDOs compared with the previous surveillance period (n = five) and might reflect a true decrease in viral outbreaks, a lack of outbreak investigation and detection, a lack of viral testing, or a combination of factors.

Compared with the previous surveillance period, the number of reported parasitic outbreaks decreased for 2003–2004. Parasites were identified in one single-agent outbreak (*G. intestinalis*) and two mixed-agent outbreaks (*Cryptosporidium* spp. and *G. intestinalis*). All three outbreaks were associated with distribution system deficiencies, but only one also was associated with the use of untreated source water (ground water under the influence of surface water in Ohio, July 2004). No parasitic outbreaks were associated with surface water systems. Both surface water systems and ground water systems under the influence of surface water are regulated under SWTR to protect the public against exposure to *Giardia* and *Cryptosporidium*, among other pathogens.

The etiologic agent was unidentified in five (16.7%) of the 30 drinking water-associated WBDOs reported during 2003–2004 (Figure 6). This finding is the lowest number and percentage of outbreaks caused by an unknown etiology in any surveillance period since the beginning of the surveillance system in 1971. Five drinking water-associated outbreaks of unknown etiology occurred during 1997–1998, but this number represented 29.4% of the reported non-*Legionella* outbreaks. This decrease probably reflects the improved diagnostic capability of laboratories and better outbreak investigations, resulting in more rapid and more appropriate specimen collection.

Deficiencies 1–4: Contamination of Water at/in the Water Source, Treatment Facility, or Distribution System

In general, EPA regulates the public drinking water supplies from the source water up to the water meter (or before the property line if the distribution system is not metered). This segment of the drinking water supply system is associated with deficiencies 1–4: 1) consumption of untreated surface water intended for drinking, 2) consumption of ground water intended for drinking, 3) treatment deficiencies, and 4) distribution system deficiencies before the water meter or property line. During the 2003–2004 surveillance period, 36.7% of drinking-water related outbreaks (n = 11) and 42.4% of deficiencies (n = 14) involved deficiencies 1–4. A single WBDO can be associated with more than one deficiency.

Source water. Discussions regarding source water type only include those WBDOs with deficiencies 1–3 because distribution system deficiencies (deficiency 4) are not dependent upon the source water type. Also excluded from discussion involving source water types are drinking water-associated WBDOs with unknown or insufficient information (deficiencies 99A) and outbreaks associated with

contamination at points not under the jurisdiction of a water utility or at the point of use (deficiencies 5A, 6–11, and 99B).

Surface water. One (12.5%) of the eight outbreaks with deficiencies 1–3 was associated with consumption of untreated surface water (deficiency 1) from a spring-fed pond supplying an individual water system (Ohio, November 2003). This emphasizes the importance of public awareness that surface water, despite its clarity, is prone to contamination by pathogens and should not be directly consumed without first being treated. If water treatment is not available as part of the water system, treatment can be provided at the point of use (e.g., filtration, disinfection by chemicals, or boiling). Manufacturers of point-of-use treatment devices and the National Sanitation Foundation (http://www.nsf.org) provide information regarding different devices, including instructions for their use and their ability to make water safe for human consumption.

The WBDO in Ohio in 2003 is the first outbreak associated with consumption of untreated surface water intended for drinking (deficiency 1) since 1999 (*3*). Since the early 1990s, a decrease has occurred in the percentage of reported WBDOs associated with either untreated or inadequately treated surface water. This decrease is likely attributed to increasingly stringent EPA regulations for treatment of surface water. However, outbreaks might still occur, particularly in water systems that are not subject to EPA regulations.

Ground water. Seven (87.5%) of the eight outbreaks with deficiencies 1–3 were associated with consumption of contaminated ground water from wells. This is the smallest number and percentage of ground water-associated WBDOs with deficiencies 1–3 in the previous four surveillance periods (1997–1998 through 2003–2004). Among these seven outbreaks, three (42.9%) involved consumption of untreated ground water (deficiency 2), and four (57.1%) involved treatment deficiencies associated with contaminated ground water (deficiency 3). The highest proportion of these outbreaks (n = three [42.9%]) were associated with noncommunity water systems, but other water system types also were implicated: community (n = 2), individual (n = one), and mixed noncommunity and individual (n = one).

The mixed-system outbreak involving noncommunity and individual water systems was the largest outbreak during this surveillance period (Ohio, July 2004). The outbreak occurred on an island in Lake Erie frequented by vacationers. It also was associated with the use of untreated contaminated ground water (deficiency 2) by noncommunity and individual drinking water systems and cross-connections to the community water distribution system (deficiency 4). The environmental investigation identified sewage-contaminated ground water wells used for drinking water as the likely source of exposure to the etiologic agents. Sewage reached the drinking water aquifer because the karst limestone geology of the island forms an aquifer that is vulnerable to contamination. Cracks and fractures in the limestone allow contaminants from upper soil layers to flow through to ground water sources. The severe soil limitations and the karst geology of the island connect sewage system effluent, lake water, and precipitation runoff to the aquifer. In addition to soils and geology, other possible contributing factors include cross-connections in the water distribution system; an increase in precipitation before the outbreak; the volume of wastewater flowing to sewage treatment systems during periods of heavy island visitation; the number, type and maintenance of sewage disposal systems; and groundwater well construction.

The seven ground water-associated outbreaks indicate that contaminated ground water that leads to illness is a continuing problem, and efforts should be intensified 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, because ground water can become contaminated with pathogens that might overwhelm the disinfection process. EPA requires appropriate treatment, including filtration and disinfection, for public water systems that use ground water under the direct influence of surface water (e.g., those involved in the Ohio outbreak). EPA's GWR establishes multiple barriers for protection against pathogen contamination of drinking water derived from ground water sources. GWR will also establish a targeted strategy to identify ground water 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, which if discovered, might require mandatory testing. In addition, continuous water treatment is needed for wells that are identified as being vulnerable.

Only public water systems will be directly covered by GWR; therefore, protections offered by GWR will not extend to individual ground water systems unless they are regulated by state or local authorities. The quality of water in wells and springs used by individuals and nonpublic systems 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 (*42*). In addition, contamination of a household well is not only a health concern for the family served by the well but is also a concern for households and other water systems that draw from the same aquifer. To safeguard the quality of well water, homeowners should seek information on needed protective measures and implement recommended operation and maintenance guidelines for private well usage. Homeowners may also choose to protect their own health by purchasing appropriately designed point-of-use devices and by following instructions for operating and maintaining these treatment devices. Although EPA does not regulate individual water systems, EPA recommendations for protecting private wells are available at http://www.epa.gov/safewater/pwells1.html. Additional efforts should be taken by public health officials to educate well owners, users, drillers, and local and state drinking water personnel to encourage practices that best ensure safe drinking water for private well-users.

Water treatment. During 2003–2004, four drinking water-related WBDOs associated with water treatment deficiencies were reported. Two outbreaks resulted in burns after the discharge of sodium hydroxide into the distribution system during well maintenance. The other two outbreaks involved temporary interruptions of disinfection (one resulting from a broken chlorine pump [Pennsylvania, June 2004] and one resulting from a faulty ultraviolet light water-treatment apparatus [Montana, August 2004]). All four outbreaks indicate the need for proper equipment handling, maintenance, and postmaintenance safety checks.

Distribution system. Distribution system deficiencies make up the largest proportion of the SWTD deficiencies occurring before the water meter or property line during this surveillance period. During 2003–2004, six drinking water-related WBDOs involving distribution system deficiencies occurred. Four (66.7%) of the six WBDOs involved cross-connections to nonpotable water sources. As the use of nonpotable water increases in the United States (e.g., for landscape and agricultural irrigation, toilet flushing, industrial processing, and power plant cooling), the risk for cross-connections between potable and nonpotable water supplies will also probably increase (*43*). These four outbreaks demonstrate the importance of identifying and clearly labeling potable and nonpotable water lines to prevent cross-connections, which can result in illness.

Water systems. Discussions regarding water system types (i.e., community, noncommunity, and individual) include drinking water-associated WBDOs with deficiencies 1–4. Deficiencies in the distribution system are included in these discussions because distribution system problems might be dependent on the type of water system involved. Among the 11 drinking water-associated WBDOs with a deficiency of 1–4, four (36.4%) were associated with community water systems, four (36.4%) with noncommunity water systems, two (18.2%) with individual water systems, and one (9.1%) with both noncommunity and individual water systems (Ohio, July 2004). The proportion (27.3%) of drinking water-related WBDOs associated with unregulated individual water systems (including the Ohio, July 2004 WBDO) is the lowest proportion of outbreaks within the last three surveillance periods (i.e., 1999–2000, 2001–2002, and 2003–2004). This decrease in the proportion of WBDOs associated with individual drinking water systems might reflect a detection bias (given the limited number of persons who are usually affected by these WBDOs), limited resources available to investigate these outbreaks, and the limited number of regulations that govern these systems.

Deficiencies 5A, 6-11, and 99B: Contamination of Water at Points Not Under the Jurisdiction of a Water Utility or at the Point of Use

By creating additional deficiency classifications, a clear distinction can be made between deficiencies that occur at points NWU/POU and SWTD. During the 2003–2004 surveillance period, more WBDOs were associated with NWU/POU (17 [51.5%]) than with SWTD (14 [42.4%]) (Figure 7).

Deficiency 5A: *Legionella* in Water Intended for Drinking. Legionellosis includes two clinically distinct syndromes: LD, a form of pneumonia, and PF, an influenza-like illness without pneumonia. When outbreaks of legionellosis occur in the setting of contaminated drinking water, they typically manifest as cases of LD rather than PF. Regardless of the syndrome, all legionellosis outbreaks share the common features of warm stagnant water, usually documented inadequate biocide concentrations, and aerosolization, which provides the mechanism for inhalation into the lungs. The outbreaks of legionellosis described in this report highlights multiple challenges related to the detection and prevention of legionellosis.

LD, the more severe form of legionellosis, is underdiagnosed because multiple patients with community-acquired pneumonia can be treated empirically with broad-spectrum antibiotics (*44*). However, because *Legionella* spp. are not transmitted from person-to-person and are always acquired from an environmental source, even

a single case of LD implies the presence of a contaminated aquatic source to which others can be exposed. Because host factors, (e.g., underlying lung disease and immunodeficiencies) are essential for the development of disease, the attack rate during documented LD outbreaks is <5%. Identification of two or more cases of LD in association with a potential source is adequate justification for an investigation. All of the outbreaks described in this report involved seven or fewer cases. Nonetheless, in all instances except for one, the epidemiologic and laboratory data were compelling enough to implicate point sources that were subsequently remediated.

Three outbreaks occurred among persons in residential settings (i.e., a condominium complex [Maryland, December 2004], an apartment building [New Jersey, June 2004], and a senior housing center [New Jersey, July 2004]). Approximately 70% of sporadic cases of residentially acquired LD occur among persons living in single family homes (*45*). However, because persons living in multiple-unit settings can be epidemiologically linked to each other, outbreaks that occur in these settings have a higher potential to be recognized by public health authorities. The plumbing systems that serve such buildings tend to be colonized with *Legionella* spp. in multiple locations, which could increase the risk of LD to other residents of such buildings (*46*). Guidelines for reducing the risk for legionellosis associated with building water systems are available (*47*). Providing these guidelines to managers of large residential buildings in addition to other settings more commonly associated with outbreaks of legionellosis might be a useful practice for local and state public health authorities.

Three outbreaks demonstrate the propensity for *Legionella* spp. to colonize potable water systems and cause disease over prolonged periods. *Legionella* spp. colonize the biofilm layer frequently found inside large, complex plumbing systems (*48*). This biofilm protects *Legionella* from biocides and allows the bacteria to amplify to levels sufficient to be transmitted. One outbreak (Maryland, November 2002) previously unreported in any *Surveillance Summaries* was associated with a health club and resulted in apparent disease transmission during an 8-week period; all ill persons were men aged ≥65 years. In 2004, the potable water system of a long-term–care facility, which also had experienced an outbreak in 2002, was the source of three additional cases, including one fatality, despite aggressive remediation after the 2002 outbreak (Pennsylvania, April 2004). Finally, LD detected among three guests of a hotel led to an epidemiologic and environmental investigation that identified the potable water system as the likely source (U.S. Virgin Islands, November 2002). The comparison of strains of *Legionella* spp. isolated during this outbreak with strains recovered from an outbreak at the same hotel that occurred during 1981–1982 revealed remarkable similarity, suggesting that the same strain had colonized the system continuously (*49*). In summary, *Legionella* is a hardy organism that resists remediation efforts and therefore can colonize the same potable water system for years or decades. This hotel-associated outbreak also highlights the importance of timely reporting of individual cases of travel-associated legionellosis, as was recently recommended in a 2005 CSTE position statement (http://www.cste.org/PS/2005pdf/final2005/05-ID-01final.pdf).

Legionella outbreaks represented >25% of all drinking water-associated WBDOs reported during 2003–2004 and 47.1% of all NWU/POU deficiencies, indicating that *Legionella* as a public health threat requires further attention. Concerted action is necessary to maintain systems according to published guidelines and to detect and respond to clusters of cases of legionellosis when they occur (*47*).

Deficiencies 6–11. Deficiencies involving water intended for drinking that occur at points after the water meter or the property line include 1) problems with the plumbing; 2) problems with water treatment after the water meter or property line; 3) problems with equipment/devices that use or distribute water (e.g., beverages contaminated by plumbing failures in drink mix/soda machines); 4) contamination of ice or beverages as a result of the use of contaminated water; 5) contamination during commercial bottling; 6) contamination during shipping, hauling, or storage; and 7) contamination at the point of use. The latter three deficiencies frequently involve commercially bottled water. Commercially bottled water is assumed to be a safe source of drinking water; however, the WBDOs associated with commercially bottled water reported during 2003–2004 are examples of the different situations in which contamination can occur. In one WBDO (Florida, November 2003), contamination by disinfection by-products occurred at the plant during production and bottling, indicating that the process of disinfection of bottled water must be closely monitored. In another WBDO (Maine, December 2003), a cleaning product spilled near the bottled water and leached through the plastic bottle to contaminate the water, demonstrating that plastic bottles are permeable to chemicals and therefore commercially bottled water is vulnerable to chemical contamination after production but before the seal is broken. Proper shipping, hauling, and storage of commercially bottled water can prevent this route of contamination. Commercial vendors and the general

public need to be aware that commercially bottled water should be stored off the floor and away from any chemical products. In a third WBDO (Florida, January 2003), a large container of commercially bottled water from which multiple persons were served was contaminated at the point of use after the bottle had been opened, underscoring the vulnerability of shared bottles or containers and the importance of practicing good hygiene. A similar outbreak involving a shared container (Michigan, September 2003) further illustrates this problem; however, this WBDO was not associated with commercially bottled water.

Three WBDOs were associated with illness attributed to ingestion of copper from drink mix/soda machines. In two of these outbreaks (Minnesota, June 2003; South Carolina, July 2004), problems occurred with backflow of highly acidic, carbonated water from the carbonators back into the building piping and resulted in copper leaching from the pipes. The cause of the malfunction in the third WBDO (Minnesota, November 2003) was less clear and appeared to be a problem with the internal plumbing of a juice machine. Proper installation and maintenance of drink mix/soda machines, with particular attention given to check valves, are critical.

One WBDO (Pennsylvania, January 2004) involved a drinking water pipe being inappropriately cross-connected with a nonpotable water source within a building. This WBDO illustrates that cross-connections can be problematic, not only within the distribution system, as illustrated by four outbreaks discussed regarding deficiency 4, but also within building/home plumbing. Potable and nonpotable water lines should be clearly labeled, and plumbing systems should be assessed to prevent and ensure that opportunities for cross-connections do not exist. Approved devices can prevent both the backflow of nonpotable water into the potable water system from backpressure and backsiphonage, but the devices must be maintained and periodically tested (*50*). The risk for contamination can be reduced by water utilities 1) being cognizant of the potential for the intrusion of contaminants into the water distribution system during transient low or negative water pressure, 2) maintaining an effective disinfectant residual throughout the distribution system, and 3) detecting and repairing pipeline leaks (*51*).

Waterborne Disease and Outbreaks Associated with Water Not Intended for Drinking

During the 2003–2004 surveillance period, three WBDOs occurred that were associated with WNID. Two of these outbreaks were associated with *Legionella* spp. and involved water in cooling towers. The remaining WBDO was associated with *E. coli* O157:H7 and involved a broken septic line at a camp, which resulted in sewage seepage near the housing area and a septic back-up in a wash house. Whereas WNID outbreaks are less commonly reported than drinking water-related WBDOs, these three outbreaks illustrate that, whether through inhalation or contact, WNID is still associated with disease and requires attention. Broken septic lines, sewage seepage, and improper sewage disposal are public health threats because direct contact with sewage and contamination of drinking water can occur from either ground water or surface water sources. Sewage disposal systems must be properly sited and maintained. If drinking water contamination is suspected, public health officials should 1) institute appropriate measures to prevent consumption of contaminated water (e.g., issuances of boil-water advisories and recommendations to use commercially bottled water), 2) evaluate the sewage disposal system, and 3) address any deficiencies that are identified.

Additional Reporting of Historical Outbreaks

This report discusses information concerning nine previously unreported drinking water outbreaks. Six of these outbreaks occurred during 1980–2002 in New York State. Inclusion of the information regarding New York was facilitated by a CDC-funded pilot project to improve waterborne-disease surveillance and waterborne outbreak investigations in New York. In 2005, CDC initiated the project in partnership with the New York State Department of Health (NYSDOH) as part of CDC's Environmental Health Specialist Network (EHS-Net). One element of the project was the hiring of a new full-time employee within the NYSDOH to coordinate the EHS-Net water pilot project. Initial efforts of the pilot project were focused on characterizing the reporting system for waterborne disease in New York State, including reviewing different databases that might contain information concerning waterborne-disease outbreaks. Databases maintained by multiple organizations within NYSDOH and data housed in certain local health departments were reviewed, which resulted in the verification of nine outbreaks associated with water intended for drinking during 1980–2002. Three of these outbreaks had been previously reported to CDC. One outbreak that occurred in 2002 was reported to CDC along with the 2003–2004 outbreaks. The five remaining outbreaks had not been reported to CDC.

The EHS-Net water pilot project activities indicate that increased effort and resources, specifically directed at waterborne disease reporting, could result in the identification of previously unreported historical outbreaks. As the EHS-Net water pilot project refines the process for identifying and investigating current waterborne-disease incidents, these efforts might result in enhanced reporting of waterborne outbreaks from New York. In addition, the experience of NYSDOH could provide a template for improving waterborne-disease reporting in other locations.

Conclusion

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

Surveillance for waterborne agents and WBDOs occurs primarily at the local and state levels (including territories and FAS). Public health authorities at these levels should be able to detect and recognize drinking water-associated WBDOs and implement appropriate prevention and control measures. Improved communication among local and state public health departments, regulatory agencies, and water utilities would aid the detection and control of WBDOs. Routine reporting or sharing of water-quality data within the health department is recommended. Other means of improving surveillance at the local, state, and federal levels 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). CSTE passed a position statement at the 2006 annual meeting making waterborne-disease outbreaks, as a unit of reporting, nationally notifiable and reportable to CDC starting in 2007. Adoption of this CSTE recommendation at the state level through state-specific legislative action might improve reporting of waterborne outbreaks at the state and local levels. CSTE also asked CDC and EPA to 1) develop training for WBDO investigations for local and state/territorial public and environmental health workers responsible for WBDO detection, investigation, and reporting; and 2) work with CSTE and EPA to develop national WBDO investigation and surveillance guidelines. The position statement is available at http://www.cste.org/PS/2006pdfs/PSFINAL2006/06-ID-12FINAL.pdf (Box).

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BOX. Organizations that provide assistance in investigations of waterborne disease and outbreaks (WBDOs)

State and territorial health departments may request epidemiologic assistance and laboratory testing from CDC to investigate WBDOs. CDC and the U.S. Environmental Protection Agency (EPA) may be consulted regarding engineering and environmental aspects of drinking-water treatment during and after outbreaks and collection of large-volume water samples to identify pathogens that require special protocols for their recovery. EPA and the U.S. Geological Survey may be consulted for assistance with hydrogeologic investigations of outbreaks where untreated ground water is suspected.

Environmental Protection Agency Safe Drinking Water Hotline
Telephone: 800-426-4791
E-mail: hotline-sdwa@epa.gov
Internet: http://www.epa.gov/safewater

Testing for Bacterial Enteric Organisms
Telephone: 404-639-1798
Division of Foodborne, Bacterial and Mycotic Diseases
National Center for Zoonotic, Vector-borne, and Enteric Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC

Information or Testing for *Legionella*
Telephone: 404-639-2215
Internet: http://www.cdc.gov/legionella
Division of Bacterial Diseases
National Center for Immunization and Respiratory Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC

Testing for Parasites
Telephone: 770-488-7775
Division of Parasitic Diseases
National Center for Zoonotic, Vector-borne, and Enteric Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC

Testing for Viral Organisms
Telephone: 404-639-3607
Division of Viral Diseases
National Center for Immunization and Respiratory Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC

State Reporting of Waterborne Disease and Outbreaks
All WBDOs at the local level should be reported to the state health department.
Telephone: 770-488-7775
Fax: 770-488-7761
Division of Parasitic Diseases
National Center for Zoonotic, Vector-Borne, and Enteric Diseases (proposed)
Coordinating Center for Infectious Diseases, CDC

CDC Reporting Form CDC 52.12 (rev.01/2003)
Internet: http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf

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Appendix A
Glossary of Definitions

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.
agent	See etiologic agent.
aquifer	A geologic formation or part of a formation (e.g., gravel, sand, or porous stone) that yields water to wells or springs.
backflow	A hydraulic condition caused by a difference in water pressure that causes nonpotable water or other liquid to enter the potable water system by either backpressure or backsiphonage. See cross-connection.
backpressure	Backflow occurs when pressure from a customer's water system (e.g., potentially nonpotable water) is higher than pressure in the public water system.
backsiphonage	Backflow caused by negative or subatmospheric pressure within a water system.
biofilm	Microbial cells that adhere to a surface through a matrix of primarily polysaccharide materials in which they are encapsulated. These can grow on piping and surfaces of water systems and can be difficult to remove. They offer protection to microbes from disinfectants (e.g., chlorine) in the water.
boil-water advisory	A statement to the public advising that tap water must be boiled before drinking.
bottled water	Commercially produced bottled water.
class	Waterborne disease and outbreaks are classified according to the strength of the epidemiologic and water-quality data implicating water as the source of the disease or outbreak (see Table 3).
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). Coliforms are mostly harmless bacteria that live in soil and water as well as the gut of humans and animals.
community water system	A public water system that has at least 15 service connections used by year-round residents or regularly serves at least 25-year-round residents. The system might be owned by a private or public entity providing water to a community, subdivision, or mobile home park.
cross-connection	Any actual or potential connection between a drinking water supply and a possible source of contamination or pollution (i.e., nonpotable water). Under this condition, contaminated water might flow back into the drinking water system. See backflow.
deficiency	An antecedent event or situation contributing to the occurrence of a waterborne disease or outbreak.
dermatitis	Inflammation of the skin. In this report, the term dermatitis is used to denote a broad category of skin-related symptoms (e.g., folliculitis, cellulitis, chemical burns, or rash).

disinfection by-products	Chemicals formed in water by the reaction between organic matter and other waste products and disinfectants.
disinfection	A treatment that kills microorganisms (e.g., bacteria, viruses, and protozoa); in water treatment, a chemical (commonly chlorine, chloramine, or ozone) or physical process (e.g., ultraviolet light) may be used.
distribution system	Water pipes, storage reservoirs, tanks, and other means used to deliver drinking water to consumers or to store finished water before delivery to a customer. In community water systems, the distribution system is under the jurisdiction of a water utility and ends at the water meter or at the customer's property line (if the system is not metered). In noncommunity and nonpublic individual water systems, the distribution system ends at the point where water enters the building or house. See plumbing.
etiologic agent	The pathogen, chemical, or toxin causing a waterborne disease or outbreak. Infectious etiologic agents are bacteria, parasites, viruses, or fungi.
fecal coliforms	Coliform bacteria that grow and ferment lactose to produce gas at 112.1°F (44.5°C) in $\leq$24 hours. These bacteria are associated with human and animal wastes, and their presence in water is a strong indication of recent sewage or animal waste contamination.
filtration	In water treatment, the process of passing water through one or more permeable membranes or media of small diameter (e.g., sand, anthracite, and diatomaceous earth) to remove suspended particles from the water. Filters might be effective in removing pathogens, depending on the type and operation.
finished water	The water (e.g., drinking water) delivered to the distribution system after treatment, if any.
free chlorine	The chlorine in water that is not combined with other constituents, therefore, serving as an effective disinfectant (also referred to as free available chlorine and residual chlorine).
ground water	Water that is contained in interconnected pores in an aquifer.
ground water system	A system that uses water extracted from an aquifer (i.e., a well or spring) as its source.
ground water under the direct influence of surface water	As defined by the U.S. Environmental Protection Agency (EPA), any water beneath the surface of the ground with substantial occurrence of insects or other macrooganisms, algae, or large-diameter pathogens (e.g., *Giardia intestinalis* or *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.
individual water system	A water system that does not meet the EPA definition for a public water system. The system might serve a single family or farm not having access to a public water system, or it might regularly serve as many as 24 persons or 14 connections. States are responsible for regulating these water systems.
karst aquifer	An aquifer characterized by water-soluble limestone and similar rocks in which fractures or cracks have been widened by the dissolution of the carbonate rocks by ground water; the aquifer might contain sinkholes, tunnels, or even caves.

maximum contaminant level	The maximum permissible concentration (i.e., level) of a contaminant in water supplied to any user of a public water system.
mixed-agent outbreak	More than one type of etiologic agent is identified in clinical specimens from affected persons, and each etiologic agent is found in ≥5% of positive clinical specimens (e.g., an outbreak with *Giardia* spp. [parasites] and *Salmonella* spp. [bacteria] with each agent identified in ≥5% of stool specimens).
mixed-illness outbreak	More than one type of illness is reported by ≥50% of patients in a single outbreak (e.g., a combination of gastroenteritis and dermatitis).
mixed-source outbreak	More than one type of source water is implicated in the outbreak (e.g., a combination of ground water and surface water).
mixed-system outbreak	More than one type of water system is implicated in the outbreak (e.g., a combination of noncommunity and individual water systems).
noncommunity water system	A public water system that is not a community system; it does not serve year-round residents. There are two types: transient and nontransient noncommunity systems.
nontransient noncommunity water system	A public water system that is not a community system and that regularly serves at least 25 of the same persons for more than 6 months per year (e.g., a school, a factory, or a business with its own water supply).
plumbing	Water pipes, storage reservoirs, tanks, and other means used to deliver drinking water to consumers inside buildings or houses or to store drinking water inside buildings or houses before consumption. In community water systems, the plumbing begins after the water utility's water meter or at the property line (if the distribution system is not metered). In noncommunity and nonpublic individual water systems, the plumbing begins at the point where water enters the building or house. See distribution system.
predominant illness	The category of illness reported by at least 50% of ill respondents (e.g., gastroenteritis, dermatitis, or acute respiratory illness). When more than one illness category is reported for a single waterborne disease and outbreak (WBDO), they are listed together as predominant illnesses. These mixed illness WBDOs are analyzed separately from WBDOs with single illnesses.
primary water exposure	For use in this report, a classification used for the source of contaminated water for water not intended for drinking or water of unknown intent.
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. Such a system must have at least 15 service connections or regularly serve at least 25 persons daily for at least 60 days per year.
raw water	Surface water or ground water that has not been treated in any way.
reservoir, impoundment	An artificially maintained lake, created for the collection and storage of water. This body of water may be available as a source of raw water for drinking purposes and/or recreational use. In some instances, a finished water storage facility in the distribution system might also be called a reservoir.
setting	Location where exposure to contaminated water occurred (e.g., restaurant, water park, and hotel).
source water	Untreated water (i.e., raw water) used to produce drinking water.

surface water	All water on the surface (e.g., lakes, rivers, reservoirs, ponds, and oceans) as distinguished from subsurface or ground water.
total coliforms	Fecal and nonfecal coliforms that are detected by using a standard test. The extent to which total coliforms are present in water can indicate the general quality of that water and the likelihood that the water is fecally contaminated by animal and/or human sources.
transient noncommunity water system	A public water system that that is not a community system and that does not regularly serve at least 25 of the same persons over 6 months per year. These systems provide water to places where persons do not remain for long periods (e.g., restaurants, campgrounds, highway rest stations, and parks with their own public water systems).
untreated water	Surface water or ground water that has not been treated in any way (i.e., raw water).
water not intended for drinking	Water that has not been treated for human consumption in conformance with EPA drinking water standards and that is provided for uses other than for drinking.
water of unknown intent	The information about the water is insufficient to determine for what purpose it is being provided or used and whether is has been treated for human consumption in conformance with EPA drinking water standards.
water system	A system for the provision of water for human consumption through pipes or other constructed conduits. This includes any collection, treatment, storage, and distribution facilities used primarily in connection with such a system.

Appendix B

Descriptions of Selected Waterborne Disease and Outbreaks (WBDOs) Associated with Drinking Water, Water Not Intended for Drinking, and Water of Unknown Intent

WBDO date	State/Territory in which WBDO occurred	Etiologic agent	No. of cases (deaths)	WBDO description
Bacteria				
May 2003	Washington	*Campylobacter* spp.	110	Attendees of a tent revival experienced gastrointestinal illness. Participants were from British Columbia, Idaho, Montana, Oregon, and Washington. A case-control study suggested an association between illness and consumption of farm water. The farm had both domestic and irrigation wells. Water samples from both wells were positive for fecal coliforms. Leaking valves and backsiphonage through cross-connections might have contributed to contamination of the domestic well water.
November 2003	Ohio	*C. jejuni* and *Shigella* spp.	57	An unlicensed caterer prepared food for several luncheons at her home to be served at a worksite. Iced tea made from untreated water from a spring-fed pond was associated with gastrointestinal illness. Tests performed on water from the caterer's kitchen sink and pitcher carbon filter were positive for total coliforms and *Escherichia coli* but negative for *Campylobacter* and *Shigella*.
December 2004	Wisconsin	*C. jejuni*	20	Restaurant patrons experienced gastrointestinal illness. A well supplying water for the restaurant tested positive for total coliforms and *E.coli*. The well water was untreated and taken from a karst aquifer. Years before this outbreak, the restaurant water also tested positive for coliform bacteria and had been issued with a boil-water advisory.
November 2002	Maryland	*Legionella pneumophila* serogroup 1	3	Health club patrons became ill with laboratory-confirmed Legionnaires' disease during an 8-week period. *L. pneumophila* serogroup 1 was isolated from a locker room shower. No clinical isolates were available for comparison.
November 2002	Virgin Islands	*L. pneumophila* serogroup 1	3	Three Danish travelers had laboratory-confirmed Legionnaires' disease after staying at a hotel implicated in a Legionnaires' disease outbreak during 1981–1982. All three cases were reported to local authorities by the European Surveillance Scheme for Travel-Associated Legionnaires' disease (http://www.ewgli.org), a surveillance program in place since 1987. Comparison of environmental strains collected from the hotel suggests that the potable water system was colonized with the same strain of *Legionella* for over 20 years. (**Source:** Cowgill KD, Lucas CE, Benson RF, et al. Recurrence of Legionnaires' disease at a hotel in the United States Virgin Islands over a 20-year period. Clin Infect Dis 2005;40:1205–7.)
October 2003	Maryland	*L. pneumophila* serogroup 1	7	Seven laboratory-confirmed cases were detected among guests of a hotel. This outbreak was detected by enhanced surveillance conducted by a single state (**Source:** CDC. Legionnaires' disease associated with potable water in a hotel—Ocean City, Maryland, October 2003–February 2004. MMWR 2005;54:165–8.)
January 2004	New York	*L. micdadei*	2	One definite health-care–associated case and one possible health-care–associated case were hospitalized at the same facility. Comparison of clinical and environmental isolates of *L. micdadei* revealed that they were related.
April 2004	Pennsylvania	*L. pneumophila* serogroup 1	3 (1)	Three laboratory-confirmed cases of Legionnaires' disease were residents of a long-term–care facility that was the source of an outbreak in 2002. In that outbreak and this one, *L. pneumophila* serogroup 1 was isolated from the facility's potable water system.
July 2004	Ohio	*L. pneumophila* serogroup 1	2	Two laboratory-confirmed cases of Legionnaires' disease occurred among workers at a street maintenance garage. The source of the cluster was not identified.
September 2004	North Carolina	*L. pneumophila* serogroup 1	7 (3)	The presence of laboratory-confirmed cases of Legionnaires' disease among residents of a long-term–care facility suggested that the potable water system of the facility was the source. However, further investigation revealed that a cooling tower approximately one quarter of a mile away was the likely source of these cases as well as community-acquired cases.
August 2004	Montana	*Salmonella typhimurium*	70	Restaurant patrons experienced diarrheal illness. Investigators determined that well water samples were positive for coliform bacteria and the ultraviolet disinfection unit was out of service. In addition, an existing cross-connection in the distribution system might have resulted in the backflow of water supplying a poultry pen.
Viruses				
January 2004	Pennsylvania	Norovirus	70	Visitors to a ski facility experienced gastrointestinal illness after drinking beverages from a soda fountain that had been cross-connected with a nonpotable water line drawing water from a pond. The pond water was untreated and tested positive for fecal coliforms. Potential sources of contamination of the pond water included snow melt and an adjacent septic system.

WBDO date	State/Territory in which WBDO occurred	Etiologic agent	No. of cases (deaths)	WBDO description
Chemicals/Toxins				
November 2003	Florida	Bromate and other disinfection by-products	2	Two persons consuming commercially bottled water experienced gastrointestinal illness. The water had a chemical odor. Testing of both opened and sealed bottles revealed above standard levels of bromate and other byproducts of chemical disinfection. This contamination likely occurred during the bottling process.
December 2003	Maine	Cleaning product	2	Two persons consuming commercially bottled water experienced gastrointestinal illness. Testing indicated contamination of both the water and the outside of the bottles. The bottles were purchased at the same grocery store. The bottom of one of the boxes containing the bottles showed evidence of a spill. An investigation into possible contamination revealed that boxes of commercially bottled water were stored in direct contact with the floor. During the investigation, a store employee reported that a cleaning product had been spilled near the boxes of bottled water and that two to three bottles had to be wiped off during the clean up.
June 2003	Minnesota	Copper	4	Restaurant patrons had gastrointestinal illness after consuming soda from a fountain machine. Beverage samples from the machine had copper levels above the acceptable 1.3 parts per million (ppm). A faulty check valve on the carbonator was found, suggesting that carbon dioxide was leaking into the water supply, reducing the pH of the water, resulting in copper leeching from the pipes.
November 2003	Minnesota	Copper	5	Restaurant patrons experienced gastrointestinal illness after consuming lemonade from a juice machine receiving frozen concentrated lemonade and diluting it with water before dispensing. Copper levels in samples from the machine were elevated (6.4 to 12.8 mg/L). Installation of a check valve and attachment to a different water supply did not reduce copper levels below the EPA action level (1.3 mg/L), suggesting internal plumbing problems.
July 2004	South Carolina	Copper	7	Restaurant patrons had gastroenteritis after consuming beverages from a soda fountain machine. Official samples collected from the soda fountain machines were within normal limits for metals. However, a pooled sample of three left-over beverages consumed by patrons had a copper level (8.1 mg/L) exceeding EPA standards. Copper levels in two serum specimens and six urine specimens from ill patrons were within normal limits (dates of specimen collection not reported). An inspection of the soda fountain machines did not reveal any critical violations.
March 2003	New York	Sodium hydroxide	4	Four persons suffered chemical burns after repairs were made on a check valve in the discharge line of a well supplying a community water system. While the discharge line was depressurized during maintenance, caustic soda had siphoned into the discharge main. When the well was placed back into service, approximately 50–100 gallons of 50% sodium hydroxide flowed into the distribution system. The water utility received complaints of “dirty water” and “burning sensation” from members of the community following well maintenance. An investigation found that a high pH was responsible.
April 2004	New Jersey	Sodium hydroxide	2	One person received a first degree chemical burn while showering and another person suffered an esophageal chemical burn after consuming water from a community water system. Failure of a check valve for the sodium hydroxide feed on a well resulted in discharge of this chemical into the distribution system. The pH meter at the well treatment plant recorded a maximum pH of 12.5.
Mixed agents				
December 2002	New York	*C. jejuni*, *Entamoeba* spp., and *Giardia* spp.	27	Residents and visitors in an apartment complex experienced gastrointestinal illness. A broken sewer line from an on-site sewage disposal system had flooded the basement of the main building in which a well supplying drinking water for the complex was located. Several inches of water and sewage covered the well head resulting in fecal contamination of the well water. Because of its relatively small size, the facility had not been identified or regulated as a community water supply before the reports of illness.
January 2004	Ohio	*C. jejuni, C. lari, Cryptosporidium* spp., and *Helicobacter canadensis*	82	Workers at a factory experienced gastrointestinal illness. Contamination of the potable water supply occurred through an open valve connecting the plant’s municipal water supply with the coolant line drawing nonpotable water from holding ponds behind the plant. The pond water was used to cool the plant’s machinery and tested positive for *Cryptosporidium* spp.
July 2004	Ohio	*C. jejuni*, norovirus, and *G. intestinalis*	1,450	Residents and visitors at a resort island in Lake Erie experienced gastrointestinal illness. A number of noncommunity public and private wells tested positive for total coliforms and *E. coli*, among other microorganisms (e.g., other bacteria, parasites, and viruses). Investigators concluded that substantial microbiological contamination of the ground water in the karst aquifer from multiple land uses was present, such as on-site septic systems, land application of septage, infiltration of land run-off, and possibly from the direct hydraulic connection with Lake Erie. Water quality degradation most likely occurred over a long period. Other possible contributing factors included cross-connections in the water distribution system; an increase in precipitation before the outbreak; the volume of wastewater flowing to sewage treatment systems during periods of heavy island visitation; the number, type, and maintenance of sewage disposal systems; and groundwater well construction.

WBDO date	State/Territory in which WBDO occurred	Etiologic agent	No. of cases (deaths)	WBDO description
Unidentified				
January 2003	Florida	Norovirus suspected	419	Players, coaches, and spectators who attended a volleyball tournament experienced gastrointestinal illness. The incubation period, clinical presentation, and duration of illness suggested norovirus as the etiologic agent. During the tournament, numerous opportunities existed for contact between players. Some also reported touching their refillable water bottles to the spouts of 5-gallon commercially bottled water containers beside the courts. The only statistically significant relative risk (RR = 2.24; confidence interval = 1.14–4.41) in a cohort study among the players was drinking water from these containers. While the water tested negative for norovirus, contaminated spouts or levers on the containers that the players depressed to dispense water might have contributed to the spread of illness. Person-to-person transmission, fomite transmission, and aerosolization of vomitus likely also played roles.
July 2003	Illinois	Unidentified	180	Visitors to a water park experienced gastrointestinal illness. Testing of stool samples from eight persons failed to identify an etiologic agent. An epidemiologic study implicated drinking water at the park. Chlorinated drinking water was supplied from 13 on-site wells. *E. coli* was detected in 10 of 29 water samples.
September 2003	Michigan	Unidentified	4	Construction workers installing sewer lines experienced gastrointestinal illness. Stool cultures for each ill worker were negative. All ill workers drank from a communal water jug that might also have been used to wash parts.
June 2004	Pennsylvania	Unidentified	174	Attendees of a camp experienced gastrointestinal illness. Testing of stool samples from five persons failed to identify an etiologic agent. Sometime in the week before the outbreak, a vehicle damaged a sewer pipe and sewage flowed into a lake. A shallow well supplying drinking water was located near the edge of this lake. Two days before the onset of the first case, camp staff discovered that the chlorine pump on this well was broken. Testing of the well water revealed high coliform levels, suggesting that the well water was under the influence of surface water.

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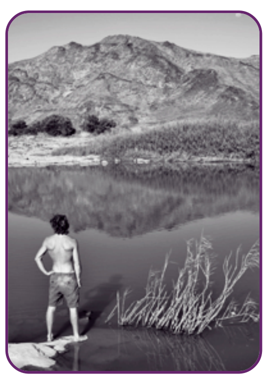
Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water Use and Other Aquatic Facility-Associated Health Events — United States, 2005–2006

and

Surveillance for Waterborne Disease and Outbreaks Associated with Drinking Water and Water not Intended for Drinking — United States, 2005–2006



DEPARTMENT OF HEALTH AND HUMAN SERVICES

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CONTENTS

On the Cover (*left to right*)**:** A child filling a cup with tap water. A man standing in a natural body of water. Young children playing in a swimming pool.

Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water Use and Other Aquatic Facility-Associated Health Events — United States, 2005–2006

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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 collaboratively maintained the Waterborne Disease and Outbreak Surveillance System for collecting and reporting data related to waterborne-disease outbreaks (WBDOs) associated with drinking water. In 1978, WBDOs associated with recreational water (natural and treated water) were added. This system is the primary source of data regarding the scope and effects of disease associated with recreational water in the United States. In addition, data are collected on individual cases of recreational water-associated illnesses and infections and health events occurring at aquatic facilities but not directly related to water exposure.

Reporting Period: Data presented summarize WBDOs and case reports associated with recreational water use that occurred during January 2005–December 2006 and previously unreported disease reports and outbreaks during 1978–2004.

Description of the System: Public health departments in the states, territories, localities, and the Freely Associated States (i.e., 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) have primary responsibility for detecting, investigating, and voluntarily reporting WBDOs to CDC. Although the surveillance system includes data for WBDOs and cases associated with drinking water, recreational water, and water not intended for drinking, only cases and outbreaks associated with recreational water and health events at aquatic facilities are summarized in this report.

Results: During 2005–2006, a total of 78 WBDOs associated with recreational water were reported by 31 states. Illness occurred in 4,412 persons, resulting in 116 hospitalizations and five deaths. The median outbreak size was 13 persons (range: 2–2,307 persons). Of the 78 WBDOs, 48 (61.5%) were outbreaks of gastroenteritis that resulted from infectious agents or chemicals; 11 (14.1%) were outbreaks of acute respiratory illness; and 11 (14.1%) were outbreaks of dermatitis or other skin conditions. The remaining eight were outbreaks of leptospirosis (n = two), primary amebic meningoencephalitis (n = one), and mixed or other illnesses (n = five). WBDOs associated with gastroenteritis resulted in 4,015 (91.0%) of 4,412 illnesses. Fifty-eight (74.4%) WBDOs occurred at treated water venues, resulting in 4,167 (94.4%) cases of illness. The etiologic agent was confirmed in 62 (79.5%) of the 78 WBDOs, suspected in 12 (15.4%), and unidentified in four (5.1%). Thirty-four (43.6%) WBDOs had a parasitic etiology; 22 (28.2%), bacterial; four (5.1%), viral; and two (2.6%), chemical or toxin. Among the 48 gastroenteritis outbreaks, *Cryptosporidium* was confirmed as the causal agent in 31 (64.6%), and all except two of these outbreaks occurred in treated water venues where *Cryptosporidium* caused 82.9% (29/35) of the gastroenteritis outbreaks.

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Case reports associated with recreational water exposure that were discussed and analyzed separately from outbreaks include three fatal *Naegleria* cases and 189 *Vibrio* illnesses reported to the Cholera and Other *Vibrio* Illness Surveillance System. For *Vibrio* reporting, the most commonly reported species were *Vibrio vulnificus*, *V. alginolyticus*, and *V. parahaemolyticus*. *V. vulnificus* illnesses associated with recreational water exposure had the highest *Vibrio* illness hospitalization (77.6%) and mortality (22.4%) rates.

In addition, 32 aquatic facility-related health events not associated with recreational water use (e.g., pool chemical mixing accidents) that occurred during 1983–2006 were received from New York. These events, which caused illness in 364 persons, are included in this report but analyzed separately.

Interpretations: The number of WBDOs summarized in this report and the trends in recreational water-associated disease and outbreaks demonstrate a substantial increase in number of reports from previous years. Outbreaks, especially the largest ones, occurred more frequently in the summer at treated water venues and caused gastrointestinal illness. Deficiencies leading to WBDOs included problems with water-quality, venue design, usage, and maintenance. Case reports of illness associated with recreational water use expand our understanding of the scope of waterborne illness by further underscoring the contribution of less well-recognized swimming venues (e.g., oceans) and illness (e.g., nongastrointestinal illness). Aquatic facilities are also a focus for injuries involving chemicals or equipment used routinely in the operation of swimming venues, thus illustrating the lack of training of some aquatics staff.

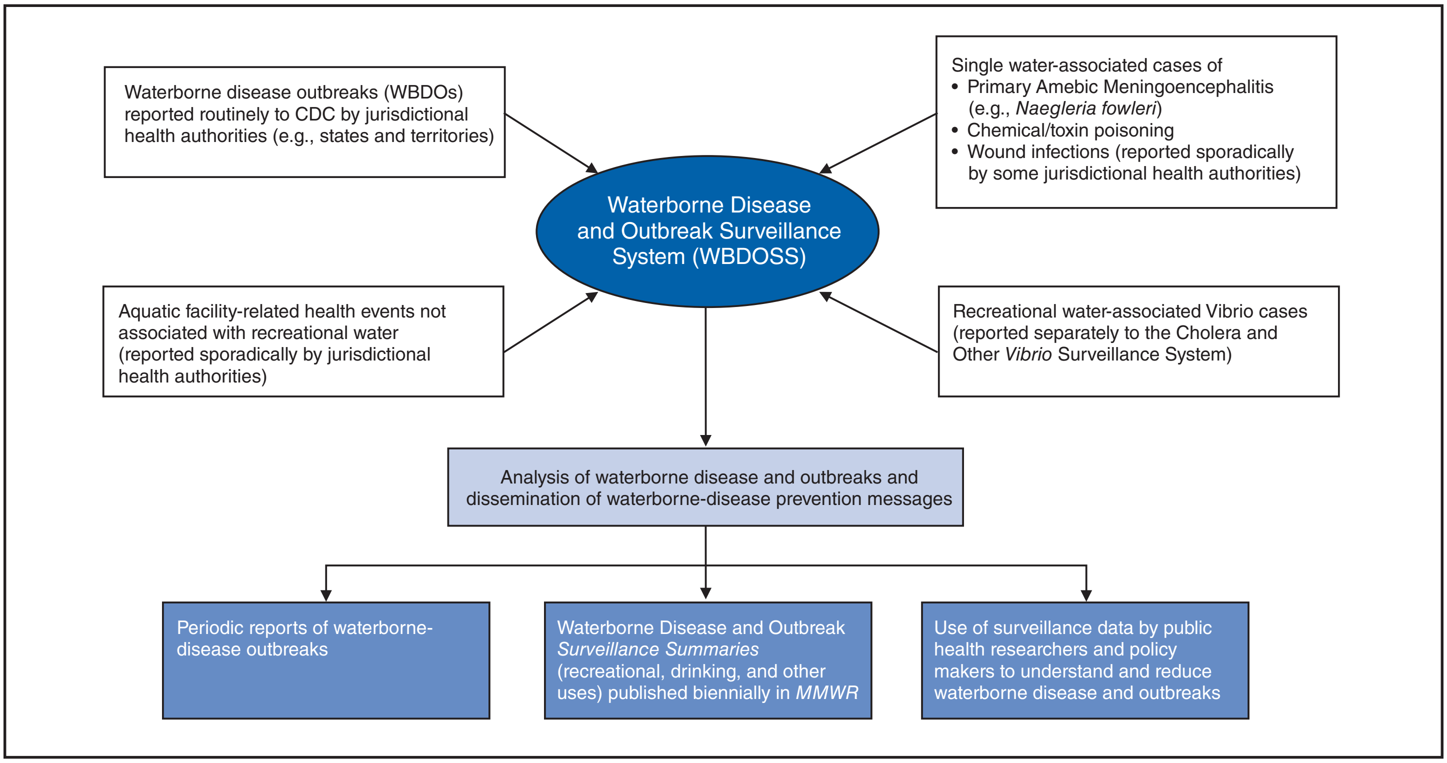
Public Health Actions: CDC uses WBDO surveillance data to 1) identify the etiologic agents, types of aquatic venues, water-treatment systems, and deficiencies associated with outbreaks and case reports; 2) evaluate the adequacy of efforts (i.e., regulations and public awareness activities) to provide safe recreational water; 3) expand the scope of understanding about waterborne disease and health events associated with swimming and aquatics facilities; and 4) establish public health prevention priorities, data, and messaging that might lead to improved regulations, guidelines, and prevention measures at the local, state, and federal levels.

Introduction

During 1920–1970, statistical data regarding waterborne-disease outbreaks (WBDOs) in the United States 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 collaboratively maintained the Waterborne Disease and Outbreak Surveillance System (WBDOSS), a surveillance system that tracks the occurrences and causes of WBDOs and cases of disease associated with drinking water (*2–11*). In 1978, WBDOs associated with recreational water were added to the surveillance system. The types of outbreaks and disease case reports included in the *Surveillance Summaries* have expanded multiple times to more accurately reflect the scope of waterborne disease in the United States. Outbreaks of Pontiac fever (PF) were added in 1989 (*9*), outbreaks of Legionnaires' disease (LD)were added in 2001 (*3,12*), and single cases of *Vibrio* illness reported to the Cholera and Other *Vibrio* Illness Surveillance System that were associated with recreational water use were added in 2003. WBDOs associated with drinking water and water not intended for drinking are presented in a separate report (*13*).

WBDO surveillance activities are intended to 1) characterize the epidemiology of waterborne disease; 2) identify trends in the etiologic agents and other factors associated with WBDOs; 3) identify major deficiencies in providing safe recreational water; 4) encourage public health personnel to detect and investigate WBDOs; 5) foster collaboration among local, state, federal, and international agencies on initiatives to prevent waterborne disease; and 6) collect data needed to support future prevention efforts. Additional data on cases of waterborne disease related to recreational water are gathered from separate disease surveillance systems and through supplementary surveillance activities (Figure 1). Some of these data are collected and analyzed in WBDOSS, and some are discussed in this report. These data are useful for expanding our understanding of the scope of waterborne disease, identifying important factors associated with unsafe or unhealthy recreational water, influencing research priorities, supporting public health recommendations, and encouraging improved water-quality policies and regulations. However, WBDOs and case reports summarized in this report are thought to represent only a portion of the illness associated with recreational water exposure. Reliable estimates of the number of unrecognized WBDOs are not available. In addition, the surveillance information described in this report does not include estimates of the number of recreational water illnesses (RWIs).

FIGURE 1. Data sources and outputs of the Waterborne Disease and Outbreak Surveillance System



Background

Regulation of Recreational Water Quality

In the United States, state and local governments establish and enforce regulations for protecting recreational water from naturally occurring or human-made contaminants. For treated water venues (e.g., swimming pools and water parks), no federal regulatory agency has authority, and no national guidelines for standards of design, construction, operation, disinfection, or filtration exist, except recent regulation to prevent entrapment injuries (*14*). Swimming pool codes are developed and enforced by state and local health departments; therefore, substantial variation is observed across the country in terms of policy, compliance, and enforcement (*15*). Efforts are underway to develop a Model Aquatic Health Code (available at http://www.cdc.gov/healthyswimming/model_code.htm) to be used as a national voluntary guideline. These data-driven and knowledge-based guidelines will be focused on promoting healthy recreational water experiences by preventing disease and injuries. The model code will be available to state and local health agencies needing guidance in writing, updating, and implementing state or local pool codes and might help standardize pool codes across the United States.

EPA sets guidelines for recreational use of natural waters (e.g., lakes, rivers, and oceans). In 1986, EPA developed recommended bacterial water-quality criteria for coastal recreation waters (*16*) and recently established federal standards for those states and territories that have not yet adopted water-quality criteria that meet or exceed the 1986 criteria (*17*). For freshwater, full-body contact beaches (e.g., lakes and rivers), EPA has recommended 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, full-body contact beaches, EPA has recommended that the monthly geometric mean water-quality indicator concentration be $\leq$35 CFU/100 mL for enterococci. However, state and local authorities have discretionary authority to determine which interventions should be used (e.g., posting signs to alert visitors of water contamination or closing the beach for swimming) when these limits have been exceeded. Beach Watch, EPA's Action Plan for Beaches and Recreational Waters (report available at http://www.epa.gov/waterscience/beaches/technical.html), was published in 1999 as part of the Clean Water Action Plan (available at http://www.epa.gov/beaches). The intent of Beach Watch is to assist state, tribal, and local authorities in strengthening and extending existing programs to protect users of fresh and marine recreational waters; as part of the BEACH Act of 2000, the U.S. Congress directed EPA to update its guidelines for recreational

water use on the basis of improved water-quality indicators and testing. As a result, EPA has been collaborating with CDC since 2002 on the National Epidemiologic and Environmental Assessment of Recreational (NEEAR) Water Study at fresh and marine water recreational beaches in the United States. Information on the NEEAR is available at http://www.epa.gov/nheerl/neear. This study is being conducted to evaluate rapid new water-quality methods that are able to produce results in <2 hours and to correlate these indicators with health effects among beachgoers. Results from freshwater Great Lakes beaches have demonstrated an association between an increasing signal detected by a quantitative polymerase chain reaction-based test method for enterococci and human health effects (*18, 19*). Children aged <10 years were at greater risk for gastrointestinal illness following exposure (*19*) to water with elevated levels of enterococci.

Methods

Data Sources

Public health departments in individual states, territories, localities, and the Freely Associated States (FAS)* have the primary responsibility for detection and investigation of WBDOs. The outbreaks are voluntarily reported to CDC through a standard form (i.e., CDC form 52.12; available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf). The form solicits data on WBDO, including characteristics of person, place, and time and results of epidemiologic studies, disease symptoms, diagnostic testing, and water sampling. Information gathered regarding the setting of the outbreak includes the type of aquatic facility, water source and treatment, sanitary measures in place, and possible factors contributing to the contamination of the water. Public health professionals in each state or locality are designated as WBDO surveillance coordinators, and CDC annually requests reports from coordinators in all states and localities and conducts as much follow-up correspondence as needed to resolve unaddressed questions. Although national reporting only includes WBDOs, single cases of certain waterborne diseases (e.g., primary amebic meningoencephalitis (PAM) and chemical toxin poisoning) are also solicited from coordinators. Outbreaks, cases, or other health events, where applicable, are assigned to a state on the basis of the location of the exposure rather than state of residence of ill persons. Numeric and text data from the CDC waterborne disease outbreak form and any supporting documentation are entered into a database for analysis. Although all WBDOs are collected through the same CDC reporting system, the recreational water-associated outbreaks are analyzed and published separately from drinking water-associated outbreaks and other WBDOs (*13*). Information on WBDOs and cases is sometimes solicited from other CDC surveillance systems and confirmed with the state or locality for inclusion in WBDOSS or *Surveillance Summary* (Figure 1). *Vibrio* illnesses associated with recreational water exposure were received from the Cholera and Other *Vibrio* Illness Surveillance System.

Definitions†

Waterborne Disease Outbreaks

The unit of analysis for the summary is an outbreak, not an individual case of a waterborne disease. To be defined as a WBDO associated with recreational water, an event must meet two criteria. First, two or more persons must be epidemiologically linked by the location of the exposure to recreational water, time, and illness. Recreational water settings include swimming pools, wading pools, spas, waterslides, interactive fountains, wet decks, and fresh and marine bodies of water. Second, the epidemiologic evidence must implicate water or volatilization of water-associated compounds into the air surrounding an aquatic facility as the probable source of the illness. For this report, WBDOs are separated by venue as untreated (i.e., fresh and marine surface water) or treated (i.e., filtered or disinfected [e.g., chlorinated]) water. WBDOs associated with ships are not included in this report.

Case Reports of Waterborne Illness or Reports of Aquatic Facility-Associated Health Events

This report also includes 1) individual cases of laboratory-confirmed PAM associated with recreational water use, 2) single cases of wound infections or other *Vibrio* infections associated with recreational water use, 3) single cases of chemical and toxin poisoning if water or air-quality data indicate contamination by the chemical or toxin, and 4) outbreaks or case reports of health events associated with aquatic facilities but not associated with the recreational water but rather contaminated aquatic facility air (e.g., mixing of chemicals in the pump room might release toxic gas that injures staff or facility users) (Figure 1). Because these four event categories do not meet WBDO definition, they are analyzed separately from WBDOs.

* 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 have been defined (Appendix A, Glossary of Definitions).

Strength of Evidence Classification for Waterborne-Disease Outbreaks

WBDOs reported to WBDOSS are classified according to the strength of evidence that implicates 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 WBDO report form. Although in certain instances WBDOs without water-quality data were included in this report, outbreaks that lacked any epidemiologic data linking the outbreak to water were excluded.

Class 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. Likewise, a classification of II, III, or IV does not imply that an investigation was inadequate or incomplete. Outbreaks and investigations occur under varying circumstances, and not all outbreaks can or should be rigorously investigated. In addition, outbreaks that affect fewer persons are more likely to receive classifications of III or IV because of the limited sample size available for data analysis.

Changes in the 2005–2006 *Surveillance Summary*

The definition of a waterborne outbreak has been modified for this report to be consistent with generally accepted public health practice (i.e., two or more epidemiologically linked cases associated with use of recreational water). Health events at aquatic facilities not associated with direct exposures to recreational water are, for the first time, presented and discussed but not analyzed as waterborne outbreaks.

Definition

Previously, the definition of a recreational waterborne disease outbreak included certain single cases of waterborne disease. The definition of a recreational waterborne-disease outbreak has been clarified to include two or more persons who have been epidemiologically linked to recreational water by location of exposure, time, and illness. Exposures include contact with or accidental ingestion of water and certain inhalation exposures (e.g., exposure to water-associated compounds [e.g., chloramines] volatilizing into the air of the aquatic facility). Single cases of PAM, recreational water-associated *Vibrio* illness, and illness related to chemical exposure caused by water are included in WBDOSS but are not classified or analyzed as outbreaks. These single cases are analyzed separately.

Aquatic Facility-Related Health Events not Associated with Recreational Water

Previous *Surveillance Summaries* only included outbreaks in which the vehicle of transmission was water or airborne chemical products originating from water (e.g., chloramines). Nonwater-related illnesses resulting from chemical inhalation or exposure at aquatic facilities have not been discussed in previous *Surveillance Summaries.* This report includes, as a separate analysis, chemical injury (e.g., mixing of pool chemicals that release toxic gas) cases and outbreaks at aquatic facilities in which direct exposure to water was not the cause of illness. Whereas these events are not classified or analyzed as waterborne outbreaks, they highlight important public health and safety concerns related to the design, operation, and maintenance of recreational water venues and are targeted to the same audiences who are the focus of the waterborne disease and outbreaks already included in this report.

TABLE 1. Classification of investigations of waterborne-disease outbreaks based on strength of evidence inplicating water as the vehicle of transmission — 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 Laboratory data or historical information (e.g., the history that a chlorinator or pH acid feed pump malfunctioned, no detectable free-chlorine residual, or a breakdown in a recirculation system)
II	Adequate	Not provided or inadequate (e.g., laboratory testing of water not conducted and no historical information)
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

Results

Waterborne-Disease Outbreaks

Excluding *Vibrio* and PAM cases and aquatic facility-related health events, a total of 78 outbreaks (38 in 2005 and 40 in 2006) associated with recreational water were reported to CDC (Tables 2–5). This is the highest number of outbreaks reported for a 2-year summary since reporting began in 1978. Of the 50 states and 10 territories, localities, and FAS participating in WBDOSS, 31 states reported WBDOs (Figure 2). Descriptions of selected WBDOs are presented in this report (Appendix B, Selected Descriptions of Waterborne Disease and Outbreaks [WBDOs] Associated with Recreational Water). These 78 outbreaks affected 4,412 persons and resulted in five deaths. The median outbreak size was 13 persons (range: 2–2,307 persons). Minnesota reported the highest number of WBDOs (nine), New York and Florida each reported seven WBDOs, and Wisconsin reported six WBDOs.

During 2005–2006, treated water venues were associated with 58 (74.4%) of the recreational water outbreaks and 4,167 (94.4%) of the cases (Tables 2 and 3; Figure 3). Untreated venues were associated with 20 (25.6%) of WBDOs but only 245 (5.6%) of the cases (Tables 4 and 5).

Of the 78 WBDOs, 48 (61.5%) were outbreaks of acute gastroenteritis illness (AGI), 11 (14.1%) were outbreaks of dermatitis or other skin conditions, and 11 (14.1%) were outbreaks of acute respiratory illness (ARI). The remaining WBDOs resulted in leptospirosis (n = two), PAM (n = one), and mixed or other illnesses (n = five) (Table 6, Figure 3). WBDOs associated with gastroenteritis accounted for 4,015 (91.0%) of the cases of illness. The route of entry implicated for each WBDO was ingestion for 48 outbreaks (61.5%), inhalation for 10 (12.8%), contact for 8 (10.3%), combined routes for nine (11.5%), and other (*Naegleria* and *Leptospira*) for three (3.8%) Figure 3).

WBDOs occurred in every calendar month. However, the summer months (June through August) accounted for 51 (65.4%) WBDOs and 3,890 (88.2%) cases (Figure 4). Gastroenteritis was particularly clustered during these months with 40/48 (83.3%) outbreaks and 3,777/4,015 (94.1%) cases being reported.

TABLE 2. Waterborne-disease outbreaks (n = 24) associated with treated recreational water, by state — United States, 2005

State	Month	Class*	Etiologic agent	Predominant illness†	No. of cases (deaths) (n = 3,376)	Type	Setting
Connecticut	Apr	I	*Pseudomonas aeruginosa*	Skin	4	Pool, Spa	Hotel
Florida	Jun	II	*Cryptosporidium*	AGI	47	Pool	Hotel
Iowa	Jun	II	*Cryptosporidium*	AGI	24	Pool	Community
Kansas	Jul	II	*Cryptosporidium*	AGI	84	Pool	Water park
Kentucky	Jun	IV	*Cryptosporidium*	AGI	53	Pools	Community
Kentucky	Jun	IV	*Cryptosporidium*	AGI	9	Pool, wading pool	Community
Louisiana	Aug	IV	*Cryptosporidium*	AGI	31	Interactive fountain	Water park
Massachusetts	Jul	III	*Giardia intestinalis*	AGI	11	Pool	Membership club
Minnesota	May	II	Unidentified	AGI	32	Pool, spa	Membership club
Minnesota	Aug	IV	*Legionella pneumophila* serogroup 1	ARI	3	Spa	Private residence
Minnesota	Apr	I	Unidentified§	ARI, eye	20	Pool, spa	Hotel
Minnesota	Mar	IV	Unidentified¶	Skin	8	Spa	Hotel
North Carolina	Apr	III	*L. pneumophila* serogroup 1	ARI	4 (1)	Spa	Private residence
New Mexico	Apr	III	*P. aeruginosa*	Skin, ear	7	Pool, spa	Hotel
New York	Aug	II	*Cryptosporidium*	AGI	97	Pool	Camp
New York	Oct	III	*Cryptosporidium*	AGI	22	Pool	Membership club
New York	Jun	I	*C. hominis***	AGI	2,307	Interactive fountain	State park
Ohio	Jul	III	Chlorine gas††	ARI	19	Pool	Community
Ohio	Aug	III	*C. hominis*	AGI	523	Pools	Community
Oregon	Jul	II	*C. parvum*	AGI	20	Pool	Membership club
South Carolina	Oct	III	*L. pneumophila*§§	ARI	18	Spa	Hotel
Vermont	Feb	IV	Unidentified¶	Skin	18	Spa	Hotel
Wisconsin	Jul	I	*P. aeruginosa*	Skin	9	Pool, Spa	Hotel
Wyoming	Jul	IV	*Campylobacter jejuni*	AGI	6	Kiddie pool	Private residence

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12 (available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf) (see Table 1).
† Skin: illness, condition, or symptom related to skin; AGI: acute gastrointestinal illness; ARI: acute respiratory illness; Eye: illness, condition, or symptom related to eyes; and Ear: illness, condition, or symptom related to ears.
§ Etiology unidentified: contamination from excess chlorine levels or pool disinfection by-products (e.g., chloramines) suspected.
¶ Etiology unidentified: *P. aeruginosa* suspected on the basis of clinical syndrome and setting.
** Species determined using molecular technology and current taxonomic guidelines (**Source:** Xiao L, Ryan UM. 2008: Molecular epidemiology, In: *Cryptosporidium* and cryptosporidiosis. Fayer R, Xiao L, eds. Boca Raton, Florida: CRC Press; 2008:119-71).
†† Chlorine gas was released after high levels of liquid chlorine and acid were mixed in the recirculation system and subsequently released into the pool water.
§§ Fifteen persons were diagnosed with Pontiac fever and three persons were diagnosed with Legionnaires' disease.

TABLE 3. Waterborne-disease outbreaks (n = 34) associated with treated recreational water, by state — United States, 2006

State	Month	Class*	Etiologic agent	Predominant illness†	No. of cases (deaths) (n = 791)	Type	Setting
Arkansas	Jul	I	*Legionella pneumophila*§	ARI	37	Pool, spa	Hotel
California	Jul	II	*Shigella sonnei*	AGI	9	Kiddie pool	Private residence
California	Jul	III	*Cryptosporidium*¶	AGI	16	Interactive fountain	Community
Colorado	Aug	II	*Cryptosporidium***	AGI	12	Pool	Community
Colorado	Oct	II	*L. pneumophila* serogroup 1††	ARI	6	Spa	Private home
Florida	Jan	I	*L. pneumophila* serogroup 1	ARI	11 (1)	Spa	Hotel
Florida	May	III	*Giardia, Cryptosporidium*§§	AGI	55	Interactive fountain	Community
Florida	Aug	IV	*Cryptosporidium*	AGI	3	Pool	Hotel
Georgia	Aug	IV	*Cryptosporidium*	AGI	19	Pool	Community
Georgia	Feb	IV	Unidentified ¶¶	Skin	4	Spa	Cabin
Georgia	Oct	IV	*Cryptosporidium*	AGI	4	Pool	Community
Illinois	Jan	I	*Legionella****	ARI	43 (1)	Pool, spa	Hotel
Illinois	Jul	I	*C. hominis***	AGI	65	Pool	Day camp, water park
Illinois	Jun	III	Unidentified†††	Skin	9	Pool	Community
Illinois	Aug	IV	*Cryptosporidium*	AGI	4	Pool	Water park
Illinois	Aug	IV	*Cryptosporidium*	AGI	18	Pool	Water park
Indiana	Apr	IV	Unidentified	ARI, ear	12	Pool	Membership club
Kansas	Dec	IV	*Pseudomonas aeruginosa*	Skin	8	Spa	Private residence
Louisiana	Jul	II	*Cryptosporidium***	AGI	29	Pool, interactive fountain	Water park
Minnesota	Sep	II	*C. hominis*	AGI	47	Pool	Schools
Missouri	Jul	IV	*Cryptosporidium*	AGI	6	Pool	Community
Missouri	Jun	III	*Cryptosporidium*	AGI	116	Pool, interactive fountain	Water park
Montana	Jul	IV	*Cryptosporidium*	AGI	82	Pools	Community
Nebraska	Dec	III	Unidentified§§§ ¶¶¶	ARI, eye	24	Pool	Hotel
New York	Oct	III	*L. pneumophila* serogroup 1	ARI	2	Spa	Water park
New York	Mar	IV	Unidentified§§§	ARI	9	Pool	Water park
Pennsylvania	Jun	IV	*Cryptosporidium*	AGI	13	Pool	Membership club
South Carolina	Jul	III	*C. hominis***	AGI	12	Pool	Community
Tennessee	Mar	IV	Unidentified¶¶	Skin	15	Pool, spa	Hotel
Wisconsin	Feb	III	Unidentified ¶¶	Skin	28	Pool, spa	Hotel
Wisconsin	May	I	Norovirus	AGI	18	Pool	Hotel
Wisconsin	Aug	II	*Cryptosporidium*	AGI	22	Pool	Campground
Wisconsin	Aug	IV	*Cryptosporidium*	AGI	4	Pool	Community
Wyoming	Jun	II	*Cryptosporidium***	AGI	29	Pools****	Community

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12 (available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf) (see Table 1).
† ARI: acute respiratory illness; AGI: acute gastrointestinal illness; Skin: illness, condition, or symptom related to skin; Ear: illness, condition, or symptom related to ears; and Eye: illness, condition, or symptom related to eyes.
§ Pontiac fever was diagnosed in 34 persons, and Legionnaires' disease was diagnosed in three persons.
¶ Eleven pulsed-field gel electrophoresis-matched cases of *Salmonella stanley* were also detected among persons who visited the fountain during this outbreak; however, the outbreak investigation did not rule out other possible common exposures among those case-patients.
**** Source:** CDC. Cryptosporidiosis outbreaks associated with recreational water use — five states, 2006. MMWR 2007;56:729–32.
†† All cases were diagnosed as Pontiac fever.
§§ Thirty-five persons had stool specimens that tested positive for *Giardia*, seven persons had stool specimens that tested positive for *Cryptosporidium,* and two persons had stool specimens that tested positive for both *Giardia* and *Cryptosporidium*.
¶¶ Etiology unidentified: *Pseudomonas aeruginosa* suspected on the basis of clinical syndrome and setting.
*** Pontiac fever was diagnosed in 40 persons, and Legionnaires' disease was diagnosed in three persons. *L. pneumophila* and *L. maceachernii* were detected in both pool and spa water.
††† Etiology unidentified: low pH suspected on the basis of water testing and symptoms.
§§§ Etiology unidentified: chemical contamination from pool disinfection by-products (e.g., chloramines) suspected.
¶¶¶ **Source:** CDC. Ocular and respiratory illness associated with an indoor swimming pool—Nebraska, 2006. MMWR 2007;56:929–32.
**** Case-patients identified in this outbreak reported exposure to multiple community pools and to an untreated reservoir.

Etiologic Agents

Of the 78 WBDOs associated with recreational water, the etiologic agent was confirmed in 62 (79.5%), suspected in 12 (15.4%) and unidentified in four (5.1%) (Table 7). Thirty-four (43.6%) outbreaks were confirmed as being caused by parasites; 22 (28.2%), bacteria; four (5.1%), viruses; and two (2.6%), chemicals (Figure 3).

Of the 47 outbreaks associated with treated water venues with an identified etiologic agent: 31 (66.0%) involved parasites; 14 (29.8%), bacteria; one (2.1%), a virus; and one (2.1%)

TABLE 4. Waterborne-disease outbreaks (n = 14) associated with untreated recreational water, by state — United States, 2005

State	Month	Class*	Etiologic agent	Predominant† illness	No. of cases (deaths) (n = 171)	Type	Setting
California	Jul	IV	Unidentified §	Skin	2	Lake	Lake
California	Jul	IV	*Leptospira*	Lep	3	Stream	Stream
Florida	Jul	I	Unidentified ¶	Other	24	Ocean¶	Beach
Florida	Nov	II	*Leptospira*	Lep	43	Stream	Adventure race
Maine	Jul	III	Unidentified	AGI	10	Lake	Swimming beach
Massachusetts	Jul	IV	*Shigella sonnei*	AGI	5	Lake	Lake
Michigan	Jun	IV	Copper sulfate	ARI	3	Lake	Lake
Minnesota	Jun	IV	*Escherichia coli* O157:H7	AGI	4	Lake	Swimming beach
Minnesota	Jul	IV	*S. sonnei*	AGI	12	Lake	Swimming beach
Minnesota	Aug	IV	Norovirus	AGI	8	Lake	Swimming beach
New York	Jul	III	*Cryptosporidium*	AGI	27	Lake	Swimming beach
New York	Aug	III	Unidentified**	AGI	13	Lake	Lake
Oklahoma	Jul	IV	*Naegleria fowleri*	Neuro	2 (2)	Unknown††	Unknown
Pennsylvania	Jul	IV	*S. sonnei*	AGI	15	Lake	Swimming beach

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12 (available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf) (see Table 1).
† Skin: illness, condition, or symptom related to skin; Lep: leptospirosis; Other: undefined or mixed illness, condition, or symptom. AGI: acute gastrointestinal illness; ARI: acute respiratory illness; Skin: illness, condition, or symptom related to skin; and Neuro: neurologic condition or symptoms (e.g. meningitis).
§ Etiology unidentified: clinical diagnosis of cercarial dermatitis (caused by avian schistosomes).
¶ Etiology unidentified: whereas certain swimmers had symptoms consistent with seabathers eruption (caused by jellyfish larvae), a majority of persons affected in this outbreak experienced systemic, flu-like illnesses which might have been related to another etiology. Swimmers alternated between marine and chlorinated swimming venues.
** Etiology unidentified: Illness was most consistent with norovirus infection on the basis of clinical syndrome.
†† Whereas an interactive fountain at a water park was a common exposure for both case-patients, other potentially shared and untreated recreational water exposures could not be ruled out.

TABLE 5. Waterborne-disease outbreaks (n = six) associated with untreated recreational water, by state — United States, 2006

State	Month	Class*	Etiologic agent	Predominant illness †	No. of cases (n = 74)	Type	Setting
Florida	May	II	Norovirus G2	AGI	50	Lake	Swimming beach
Massachusetts	Aug	III	*Cryptosporidium*	AGI	6	Pond	Camp
Minnesota	May	II	Norovirus G1	AGI	10	Lake	Private beach
Ohio	Aug	IV	Unidentified§	Skin	2	Pond	Pond
Tennessee	Jul	IV	*Escherichia coli* O157:H7	AGI	3	Lake	Swimming beach
Wisconsin	Jun	IV	*E. coli* O157:H7	AGI	3	Lake	State park

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12 (available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf) (and Table 1).
† AGI: acute gastrointestinal illness; and Skin: illness, condition, or symptom related to skin.
§ Etiology unidentified: clinical diagnosis of cercarial dermatitis (caused by avian schistosomes).

a chemical (Table 7). Parasites were responsible for approximately 20 times more cases than bacteria (3,784 versus 167). Of the 15 WBDOs associated with untreated water venues with an identified etiologic agent, eight (53.3%) involved bacteria; three (20.0%) parasites; three (20.0%) viruses; and one (6.7%) a chemical.

Parasites

Of the 48 outbreaks of gastroenteritis, 33 (68.8%) were parasitic in origin, including 31 (93.9%) caused by *Cryptosporidium*, one (3.0%) caused by *Giardia intestinalis*, and one (3.0%) caused by both *Cryptosporidium* and *Giardia* (Tables 2–7; Figure 5). Of the 13 gastroenteritis outbreaks associated with untreated water venues, only two (15.4%) were caused by parasites. Two cryptosporidiosis outbreaks occurred; one in an untreated lake and the other in an untreated pond, causing 27 and six cases of illness, respectively. In contrast, parasites were the most common causes of gastroenteritis outbreaks associated with treated water venues; *Cryptosporidium* was the most common parasitic agent, causing 29 (82.9%) of the 35 outbreaks of gastroenteritis. Thirty-one of these parasitic gastroenteritis outbreaks occurred in treated water venues, causing illness in 3,784 persons. Three of these outbreaks each caused over 100 (range: 116–2,307 persons) cases of illness. In June 2005, an outbreak caused by *C. hominis* transmitted through a New York spray park resulted in 2,307 cases, mostly among young children. In August 2005, a *C. hominis* outbreak spread through multiple Ohio pools and resulted

in 523 cases; this outbreak subsequently was linked to an outbreak in an adjoining state (Kentucky). In June 2006, an outbreak caused by *Cryptosporidium* at a water park in Missouri caused gastroenteritis in 116 persons

The one additional parasitic outbreak was caused by *Naegleria fowleri* and led to the death of two persons in Oklahoma. Despite an investigation by local public health authorities, the location of suspected common exposure (i.e., exposure in which the two persons probably became ill at the same time and place) was not identified.

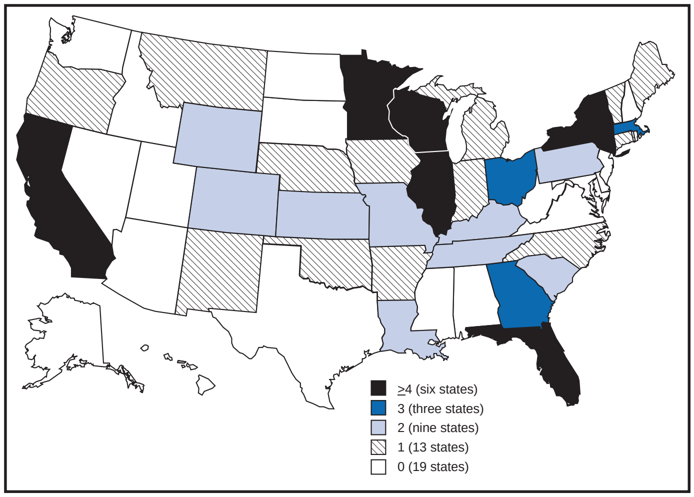
Bacteria

Eight reported gastroenteritis outbreaks of confirmed bacterial origin were reported (Figure 5), two of which were at treated water venues. An outbreak of *Campylobacter jejuni* occurred in a fill-and-drain pool at a Wyoming home in July 2005, resulting in five children and one adult becoming ill. This same type of pool was the setting for a *Shigella sonnei* outbreak at a California home in July 2006, leading to nine persons becoming ill, including three who were hospitalized. Both of these outbreaks were caused by a lack of disinfection and heavy use of these pools by young diaper-aged children. The other six outbreaks of gastroenteritis, caused by bacteria, were associated with swimming in lakes, including three additional shigellosis outbreaks and three outbreaks of *E. coli* O157:H7 infection. All six lake-associated outbreaks occurred during June and July and five were associated with exposure to lake water during holidays or weekends.

Four of the bacterial outbreaks involved 28 cases of dermatitis caused by *Pseudomonas aeruginosa*; one of these outbreaks also resulted in ear infections. All four outbreaks of *Pseudomonas* infection occurred at treated water venues that involved heated spa water (some of these outbreaks also involved pools). Five additional outbreaks were suspected to have been caused by *Pseudomonas* on the basis of the clinical symptoms and exposure to a spa.

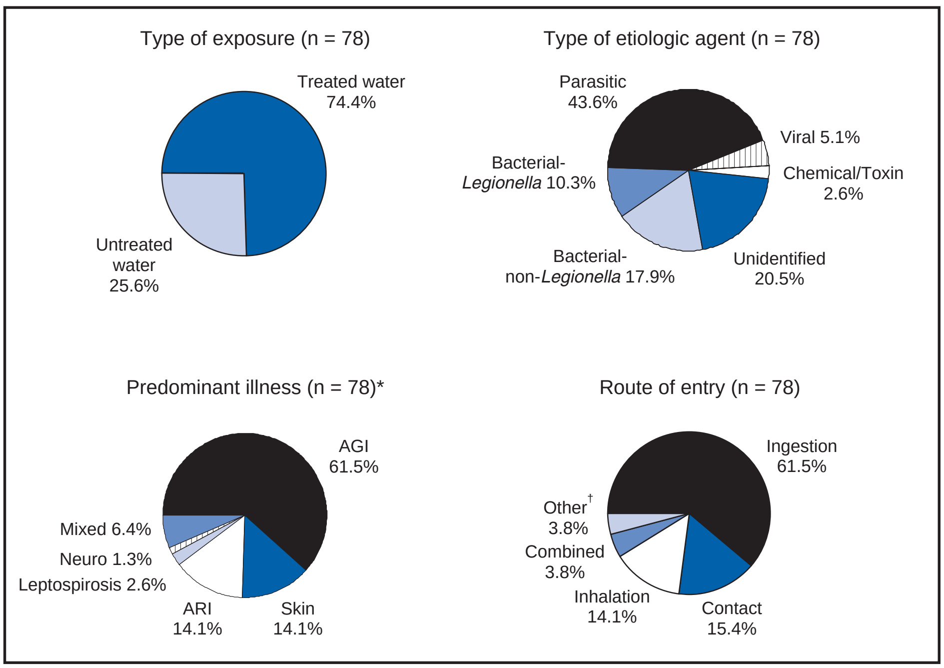
Eight outbreaks caused by *Legionella* were associated with treated recreational water venues during 2005–2006, causing 124 cases of legionellosis (i.e., LD and PF) and resulted in three deaths. The largest

FIGURE 2. Number of recreational water-associated outbreaks (n = 78) — United States, 2005–2006*



* **Note:** These numbers are largely dependent on reporting and surveillance activities in individual states and do not necessarily indicate the true incidence in a given state.

FIGURE 3. Recreational water-associated outbreaks, by type of exposure, type of etiologic agent, predominant illness, and route of entry — United States, 2005–2006



* AGI: acute gastrointestinal illness; ARI: acute respiratory illness; Skin: illness, condition or symptom related to skin; Mixed: a combination of illnesses, conditions, or symptoms that might also include the eyes and ears; and Neuro: neurologic condition or symptoms (e.g., meningitis).

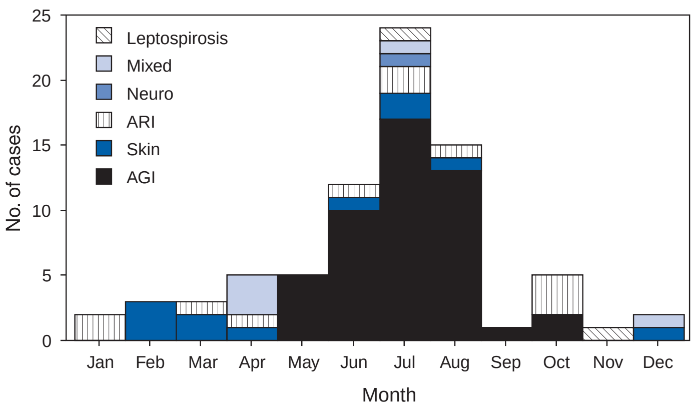
† Infection with *Naegleria* was categorized as other because of the nasal, noninhalational route of infection. Infection with *Leptospira* was categorized as other because the route of infection is typically through contact with mucous membrane or broken or abraded skin.

TABLE 6. Number of waterborne-disease outbreaks (n = 78) associated with recreational water, by predominant illness and type of water — United States, 2005–2006

	Type of water				Total	
	Treated		Untreated			
Predominant illness	No. of outbreaks	No. of cases	No. of outbreaks	No. of cases	No. of outbreaks (%)	No. of cases (%)
AGI	35	3,849	13	166	**48 (61.5)**	**4,015 (91.0)**
ARI	10	152	1	3	**11 (14.1)**	**155 (3.5)**
Ear and Skin	1	7	0	0	**1 (1.3)**	**7 (0.2)**
Ear and ARI	1	12	0	0	**1 (1.3)**	**12 (0.3)**
Eye and ARI	2	44	0	0	**2 (2.6)**	**44 (1.0)**
Leptospirosis	0	0	2	46	**2 (2.6)**	**46 (1.0)**
Neuro	0	0	1	2	**1 (1.3)**	**2 (0.0)**
Skin	9	103	2	4	**11 (14.1)**	**107 (2.4)**
Other	0	0	1	24	**1 (1.3)**	**24 (0.5)**
Total (%)	**58 (74.4)**	**4,167 (94.4)**	**20 (25.6)**	**245 (5.6)**	**78 (100.0)**	**4,412 (100.0)**

* AGI: acute gastrointestinal illness; ARI: acute respiratory illness; Ear: illness, condition, or symptom related to ears; Skin: illness, condition, or symptom related to skin; Eye: illness, condition, or symptom related to eyes;. Neuro: neurologic condition or symptoms (e.g. meningitis); and Other: etiology unidentified. Whereas certain swimmers had symptoms consistent with seabathers eruption (caused by jellyfish larvae), the majority of persons affected in this outbreak experienced systemic, flu-like illnesses which might have been related to another etiology. Swimmers alternated between marine and chlorinated swimming venues.

FIGURE 4. Number of recreational water-associated outbreaks (n = 78), by predominant illness* and month — United States, 2005–2006



* Mixed: a combination of illnesses, conditions or symptoms that also might include the eyes and ears; Neuro: neurologic condition or symptoms (e.g., meningitis); ARI: acute respiratory illness; Skin: illness, condition, or symptom related to skin; AGI: acute gastrointestinal illness.

of these outbreaks was linked to a spa at an Illinois hotel and involved 43 persons, including three cases of LD resulting in one death. The environmental investigation documented inadequate disinfection in the spa and isolated both *L. pneumophila* and *L. maceachernii* from the spa water.

Two outbreaks in untreated recreational water were caused by *Leptospira*. Leptospirosis was diagnosed in 43 persons who participated in an adventure race in Florida in November 2005. A July 2005 outbreak of leptospirosis in California involved three persons who had contact with water from a low flowing stream at the time of exposure

Viruses

Four outbreaks of confirmed viral origin occurred, all of which caused gastroenteritis. Norovirus was identified as the etiologic agent in each of the outbreaks; three occurred at lake swimming beaches, and one occurred in a treated water setting. These four norovirus outbreaks resulted in 86 cases of gastroenteritis. For the two outbreaks where lake water fecal indicator testing was conducted; no water quality-violations were documented. The water might have been contaminated by ill swimmers at the time of exposure rather than by ongoing point source water contamination. The treated venue outbreak occurred in a hotel pool and was related to inadequate disinfection and continued use by ill swimmers. One additional outbreak that was suspected to have been caused by norovirus resulted in 13 cases.

Chemicals

During 2005–2006, two outbreaks associated with chemicals involved 22 persons. In June 2005, a chemical-associated outbreak occurred in a Michigan lake causing respiratory symptoms in three swimmers. This outbreak was attributed to the unapproved addition of excessive amounts of copper sulfate to the lake water for aquatic nuisance control.

The other outbreak occurred in a treated water venue. In July 2005, the recirculation pump at a community pool was shut down for maintenance; however, the liquid chlorine (i.e., NaOCl) and muriatic (i.e., hydrochloric) acid continued to feed into the system and probably released chlorine gas in the piping. When the pump was restarted, a concentrated bolus of these swimming pool chemicals and chlorine gas was sent into a small pool where it caused respiratory distress in 19

TABLE 7. Number of waterborne-disease outbreaks (n = 78) associated with recreational water, by etiologic agent(s) and type of water — United States, 2005–2006

	Type of water				Total			
	Treated		Untreated					
Predominant illness	No. of outbreaks	No. of cases	No. of outbreaks	No. of cases	No. of outbreaks (%)		No. of cases (%)	
Bacteria	**14**	**167**	**8**	**88**	**22**	**(28.2)**	**255**	**(5.8)**
Campylobacter jejuni	1	6	0	0	**1**		**6**	
Escherichia coli spp.	0	0	3	10	**3**		**10**	
Leptospira spp.	0	0	2	46	**2**		**46**	
Legionella spp.*	8	124	0	0	**8**		**124**	
Pseudomonas aeruginosa	4	28	0	0	**4**		**28**	
Shigella sonnei	1	9	3	32	**4**		**41**	
Parasites	**31**	**3,784**	**3**	**35**	**34**	**(43.6)**	**3,819**	**(86.6)**
Cryptosporidium spp.	29	3,718	2	33	**31**		**3,751**	
Giardia intestinalis	1	11	0	0	**1**		**11**	
Naegleria fowleri	0	0	1	2	**1**		**2**	
Cryptosporidium and *Giardia* spp.†	1	55	0	0	**1**		**55**	
Viruses	**1**	**18**	**3**	**68**	**4**	**(5.1)**	**86**	**(1.9)**
Norovirus	1	18	3	68	**4**		**86**	
Chemicals/toxins	**1**	**19**	**1**	**3**	**2**	**(2.6)**	**22**	**(0.5)**
Copper sulfate	0	0	1	3	**1**		**3**	
Chlorine gas§	1	19	0	0	**1**		**19**	
Suspected etiology	**9**	**135**	**3**	**17**	**12**	**(15.4)**	**152**	**(3.4)**
Suspected chemical exposure¶	1	9	0	0	**1**		**9**	
Suspected chloramines	3	53	0	0	**3**		**53**	
Suspected norovirus	0	0	1	13	**1**		**13**	
Suspected *P. aeruginosa*	5	73	0	0	**5**		**73**	
Suspected schistosomes	0	0	2	4	**2**		**4**	
Unidentified	**2**	**44**	**2**	**34**	**4**	**(5.1)**	**78**	**(1.8)**
Total (%)	**58 (74.4)**	**4,167 (94.4)**	**20 (25.6)**	**245 (5.6)**	**78**	**(100.0)**	**4,412**	**(100.0)**

* Five outbreaks were attributed to *Legionella pneumophila*, two outbreak investigations did not identify a *Legionella* species, and one outbreak investigation detected *L. pneumophila* and *L. maceachernii* in both pool and spa water.
† Thirty-five persons had stool specimens that tested positive for *Giardia*, seven persons had stool specimens that tested positive for *Cryptosporidium,* and two persons had stool specimens that tested positive for both *Giardia* and *Cryptosporidium*.
§ Chlorine gas was released after high levels of liquid chlorine and acid were mixed in the recirculation system and subsequently released into the pool water.
¶ Low pH suspected on the basis of water testing and symptoms.

persons. Three additional outbreaks in treated venues were suspected of being caused by disinfection by-products (e.g., chloramines) on the basis of symptoms and settings (i.e., indoor pool).

Suspected Agents

Twelve outbreaks were reported in which no etiologic agent was confirmed; however, investigation reports indicated a suspected agent on the basis of symptoms, type of water, setting, and background information (Table 7). Five of these 12 outbreaks were suspected to be caused by *P. aeruginosa* in treated spas. One outbreak, which caused rashes in nine children, was suspected of being caused by low pH. Three chemical-related outbreaks were suspected to be associated with exposure to excess chloramines (i.e., disinfection by-products of chlorination) (*20–22*) in the indoor pools and surrounding areas (i.e., indoor pool air), which resulted in ARI, and eye irritation. Norovirus was the suspected pathogen in one gastroenteritis outbreak associated with a lake on the basis of epidemiologic and clinical evidence. Two outbreaks were suspected to be the result of contact with avian schistosomes, causing cercarial dermatitis

Unidentified Etiologic Agents

Data collected during investigations of four outbreaks of unidentified etiology were not sufficient to suggest an etiologic agent. Gastroenteritis was reported as the predominant illness in two of these outbreaks, and ARI and ear infections were reported for the third one. The AGI outbreak in a treated venue (Minnesota 2005) caused illness in 32 persons over the course of nearly a month; 15 persons reportedly continued to swim while ill. Stool samples tested negative for bacteria, viruses, and parasites. A lake-associated AGI outbreak sickened 10 persons and caused five hospitalizations. Environmental testing revealed water-quality violations (e.g., elevated *E. coli* levels). An outbreak of ARI and ear infections among lifeguards occurred in a pool that had not officially opened for the season. The water was reportedly cloudy and possibly contaminated by water leaking from a pipe in the facility.

Finally, an outbreak of influenza-like illness linked to an ocean beach was associated with marine and pool water; possible etiologies might include contact with jellyfish larvae and other etiologies may have contributed to some of these illnesses.

Single Cases of Waterborne Disease

Vibriosis Cases Associated with Recreational Water

During 2005–2006, a total of 189 vibriosis cases associated with recreational water use or exposure to flood water were reported from 20 states; representing 14.7% (189/1287) of the total number of vibriosis cases reported in 2005–2006 (62). Eighty-five (45.0%) of 189 patients were hospitalized, and 18 (9.5%) died (Table 8).

The most frequently isolated *Vibrio* species was *Vibrio vulnificus*, which was isolated from 67 (35.4%) persons; 52 (77.6%) were hospitalized, and 15 (22.4%) died. *V. alginolyticus* was isolated from 60 (31.7%) persons; seven (11.7%) were hospitalized, and none died. *V. parahaemolyticus* was isolated from 33 (17.5%) persons; 12 (36.4%) were hospitalized, and one (3.0%) died. Other *Vibrio* species (including *V. cholerae* non-O1, non-O139, *V. damsela*, *V. fluvialis*, *V. hollisae*, *V. mimicus*, *V. alginolyticus/parahaemolyticus* coinfection, *V. alginolyticus/fluvialis* coinfection, *V. parahaemolyticus/vulnificus* coinfection, *V. vulnificus*/unidentified *Vibrio* species coinfection and *Vibrio* species not identified) were identified in 29 (15.3%) persons; 14 (48.3%) were hospitalized, and two (6.9%) died.

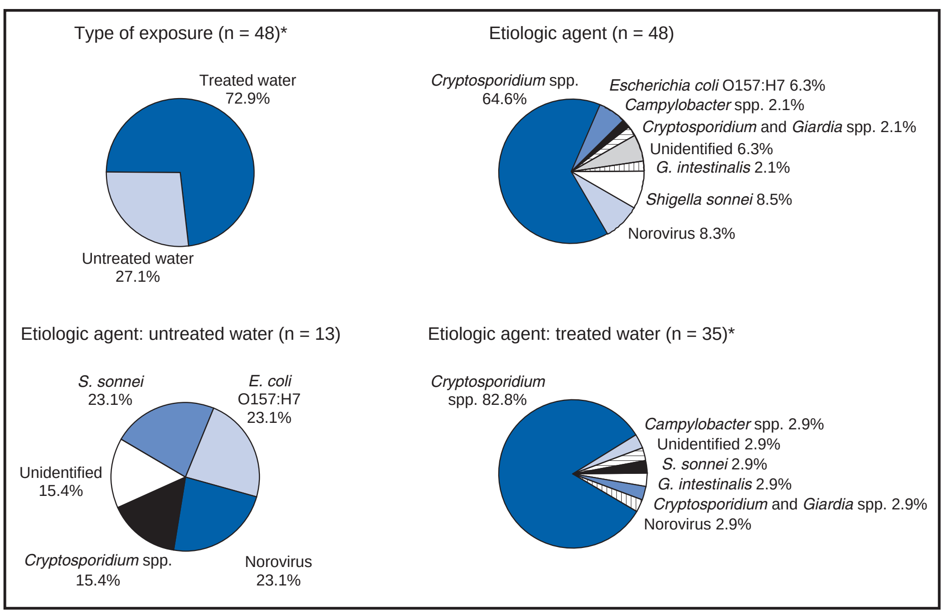
Geographic location. Nearly all *Vibrio* patients reported that they were exposed to recreational water in a coastal state (Figure 6). The most frequently reported location was the Gulf Coast (61.9%); Atlantic Coast states, excluding Florida (19.6%); Pacific Coast states (16.9%); and inland states (1.6%) (Table 9). Florida and Mississippi reported the highest number of cases, 55 and 28 cases, respectively (Figure 6; Table 9).

Seasonality. The temporal distribution of illness in patients from whom *Vibrio* species were isolated displayed a clear seasonal peak during the summer (Figure 7). The greatest frequency of *Vibrio* cases occurred during July through September.

Exposures. Activities associated with *Vibrio* cases included swimming, diving, or wading in water (70.9%); walking or falling on the shore or rocks (32.8%); and boating, skiing, or surfing (19.6%). Twenty-five case-patients reported exposure to Hurricane Katrina flood waters.

Signs/Symptoms. Symptoms associated with *Vibrio* illnesses included cellulitis (56.6%), fever (36.0%), muscle pain (21.2%), bullae (15.9%), ear infections (14.3%), nausea (13.8%), and shock (10.1%). *V. vulnificus* accounted for the majority of skin infections (e.g., cellulitis, bullae), causing 70 (50.7%) of 138. *V. vulnificus* also accounted for the majority of severe illnesses, including those with fever (51.5%), bacteremia (75.0%), shock (73.7%), and amputations (83.3%). *V. alginolyticus* accounted for the majority of ear infections (24 [92.3%] of 26). Other symptoms and infections were reported in low frequencies (e.g., bladder infections, hematuria, eye infections, respiratory symptoms, sinus infections, diarrhea, and vomiting).

FIGURE 5. Recreational water-associated outbreaks of gastroenteritis, by type of exposure and etiologic agent — United States, 2005–2006



* For one outbreak (Wyoming 2006) case-patients reported exposure to multiple community pools and to a reservoir. This outbreak is being analyzed as exposure to treated water.

Naegleria Infections

In addition to the outbreak of PAM (two cases), three individual fatal cases of PAM caused by *N. fowleri* were reported in 2005–2006 (Table 10). A child in Texas died in September 2005, 13 days after swimming in a lake. In August 2006, a child died of PAM associated with *N. fowleri* after swimming, using a personal watercraft, and tubing in an Arizona lake. In August 2006, a child died after swimming in a Georgia pond.

TABLE 8. Number of illnesses associated with *Vibrio* isolation (n = 189) and recreational water, by species and year — United States, 2005–2006

	Year						Total		
	2005			2006					
Species	Cases	Hospitalizations	Deaths	Cases	Hospitalizations	Deaths	Cases	Hospitalizations	Deaths
Vibrio alginolyticus	31	6	0	29	1	0	**60**	**7**	**0**
V. cholerae non-O1, non-O139	4	2	0	4	1	0	**8**	**3**	**0**
V. damsela	2	0	0	0	0	0	**2**	**0**	**0**
V. fluvialis	2	2	1	1	0	0	**3**	**2**	**1**
V. hollisae	1	0	0	0	0	0	**1**	**0**	**0**
V. mimicus	0	0	0	1	0	0	**1**	**0**	**0**
V. parahaemolyticus	21	8	1	12	4	0	**33**	**12**	**1**
V. vulnificus	50	41	11	17	11	4	**67**	**52**	**15**
Multiple*	3	3	1	2	1	0	**5**	**4**	**1**
Vibrio, species not identified	4	3	0	5	2	0	**9**	**5**	**0**
Total (% of cases)	**118**	**65 (55.1%)**	**14 (11.9%)**	**71**	**20 (28.2%)**	**4 (5.6%)**	**189**	**85 (45.0%)**	**18 (9.5%)**
Percentage by year	**(62.4)**	**(76.5)**	**(77.8)**	**(37.6)**	**(23.5)**	**(22.2)**	**(100)**	**(100)**	**(100)**

* Includes *V. alginolyticus/parahaemolyticus* coinfection, *V. alginolyticus/fluvialis* coinfection, *V. parahaemolyticus/vulnificus* coinfection, *V. vulnificus/* unidentified, and *Vibrio* species coinfection.

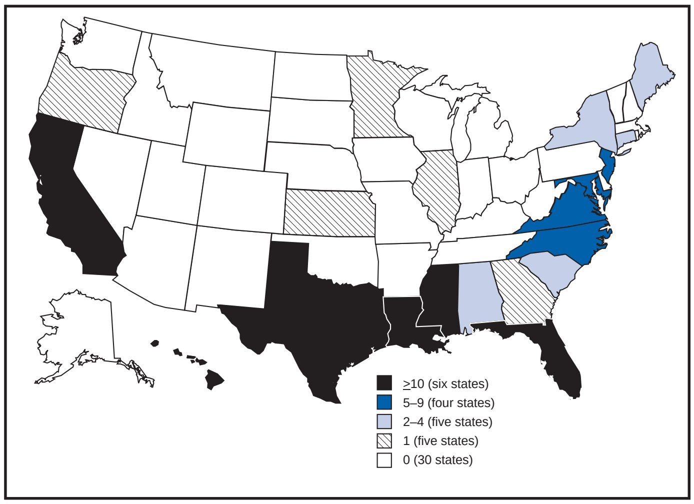
Previously Unreported Outbreaks

Thirty-one previously unreported recreational water-associated outbreaks and one case of waterborne disease during 1978–2004 were received and entered into WBDO database (Table 11). These outbreaks were summarized but not included in analysis for this report. One outbreak of leptospirosis in Hawaii was associated with exposure to flood water (*48*). Reports on the remaining 30 events were received from Minnesota, New York, and Tennessee. These states participate in the Environmental Health Specialist Network Water program (EHS-Net Water), which is an EPA and CDC funded initiative that supports a waterborne-disease environmental health specialist in each site. These three sites identified outbreaks and case reports that were previously unreported to CDC and reported them as part of a retrospective review of waterborne disease outbreaks in these states. The 31 previously unreported outbreaks affected 673 persons; 25 (80.6%) of the outbreaks occurred in treated water venues.

Surveillance Reports Not Classified as Waterborne Disease and Outbreaks

One report from New Hampshire was not included in this summary. In February 2005, three children had lesions believed to be caused by *Molluscum contagiosum*. These children all swam at the same community pool; however, after investigation, it was not clear that these lesions were associated with waterborne transmission of this organism versus other modes of transmission (e.g., person to person or contact with contaminated towels or objects).

FIGURE 6. Number* of illnesses associated with *Vibrio* isolation and recreational water (n = 189) — United States, 2005–2006



* **Note:** These numbers are largely dependent on reporting and surveillance activities in individual states and do not necessarily indicate the true incidence in a given state.

Aquatic Facility-related Health Events not Associated with Recreational Water

Thirty-two reports of nonwater related health events that occurred during 1983–2006 and were associated with aquatic facilities were reported by New York (Table 12). Although they are not counted as waterborne-disease cases or outbreaks for analysis purposes, they are included in this report because they illustrate important lessons about pool maintenance and operation. Most of these events, 90.6% (29/32), were caused by improper use of chemicals; incompatible pool chemicals (e.g., acid and bleach) were mixed, which resulted in the release of chlorine gas. Persons at these aquatic facilities expe-

TABLE 9. Number of recreational water-associated *Vibrio* isolations (n = 189) and deaths (n = 18), by region/state and species — United States, 2005–2006

	Species									
	V. alginolyticus		*V. parahaemolyticus*		*V. vulnificus*		Other/unknown species*		Total	
Region/State†	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Atlantic										
Connecticut	1	0	2	0	0	0	0	0	**3**	**0**
Georgia	0	0	0	0	1	0	0	0	**1**	**0**
Maine	2	0	0	0	0	0	0	0	**2**	**0**
Maryland	2	0	2	0	2	0	0	0	**6**	**0**
North Carolina	2	0	2	0	3	1	1	0	**8**	**1**
New Jersey	1	0	4	0	0	0	1	0	**6**	**0**
New York	1	0	0	0	0	0	1	0	**2**	**0**
South Carolina	3	0	0	0	0	0	0	0	**3**	**0**
Virginia	2	0	2	0	0	0	2	0	**6**	**0**
Total	**14**	**0**	**12**	**0**	**6**	**1**	**5**	**0**	**37**	**1**
Gulf Coast§										
Alabama	0	0	1	0	0	0	1	0	**2**	**0**
Florida¶	19	0	9	0	16	1	11	1	**55**	**2**
Louisiana	1	0	0	0	19	5	1	0	**21**	**5**
Mississippi	0	0	6	1	18	6	4	1	**28**	**8**
Texas	3	0	4	0	3	0	1	0	**11**	**0**
Total	**23**	**0**	**20**	**1**	**56**	**12**	**18**	**2**	**117**	**15**
Noncoastal										
Illinois	0	0	0	0	0	0	1	0	**1**	**0**
Kansas	0	0	0	0	0	0	1	0	**1**	**0**
Minnesota	0	0	0	0	0	0	1	0	**1**	**0**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**3**	**0**
Pacific										
California	7	0	0	0	1	0	2	0	**10**	**0**
Hawaii	15	0	1	0	4	2	1	0	**21**	**2**
Oregon	1	0	0	0	0	0	0	0	**1**	**0**
Total	**23**	**0**	**1**	**0**	**5**	**2**	**3**	**0**	**32**	**2**
Total	**60**	**0**	**33**	**1**	**67**	**15**	**29**	**2**	**189**	**18**
Percentage	**(31.7)**	**(0)**	**(17.5)**	**(5.6)**	**(35.4)**	**(83.3)**	**(15.3)**	**(11.1)**	**(100)**	**(100)**

* Includes *V. cholerae* (non-O1, non-O139), *V. damsela*, *V. fluvialis*, *V. hollisae, V. mimicus, V. alginolyticus/parahaemolyticus* coinfection, *V. alginolyticus/fluvialis* coinfection, *V. parahaemolyticus/vulnificus* coinfection, *V. vulnificus/*unidentified *Vibrio* species coinfection, and *Vibrio* species not identified.
† Refers to the reported state of exposure if the exposure did not occur in the reporting state.
§ Includes 25 cases with reported exposure to Hurricane Katrina flood waters.
¶ Nine reports from Florida indicate Atlantic coast exposure.

rienced respiratory distress. Two additional events were caused by carbon monoxide in indoor pools, and one event was caused by liquid chlorine splashing into the eye of an aquatic facility employee.

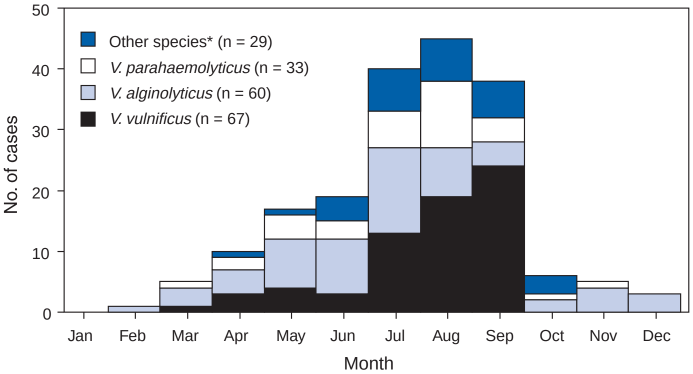
Discussion

Trends in Reporting Outbreaks

A total of 78 recreational water–associated WBDOs were reported to CDC during 2005–2006. This represents an increase from the 2003–2004 *Surveillance Summary* (n = 62) and is the largest number of outbreaks ever reported in a 2-year period (Figure 8). Overall, the number of reported recreational water-associated WBDOs reported annually have increased substantially since 1978, when CDC first began receiving these reports (Figure 8). These increases probably are a result of a combination of factors, such as the emergence of pathogens (e.g., *Cryptosporidium*), increased participation in aquatic activities, and increases in the number of aquatic venues. Increased recognition, investigation, and reporting of recreational water-associated outbreaks also might be contributing factors.

An unprecedented number of states reported outbreaks during 2005–2006, and WBDOs demonstrate geographic variation (Figure 2). Differences in reporting between states might be attributable to several factors, including ability to detect outbreaks, availability of laboratory testing, variable requirements for notifiable diseases, and the surveillance and investigation capacity of individual state and local public health

FIGURE 7. Number of illnesses associated with *Vibrio* isolation and recreational water (n = 189), by species and month — United States, 2005–2006



* Includes *V. cholerae* (non-O1, non-O139) (eight), *V. damsela* (two), *V. fluvialis* (three), *V. hollisae* (one), *V. mimicus* (one), *V. alginolyticus/parahaemolyticus* coinfection (one), *V. alginolyticus/fluvialis* coinfection (one), *V. parahaemolyticus/vulnificus* coinfection (two), *V. vulnificus*/unidentified *Vibrio* species coinfection (one), and *Vibrio* species not identified (nine).

agencies. These differences in the ability to detect, investigate, and report WBDOs probably lead to reporting and surveillance bias. Therefore, the states with the majority of outbreaks reported for this period might not be the states in which the majority of outbreaks actually occurred. An increase or decrease in the number of WBDOs reported might reflect either an actual change in the incidence of outbreaks or a change in the sensitivity of surveillance systems.

Etiologic agents with shorter incubation periods might be more easily linked to water exposures, facilitating the recognition of outbreaks. Additional factors that might influence which WBDOs are reported include the size and location of the outbreak, severity of illness, and the geographic dispersion of ill persons. Larger outbreaks are more likely to be identified by public health authorities. In contrast, smaller outbreaks (e.g., those associated with private residential pools and spas) might go undetected because fewer persons are ill, and they might attribute illness to other common exposures. In addition, outbreaks of gastroenteritis associated with large venues that draw from a wide geographic range (e.g., large lakes and marine beaches) might be difficult to detect because potentially infected persons disperse widely from the site of exposure and, therefore, might be less likely to be identified as part of an outbreak. Prospective epidemiology studies, such as the EPA's NEEAR Water Study (*18*), have revealed elevated rates of gastroenteritis in swimmers compared with nonswimmers on all beaches studied. Multiple other prospective studies of gastroenteritis associated with beach swimming have also indicated elevated rates of illness associated with swimming in lakes and oceans, though few outbreaks have been detected (*23,24*). Consistent with this finding, no ocean-associated outbreaks and only one Great Lakes-associated outbreak of gastroenteritis has been reported since 1978 (*12*). These endemic recreational water-associated illnesses are not captured by WBDOSS, supporting the need for more studies to estimate the magnitude of risk for illness for routine, nonoutbreak-associated exposures at recreational water venues.

WBDOs associated with recreational water use occur year-round, but the numbers of reported WBDOs and cases are highest during the annual summer swim season (Figure 4). For public health professionals and swimming venue operators, the seasonality of waterborne-disease outbreaks can help determine the allocation of resources so that health education messages are targeted to populations during times of the year when the risk for preventable illness is highest.

Swimming Pools

Swimming pools are designed to be chemically treated and filtered to reduce the risk for illness associated with exposure to infectious pathogens. Despite the availability of these disinfection measures, pools remain susceptible to contamination because of chlorine-resistant organisms (i.e., *Cryptosporidium*) or inadequate treatment resulting from poor operation or maintenance. In addition, an emerging focus of concern at swimming pools is the risk for chemical injury from improper handling of pool chemicals.

Infectious Gastroenteritis

Approximately 87% of all cases reported to WBDOSS during 2005–2006 were involved in infectious gastroenteritis outbreaks associated with treated recreational water venues.

TABLE 10. Single cases of non-*Vibrio waterborne disease (n = 3) associated with untreated recreational water, by state — United States, 2005–2006**

State	Date	Etiologic agent	Predominant illness†	No. of cases (deaths) (n = 3)	Type	Setting
Arizona	Aug 2006	*Naegleria fowleri*	Neuro	1 (1)	Lake	Lake
Georgia	Aug 2006	*N. fowleri*	Neuro	1 (1)	Pond	Pond
Texas	Sep 2005	*N. fowleri*	Neuro	1 (1)	Lake	Lake

* In addition to these single cases, 189 cases of recreational water-associated *Vibrio* infection were reported: 118 cases in 2005 and 71 cases in 2006.
† Neuro: neurologic condition or symptoms (e.g., meningitis).

TABLE 11. Waterborne disease (n = 1) and outbreaks (n = 31) associated with recreational water that were not included in previous *Surveillance Summaries*, by state — United States, 1978–2004

State	Date	Class*	Etiologic agent	Predominant illness †	No. of cases (n = 673)	Type	Setting
Disease							
New York	Jul 1992	NA	Unidentified§	Eye	1	Pool	Hotel
Outbreak							
Hawaii	Nov 2004	IV	*Leptospira interrogans*¶	Lep	2	Stream	University
Minnesota	Jul 1992	III	Unidentified**	Skin	6	Pool	Hotel
Minnesota	Jan 1998	III	*Giardia intestinalis*	AGI	7	Pool	Hotel
Minnesota	Apr 1998	II	Unidentified**	Ear, eye, skin	17	Pool	Community
Minnesota	May 1998	III	Unidentified**	Skin	22	Pool	Community
Minnesota	Jul 1998	IV	Norovirus††	AGI	15	Lake	Swimming beach
Minnesota	Jul 2000	I	*Legionella*§§	ARI	51	Pool, spa	Hotel
New York	Oct 1978	IV	*P. aeruginosa*	Skin	2	Spa	Hotel
New York	Aug 1981	IV	*Leptospira*	Lep	6	Stream	Swimming area
New York	Aug 1988	III	Chlorine gas¶¶	AGI, ARI	21	Pool	Community
New York	Mar 1989	III	Unidentified§	ARI, skin	3	Pool	Hotel
New York	Jul 1989	III	Chlorine gas¶¶	ARI	11	Pool	College
New York	Jun 1990	III	Chlorine gas¶¶	ARI	15	Pool	School
New York	Mar 1992	III	*P. aeruginosa*	Skin	34	Spa	Resort
New York	May 1992	III	*P. aeruginosa*	Skin	6	Pool, spa	Hotel
New York	Oct 1992	III	Unidentified***	Eye, skin, other	20	Pool	School
New York	Nov 1994	III	Unidentified§	AGI, ARI, eye, skin	51	Pool	School
New York	Mar 1995	III	Chlorine gas¶¶	ARI	5	Pool	Membership club
New York	Nov 1995	III	*P. aeruginosa*	Skin	13	Pool	Hotel
New York	Dec 1995	III	*P. aeruginosa*	Skin	3	Pool	School
New York	Jan 1996	IV	Unidentified†††	ARI, skin	29	Pool, spa	Hotel
New York	Mar 1997	III	*P. aeruginosa*	Skin	10	Pool	Hotel
New York	Mar 1997	IV	Unidentified**	Skin	19	Pool	Hotel
New York	Sep 1997	III	Chloramines	ARI, eye, skin	51	Pool	School
New York	Sep 1998	III	Hydrochloric acid	ARI	3	Pool	School
New York	Jan 1999	III	Unidentified§	Eye, skin	2	Pool	School
New York	Jun 1999	III	Unidentified§§§	AGI	140	Lake	Swimming beach
New York	Mar 2000	III	Unidentified§	Eye	2	Pool	Hotel
New York	Feb 2001	I	Chlorine¶¶¶	Skin	58	Pool, spa	Hotel
New York	Jul 2002	III	*Shigella sonnei*	AGI	20	Lake	Swimming beach
Tennessee	Jun 1997	II	*Cryptosporidium*	AGI	28	Lake	Swimming beach

* On the basis of epidemiologic and water-quality data provided on CDC form 52.12 (available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf). NA: Single cases of waterborne disease are not classified (see Table 1).
† Eye: illness, condition, or symptom related to eyes; Lep: leptospirosis; Skin: illness, condition, or symptom related to skin; AGI: acute gastrointestinal illness; Ear: illness, condition, or symptom related to ears; ARI: acute respiratory illness; and Other: undefined illness, condition, or symptom.
§ Etiology unidentified: chemical contamination from excess chlorine levels or pool disinfection by-products (e.g., chloramines) suspected.
¶ **Source**: Gaynor K, Katz AR, Park SY, Nakata M, Clark TA, Effler PV. Leptospirosis on Oahu: an outbreak associated with flooding of a university campus. Am J Trop Med Hyg 2007;76:882–5.
** Etiology unidentified: *P. aeruginosa* suspected on the basis of clinical syndrome and setting.
†† Four persons had stool specimens that tested positive for norovirus, and three persons had stool specimens that tested positive for *Staphylococcus aureus*.
§§ All cases were diagnosed as Pontiac fever (PF).
¶¶ Chlorine gas was released after high levels of liquid chlorine and acid were mixed in the recirculation system and subsequently released into the pool water.
*** Etiology unidentified: high chlorine levels, disinfection by-products, and low pH suspected on the basis of clinical syndrome and setting. In addition to burning eyes and irritated skin, swimmers experienced teeth staining and loss of body hair.
††† Etiology unidentified: *Legionella* and *P. aeruginosa* suspected on the basis of clinical syndrome (PF and rash) and setting.
§§§ Etiology unidentified: norovirus suspected on the basis of clinical syndrome.
¶¶¶ Injuries occurred after the hand-addition of chlorine into a pool while swimmers were using it.

Two outbreaks were caused by chlorine-sensitive agents (*Giardia* in Massachusetts, July 2005, and norovirus in Wisconsin, May 2006) and might have been prevented or reduced in scale by proper aquatic monitoring, maintenance, and/or operation practices. Investigation of the Massachusetts giardiasis outbreak revealed that although the chlorine levels recorded on the pool log were below the recommended level, no documented response existed that indicated that chlorine was added or that the pool was closed. Previous outbreak investigations have demonstrated that the implementation of appropriate pool operation practices (e.g., adequate disinfection) effectively stops the transmission of chlorine-sensitive pathogens (*25*).

TABLE 12. Other aquatic facility-related health events* (n = 32) not associated with recreational water use — New York, 1983–2006

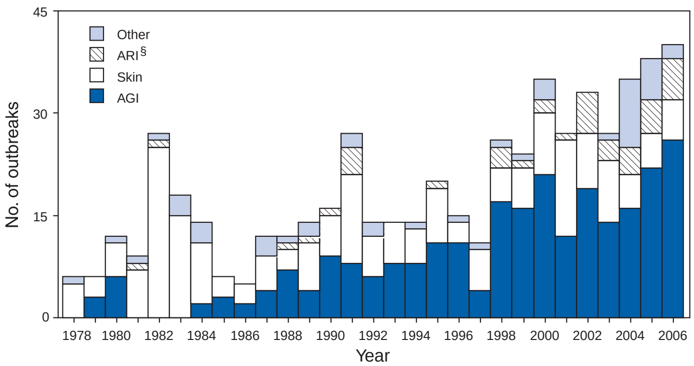
State	Date	Etiologic agent	Predominant illness†	No. of cases (n = 364)	Type	Setting
New York	Mar 1983	Chlorine gas§	ARI	3	Pool	Housing complex
New York	Aug 1983	Chlorine gas§	ARI	1	Pool	Housing complex
New York	May 1984	Chlorine gas¶	ARI	8	Pool	College
New York	Jun 1987	Chlorine gas§	ARI	6	Pool	Community
New York	Aug 1987	Chlorine gas§	ARI	41	Pool	Membership club
New York	Aug 1988	Chlorine gas§	ARI	10	Pool	Membership club
New York	Oct 1988	Chlorine gas§	ARI	1	Pool	School
New York	Dec 1988	Chlorine gas§	ARI, eye	29	Pool	Institution
New York	Feb 1989	Chlorine gas§	ARI	6	Pool	School
New York	Jul 1989	Chlorine gas¶	ARI	1	Pool	Community
New York	Jul 1989	Chlorine gas§	ARI	1	Pool	Hotel
New York	Jul 1991	Chlorine gas§	ARI	5	Pool	School
New York	Jan 1992	Chlorine gas§	ARI	2	Pool	Membership club
New York	Jun 1992	Chlorine gas§	ARI, eye	2	Pool	School
New York	Feb 1993	Carbon monoxide suspected	AGI, ARI	18	Pool	School
New York	Sep 1993	Chlorine gas§	ARI	3	Pool	Membership club
New York	Jun 1994	Chlorine gas§	ARI	1	Pool	Membership club
New York	Jun 1994	Chlorine gas§	ARI	1	Pool	Institution
New York	Jun 1995	Chlorine gas§	ARI	48	Pool	School
New York	Oct 1995	Chlorine gas§	ARI	91	Pool	School
New York	Jul 1996	Chlorine gas§	ARI	1	Pool	Membership club
New York	Apr 1997	Chlorine gas§	ARI	14	Pool	School
New York	Jun 1997	Chlorine gas§	ARI	15	Pool	Membership club
New York	Aug 1997	Chlorine gas§	ARI	18	Pool	School
New York	Dec 1997	Chlorine gas§	ARI	17	Pool	Membership club
New York	Jul 1998	Chlorine liquid	Eye	1	Pool	Hotel
New York	Feb 2000	Carbon monoxide	ARI	4	Pool	Hotel
New York	Jan 2001	Chlorine gas§	ARI	1	Pool	School
New York	Jun 2002	Chlorine gas§	ARI	1	Pool	Housing complex
New York	Apr 2005	Chlorine gas§	ARI	9	Pool	Membership club
New York	Jul 2006	Chlorine gas§	ARI	1	Pool	Community
New York	May 2006	Chlorine gas§	ARI	4	Pool	Community

* These events are not considered waterborne outbreaks because the vehicle of transmission was not water.
† AGI: acute gastrointestinal illness; ARI: acute respiratory illness; and Eye: illness, condition or symptom related to eyes.
§ Chlorine gas was generated after inappropriate chemical preparation or mixing (e.g., liquid chlorine bleach and acid).
¶ Chlorine gas that was used to disinfect pool water was released, causing injury.

During 2005–2006, *Cryptosporidium* spp. caused 31 recreational water–associated outbreaks, which involved 3,751 persons; 99.1% of these cases were associated with treated water venues. The number of the cryptosporidiosis outbreaks reported annually has substantially increased from nine in 1997–1998 to 31 in 2005–2006 (Table 7). This increase is particularly noticeable in the proportion of AGI outbreaks associated with *Cryptosporidium* in treated recreational water venues (Figures 5 and 9). These increases contribute to the observed increases in the total number of recreational water–associated outbreaks and, more specifically, outbreaks of gastroenteritis. Concurrently, cases of cryptosporidiosis reported to CDC have nearly doubled since 2004 (*26*). Although the reasons for increased cryptosporidiosis case and outbreak reporting are not completely understood, outbreaks associated with treated recreational water venues continue to be an important means of transmitting *Cryptosporidium*.

During 1997–2006, *Cryptosporidium* was infrequently attributed to outbreaks associated with lakes and rivers (12.7% of outbreaks), although it caused 68.3% of outbreaks associated with treated venues (Figure 9). This observation is consistent with the finding that *Cryptosporidium* requires extended contact time with chlorine for inactivation; oocysts can survive for days in the chlorine levels that are typically recommended for swimming pools (1–3 ppm free chlorine; *27*). The continued reporting of cryptosporidiosis outbreaks associated with the use of treated recreational water venues underscores the importance of other prevention measures that reach beyond conventional pool chlorination and filtration, which are the primary barriers to infectious disease transmission (*28*). WBDOs of cryptosporidiosis have stimulated the use of alternative treatment technologies and other potential risk-reduction steps to keep swimming venues safe. Ultraviolet light (*29–31*) and ozonation (*27,32*) disinfection effectively inac-

FIGURE 8. Number of recreational water-associated outbreaks (n = 557),* by year and illness† — United States, 1978–2006



* Single cases of primary amebic meningoencephalitis (n = 60) have been removed from this figure; therefore, it is not comparable to figures in previous Surveillance Summaries.

† AGI: acute gastrointestinal illness; Skin: illness, condition, or symptom related to skin; ARI: acute respiratory illness; Other: includes keratitis, conjunctivitis, otitis, bronchitis, meningitis, meningoencephalitis, hepatitis, leptospirosis, and combined illnesses.

§ All outbreaks of legionellosis (i.e., Legionnaires' disease and Pontiac fever) are classified as ARI.

tivate *Cryptosporidium* and are available for use at aquatic venues. Other potential risk-reduction steps include increased circulation flow rates, flocculants, remedial biocidal shock treatments [i.e., routine hyperchlorination: 20 ppm free chlorine for 12.75 hours or the equivalent (*31,33*)], and occupancy-dependent water replacement. In addition, cryptosporidiosis outbreaks highlight the need for improved operator training and continued education of the general public concerning healthy swimming practices to reduce the risk for RWI.

Because *Cryptosporidium* is resistant to the chlorine levels used in pools, outbreaks can occur, even in facilities that are well-maintained. Therefore, rapid public health response and increased community involvement are needed to prevent the expansion of these outbreaks (*34*). One cryptosporidiosis outbreak (Iowa, June 2005) that occurred in a community swimming pool demonstrates how a rapid community-wide public health response during the early stages of an outbreak can help control the potential spread of illness into the community. In Iowa, detection and investigation started 2 weeks after exposure. The response included mitigating actions (e.g., ordering hyperchlorination of the implicated pool and all pools within a 20-mile radius and then confirming compliance; containing the outbreak through collaborative efforts between epidemiologists and environmental health specialists; posting signs at the implicated pool's entrance; instructing those with diarrhea not to enter the pool; and educating the public about good hygiene practices). The investigation indicated that no transmission had apparently occurred outside of the single implicated community pool, suggesting that these control measures might have prevented further spread. An interstate cryptosporidiosis outbreak (Kentucky, June 2005; and Ohio, August 2005) highlighted the need for additional intra-agency collaboration (e.g., between epidemiologists detecting cases and environmental health specialists permitting and inspecting pools) and communication between states.

Modification of swimming behavior is a critical component in reducing recreational water-associated outbreaks. Swimming is essentially communal bathing, and continued swimming during diarrheal illness and the common occurrence of swallowing recreational water pose a public health challenge. Multiple findings underscore the relation between human behavior and disease transmission at recreational water venues. First, in multiple outbreaks, fecal accidents were observed at the implicated pools on the days when the outbreak exposures were thought to have occurred (Florida, August 2006; and Illinois, July 2006). Second, at least five outbreaks (New York, June 2005; Ohio, August 2005; Illinois, July 2006; Minnesota, September 2006; and South Carolina, July 2006) were caused by *Cryptosporidium hominis*, indicating a human source of water contamination. Third, swallowing water at the implicated recreational water venue was associated with illness in three outbreaks (Colorado, August 2006; Florida, June 2005; and New York, June 2005). All of these outbreaks highlight how recreational water can amplify transmission of fecal-oral pathogens. These findings underscore the need for public education about the importance of not swimming during diarrheal illness and not swallowing recreational water, and the importance of clarifying with the public that recreational water is neither drinking water nor sterile. Aquatic facilities should be diligent about informing patrons of these public health concerns and emphasizing that persons with diarrhea should not swim and all swimmers should practice good hygiene. These policies should apply to all patrons, particularly young children and visitors from high-risk settings (e.g., child care centers), which have diarrhea exclusion policies but might not enforce them routinely. They also should apply to all aquatics facility staff. Standardized policies for restricting staff who are ill with diarrhea from entering pools, similar to restricting ill foodhandlers from food preparation, should be established, implemented, and enforced (*35*).

Finally, good hygiene is essential to ensure the cleanliness of swimmers entering pools. An adequate number of functioning, accessible hygiene facilities (i.e., toilets, diaper-changing areas, and showers) should be located near pools and should provide hot water and handwashing access to promote compliance. Documented fecal contamination of persons (*36*) suggests that swimmers should be encouraged to shower thoroughly (i.e., washing the peri-anal surface in par-

ticular) before going to or entering the pool. Diaper-changing facilities, with handwashing stations, should be located close to or at the poolside to encourage hygienic diaper-changing and handwashing.

Chemical Toxicity

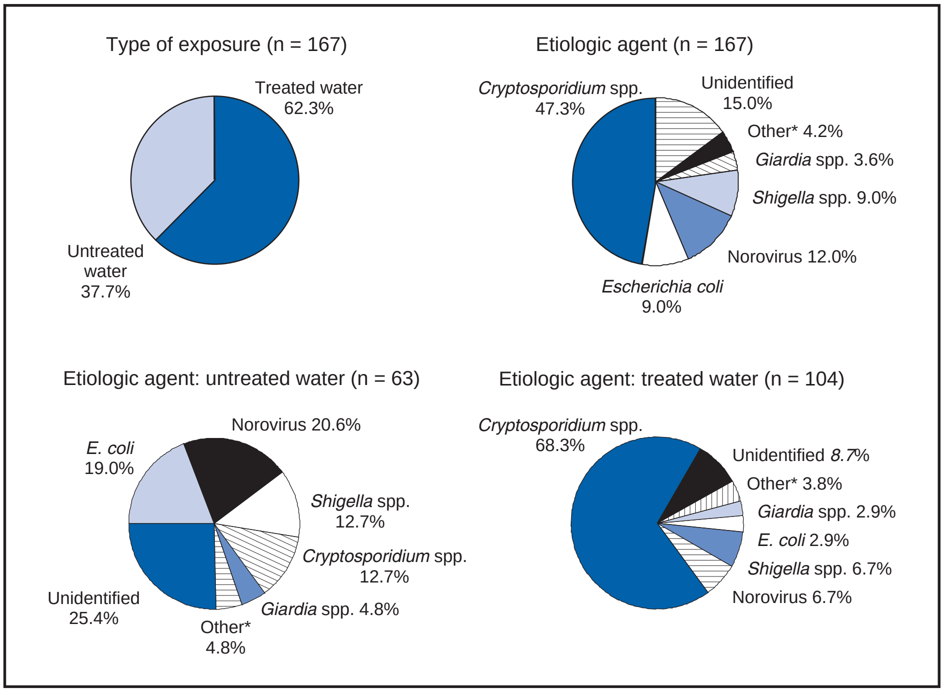
During 2005–2006, pool chemicals or disinfection by-products were confirmed as the etiologic agent in one (Ohio, July 2005) and suspected to be the etiologic agent in four (Minnesota, April 2005; Illinois, June 2006; Nebraska, December 2006; and New York, March 2006) pool-associated outbreaks. Chemicals are added to pool water to protect against microbial and algal growth, improve the water quality, maximize the efficacy of the disinfection process (e.g., pH control), and prevent corrosion and scaling of equipment. However, these same chemicals can become sources of illness or injury if they are not properly handled or if water quality and ventilation are poor. In an ARI outbreak in Ohio, a pool recirculation pump shut down for unknown reasons, but the chemical feed pump continued to feed hypochlorous acid and muriatic (hydrochloric) acid into the recirculation system, resulting in the release of chlorine gas into the pool that was still in use by swimmers when the recirculation pump was restarted. Nineteen persons became ill, of whom four of them were hospitalized. A dermatitis outbreak (Illinois) was suspected to have resulted from water chemistry deficiencies (pH <7 and chlorine level at 0 ppm) that occurred when the automatic chemical-feeding system malfunctioned. These outbreaks underscore the need for engineering controls (e.g., an electrical interlock system that shuts down the chemical feed pump when the recirculation pump shuts down), regular systems checks, and preventive maintenance of equipment.

Three additional outbreaks of acute respiratory symptoms or eye irritation were suspected to have resulted from an accumulation of chloramines in the water and air of indoor pools. Chloramines are disinfection by-products that result from chlorine oxidation of nitrogenous compounds (e.g., perspiration, saliva, urine, and body oils) commonly shed into pools by swimmers (*20*). Chloramines are produced in the water and volatilize into the surrounding air. In indoor pool settings, chloramines can accumulate in the enclosed space if ventilation is inadequate (*21*). The resulting high levels of chloramines can cause ocular, respiratory tract, and mucous membrane irritation (*20*); these high levels in indoor pool settings are also potentially linked to asthma (*37*). The investigation of the Nebraska outbreak, which resulted in one young swimmer being admitted to a pediatric intensive-care unit for severe chemical epiglottitis and laryngotrach-eobronchitis, revealed inadequate facility maintenance that resulted in prolonged deterioration of the water chemistry (e.g., 0.8 ppm free chlorine, 4.2 ppm combined chlorine, and a pH = 3.95) (*38*).

The shortage of laboratories that perform analyses for airborne chloramines and the variability in indoor air quality from day-to-day impedes investigators' ability to respond to reports of ocular and respiratory distress related to indoor pools or to obtain rapid and quantitative air measurements at implicated pools. Water-testing data useful for evaluating an indoor air-quality problem include the pH level and total (i.e., free plus combined chlorine) and free chlorine concentrations, which can be used to calculate the level of combined chlorine in the water. Levels that exceed test kit capacity should be re-measured by making dilutions using distilled water. These outbreaks underscore the need to train pool operators and aquatic staff so that they routinely monitor and maintain water chemistry to protect the health of patrons and staff.

Air-quality improvements in indoor pools will require technological improvements in water chemistry and treatment and air circulation and ventilation. New studies suggest that

FIGURE 9 . Recreational water-associated outbreaks of gastroenteritis, by type of exposure and etiologic agent— United States, 1997–2006



* These include outbreaks of *Salmonella, Campylobacter, Plesiomonas*, and mixed pathogens.

installation of ultraviolet treatment devices in pool water recirculation systems can reduce pool chloramine levels (*39*) and also can effectively inactivate pathogens (including chlorine-resistant *Cryptosporidium*) (*39,40*). Plans to improve air quality also can be aided by working with the public to improve swimmer hygiene. The resulting reduction in urine and other nitrogenous waste (e.g., decreased public urination in pools and increased showering before entering pools) should lead to reductions in chloramine levels in both water and air. Such an effort should raise public awareness about the role of urine and sweat in creating the irritants associated with indoor pool swimming. Operators should encourage showering before entering any pool or spa and facilitate frequent bathroom breaks for swimmers, particularly for young children (e.g., instituting adult-only swim times and short closures for water-quality testing).

Multiple challenges are associated with understanding the numbers of water-related, chemical illnesses at aquatic venues. Lack of rapid testing and routine testing for chloramines suggests that surveillance for recreational water-associated outbreaks of acute chemical poisoning is likely to have multiple barriers, resulting in underestimation of the true magnitude of the problem. Acute chemical-related WBDOs might be more likely to involve first responders than the traditional epidemiologic or environmental health staff investigating other WBDOs and reporting to WBDOSS. As a result, more efficient reporting will require building strong and effective intra- and interagency communication networks within health departments and with other groups (e.g., first responders and pool operators) to improve the reporting of WBDOs associated with recreational water.

Spas

Spas are susceptible to human contamination by the same pathogens that contaminate swimming and wading pools, but outbreaks of gastrointestinal illness from spas might be limited because spa usage does not involve as much full body (e.g., head-to-toe submersion) activities as pools, resulting in less water ingestion. However, spa operation is challenging because of difficulty with maintaining disinfectant levels at higher water temperatures or with aeration and the relatively high bather load to water volume typical of spas. As a result, these venues are ideal for amplification of naturally occurring environmental contaminants (e.g., thermophilic pathogens, *P. aeruginosa*, and *Legionella*).

Skin Infections

Spa-associated outbreaks are commonly associated with dermatitis and folliculitis; *P. aeruginosa* is the most commonly reported agent implicated in these settings (*41*). During 2005–2006, four WBDOs caused by *Pseudomonas* (Connecticut, April 2005; New Mexico, April 2005; Wisconsin, July 2005; and Kansas, December 2006), and five WBDOs suspected to have been caused by *Pseudomonas* (Minnesota, March 2005; Vermont, February 2005; Georgia, February 2006; Tennessee, March 2006; and Wisconsin, February 2006) were reported; four of these outbreaks involved spas, and five involved both spas and pools. The frequent co-location and use of both spas and pools by patrons means that it can be epidemiologically difficult to implicate a particular pool or spa at a single venue. However, amplification of *Pseudomonas* is most likely to occur at the higher temperatures in spas (*42*).

Nearly all of the *Pseudomonas*-associated outbreaks occurred as a result of spa use at a hotel, motel, or rented cabin, underscoring the need for improved recreational water quality in these transient visitation, travel-associated settings. Multiple outbreaks included large gatherings (e.g., birthday pool party [Connecticut] and sports tournament [Minnesota]), which can rapidly overwhelm the disinfection capacity of spas and lead to bacterial amplification. In addition, these gatherings often occurred on weekends (Wisconsin), when hotel staff trained in spa maintenance are likely to be off duty. Hotels and motels should consider having only trained employees operate and maintain pools and spas, particularly on weekends when usage is typically highest. Enhanced water-quality monitoring and maintenance should be considered when a large group or event at a hotel is scheduled. Users should be educated about not adding contaminants that might disrupt the spa's water chemistry (e.g., shampoo [Minnesota] and wine [Georgia]).

To prevent spa-associated outbreaks, operators must understand the risk factors and steps that can be taken to limit transmission of pathogens, particularly thermophiles. Proper chlorination or bromination effectively kills *Pseudomonas* and other skin-infecting bacteria. A review of 18 *Pseudomonas* outbreaks demonstrated that inadequate disinfection was associated with all outbreaks linked to spas (*43*). Bacterial amplification and biofilm build-up can be prevented by properly maintaining spas, ensuring that chlorine or bromine levels consistently remain >2 ppm, and that pH levels remain in a range of 7.2–7.8. Poor maintenance of spas has been well-documented (*44*), and studies have demonstrated that *Pseudomonas* and other bacteria can remain protected in spa biofilms, even in the presence of adequate disinfectant, then rapidly proliferate if the disinfectant level drops (*42*).

Legionellosis

Legionellae, which cause both LD and PF, are ubiquitous in freshwater environments (*45*). Environmental conditions in

whirlpool spas (e.g., warm temperatures and water aerosolization) promote the amplification and transmission of the bacteria when combined with low or erratic disinfectant levels. Exposure to *Legionella* is more likely to occur in the absence of adequate levels of disinfectant, underscoring the importance of maintaining adequate disinfectant levels and pH control. When lapses in preventive measures result in a legionellosis outbreak, morbidity can be reduced by rapid recognition of the outbreak, identification of its source, and immediate implementation of remediation. Remediation methods include cleaning and disinfecting the spa to eliminate *Legionella* colonization and performing follow-up cultures for *Legionella* to ensure that re-colonization does not occur (*46*).

All eight legionellosis WBDOs associated with recreational water during 2005–2006 were associated with spas. Five of these outbreaks occurred at hotels which highlights the role of travel in *Legionella* transmission and illustrates the potential difficulty of detecting travel-associated illnesses when travelers disperse to their resident state or country. CDC's supplementary reporting system for legionellosis collects exposure and travel information. In a 2005 CSTE position statement (http://www.cste.org/PS/2005pdf/final2005/05-ID-01final.pdf), surveillance and active follow up of potential travel-associated case reports was recommended position statement to improve detection of travel-associated clusters of illness and to increase opportunities for disease prevention. During 2005–2006, a total of 10 clusters were identified (*47*) although not all met WBDO definition. After CSTE's recommendations in 2005, CDC 1) improved communication with international, state, and local public health partners concerning travel-associated LD cases; 2) developed a standardized notification and tracking system; and 3) created a dedicated e-mail address for case reporting (travellegionella@cdc.gov). In addition, CDC's legionellosis website (http://www.cdc.gov/legionella) has been updated to provide useful tools for investigating legionellosis outbreaks (including sample questionnaires), sample letters for hotel management, and protocols for environmental assessments of water systems.

Interactive Fountains/Wet Decks and Fill-and-Drain Pools

Infectious Gastroenteritis

Certain treated water venues (e.g., interactive fountains, which also are called wet decks or spray parks) might be overlooked as potential sites for transmission of infection or pool regulation because they do not have standing water as traditionally found in swimming pools. These venues are particularly prone to contamination by fecal material, vomit, and dirt because of the young users of the small volume of recirculating water. These contaminants can potentially drain into the water reservoir and be sprayed back on users, increasing the likelihood of contaminated water ingestion. The use of interactive fountains has previously been associated with outbreaks of gastroenteritis (*48*), and outbreaks reported here (Louisiana, August 2005; New York, June 2005; California, July, 2006; and Florida, May 2006) demonstrate that transmission continues to occur in these settings. Not all states regulate interactive fountains which might increase chance of improper design, maintenance, or operation in these venues.

In one of the largest outbreaks reported to the WBDOSS, approximately 2,300 persons developed cryptosporidiosis following exposure to a New York spray park. The environmental investigation revealed that recycled water was not adequately filtered and disinfected. In response, New York passed emergency legislation requiring that supplementary disinfection (e.g., ultraviolet radiation or ozonation) be installed on water returning through the sprayers. Designs that improve water treatment for these interactive fountains are needed to reduce the risk for RWIs. Reports of investigations from three additional cryptosporidiosis outbreaks (California, 2006; Florida, 2006; and New York 2005) indicated inadequate disinfection levels (<1.0 ppm chlorine) and the use of sand or cartridge filters, both of which might not be adequate for *Cryptosporidium* oocyst removal. Filters with diatomaceous earth might be more effective at removing oocysts than sand or cartridge filters.

The use of tap water to fill or operate temporary aquatic venues (e.g., fill-and-drain pools) used by young children continues to be a public health challenge (California, July 2006; and Wyoming, July 2005). Lack of disinfection and the traditional use by toddlers and diaper-aged children have resulted in multiple outbreaks being associated with use in both residential and institutional settings (*12,49,50*). In the California outbreak, nine persons became ill with AGI after attending a pool party where guests swam in a plastic pool filled with untreated tap water. Three children were hospitalized; *S. sonnei* was confirmed in stool samples from six ill persons. In Wyoming, an outbreak of campylobacteriosis occurred after two families filled a pool with untreated water from a shallow well. In addition, a dog known to roll around in cow feces entered the pool. The potential risk for infection associated with using temporary pools filled with tap water without additional disinfection and filtration should be considered before they are used in residential settings. To reduce the risk for pathogen transmission, persons with gastroenteritis should be excluded, and the pool should be drained and cleaned daily. On the basis of documented outbreaks, fill-and-drain pools should be eliminated from institutional settings or large group events (*50*).

Lakes and Rivers

Infectious Gastroenteritis

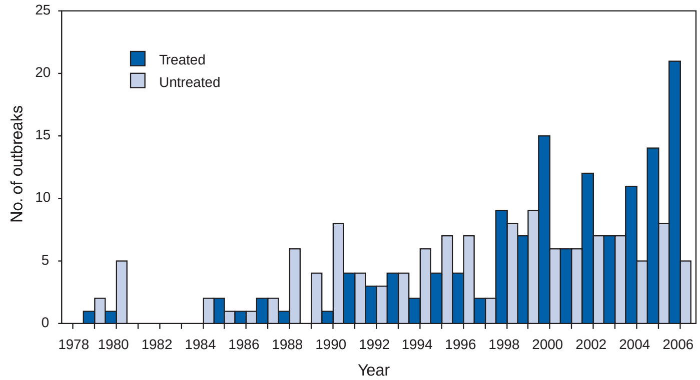
Although the proportion of AGI outbreaks associated with untreated venues (e.g., lakes and rivers) relative to treated venues decreased over the previous decade, the number of outbreaks associated with untreated venues has remained relatively constant (Figure 10). During 2005–2006, a total of 13 outbreaks of gastroenteritis associated with untreated freshwater venues were reported; all of these were linked to swimming in lakes or ponds. Freshwater venues have a higher proportion of outbreaks caused by bacterial and viral etiologic agents compared with treated water venues (Figure 5).

Multiple studies have determined the utility of water-quality monitoring (*16*) for assessing the associated risk for swimmer illness (*18*) in large bodies of water (e.g., Great Lakes and the ocean). However, the small inland water bodies associated with the outbreaks in this report do not have consistent external sources of contamination (e.g., sewer overflow), suggesting that swimmers might be an important source of water contamination and infection transmission. As with treated venues, human behavior plays a key role in the spread of pathogens in untreated bodies of water. Modification of swimmer behavior might be a more critical factor in natural water venues that lack the benefit of disinfection and filtration barriers to transmission. Recommendations for swimmer hygiene in natural waters are the same as those previously discussed for treated pools. In addition, beach managers and swimmers should be aware that shallow, poorly circulated swimming areas, although desirable to many swimmers, might pose a higher risk of exposure to certain pathogens compared to deeper, well circulated swimming areas. Potential methods to improve circulation of water through beach areas should be explored to reduce the longevity of focal, swimmer-derived contamination and waterborne-disease transmission. Reducing exposure to high fecal indicator bacterial levels at sites affected by runoff can be achieved by avoiding swimming immediately after heavy rainfall (reducing exposure to any increase in contaminated runoff) and by not swimming near storm drains or pipes that might release contamination into water bodies (*24*).

Primary Amebic Meningoencephalitis

During 2005–2006, five fatal cases of PAM caused by *N. fowleri* were reported; for two of these cases, there was possibly a common exposure to either a creek or a small spray park. For the remaining three cases, no common exposure was identified (Tables 4, 10). This rare disease is of public health importance because of the high fatality rate associated with infection (>99%) (*51*) and the public alarm it raises for use of natural waters in the southern tier states in the United States. *N. fowleri* is a free-living ameba that proliferates in warm freshwater and hot springs. Disease occurs when the ameba coincidentally enters the nasal passages, travels to the olfactory lobe of the brain, and infects brain tissue. The five cases all occurred in southern tier states (Arizona, Georgia, Oklahoma, and Texas) during warm weather months (Tables 4, 10). Three of the five children who died of PAM during 2005–2006 had participated in activities in warm water before onset of symptoms, similar to other known cases of PAM. The source of exposure for the two Oklahoma cases could not be determined despite a public health investigation.

FIGURE 10. Number of recreational water-associated outbreaks of gastroenteritis (n = 259), by water type and year — United States, 1978–2006



The low number of *Naegleria* infections makes it difficult to determine why certain persons become infected compared with the millions of others with the same or similar exposures to waters across the United States. As a result, the efficacy of existing risk-reduction strategies are uncertain. The finding of *Naegleria* in the majority of lake water surveys conducted in southern tier states suggests that this minimal likelihood of *Naegleria* infection always will be associated with swimming in warm, freshwater lakes, rivers, and hot springs. While the most certain way to prevent infections is to refrain from swimming in these freshwater bodies, swimmers might reduce their risk for PAM by not swimming or jumping into bodies of warm freshwater, hot springs, and thermally polluted water (e.g., water around power plants); not swimming or jumping into freshwater during periods of high water temperature and low water volume; holding the nose shut or using nose clips when jumping or diving into bodies of warm freshwater; and refraining from digging in or stirring up sediment while swimming in shallow, warm, freshwater areas. CDC is collaborating with CSTE to more effectively describe the scope of *Naegleria* infections in the United States, improve surveillance, and analyze available exposure and environmental occurrence data to develop more evidence-based risk-reduction measures and messages (*52*).

Leptospirosis

Although infections caused by *Leptospira* are considered to be more common in tropical and semitropical areas of the world (*53*), outbreaks reported during 2005–2006 illustrate the potential risk for leptospirosis outbreaks associated with recreational water contact in the United States. *Leptospira* can be found in the urine of infected wild and domesticated animals, so contamination of natural waters can occur where infected animals live. The route of transmission in humans usually is through contaminated water contact with broken or abraded skin or through contact with the mucosal surfaces of the eye, mouth, nasopharynx, or esophagus. Exposure might also occur through inhalation, ingestion, or prolonged immersion in water, resulting in increased permeability of the skin. Increased skin permeability might play a role in infections resulting from contact with contaminated surface water after flooding (*54*) or with prolonged use of contaminated surface waters as part of sports or other events (e.g., triathlons) (*55,56*). Two outbreaks of leptospirosis involving 46 persons were reported for 2005–2006 as well as a previously unreported outbreak in Hawaii in 2004 (*57*). One outbreak in California (July 2005) was associated with persons working in a drought-affected stream. The second larger outbreak occurred in Florida (November 2005) and was associated with participation in an adventure race. This is consistent with previous outbreaks in other similar competitive venues (*55,56*). To reduce risk for infection, persons should wear protective clothing, avoid swimming when they have open wounds or abrasions and avoid water contaminated by animal urine.

Cercarial Dermatitis

During the 2005–2006 surveillance period, two WBDOs of suspected cercarial dermatitis caused by avian schistosomes were reported (California, July 2005 Ohio August 2006). Although the diagnosis was not confirmed, this self-limited disease is known to occur among persons exposed to lakes across the United States where infected birds contaminate water supporting the intermediate host snail (*58*). The risk for acquiring cercarial dermatitis might be reduced by warning swimmers of potentially contaminated lakes, avoiding shallow swimming areas where infected snails reside, instituting a snail control program, and by not attracting birds to swimming areas (e.g., by not feeding them).

Marine Water

No waterborne disease outbreaks associated with marine waters were reported to WBDOSS before 2005–2006; however, evidence from multiple sources demonstrates that contamination of marine waters is common and that swimmers in marine waters are at increased risk for acquiring AGI (*23,59*). States and territories report water-quality testing results and notification data for their coastal and Great Lakes recreational water to EPA. In 2006, 32% of monitored beaches were affected at least once by either an advisory or closing as a result of the EPA microbial fecal indicator limits being exceeded or water-quality standards not being met (*17*). Multiple studies have linked these water-quality indicators with increased risk for RWIs (*23,59,60*), although RWIs also can occur when water-quality indicators are within established limits (*24*). The reasons for a lack of reported marine-associated outbreaks might include the wide geographic spread of beachgoers, the fact that some of the marine-associated illnesses are not enteric illnesses typically linked to waterborne causes, and a lack of illness attribution to marine waters.

Vibrio Illness

Although WBDOs associated with marine waters might be difficult to detect, single cases of *Vibrio* infections from marine water exposure might be more likely to be reported because of the severity of the illness associated with infection. The number of *Vibrio* infections associated with water exposures during 2005–2006 (n = 189) was higher than the number reported in 2003–2004 (n = 142), although recreational water exposure constitutes only a small fraction (14.7%) of the 1,287 vibriosis cases from all exposures reported in 2005–2006 (*61*). Some of the increase in reported cases for 2005 might be attributable to flood water exposure in the Gulf Coast immediately following Hurricane Katrina (*62*) when active case-finding facilitated identification of *Vibrio* infections. Reported hurricane-related infections were primarily among persons with wounds who waded through flood waters. The majority of hurricane-related *Vibrio* infections were caused by *V. vulnificus*, which predominately occurs in the Gulf Coast. Wound infections from *V. vulnificus* can cause severe illness and sequelae, including septicemia and the need for amputation. For nonfoodborne cases of *V. vulnificus* infection, the hospitalization rate is approximately 90% and the case fatality rate is 17%–24% (*63,64*), similar to the 22.3% case fatality rate among cases reported during 2005–2006 (Table 8). Disease is more common and severe among persons with preexisting wounds and other medical conditions (e.g., diabetes, heart disease, or liver disease) (*64,65*). *V. parahaemolyticus* and nontoxigenic *V. cholerae* infections were also reported among persons with hurricane-related *Vibrio* infections. The burden of wound-related vibriosis is unknown, although an estimated 8,000 *Vibrio* infections occur annually, including an estimated 2,800 annual cases not associated with food exposure (*64*).

CSTE added vibriosis to the list of nationally notifiable diseases in January 2007. Vibriosis is reportable in 35 states,

although all other states and territories can report vibriosis cases to CDC. Cases are reported to CDC by using the Cholera and Other *Vibrio* Illness Surveillance report form, which is available at http://www.cdc.gov/nationalsurveillance/PDFs/CDC5279_COVISvibriosis.pdf. Annual summaries of national data on vibriosis are available at http://www.cdc.gov/nationalsurveillance/cholera_vibrio_surveillance.html. Improved surveillance and reporting are designed to increase understanding of the magnitude and distribution of *Vibrio* illness related to marine water, to better characterize the risk and contributing environmental factors, and to guide the development of appropriate prevention messages (e.g., persons with wound or certain preexisting conditions not swim in warm marine water).

Seabather's Eruption

One outbreak was reported for 2005–2006 in which swimmers were exposed to marine water. Certain ill persons had symptoms consistent with Seabather's Eruption, a skin condition caused by contact with toxins from stinging jellyfish larvae. However, the majority of persons also exhibited an influenza-like illness which, although previously associated with Seabather's Eruption (*66*), could also indicate another water-associated etiology. Seabather's Eruption occurs primarily in the marine waters off Florida, the Gulf of Mexico, and the Caribbean Sea particularly during spring and summer months. Whereas risk factors associated with developing Seabather's Eruption are not fully understood, swimmers might be able to reduce their risk by removing bathing suits and thoroughly showering to remove jellyfish larvae after marine water exposure (*67*). Ongoing research is needed to understand the water conditions that lead to increased risk for illness among swimmers so that appropriate risk-reduction messages can be given to ocean beach visitors.

Previously Unreported Outbreaks

The retrospective review of waterborne-disease outbreaks in Minnesota, New York, and Tennessee by EHS-Net Water staff resulted in the reporting of 30 previously unreported recreational water–associated outbreaks and case reports (Table 11). The addition of previously unreported outbreaks increases understanding about the epidemiology of waterborne disease in these jurisdictions. The success of the EHS-Net Water surveillance improvement effort underscores the utility of acquiring personnel who can focus on waterborne disease detection, investigation, and reporting (*13*). An additional outbreak from 2004 was reported by Hawaii (*57*).

Aquatic Facility-Related Health Events not Associated with Recreational Water Use

All 32 aquatic facility–related health events not associated with recreational water use (Table 12) were reported by New York, which had captured these events through a system, which mandates reporting of chemical injuries. Three events, all of which involved mixing of incompatible pool chemicals that resulted in the release of chlorine gas, were reported during 2005–2006. The first outbreak of ARI resulted from a spill of 50–75 gallons of hypochlorous acid (i.e., bleach), which might have interacted with other chemicals in the spill area. The second event resulted from using a container that was previously used for hypochlorous acid as a container for the acid used to adjust pool pH. Subsequent contact of the pool acid with the hypochlorous acid residue released a chlorine gas plume. The third event involved adding both calcium hypochlorite (chlorine) and trichloro-s-triazinetrione (a chlorinated isocyanurate commonly called trichlor) to the pool chlorinator system, which resulted in a release of chlorine gas. The material safety data sheet for trichloro-s-triazinetrione states that it is not to be mixed with other chemicals, especially calcium hypochlorite; alkalis; and other swimming pool/spa chemicals in their concentrated forms. These events and others (Table 12) highlight the need for new or improved 1) pump room and chemical storage area design and construction (e.g., improved ventilation, and chemical containment and separation), 2) chemical packaging (e.g., to easily differentiate between key pool chemicals), 3) chemical storage (e.g., to prevent mixing accidents), 4) staff training on how to safely store and handle chemicals and maintain and repair chemical-using pool systems, and 5) emergency response protocols.

Prevention

Prevention of RWIs is likely to be accomplished only through a concerted team effort by public health professionals, swimming venue operators, and the general public. Operators at treated water venues are equipped with various methods that should be employed to prevent outbreaks. The traditional reliance on two water-treatment barriers at treated water venues, chlorination and filtration, likely needs to be expanded to include in-line (i.e., usually installed after filtration and before chlorination) supplemental disinfection (e.g., ultraviolet treatment and ozonation) to increase the level of protection against pathogens, particularly chlorine-resistant *Cryptosporidium*. Such supplemental disinfection systems will not eliminate waterborne-disease transmission (because these systems are circulation-time dependent), so improved monitoring of water-quality and

facility-maintenance programs and improved policies to educate the public and decrease contamination of aquatic facilities with bodily waste also are critical. In response to the lack of protective barriers at untreated swimming venues (e.g., lakes and oceans), beach managers and public health officials should implement water-quality testing programs and educate swimmers concerning appropriate prevention measures (e.g., not swimming after heavy rainfall). Specific efforts should address environmental pathogens unlikely to be prevented by current water-quality guidelines (e.g., illnesses caused by *Vibrio* and otitis media infections).

Public health professionals should 1) improve training for pool inspectors, 2) update and improve pool codes to stay current with changing designs and needs demonstrated by outbreaks summarized in this report, 3) lead and collaborate with aquatic staff to educate the general public, and 4) develop expertise in detecting and investigating recreational water-associated outbreaks, particularly those associated with chemicals. Safe handling and use of chemicals at aquatic facilities needs to be a standard training element that is regularly reinforced. In addition, to improve overall indoor air quality, public health professionals and pool managers need to understand the importance of implementing improvements in pool water quality, swimmer hygiene, air-turnover rates, and ventilation.

Educating swimmers can play a vital role in reducing RWIs by encouraging them to follow basic guidelines for healthy swimming. Fecal shedding of pathogens is common (*36*), so reducing the risk for water-related infection is best achieved by implementing diarrhea-exclusion policies, using appropriate hygiene measures, and advising the public to avoid swallowing recreational water. In addition, the public can inform themselves about RWI prevention. They can become activist swimmers (e.g., checking chlorine and pH levels themselves) and advocate for healthy swimming venues.

Conclusion

Data collected by WBDOSS are used to characterize the epidemiology of waterborne disease and outbreaks associated with both recreational and drinking water. Swimming is a common activity in the United States (*68*). Certain disease-causing agents are transmitted through shared bodies of water, and new waterborne pathogens that infect humans (e.g., *Cryptosporidium* and toxigenic *E. coli*) have emerged in the previous 3 decades. RWIs and outbreaks are associated with both treated and untreated water and with every type of aquatic venue. Common themes derived from the outbreaks in this report include 1) low disinfectant levels or poor filtration; 2) inadequate water-quality monitoring; 3) high bather loads during large events; 4) breakdowns of equipment and delayed detection or repair times; 5) not using ultraviolet radiation or ozonation to treat for *Cryptosporidium* in pools and interactive fountains; 6) accumulation of combined chlorines in pools accompanied by inadequate indoor air ventilation; 7) inadequately trained aquatic staff, particularly on safe chemical handling practices, 8) lack of communication within and between public health agencies; 9) outbreaks occurring on weekends when trained staff might be off duty; 10) lack of awareness by the general public of appropriate healthy swimming behaviors; and 11) lack of health department familiarity with chemical-associated RWIs.

Although no easy solution exists for reducing WBDOs associated with recreational water, a sustained effort by the swimming public, the aquatic management sector, and public health agencies can reduce the associated risk. The millions of persons in the United States who use recreational water every year can best reduce their risk by staying informed regarding the health and safety concerns associated with swimming. Public health officials should lead this educational effort to promote healthy swimming behaviors. Prevention methods discussed in this report should help make swimming experiences healthier, safer and more enjoyable. The aquatic sector also can benefit from the recommendations, which address changes that are needed in operation, maintenance, and chemical handling procedures. Large numbers of violations of state and local pool codes occur each year (*15,44*), indicating that improved pool operation, disinfection policies, and enforcement are needed to prevent RWIs (*33*). In addition, improvements in indoor air quality monitoring and widespread dissemination of validated testing protocols are needed to support improved air quality in indoor swimming pool settings. As a result of recommendations from a 2005 national workshop on how to prevent RWIs, CDC is sponsoring development of a national model aquatic health code (MAHC), which involves public health and aquatics sector personnel from across the country and is designed to transform the typical health department program into a data-driven, knowledge-based, risk-reduction effort to prevent disease and injuries and promote healthy recreational water experiences. MAHC will provide uniform guidelines for the design, construction, operation, and maintenance of swimming pools and other disinfected swimming venues. Although nonregulatory in nature, the MAHC should ensure that the best available standards and practices for protecting public health are available for adoption by state and local agencies. Further information is available at http://www.cdc.gov/healthyswimming/model_code.htm.

Public health professionals at all levels of government should lead a multidisciplinary approach to prevent RWI that includes surveillance, health education, epidemiologic studies, laboratory support, and environmental health research. Educational resources and campaigns are needed for swimmers, parents, aquatic venue operators, and public health staff. Improved communications, particularly during outbreak investigations, between all areas of the public health system (e.g., infectious disease, environmental health, and surveillance staff) and between agencies in neighboring jurisdictions can 1) enhance awareness concerning ongoing occurrences of RWIs, 2) facilitate reporting to WBDOSS in a timelier manner, and 3) strengthen WBDO investigations and responses to protect the public. The timely collection of clinical specimens and water samples for testing during a WBDO investigation and prompt initiation of an environmental investigation will result in more rapid identification of the etiologic agent and determination of the conditions leading to the outbreak. However, the capacity of public health departments and laboratories to detect and investigate potential WBDOs varies and needs to be strengthened to meet these challenges. WBDO investigations typically require input from various disciplines, including infectious disease epidemiology, environmental health, clinical medicine, water and sanitation engineering, chemists/toxicologists, and microbiology. Additional cross-training of existing personnel in these areas or additional staffing and resources are needed to improve WBDO detection, investigation, and reporting. Other methods of improving surveillance at the local, state, and federal levels include additional review and follow-up of information gathered through other mechanisms (e.g., media reports or emergency responder reports of illness associated with recreational water venues). CSTE passed a 2006 position statement making waterborne-disease outbreaks, as a unit of reporting, nationally notifiable and reportable to CDC starting in 2007. Adoption of this CSTE recommendation at the state level through state-specific legislative action might improve reporting of waterborne outbreaks. In addition, to improve timeliness and completeness of reporting, CDC and EPA are collaborating with public health jurisdictions to implement electronic reporting of WBDOs through the National Outbreak Reporting System (NORS). NORS will be a more systematic data collection tool that will provide public health agencies and waterborne-disease researchers with the evidence base they need to identify the causes of WBDOs and understand the interrelated factors contributing to these outbreaks.

EHS-Net Water, a collaborative project between EPA, CDC, and five state health departments, is an effort to improve WBDO identification, investigation, response, and reporting. Environmental health specialists initially focused on understanding their state-specific surveillance systems, leading to the reporting of numerous historical outbreaks to WBDOSS. Although this project has focused primarily on improving drinking water-associated disease outbreak surveillance, it also has markedly improved our understanding of recreational water-associated outbreaks in EHS-Net Water states, which demonstrates the value of investing water-specific resources in certain jurisdictions.

Focusing on improving awareness, training, resources, and communication will improve the quality of the data in WBDOSS. These efforts should make public health activities related to waterborne disease more efficient and, in turn, reduce the burden of recreational water-associated disease and injury (Box).

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BOX. Organizations that provide assistance in investigations of waterborne diseases and outbreaks (WBDOs) associated with recreational water exposure

State health departments can request epidemiologic assistance and laboratory testing from CDC to investigate WBDOs. CDC and the U.S. Environmental Protection Agency (EPA) can be consulted regarding engineering and environmental aspects of recreational water treatment and collection of proper water samples to identify pathogenic viruses, bacteria, and parasites, which require special protocols for their recovery.

- **How to Report Waterborne-Disease Outbreaks**
  Waterborne Disease Outbreak Coordinator
  Division of Parasitic Diseases, MS F-22
  National Center for Zoonotic, Vector-Borne and Enteric Diseases
  Coordinating Center for Infectious Diseases, CDC
  Atlanta, GA 30333
  Telephone: 770-488-7775
  Fax: 770-488-7761
  CDC Reporting Form (CDC 52.12, rev.01/2003)
  Internet: http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf
- **Requests for Testing for Viral Organisms**
  Division of Viral Diseases
  National Center for Immunization and Respiratory Diseases
  Coordinating Center for Infectious Diseases, CDC
  Telephone: 404-639-3607
- **Requests for Testing for Bacterial Enteric Organisms**
  Division of Foodborne, Bacterial, and Mycotic Diseases
  National Center for Zoonotic, Vector-Borne and Enteric Diseases
  Coordinating Center for Infectious Diseases, CDC
  Telephone: 404-639-1798
- **Requests for Testing for Parasites**
  Division of Parasitic Diseases
  National Center for Zoonotic, Vector-Borne and Enteric Diseases
  Coordinating Center for Infectious Diseases, CDC
  Telephone: 770-488-7775
- **Requests for Information on Testing for *Legionella***
  Division of Bacterial Diseases
  National Center for Immunization and Respiratory Diseases
  Coordinating Center for Infectious Diseases, CDC
  Telephone: 404-639-2215
  Internet: http://www.cdc.gov/legionella

CDC provides public health professionals, clinicians, laboratorians, and persons in other allied health fields with background and clinical information, guidance on investigations, and resources concerning Legionnaires' disease and Pontiac fever cases or potential outbreaks. Resources include outbreak investigative tools, environmental sampling protocols, fact sheets, clinical evaluation and management guides, and laboratory testing protocols.

- **Information Regarding Healthy Swimming**
  CDC Internet: http://www.cdc.gov/healthyswimming
  — Recreational water health communication and education resources for the general public and aquatic staff
  — Pool and spa operation guidelines, including disinfection and responses to fecal accidents
  — Outbreak investigation toolkit and technical information concerning laboratory diagnostics.
- **Information Regarding Beaches**
  EPA Internet: http://www.epa.gov/OST/beaches

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Appendix A

Glossary of Definitions

aquatic facility-related health events not associated with recreational water	Chemical injury cases and outbreaks (e.g., mixing of pool chemicals that release toxic gas) at aquatic facilities in which exposure to water was not the cause of illness. Although these events are not classified or analyzed as waterborne-disease outbreaks, they highlight important public health and safety concerns related to the design, operation, and maintenance of recreational water venues.
backwash	Flow of water through filter element(s) or media in a reverse direction to dislodge accumulated dirt, debris, and/or filter aid, and remove them from the filter tank.
backwash cycle	Time required to thoroughly backwash the filter system.
bather load	The number of bathers using a swimming pool or spa at any one time. The maximum bather load is usually determined by a state or local pool code, based on surface area and depth of the pool or spa.
biofilm	Microbial cells that adhere to a surface through a matrix of primarily polysaccharide materials in which they are encapsulated. These can grow on piping and surfaces of aquatic venues and can be notoriously difficult to remove. They offer protection to microbes from disinfectants (e.g., chlorine) in the water.
cercarial dermatitis	Dermatitis caused by contact with or direct invasion through the skin or a break in the skin by the cercariae (larval stage) of certain species of schistosomes, a type of parasite, for which the normal hosts are birds and nonhuman mammals. Dermatitis is an allergic response to contact with cercariae and does not lead to parasitic infestation in humans and produces no long-term disease.
class	Waterborne disease and outbreaks are classified according to the strength of the epidemiologic and laboratory data implicating recreational water as the source of the disease or outbreak (see Table 1).
chloramines	A group of disinfection by-products or weak disinfectants formed when free chlorine combines with nitrogen-containing compounds in the water (e.g., urine or perspiration). Tri- and di-chloramine can cause eye, skin, lung, and throat irritation and can accumulate in the water and air surrounding treated recreational water venues. In drinking water treatment, monochloramine is used for disinfection to reduce formation of disinfection by-products created when using chlorine as a disinfectant (see combined chlorine level).
coliforms	All aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 95ºF (35ºC).
combined chlorine level	See chloramines. Chlorine that has combined with organic compounds in the water and is no longer an effective disinfectant for recreational water. This value is derived by subtracting the free chlorine test level from total chlorine test level. The combined chlorine level is likely to include combined compounds in addition to chloramines.
contact time	The length of time water (and pathogens) is exposed to a disinfectant, usually measured in minutes (e.g., chlorine contact time).

Cryptosporidium	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 infects only humans, primates, and monkeys. Both species were referred to previously as *C. parvum*.
dermatitis	Inflammation of the skin. In this *Surveillance Summary*, the term dermatitis is used to denote a broad category of skin-related symptoms (e.g., folliculitis, cellulitis, burns, or rash).
disinfection by-products	Chemicals formed in water through reactions between organic matter and disinfectants. Includes chloramines, also known as combined chlorines.
etiologic agent	The pathogen, chemical, or toxin causing a waterborne disease or outbreak. Infectious etiologic agents include bacteria, parasites, and viruses.
fecal coliforms	Coliforms that grow and ferment lactose to produce gas at 112.1ºF (44.5ºC) within 24 hours.
fill-and-drain pools	Small pools, often constructed of plastic, which might be inflatable, and filled with tap water without any ongoing chemical disinfection or filtration. Sometimes called kiddie pools.
filtration	The process of removing suspended particles from water by passing it through one or more permeable membranes or media of limited pore 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 chlorine	The chlorine in water not combined with other constituents; therefore, it is able to serve as an effective disinfectant (also referred to as free available chlorine or residual chlorine). Measuring the free chlorine level is a common water-quality test.
freshwater (untreated water)	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 or water spray device intended for (or accessible to) recreational use. They usually do not have standing water as part of the design. These are sometimes called spray pads, splash pads, wet decks, or spray grounds. 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 or estuarine setting.
microcystin toxin	A secondary metabolite of blue-green algae (cyanobacteria) that can have toxic effects on humans and animals, potentially causing a wide range of illness or even death when exposure to accumulated toxins in fresh or marine water occurs.
mixed agent outbreak	More than one type of etiologic agent is identified in clinical specimens from affected persons, and each etiologic agent is found in >5% of positive clinical specimens (e.g., an outbreak with *Giardia* spp. [parasites] and *Salmonella* spp. [bacteria], with each agent identified in >5% of stool specimens).
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.

predominant illness	The type of illness most commonly expressed in a substantial proportion (>50%) of patients (e.g., gastroenteritis, dermatitis, and acute respiratory illness). When more than one illness type seems to define the character of the waterborne disease and outbreak, they are listed together as predominant illnesses.
recreational water venue	A body of water used for the purpose of recreation (e.g., swimming, soaking, or athletics), including any structure that encloses this water. It can include lakes and ponds, rivers, springs, the ocean, and man-made venues (e.g., swimming pools, spas, and water parks) that do not necessarily include standing water (e.g., interactive fountains).
reservoir, impoundment	An artificially maintained lake or other body of water created for the collection and storage of water. This body of water might be available for recreational use.
setting	Location where exposure to contaminated water occurred (e.g., swimming beach, water park, and hotel).
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 purposes 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. It sometimes is referred to as a hot tub or whirlpool.
spray park	A recreational water venue solely consisting of multiple interactive fountains.
total chlorine	A common water-quality test that measures the chlorine in water that is free for disinfection (free chlorine) plus that combined with other organic materials (combined chlorine). The combined chlorine level is derived by subtracting the free chlorine test result from the total chlorine test result.
total coliforms	Nonfecal and fecal coliforms that are detected by using a standard test.
treated water	Water that has undergone a disinfection or treatment process (e.g., chlorination and filtration) for the purpose of making it safe for recreation. Typically, this refers to any recreational water in an enclosed, manufactured structure but might include swimming or wading pools, fountains, or spas filled with treated tap water (e.g., small wading kiddie pool) or untreated water (e.g., mineral spring water) that receives no further treatment.
turbidity	A measurement of suspended particulate matter in water expressed as nephelometric turbidity units (NTU).
turnover rate	The time required to theoretically recirculate the entire volume of water in a swimming pool, spa, or hot tub.
ultraviolet light	The segment of the light spectrum between 100-300 nanometers (nm).
ultraviolet light disinfection unit	A device that produces ultraviolet light between 250-280 nm for the purpose of inactivation of microorganisms by UV radiation.
untreated water	Surface water that has not been treated or disinfected in any way (i.e., lakes, rivers, oceans, and reservoirs).
user	Any person using a pool, spa, or hot tub and adjoining deck area.
Vibrio species	A genus of comma-shaped, gram-negative Proteobacteria that include various human pathogens. Certain species are found in salty or brackish water and can cause illness by contamination of a wound or epithelial site (e.g., eardrums or sinus cavities). Sequelae can include sepsis and death.

waterborne-disease outbreak	Water exposure in which two or more persons have been epidemiologically linked to recreational water by location of exposure, time, and illness.
waterborne disease and outbreak surveillance system (WBDOSS)	The surveillance system that contains the outbreaks and case reports reported by jurisdictional public health authorities. Inputs into this system are illustrated in Figure 1.
WBDOSS *Surveillance Summary*	The biennial summaries of waterborne-disease outbreaks and cases associated with recreational water, drinking water and water not intended for drinking are published in the MMWR. These publications also discuss waterborne-disease data from other surveillance systems (e.g., *Vibrio*) and disseminate waterborne-disease prevention messages.
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 with a density or concentration that correlates best with health effects associated with a type of hazard or pollution (e.g., turbidity, coliforms, fecal coliforms, *Escherichia coli*, enterococci, free chlorine level).

Appendix B

Descriptions of Selected Waterborne Disease and Outbreaks Associated with Recreational Water Use

Date	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
Bacteria				
July 2005	Wyoming	*Campylobacter jejuni*	6	Two families celebrated a holiday weekend together at a private residence. A small pool was set up for the adults and treated with a jug of bleach. A fill-and-drain pool (kiddie pool) was set up for the children and filled with untreated well water. A dog known to roll around in cow feces might have introduced fecal matter into the children's pool. Five children, ranging from ages 13 months–8 years, and one adult developed gastrointestinal illness. Stool specimens from two of the children tested positive for *Campylobacter*.
July 2005	California	*Leptospira* spp.	3	Three men became ill and were diagnosed with laboratory-confirmed leptospirosis after removing brush and picking berries in a stream near their homes. The stream was very low and slow-flowing at the time of exposure.
November 2005	Florida	*Leptospira* spp.	43	Racers from approximately 30 U.S. states and two Canadian provinces were exposed to surface water from multiple sources, including creeks, swamps, and a river during an endurance race. In all, 192 (96%) of the racers were interviewed to collect information about exposures and signs and symptoms of illness. Mean incubation times were similar for suspected cases (12.8 days) and confirmed cases (13.5 days). The most common symptoms reported were fever (100%), headache (91%), chills (69%), sweats (68%), and muscle/joint pain (68%). Swallowing river and swamp water and being submerged were significantly associated with developing illness.
January 2006	Florida	*Legionella pneumophila* serogroup 1	11 (1)	Eleven persons became ill (3 confirmed Legionnaires' disease and eight atypical pneumonia cases) after staying at a hotel. A case-control study was conducted and revealed that only exposure to the hotel's indoor spa was a significant risk factor for developing illness. Environmental samples did not yield *Legionella.* However, several deficiencies were noted during the investigation, including suboptimal water temperatures and stagnation and sediment within the hot-water system. Bromine levels in the indoor spa were measured at 0.5 ppm at the time of investigation.
January 2006	Illinois	*Legionella* spp.	43 (1)	Forty-three persons became ill (three confirmed Legionnaires' disease and 40 Pontiac fever cases) following a hotel stay. A retrospective cohort study was conducted; exposure to the pool area was a significant risk factor for developing illness. *L. pneumophila* and *L. maceachernii* were isolated from water samples of both the pool and spa. No disinfectant residual was found in the pool or spa water.
July 2006	California	*Shigella sonnei*	9	Five families attended a party at a private residence. A fill-and-drain pool was filled with tap water with no additional treatment. *Shigella sonnei* was isolated from stool samples submitted by six attendees. A retrospective cohort study revealed a significant association between pool use and subsequent illness.

Date	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
Viruses				
May 2006	Wisconsin	Norovirus	18	A total of 18 persons developed gastrointestinal illness after using a hotel swimming pool and spa; three patients' stool specimens tested positive for norovirus. A case-control study showed a significant association between spa and/or pool use and illness. The pool had a high bather load, and an ill person had used the pool. Water testing records revealed inadequate disinfection during the time of suspected exposure. The hotel was advised to close the facilities and either hyperchlorinate or drain and refill them.
Parasites				
June 2005	Florida	*Cryptosporidium* spp.	47	This outbreak affected persons who played in or attended a youth sports tournament. Two teams with players who had gastrointestinal illness stayed in the same hotel. Although no pool water was tested for *Cryptosporidium*, swimming was the only risk factor significantly associated with illness. As a result of the investigation, the hotel was advised to keep daily maintenance logs for the swimming area.
June 2005	New York	*C. hominis*	2,307	An outbreak of gastrointestinal illness was traced to a water park with an interactive fountain. Stool samples for 495 of 572 people were positive for *Cryptosporidium* spp. Typing of 147 isolates identified them as *C. hominis*, indicating human contamination. The venue used chlorine and rapid sand filtration. Water samples collected from two tanks on three dates in mid-August contained *C. hominis* oocysts. *C. hominis* oocysts were also identified in a water filter and effluent from a sewer pump station. Polymerase chain-reaction tests were conducted on one water sample from each tank. The samples both contained 150 oocysts/L. Investigators determined that multiple factors contributed to the outbreak, including an inadequate recirculation design in which some water bypassed treatment and filtration as a result of the demand of the fountain.
July 2005	Oregon	*C. parvum*	20	A cohort study was conducted after two confirmed and 15 suspected cases of cryptosporidiosis were reported to a local health department. Gastrointestinal illness was epidemiologically linked with swimming in a pool at a membership club. A child with laboratory-confirmed cryptosporidiosis swam in the pool during the days that water contamination was suspected to have occurred. Control measures were quickly implemented and included hyperchlorination at the membership club pool, hyperchlorination of area public pools, and posting of signs at multiple pools to discourage swimming by ill individuals; prevention messages were disseminated by local media.
July 2005	Massachusetts	*Giardia intestinalis*	11	An outbreak at an athletic club implicated three outdoor pools (one adult pool and two children's pools) with a shared filtration system. All 11 cases were laboratory confirmed. Although not observed, the occurrence of a fecal accident was strongly suspected. Records did not indicate that disinfectant levels were adjusted or that the pools were closed when chlorine readings were below recommended levels in early August. A water sample taken during the investigation revealed indicator bacteria (coliforms and *E. coli*) levels above allowable limits.
July 2005	Oklahoma	*Naegleria fowleri*	2 (2)	Postmortem clinical specimens from two boys who died several days after they became ill indicated that they were infected with *N. fowleri.* Although both of the boys had spent time at a local water park before becoming ill, at least one child went swimming in untreated, stagnant water near his home before becoming ill. The boys' homes were not far apart from each other. Water samples from a local creek and the water park's spray deck were collected in July and August, respectively. Testing of cultures from both locations did not detect *N. fowleri*. PCR testing of the creek water was also negative. Water testing revealed temperatures ≥95°F (35°C) at both locations.

Date	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
August 2005	Ohio	*C. hominis*	523	A large, communitywide cryptosporidiosis outbreak affected 747 persons in Ohio. Recreational water exposure was associated with 70% (523/747) of the cases. This outbreak was linked by time and proximity to a cryptosporidiosis outbreak in Kentucky. Six pools were implicated as a source of exposure to contaminated water. More than 300 stool samples tested positive for *Cryptosporidium*. CDC performed additional molecular characterization of the *Cryptosporidium* isolates from one pool filter sand sample from the water park and seven clinical stool specimens; the subtype of the isolates of six of the stool specimens matched the pool filter sample's isolate.
July 2006	California	*Cryptosporidium* spp.	16	This outbreak was initially detected by a laboratory-based active cryptosporidiosis surveillance system. Some of the case-patients shared a common exposure at a public park with an interactive fountain. A 10 L sample from the fountain system contained 137 oocysts/L and had a chlorine residual of 0.9 ppm. The fountain used a sand filtration system that was not designed to remove *Cryptosporidium* spp. and did not have an automated disinfection system. Similar public fountains in the area were closed if they had inadequate filtration and disinfection. Ill children were restricted from attending school and daycare to limit possible person-to-person transmission.
July 2006	Illinois	*C. hominis*	65	Attendees of a private day camp developed gastrointestinal illness that was epidemiologically linked to recreational swimming at a private day camp pool and at a public outdoor water park. A total of seven laboratory-confirmed cases and 58 probable cases were identified. PCR detected *C. hominis* in stool specimens from three patients. An inspection of the day camp pool revealed poor water quality, unsanitary pool facilities and an absence of policies intended to prevent disease transmission; however, *Cryptosporidium* was not detected in a sample of pool water. Pool water from the water park met state guidelines for water quality but tested positive for *C. parvum.* Fecal accidents were reported in both pools. All areas of the water park shared one filtration and treatment system; outbreak prevention recommendations for the water park included installation of ultraviolet (UV) disinfection, as well as education for the staff and the public. (**Source:** CDC. Cryptosporidiosis outbreaks associated with recreational water use—five states, 2006. MMWR 2007; 56:729–32).
August 2006	Colorado	*Cryptosporidium* spp.	12	Certain persons developed cryptosporidiosis after attending a party at a community recreational center with a pool that had UV disinfection in addition to chlorination and rapid sand filtration. Swimming, swallowing water, and getting water in the mouth were significant risk factors. Pool use by diaper-aged children and the use of combined filtration systems for the adult and child pools were suspected to have been contributing factors in the outbreak. (**Source:** CDC. Cryptosporidiosis outbreaks associated with recreational water use—five states, 2006. MMWR 2007;56:729–32).
Chemicals/Toxins				
June 2005	Michigan	Copper sulfate	3	A local resident treated a state lake with copper sulfate to prevent swimmer's itch by controlling snail populations. The pesticide was applied without a permit; the quantity was 30 times the label-recommended amount for algae treatment and three times the label-recommended amount for snail control. Subsequently, three children who spent time near or in the lake developed respiratory symptoms, and one was hospitalized. A water test conducted within 1–2 months of the pesticide application did not find hazardous levels of copper sulfate in the water.

Date	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
July 2005	Ohio	Chlorine gas	19	A chlorine surge at a community pool caused illness in 19 persons. The majority of swimmers were children. The predominant symptoms were breathing difficulties, cough, sore throat, and eye irritation. The recirculation pump failed, but chemical feed pumps continued to feed chlorine and acid. When the mechanical pump was restarted, a concentrated surge of chlorine gas created by the mixing of the concentrated hypochlorous acid and chlorine was introduced into the pool. The facility responded to the event by installing an electrical interlock that would automatically stop the flow of chemicals if the recirculation pump failed.
Unidentified				
April 2005	Minnesota	Suspected chloramines	20	A case-control study was conducted after reports of respiratory and ocular symptoms among attendees at a birthday party at a hotel pool. Multiple other symptoms were documented, including burning nose and throat, nausea, and headache; 12 case-patients sought medical care within 1 day of attending the party. Water contact and entering the pool enclosure were significantly associated with illness. The outbreak investigation determined that the chlorine levels in the pool might not have been properly maintained, record-keeping was inadequate, showering facilities in the pool area were inadequate, no pool operator was on duty, and official bather load was exceeded for the pool during the party.
July 2005	Florida	Suspected jellyfish larvae	24	Attendees of a conference reported symptoms such as fever, fatigue, headache, chills, and muscle ache. Illness was significantly associated with swimming in the ocean and chlorinated resort pools. No clinical specimens were collected because symptoms had resolved before the investigation was initiated. Multiple symptoms were consistent with exposure to toxins released by minute jellyfish larvae (seabather's eruption). Although weather patterns at the time, as well as the month of the outbreak, supported the hypothesis of seabather's eruption, investigators concluded that certain illnesses might have occurred as a result of other etiologies. Interview data described poor pool water quality and high bather loads. An inspection of the pool facilities was conducted as part of the investigation and led to pool closure.
June 2006	Illinois	Suspected low pH	9	Swimmers from two classes at a neighborhood swimming pool had burning rashes on their bodies after they left the pool. The swimmers were ages 4–8 years. The instructor, who was in the water for a total of 80 minutes, reported a similar rash on his arms. Testing indicated that the pool water had a low pH. The exact pH could not be determined; the lower limit for the test strip was seven. The problem was traced back to the automatic sensing unit for feeding acid, which was not working correctly.
December 2006	Nebraska	Suspected chloramines	24	A child attending a family event at a motel swam for 3 hours in the indoor pool, during which time he developed respiratory symptoms. He was hospitalized overnight with severe chemical epiglottitis and laryngotracheobronchitis. A follow-up investigation identified 24 case-patients who had developed ocular and/or respiratory symptoms after being in or near the pool. The state health department inspected the pool and closed it as a result of multiple state health code violations. Pool water pH was 3.95 (acceptable range: 7.2–7.8); the free chlorine level was 0.8 ppm (acceptable range: 2–10 ppm) and the combined chlorine level was 4.2 ppm (acceptable limit: $\leq$0.5 ppm). Pool records indicated that water quality violations had occurred frequently during a 26-day period before the outbreak. Chloramine levels might have been higher on the day that the child became ill because of inadequate ventilation; the only ceiling exhaust fan was turned off, and all of the nearby windows were closed. Although the motel was licensed by the state of Nebraska, it was a nonmunicipal public pool and, therefore, pool operators were not required to undergo training and certification. (**Source:** CDC. Ocular and respiratory illness associated with an indoor swimming pool—Nebraska, 2006. MMWR 2007;56:929–32).

Date	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
***Vibrio* infections**				
August 2005	Louisiana	*Vibrio vulnificus*	1 (1)	A man aged 60 years waded for 3 days in flood waters after Hurricane Katrina in New Orleans, Louisiana, and arrived in Texas during the end of August 2005. His medical history included stroke, hypertension, and alcohol abuse. The day after he arrived in Texas, he went to an emergency department; he had ankle wounds and diarrhea. He was released after treatment but was admitted to the hospital 1 day later when *Vibrio vulnificus* was positively identified from a blood culture. He died in the hospital the next day. (**Source:** CDC. *Vibrio* illnesses after Hurricane Katrina—multiple states, August–September 2005. MMWR 2005;54:928–31).
August 2005	Mississippi	*V. parahaemolyticus*	1 (1)	A man aged 61 years died shortly after seeking medical treatment for *V. parahaemolyticus* infection; he had hypothermia and multiple second-and third–degree abrasions on his body after exposure to Hurricane Katrina flood waters. The patient was also known to have human immunodeficiency virus infection, coronary artery disease, and hyperlipidemia. (**Source:** CDC. *Vibrio* illnesses after Hurricane Katrina—multiple states, August–September 2005. MMWR 2005;54:928–31).

Surveillance for Waterborne Disease and Outbreaks Associated with Drinking Water and Water not Intended for Drinking — United States, 2005–2006

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Abstract

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

Reporting Period: Data presented summarize 28 WBDOs that occurred during January 2005–December 2006 and four previously unreported WBDOs that occurred during 1979–2002.

Description of System: The surveillance system includes data on WBDOs associated with recreational water, drinking water, water not intended for drinking (WNID) (excluding recreational water), and water use of unknown intent. Public health departments in the states, territories, localities, and Freely Associated States (FAS) (i.e., 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) are primarily responsible for detecting and investigating WBDOs and voluntarily reporting them to CDC by a standard form. Only cases and outbreaks associated with drinking water, WNID (excluding recreational water), and water of unknown intent (WUI) are summarized in this report. Cases and outbreaks associated with recreational water are reported in a separate *Surveillance Summary*.

Results: Fourteen states reported 28 WBDOs that occurred during 2005–2006: a total of 20 were associated with drinking water, six were associated with WNID, and two were associated with WUI. The 20 drinking water-associated WBDOs caused illness among an estimated 612 persons and were linked to four deaths. Etiologic agents were identified in 18 (90.0%) of the drinking water-associated WBDOs.

Among the 18 WBDOs with identified pathogens, 12 (66.7%) were associated with bacteria, three (16.7%) with viruses, two (11.1%) with parasites, and one (5.6%) mixed WBDO with both bacteria and viruses. In both WBDOs where the etiology was not determined, norovirus was the suspected etiology.

Of the 20 drinking water WBDOs, 10 (50) were outbreaks of acute respiratory illness (ARI), nine (45%) were outbreaks of acute gastrointestinal illness (AGI), and one (5.0%) was an outbreak of hepatitis. All WBDOs of ARI were caused by *Legionella*, and this is the first reporting period in which the proportion of ARI WBDOs has surpassed that of AGI WBDOs since the reporting of *Legionella* WBDOs was initiated in 2001.

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A total of 23 deficiencies were cited in the 20 WBDOs associated with drinking water: 12 (52.2%) deficiencies fell under the classification NWU/POU (deficiencies occurred at points not under the jurisdiction of a water utility or at the point-of-use), 10 (43.5%) deficiencies fell under the classification SWTDs (contamination at or in the source water, treatment facility, or distribution system), and for one (4.3%) deficiency, classification was unknown. Among the 12 NWU/POU deficiencies, 10 (83.3%) involved *Legionella* spp. in the drinking water system. The most frequently cited SWTD deficiencies were associated with a treatment deficiency (n = four [40.0%]) and untreated ground water (n = four [40.0%]). Three of the four WBDOs with treatment deficiencies used ground water sources.

Interpretation: Approximately half (52.2%) of the drinking water deficiencies occurred outside the jurisdiction of a water utility. The majority of these WBDOs were associated with *Legionella* spp, which suggests that increased attention should be targeted towards reducing illness risks associated with *Legionella* spp. Nearly all of WBDOs associated with SWTD deficiencies occurred in systems using ground water. EPA's new Ground Water Rule might prevent similar outbreaks in the future in public water systems.

Public Health Actions: CDC and EPA use surveillance data to identify the types of water systems, deficiencies, and etiologic agents associated with WBDOs and to evaluate the adequacy of current technologies and practices for providing safe drinking water. Surveillance data also are used to establish research priorities, which can lead to improved water-quality regulation development. The majority of drinking water deficiencies are now associated with contamination at points outside the jurisdiction of public water systems (e.g., regrowth of *Legionella* spp. in hot water systems) and water contamination that might not be regulated by EPA (e.g., contamination of tap water at the POU). Improved education of consumers and plumbers might help address these risk factors.

Introduction

Statistical data on waterborne-disease outbreaks (WBDOs) in the United States have been collected since 1920. Researchers reported these statistics during 1920–36 (*1*), 1938–1945 (*2*), 1946–1960 (*3*), and 1961–1970 (*4*). Since 1971, CDC, the U.S. Environmental Protection Agency (EPA), and the Council of State and Territorial Epidemiologists (CSTE) have maintained a collaborative Waterborne Disease and Outbreak Surveillance System (WBDOSS), which tracks the occurrences and causes of WBDOs and cases of disease associated with drinking water. The history of WBDO surveillance in the United States is summarized in the 2003–2004 WBDOSS *Surveillance Summary* (*5*). The 2005–2006 *Surveillance Summary* presents data on 28 WBDOs reported by public health departments in the states, territories, and localities that occurred during January 2005–December 2006, and four previously unreported WBDOs that occurred during 1979–2002. However, the statistics in this report represent only a portion of the burden of illness associated with water exposure. They do not include endemic waterborne-disease cases (sporadic cases not known to be associated with a WBDO), WBDOs associated with recreational water use, or reliable estimates of the number of unrecognized WBDOs.

Background

U.S. Environmental Protection Agency Drinking Water Regulations

The majority of WBDOs reported in this *Surveillance Summary* occurred in public drinking water systems. The Safe Drinking Water Act (SDWA) of 1974 and its subsequent 1986 and 1996 amendments (Table 1) authorize EPA to set national standards to protect public drinking water and its sources against naturally occurring or man-made contaminants (*6–8*). EPA has set health-based standards for approximately 90 chemical, microbiologic, radiologic, and physical contaminants in drinking water. Standards include a maximum contaminant level* (amount of a contaminant allowed in water delivered to the consumer) or treatment technique (required procedure or level of technological performance) that apply to systems providing water to at least 15 service connections or 25 persons for at least 60 days in a year (Public Water Systems). EPA also has recommended guidelines (Secondary Drinking Water Regulations), for water contaminants that primarily affect the aesthetic qualities of drinking water (e.g., taste, odor, and staining of laundry) that states may choose to adopt and enforce. EPA regulations and guidelines do not apply to private, individual water supplies (Figure 1); however, certain states set standards for individual water supplies.

* Additional terms have been defined (Appendix A, Glossary of Definitions).

TABLE 1. U.S. Environmental Protection Agency regulations regarding drinking water, by year enacted — United States, 1974–2006

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
Lead and Copper Rule — action levels	2000
Filter Backwash Recycling Rule	2001
Long Term 1 Enhanced SWTR	2002
Unregulated Contaminant Monitoring Regulations	2002
Drinking Water Contaminant Candidate List 2	2005
Long Term 2 Enhanced SWTR	2006
Stage 2 D-DBP Rule	2006
Ground Water Rule	2006

Public and individual water system types and subtypes have been defined (Appendix A, Glossary of Definitions).

Standards by which microbial contamination is regulated include the Total Coliform Rule (TCR) (*9,10*), Ground Water Rule (GWR) (*11,12*), Wellhead Protection Program (*11*), Surface Water Treatment Rule (SWTR) (*13*), Interim Enhanced SWTR (*14*), Long Term 1 Enhanced SWTR (*15*), Long Term 2 Enhanced SWTR (*16–18*), Stage 2 Disinfectants and Disinfection By-products Rule (*16, 17*), and Filter Backwash Recycling Rule (*19*). EPA's lead, copper, and arsenic rules prescribe action levels at which a system operator must take corrective steps (*20,21*). In addition, EPA is required to publish periodically a list of contaminants that might need to be regulated (*22,23*) and establish criteria for a program to monitor unregulated contaminants (*24–27*). EPA decides whether or not to regulate contaminants on the list based on projected adverse health effects from the contaminant, an assessment of the extent of occurrence of the contaminant in drinking water, and the potential for reducing risks to health. Instead of a regulation, EPA can issue guidance or a health advisory. All of these requirements have been described in previous *Surveillance Summaries* (*5,28*). In 2007, EPA established an advisory committee to provide recommendations on revisions to the TCR and on information needed to better understand the public health risks associated with the degradation of water quality in pipes, storage tanks, and other appurtenances used to distribute drinking water to consumers (*29*).

Methods

Data Sources

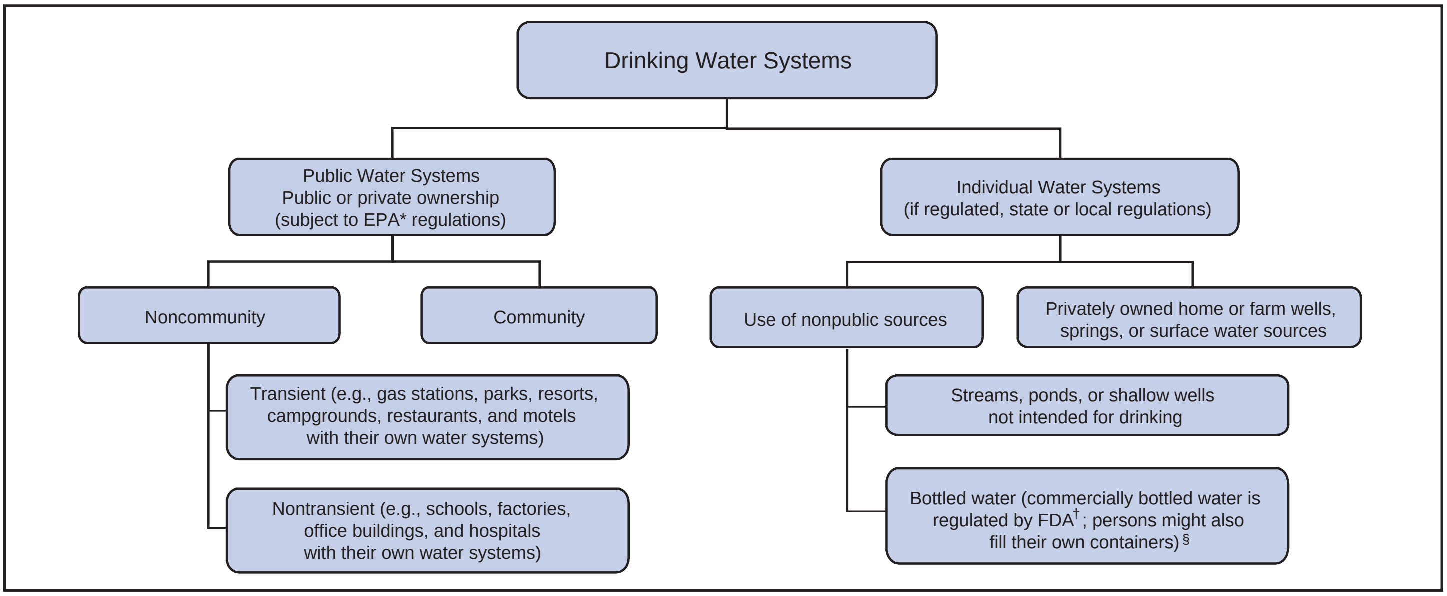
Public health departments in the states, territories, localities, and FAS have primary responsibility for detecting and investigating WBDOs, which they report voluntarily to CDC using a standard form (CDC form 52.12, available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf). The form solicits data on characteristics of WBDO (e.g., number of cases, time, and location); results from epidemiologic studies; results from clinical specimen and water sample testing; and other factors potentially contributing to WBDO (e.g., environmental conditions, disinfection deficiencies, and filtration problems). CDC annually requests reports of WBDOs and single cases of certain waterborne diseases, as specified in the definitions in the next section, from state, territorial, and FAS epidemiologists or persons designated as WBDO surveillance coordinators and obtains additional information regarding water quality and water treatment as needed. In certain instances, information on WBDOs and cases is solicited from other CDC surveillance systems and confirmed with the state or locality for inclusion in WBDOSS and/or *Surveillance Summary*, which is illustrated in more detail in a separate *Surveillance Summary* (*30*). Numerical and text data are abstracted from WBDO report form and supporting documents and entered into a database for analysis. Although reports of WBDOs are collected through WBDOSS, the cases and outbreaks associated with drinking water, water not intended for drinking (WNID), and water of unknown intent (WUI) are analyzed and published separately from the cases and outbreaks associated with recreational water (*30*).

Definitions

WBDOSS collects data on both outbreaks and individual cases of waterborne disease. Two criteria must be met for an event to be defined as a waterborne-disease outbreak associated with drinking water, WNID (excluding recreational water), or WUI. First, two or more persons must be epidemiologically linked by location of exposure to water, and by time, and characteristics of illness. Second, the epidemiologic evidence must implicate water as the probable source of illness.

In addition to WBDOs, single cases of laboratory-confirmed primary amebic meningoencephalitis (PAM) as a result of *Naegleria fowleri* infection with a known water exposure and single cases of chemical/toxin poisoning, if water-quality data indicate contamination by the chemical/toxin, are also reported in WBDOSS. All single cases are discussed separately from WBDOs. Single cases of legionellosis are reported elsewhere (*31*).

FIGURE 1. Types of drinking water systems — United States



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

Reported outbreaks associated with contaminated drinking water; commercially bottled water, ice, or beverages made with contaminated water; and water contaminated by malfunctions in equipment/devices in which water is used or distributed (e.g., beverages contaminated by plumbing failures in drink mix/soda machines) are classified as WBDOs. Tabulation of WBDOs is based on location of water exposure, not on state of residence of the ill persons. WBDOs associated with cruise ships are not summarized in this report.

Of the approximately 155,693 public water systems in the United States, 52,110 (33.5%) are community systems and 103,583 (66.5%) are noncommunity systems, including 84,744 transient systems and 18,839 nontransient systems. Community systems serve 286.5 million persons, and only 8% of these systems provide water to 82% of the U.S. population through large municipal water systems (*32*). Noncommunity, nontransient systems provide water to 6.3 million persons, and noncommunity, transient systems provide water to 13.8 million persons (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) (*32*). Although the majority of public water systems (91%) are supplied by ground water, more persons (68%) are supplied year-round by community water systems that use surface water (*32*). Approximately 15.0% of the U.S. population relies on individual water systems that are privately owned (*33*).

WBDOs associated with commercially bottled water are classified separately from the water systems described in this *Surveillance Summary*. Separating piped from nonpiped water distinguishes between drinking water systems regulated by EPA (community and noncommunity) and the Food and Drug Administration (FDA) (bottled).

The purpose of WBDOSS is not only to evaluate the relation between water and reported disease outbreaks and cases, but also to identify system breakdowns, operator errors, other engineering-related activities, and environmental situations that lead to outbreaks. To understand the circumstances and system breakdowns that lead to illness, each WBDO is classified as having one or more deficiencies (Table 2).

Waterborne Disease and Outbreak Strength of Evidence Classification

All WBDOs reported to the surveillance system have been classified according to the strength of the evidence implicating water as the vehicle of transmission (Table 3). The classification scheme (i.e., Classes I–IV) is based on the epidemiologic and water-quality data provided with WBDO report form. Although WBDOs without water-quality data were included in this report, reports that lacked epidemiologic data, linking the outbreak to water, have been excluded.

A classification of I indicates that adequate epidemiologic and water-quality data were reported. However, this classification does not necessarily imply that the investigation was conducted optimally nor does a classification of II, III, or IV imply that the investigation was inadequate or incomplete.

TABLE 2. Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent

Deficiency
Contamination of water at/in the water source, treatment facility, or distribution system (SWTD)*
1: Untreated surface water intended for drinking
2: Untreated ground water intended for drinking
3: Treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, inadequate or no filtration)
4: Distribution system deficiency, including storage (e.g., cross-connection, backflow, contamination of water mains during construction or repair)
13: Current treatment processes not expected to remove a chemical contaminant (e.g., pesticide contamination of groundwater treated with disinfection only)
A: Surface water
B: Ground water
Contamination of water at points not under the jurisdiction of a water utility or at the point of use (NWU/POU)†
5: *Legionella* spp. in water system
A: Water intended for drinking
B: Water not intended for drinking (excluding recreational water)
C: Water of unknown intent
6: Plumbing system deficiency after the water meter or property line (e.g., cross-connection, backflow, corrosion products)
7: Deficiency in building/home-specific water treatment after the water meter or property line
8: Deficiency or contamination of equipment using or distributing water (e.g., drink-mix machines)
9: Contamination or treatment deficiency during commercial bottling
10: Contamination during shipping, hauling, or storage
A: Water intended for drinking – Tap water
B: Water intended for drinking – Commercially bottled water
11: Contamination at point-of-use
A: Tap
B: Hose
C: Commercially bottled water
D: Container, bottle, or pitcher
E: Unknown
12: Drinking or contact with water not intended for drinking (excluding recreational water)
Unknown/Insufficient Information
99: Unknown/Insufficient information
A: Water intended for drinking – Tap water
B: Water intended for drinking – Commercially bottled water
C: Water not intended for drinking (excluding recreational water)
D: Water of unknown intent

* Contamination of water and deficiencies occurring in the drinking water system at/in the water source, treatment facility, or distribution system of pipes and storage facilities. For a community water system, the distribution system refers to the pipes and storage infrastructure under the jurisdiction of the water utility before the water meter or property line (if the system is not metered). For noncommunity and nonpublic individual water systems, the distribution system refers to the pipes and storage infrastructure before entry into a building or house (e.g., in a service line leading to a house or building).

† Contamination of drinking water and deficiencies occurring in plumbing and pipes that are not part of the distribution system or at other points outside the jurisdiction of a water utility. For community systems, this means after the water meter or property line (if the system is not metered), and for noncommunity and nonpublic systems, this means within the building or house (e.g., in the plumbing inside a house or building). This category also includes contamination during shipping or hauling, during storage other than in the distribution system, and at point-of-use).

WBDOs and their resulting investigations occur under different circumstances, and not all WBDOs can be rigorously investigated. In addition, WBDOs that affect few persons are more likely to receive a classification of III or IV because of the limited sample size available for epidemiologic analysis.

Changes in the 2005–2006 *Surveillance Summary*

Definitions and deficiencies in this report have been modified to better reflect the epidemiology of WBDOs and capture the scope of water-related disease. This section highlights those changes.

Deficiencies

One deficiency, 13, has been added to the deficiency classification table (Table 2). This deficiency will allow for the classification of chemical contamination of source water when the existing treatment provided for the system is not designed to remove that chemical contamination. WBDOs associated with chemical contamination of untreated source water will continue to be reported under deficiencies 1 or 2 as appropriate.

Definition

The definition of a waterborne disease outbreak (WBDO) has been modified to include only water exposure in which more than two persons become ill. Single cases of PAM and

TABLE 3. Classification of investigations of waterborne disease and outbreaks based on strength of evidence implicating water as a vehicle of transmission — United States, 2005–2006

Class	Epidemiologic data	Water-quality data
I	Adequate Data provided concerning exposed and unexposed persons, with relative risk or odds ratio $\geq$2 or p$\leq$0.05	Provided and adequate Laboratory data or historical information (e.g., reports of a chlorinator malfunction, a water main break, 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 and no historical information)
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

illnesses caused by exposure to chemically-contaminated water will continue to be included in WBDOSS but will not be classified or analyzed as outbreaks. This change will provide a consistent outbreak definition of two or more persons epidemiologically linked by location of exposure to water, and by time, and characteristics of illness.

Results

During 2005–2006, a total of 14 states reported 28 WBDOs (i.e., 13 for 2005 and 15 for 2006). These WBDOs were associated with drinking water (n = 20), WNID (n = six), and WUI (n = two) and are tabulated by year and state (Tables 4–6). Four previously unreported WBDOs that occurred during 1979–2002 also were reported (Table 7).

Waterborne Disease and Outbreaks Associated with Drinking Water

The 20 drinking water-associated WBDOs (i.e., eight in 2005 and 12 in 2006) were reported by 11 states (Figure 2). Multiple etiologic agents were implicated (Figure 3), and WBDOs occurred throughout the year (Figure 4). Selected descriptions of WBDOs are presented (Appendix B).

The 20 drinking water-associated WBDOs reported during 2005–2006 caused illness among at least 612 persons and resulted in four deaths. The median number of persons affected in a WBDO was 10 (range: two–148). One WBDO was associated with hepatitis A. The remaining WBDOs were associated with either acute gastrointestinal illness (AGI) or acute respiratory illness (ARI). All ARI outbreaks were associated with exposure to *Legionella* spp. (Figure 5).

Four (20.0%) of the 20 drinking water-associated WBDOs were given a strength of evidence Class I ranking on the basis of epidemiologic and water-quality data; two (10.0%) were ranked as Class II; 13 (65.0%) were ranked as Class III; and one (5.0%) was ranked as Class IV. Drinking water-associated WBDOs are tabulated by etiologic agent and type of water system (Table 8), etiologic agent and type of water source (Table 9), type of deficiency and type of water system (Table 10), type of deficiency and type of water source (Table 11), predominant illness and type of water system (Table 12), and predominant illness and type of water source (Table 13). WBDOs were included (Tables 8–13) only if the type of deficiency might be relevant in the cause of WBDO (e.g., understanding the source of raw untreated water is unlikely to be important for a legionellosis outbreak associated with a building plumbing system).

Etiologic Agents

Of the 20 drinking water-associated WBDOs, 12 (60.0%) were caused by bacteria, three (15.0%) were caused by viruses, two (10.0%) were caused by parasites, and one (5.0%) was caused by more than one etiologic agent type. Two (10.0%) were of unknown etiology (Figure 6).

Bacteria. Twelve WBDOs affecting 135 persons were attributed to bacterial infections: 10 outbreaks caused by *Legionella*; one outbreak caused by *Campylobacter*; and one outbreak (Oregon, 2005) in which persons had multiple stool specimens that tested positive for *C. jejuni*, *Escherichia* O157:H7, and *E. coli* O145. Illnesses from these 12 WBDOs resulted in four deaths, all of which were associated with *Legionella* spp.

Viruses. Three WBDOs affecting 212 persons were attributed to viral infections: two outbreaks caused by norovirus G1, and one outbreak caused by hepatitis A. No deaths were reported.

Parasites. Two WBDOs affecting 51 persons were attributed to parasites: one outbreak caused by *Giardia intestinalis* and one outbreak caused by *Cryptosporidium*. No deaths were reported.

TABLE 4. Waterborne-disease outbreaks associated with drinking water (n = eight), by state — United States, 2005

State	Month	Class	Etiologic agent	Predominant illness*	No. of cases (deaths)† (n = 180)	Type of system§	Deficiency¶	Water source	Setting
California	Aug	II	*Giardia intestinalis*	AGI	41	Unknown	11D	Unknown	Gym
Florida	Nov	IV	*Legionella pneumophila* serogroup 1	ARI	2	Unknown**	5A	Unknown††	Senior housing center
New York	Dec	III	*L. pneumophila* serogroup 6	ARI	2	Com	5A	Lake††	Hospital
New York	Dec	III	*L. pneumophila* serogroup 6	ARI	8	Com	5A	Lake††	Hospital
New York	Dec	III	*L. pneumophila* serogroup 1	ARI	4 (1)	Com	5A	Lake††	Hospital
Ohio	Aug	I	Unidentified§§	AGI	59	Ncom	3	Spring	Restaurant¶¶
Oregon	May	III	*Escherichia coli* O157:H7 *Campylobacter jejuni,* *and E. coli* O145***	AGI	60	Ncom	3	River	Camp
Pennsylvania	Nov	III	*L. pneumophila* serogroup 1	ARI	4	Ncom	5A	Unknown††	Long-term–care facility

* AGI: acute gastrointestinal illness; and ARI: acute respiratory illness.
† Deaths are indicated in parentheses if they occurred.
§ Com: community; and Ncom: noncommunity. Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and schools), whereas transient systems provide water to places in which persons do not remain for long periods (e.g., restaurants, highway rest stations, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
¶ Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).
** Senior Housing center is served by a community system with a ground water source; however, case-patients traveled together to other cities where exposure might have occurred.
†† Transmission of *Legionella* thought to be a result of building-specific factors and not related to water source.
§§ Etiology unidentified; norovirus suspected based upon incubation period, symptoms, and duration of illness.
¶¶ Private residence was licensed to serve food.
*** Nine persons had stool specimens that tested positive for *E. coli* O157:H7, three persons had stool specimens that tested positive for *C. jejuni*, two persons had stool specimens that tested positive for *E. coli* O145, and three persons had stool specimens that tested positive for both *E. coli* O157:H7 and *C. jejuni*.

Mixed agent types. One WBDO was attributed to more than one type of etiologic agent; no deaths were reported. This outbreak affected 139 persons and involved two viruses (norovirus G1 and norovirus G2) and one bacterium (*C. jejuni*) (*34*).

Unidentified etiologic agents. Two WBDOs involving AGI of unidentified etiology affected 75 persons; no deaths were reported. No viral testing was attempted in one of the outbreaks (Ohio 2005). In the other outbreak (New York 2006), norovirus, enterovirus, and rotavirus were isolated from water samples. In both of the outbreaks, norovirus was the suspected etiology on the basis of incubation period, symptoms, and duration of illness.

Deficiencies

Twenty-three deficiencies were cited in the 20 drinking water-associated WBDOs. Ten (43.5%) deficiencies involved the source water, treatment facility, or distribution system (SWTD) and 12 (52.2%) deficiencies occurred at points not under the jurisdiction of a water utility or at the point-of-use (NWU/POU). One WBDO (4.3%) had an unknown deficiency (Figure 7; Table 14).

Deficiencies 1–4 and 13: Contamination of Water at/in the Water Source, Treatment Facility, or Distribution System

Eight WBDOs were given a deficiency classification of 1–4. Three (37.5%) of these WBDOs were associated with viruses, two (25.0%) were associated with bacteria, two (25.0%) were associated with unidentified etiologic agents, and one (12.5%) was associated with mixed agent types.

Water-quality data. All eight WBDOs with a deficiency classification of 1–4 had water-quality data (e.g., laboratory data regarding the presence of coliform bacteria, pathogens, or chemical/toxin contaminants; or historical data [e.g., levels of disinfectants]). Positive total or fecal coliform results from the implicated water were reported for four (66.7%) of the six WBDOs with confirmed infectious etiologies. In two WBDOs caused by norovirus G1 and hepatitis A virus, the implicated pathogens were isolated from water in addition to fecal coliforms and *E. coli*.

Water systems. Five (62.5%) of eight WBDOs with deficiencies 1–4 involved noncommunity water systems, two (25.0%) involved individual water systems, and one (12.5%) involved a community water system (Tables 8, 10, and 12; Figure 6). Among the five outbreaks involving noncommu-

TABLE 5. Waterborne-disease outbreaks associated with drinking water (n = 12), by state — United States, 2006

State	Month	Class	Etiologic agent	Predominant illness*	No. of cases (deaths)† (n = 432)	Type of system§	Deficiency¶	Water source	Setting
Indiana	Feb	I	*Campylobacter*	AGI	32	Com	3, 4	Well	Community
Maryland	Jul	III	Norovirus G1	AGI	148	Ncom	3, 4, 11B	Well	Camp
North Carolina	Jul	I	Hepatitis A	Hep	16	Ind	2	Spring	Private residence
New York	Aug	III	Unidentified**	AGI	16	Ind	2	Well	Bed and Breakfast
New York	Jun	III	*Legionella*††	ARI	4	Com	5A	Lake§§	Hospital
New York	Jan	III	*L. pneumophila* serogroup 3	ARI	2	Com	5A	Reservoir§§	Hospital
Ohio	Sep	II	*Cryptosporidium*	AGI	10	Com	99A	Well	Church
Ohio	Aug	III	*L. pneumophila* serogroup 1	ARI	3	Com	5A	Lake§§	Hospital
Oregon	Dec	III	Norovirus G1	AGI	48	Ncom	2	Well	Restaurant
Pennsylvania	Apr	III	*L. pneumophila* serogroup 1	ARI	4	Ncom	5A	Well§§	Hotel
Texas	Apr	III	*L. pneumophila*††	ARI	10 (3)	Com	5A	Unknown§§	Hospital
Wyoming	Jun	I	Norovirus G1, *C. jejuni*, Norovirus G2¶¶	AGI	139	Ncom	2	Well	Camp

* AGI: acute gastrointestinal illness; ARI: acute respiratory illness; and Hep: viral hepatitis.
† Deaths are indicated in parentheses if they occurred.
§ Com: community; Ncom: noncommunity; and Ind: individual. Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and schools), whereas transient systems provide water to places in which persons do not remain for long periods (e.g., restaurants, highway rest stations, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
¶ Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).
** Etiology unidentified; norovirus suspected based upon incubation period, symptoms, and duration of illness. Norovirus, enterovirus, and rotavirus were isolated from the well.
†† Environmental testing detected *L. pneumophila* serogroup 1, *L. pneumophila* other than serogroup 1, and non-*pneumophila Legionella* species.
§§ Transmission of *Legionella* thought to be as a result of building-specific factors and not related to water source.
¶¶ Eight persons had stool specimens that tested positive for norovirus G1, six persons had stool specimens that tested positive for *C. jejuni*, and three persons had stool specimens that tested positive for norovirus G2. **Source**: CDC. Gastroenteritis among attendees at a summer camp—Wyoming, June–July 2006. MMWR 2007;56:368–70.

TABLE 6. Waterborne-disease outbreaks associated with water not intended for drinking (WNID) (excluding recreational water) and water of unknown intent (WUI) (n = eight) — United States, 2005–2006

State	Water type	Month/ Year	Class	Etiologic agent	Predominant illness*	No. of cases (deaths)† (n = 96)	Deficiency§	Primary water exposure	Setting
California	WNID	Jul 2005	IV	*Giardia intestinalis*	AGI	3	12	Canal	Private residence
Colorado	WNID	May 2006	II	*G. intestinalis*	AGI	6	12	River	Wilderness
New York	WNID	Jul 2005	III	*Legionella pneumophila* serogroup 1	ARI	22 (3)	5B	Cooling tower	Hospital
New York	WNID	Jan 2006	III	*L. pneumophila* serogroup 1	ARI	2	5B	Cooling tower	Hospital
New York	WNID	Aug 2006	III	*L. pneumophila* serogroup 1	ARI	28 (3)	5B	Cooling tower	Nursing home
Pennsylvania	WUI	Jul 2005	IV	*L. pneumophila* serogroup 1	ARI	3	5C	Unknown	Hotel
South Dakota	WNID	May 2005	I	*L. pneumophila* serogroup 1¶	ARI	18 (1)	5B	Decorative fountain	Restaurant
Tennessee	WUI	Aug 2005	II	*Escherichia coli* O157:H7	AGI	14	99D	Unknown**	Sports camp

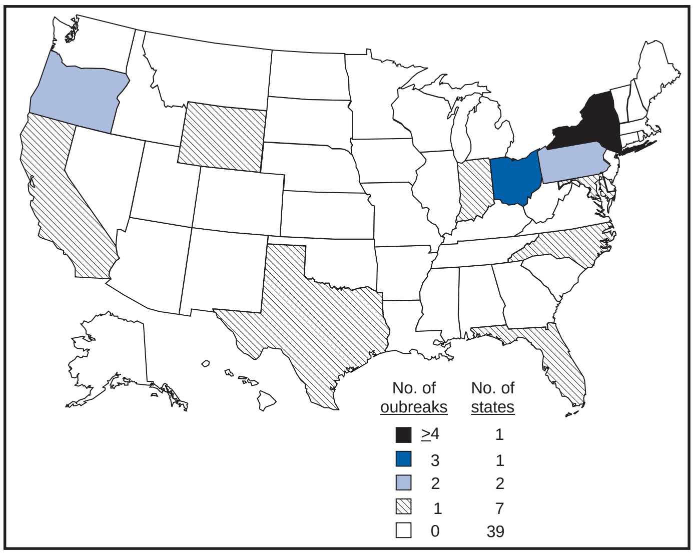
* AGI: acute gastrointestinal illness; and ARI: acute respiratory illness.
† Deaths are indicated in parentheses if they occurred.
§ Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).
¶ **Source:** O'Loughlin RE, Kightlinger L, Werpy MC, et al. Restaurant outbreak of Legionnaires' disease associated with a decorative fountain: an environmental and case control study. BMC Infect Dis 2007; 7:93.
** Illnesses were associated with attendance at a tennis camp and swimming in an outdoor pool at the camp. Fecal contamination was detected in nonpotable well water delivered to outdoor faucets located at multiple locations around the tennis courts. Faucets were intended for irrigation, but no signs were posted to warn the public about nonpotable water.

TABLE 7. Waterborne-disease outbreaks associated with drinking water (DW) and water not intended for drinking (WNID) that were not included in previous *Surveillance Summaries* (n = four), by state— United States, 1979–2002

State	Water type	Month/ Year	Class	Etiologic agent	Predominant illness*	No. of cases (deaths)† (n = 126)	Type of system§	Deficiency¶	Water source	Setting
Louisiana	WNID	May 2002	III	*Pseudomonas aeruginosa***	Skin	27	Not applicable	12	Unknown	Factory
Minnesota	DW	Jun 1979	IV	Detergent	AGI	2	Unknown	11D	Unknown	Golf course
Tennessee	DW	Oct 1988	III	Unidentified	AGI	89	Ncom	3	Creek	Restaurant
Tennessee	DW	Sep 1995	III	Hepatitis A	Hep	8	Ind	2	Well, spring	Private residences

* Skin: illness, condition, or symptom related to skin; AGI: acute gastrointestinal illness; and Hep: viral hepatitis.
† Deaths are indicated in parentheses if they occurred.
§ Ncom: noncommunity. Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
¶ Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).
** **Source**: Hewitt DJ, Weeks DA, Millner GC, Huss RG. Industrial *Pseudomonas* folliculitis. Am J Ind Med 2006;49:895–9.

FIGURE 2. Number* of waterborne-disease outbreaks associated with drinking water — United States, 2005–2006



* n = 20; numbers are dependent on reporting and surveillance activities in individual states and do not necessarily indicate that more outbreaks occurred in a given state.

nity water systems, two (40.0%) were associated with untreated ground water, two (40.0%) were associated with a treatment deficiency, and one (20.0%) was associated with both a treatment deficiency and a distribution system deficiency. Among the two outbreaks involving individual water systems, both were associated with contaminated, untreated ground water. The one outbreak involving a community water system was associated with both a treatment deficiency and a distribution system deficiency (Table 10).

Water sources. Seven (87.5%) of the eight WBDOs with deficiencies 1–3 were associated with ground water sources involving wells, and one (12.5%) WBDO was associated with surface water derived from a river (Table 9). Among the seven outbreaks related to ground water sources, four (57.1%) were associated with treatment deficiencies, either inadequate or interrupted chlorination as the only treatment provided, and three (42.9%) were associated with consumption of untreated, contaminated ground water, (Tables 9, 11, and 13; Figure 6). The surface water outbreak occurred during a period of heavy rainfall in a noncommunity system that provided inadequate filtration and disinfection.

Deficiencies 5A, 6–11: Contamination of Water at Points Not Under the Jurisdiction of a Water Utility or at the Point-of-Use

Twelve WBDOs were given a deficiency classification of 5A or 6–11. Ten (83.3%) of these WBDOs were associated with *Legionella* spp., one (8.3%) was associated with *Giardia*, and one (8.3%) was associated with norovirus G1 (Tables 4 and 5).

Water-quality data. Water-quality data indicating a problem with the drinking water were available for 10 (83.3%) of the 12 WBDOs with an NWU/POU deficiency. *Legionella* spp. were isolated from the implicated water sampled in nine (90.0%) of 10 legionellosis outbreaks. Water testing in the norovirus outbreak detected norovirus in the storage tank (Maryland, 2006). No water was tested in the giardiasis outbreak; the outbreak was confirmed by clinical testing results.

Deficiency 5A: *Legionella* in drinking water. All 10 of the drinking water-associated legionellosis WBDOs occurred in residential buildings, hotels, or in institutional settings and were related to the multiplication of *Legionella* spp. in the building plumbing systems. The majority of cases of legionellosis were diagnosed by urinary antigen testing, which is specific for *L. pneumophila* serogroup 1 (*35*).

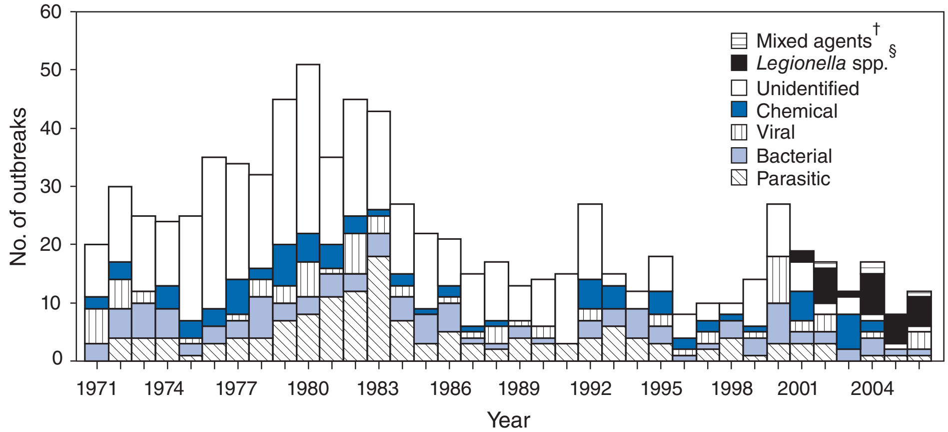
Deficiencies 6–11. Two WBDOs were associated with deficiencies 6–11. In one outbreak (California, July 2005), per-

sons ill with giardiasis had used a water dispenser at a gym. The water dispenser had been removed at the time of the public health investigation and could not be tested; however, point-of-use contamination of the dispenser spout seemed the most likely cause of the outbreak. The second outbreak with a POU deficiency (Maryland, 2006) also had SWTD deficiencies 3 and 4.

Deficiency 99A–B: Unknown/Insufficient Information Concerning Contamination of Tap Water

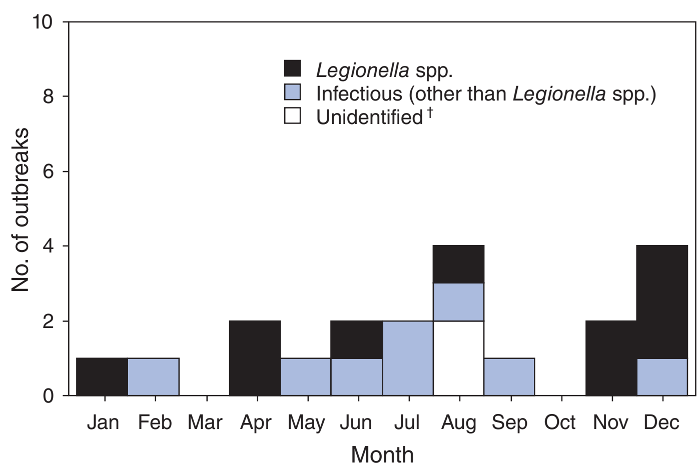
The deficiency involved in one (5.0%) of the 20 WBDOs could not be identified because the cause of contamination was unknown. Persons at a church served by a community water system became ill with cryptosporidiosis (Ohio, 2005). No communitywide outbreak was detected and no water-quality violations were detected, suggesting that the contamination might have occurred outside the jurisdiction of the water utility. Investigators noted antiquated and piecemeal water plumbing and sewage lines. However, because it was unclear that this outbreak was caused by premise plumbing contamination, this WBDO is not included in the analysis of the SWTD or NWU/POU deficiencies.

FIGURE 3. Number of waterborne-disease outbreaks associated with drinking water (n = 814),* by year and etiologic agent — United States, 1971–2006



* Single cases of disease related to drinking water (n = 16) have been removed from this figure; therefore, it is not comparable to figures in previous *Surveillance Summaries*.
† Beginning in 2003, mixed agents of more than one etiologic agent type were included in the surveillance system. However, the first observation is a previously unreported outbreak in 2002.
§ Beginning in 2001, Legionnaires' disease was added to the surveillance system, and *Legionella* species were classified separately in this figure.

FIGURE 4. Number* of waterborne-disease outbreaks associated with drinking water, by etiologic agent and month — United States, 2005–2006



* n = 20.
† Unidentified etiology includes suspected etiologies not confirmed during the outbreak investigation.

Waterborne Disease and Outbreaks Associated with Water Not Intended for Drinking and Water of Unknown Intent

Eight WBDOs were associated with either WNID (n = six) or WUI (n = two) (Table 6). The eight WNID/WUI outbreaks caused illness among at least 96 persons and resulted in seven deaths. All deaths were associated with legionellosis. Five (62.5%) WNID/WUI outbreaks involved ARI, and three (37.5%) involved AGI. One (12.5%) of the eight WNID/WUI outbreaks was categorized as a strength of evidence Class I ranking, two (25.0%) were ranked as Class II, three (37.5%) were ranked as Class III, and two (25.0%) were ranked as Class IV.

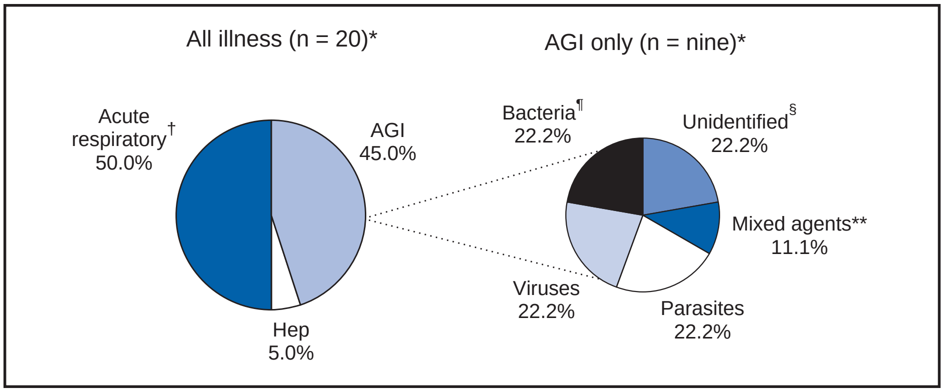
Etiologic Agents

Five (62.5%) of the eight WNID/WUI outbreaks were attributed to *L. pneumophila* serogroup 1; these five outbreaks affected 73 persons and resulted in seven deaths. Two of the WNID/WUI outbreaks were attributed to *Giardia intestinalis* and one outbreak was attributed to *E. coli* O157:H7 (Table 6).

Deficiencies 5B, 5C, 12, and 99D

Each of the eight WNID/WUI outbreaks had one known deficiency: five (62.5%) involved *Legionella* spp. in the water system (deficiencies 5B and 5C), two (25.0%) involved WNID unrelated to *Legionella* (deficiency 12), and one (12.5%) involved WUI (deficiency 99D). Four (80.0%) of the five legionellosis outbreaks involved WNID (deficiency 5B). In three of these outbreaks, the aerosolized water from cooling towers was tested and identified as the source of *Legionella*

FIGURE 5. Percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water, by illness and etiology — United States, 2005–2006



* AGI: acute gastrointestinal illness; ARI: acute respiratory illness; Hep: viral hepatitis.
† All acute respiratory illness was attributed to *Legionella* spp.
§ Norovirus suspected based upon incubation period, symptoms, and duration of illness.
¶ Including one outbreak that involved multiple bacterial agents.
** One outbreak that involved bacterial and viral agents.

spp. In the fourth outbreak, epidemiologic and environmental testing implicated a decorative fountain in a restaurant (*36*). One legionellosis outbreak (20.0%) involved WUI (deficiency 5C). In this outbreak (Pennsylvania, July 2005), environmental water testing failed to determine the source of *Legionella* spp. Among the three (37.5%) outbreaks unrelated to *Legionella*, two involved *G. intestinalis*, and one was caused by *E. coli* O157:H7. In the first giardiasis outbreak (California, July 2005), household members became ill while using canal water that had been piped into their home for washing and bathing. In the second giardiasis outbreak (Colorado 2006), hikers became ill after drinking water from a stream. The outbreak investigation revealed a greater risk for becoming ill among those hikers who were less rigorous in their water-treatment practices (i.e., boiling, filtering, or use of chemicals). One outbreak at a sports camp involving 14 persons was caused by *E. coli* O157:H7 (Tennessee 2005). Whereas the environmental investigation did not identify this organism in the water, nonpotable water contaminated with coliforms was leaking onto the pool deck and the tennis courts (Table 6).

Previously Unreported Outbreaks

Reports of four previously unreported WBDOs associated with drinking water and WNID that occurred during 1979–2002 were received for this surveillance period (Table 7).

TABLE 8. Number of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = eight),* by etiologic agent and type of water system — United States, 2005–2006

	Type of water system†									
	Community		Noncommunity		Individual§		Mixed system		Total	
Etiologic agent	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases
Bacteria	**1**	**32**	**1**	**60**	**0**	**0**	**0**	**0**	**2**	**92**
Campylobacter spp.	1	32	0	0	0	0	0	0	**1**	**32**
Escherichia coli O157, *C. jejuni*, and *Escherichia coli* O145	0	0	1	60	0	0	0	0	**1**	**60**
Viruses	**0**	**0**	**2**	**196**	**1**	**16**	**0**	**0**	**3**	**212**
Hepatitis A	0	0	0	0	1	16	0	0	**1**	**16**
Norovirus G1	0	0	2	196	0	0	0	0	**2**	**196**
Mixed agents¶	**0**	**0**	**1**	**139**	**0**	**0**	**0**	**0**	**1**	**139**
Norovirus G1, *C. jejuni*, and Norovirus G2	0	0	1	139	0	0	0	0	**1**	**139**
Unidentified	**0**	**0**	**1**	**59**	**1**	**16**	**0**	**0**	**2**	**75**
Unidentified**	0	0	1	59	1	16	0	0	**2**	**75**
Total	**1**	**32**	**5**	**454**	**2**	**32**	**0**	**0**	**8**	**518**
Percentage	**(12.5)**	**(6.2)**	**(62.5)**	**(87.6)**	**(25.0)**	**(6.2)**	**(0.0)**	**(0.0)**	**(100.0)**	**(100.0)**

* WBDOs with deficiencies 1–4 and 13 (i.e., surface water contamination, ground water contamination, water treatment deficiency, distribution system contamination, and untreated chemical contamination of source water) were used for analysis.
† Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
§ Excludes commercially bottled water and water not intended for drinking, therefore, not comparable to *Surveillance Summaries* before 2003–2004.
¶ Multiple etiologic agent types (bacteria, parasite, virus, and/or chemical/toxin) identified.
** Norovirus suspected based on incubation period, symptoms, and duration of illness.

TABLE 9. Number of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = eight),* by etiologic agent and water source — United States, 2005–2006

	Water source									
	Ground water		Surface water		Unknown		Mixed source		Total	
Etiologic agent	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases	WBDOs	Cases
Bacteria	**1**	**32**	**1**	**60**	**0**	**0**	**0**	**0**	**2**	**92**
Campylobacter spp.	1	32	0	0	0	0	0	0	**1**	**32**
Escherichia coli O157*, C. jejuni* *and Escherichia coli* O145	0	0	1	60	0	0	0	0	**1**	**60**
Viruses	**3**	**212**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**212**
Hepatitis A	1	16	0	0	0	0	0	0	**1**	**16**
Norovirus G1	2	196	0	0	0	0	0	0	**2**	**196**
Mixed agent type†	**1**	**139**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**139**
Norovirus G1, *C. jejuni*, and Norovirus G2	1	139	0	0	0	0	0	0	**1**	**139**
Unidentified	**2**	**75**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**75**
Unidentified§	2	75	0	0	0	0	0	0	**2**	**75**
Total	**7**	**458**	**1**	**60**	**0**	**0**	**0**	**0**	**8**	**518**
Percentage	**(87.5)**	**(88.4)**	**(12.5)**	**(11.6)**	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**	**(100.0)**	**(100.0)**

* WBDOs with deficiencies 1–3 and 13 (i.e., surface water contamination, ground water contamination, water treatment deficiency, and untreated chemical contamination of source water) were used for analysis.
† Multiple etiologic agent types (bacteria, parasite, virus, and/or chemical/toxin) identified.
§ Norovirus suspected based on incubation period, symptoms, and duration of illness.

TABLE 10. Number and percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = eight),* by type of deficiency (n = 10)† and type of water system — United States, 2005–2006

	Type of water system§									
	Community		Noncommunity		Individual¶		Mixed system		Total	
Type of deficiency	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1: Untreated surface water intended for drinking	0	0.0	0	0.0	0	0.0	0	0.0	**0**	**0.0**
2: Untreated ground water intended for drinking	0	0.0	2	33.3	2	100.0	0	0.0	**4**	**40.0**
3: Treatment deficiency	1	50.0	3	50.0	0	0.0	0	0.0	**4**	**40.0**
4: Distribution system deficiency, including storage	1	50.0	1	16.7	0	0.0	0	0.0	**2**	**20.0**
Total	**2**	**100.0**	**6**	**100.0**	**2**	**100.0**	**0**	**0.0**	**10**	**100.0**

* WBDOs with deficiencies 1–4 and 13 (i.e., surface water contamination, ground water contamination, water treatment deficiency, distribution system contamination, and untreated chemical contamination of source water) were used for analysis.
† Certain WBDOs have multiple deficiencies that are tabulated separately. This table reports 10 deficiencies from eight WBDOs.
§ Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and schools), whereas transient systems provide water to places in which persons do not remain for long periods (e.g., restaurants, highway rest stations, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
¶ Excludes commercially bottled water and water not intended for drinking, therefore, not comparable to *Surveillance Summaries* before 2003–2004.

TABLE 11. Number and percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = eight),* by type of deficiency (n = eight) and source of water — United States, 2005–2006

	Water source									
	Ground water		Surface water		Unknown		Mixed source		Total	
Type of deficiency	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1: Untreated surface water intended for drinking	0	0.0	0	0.0	0	0.0	0	0.0	**0**	**0.0**
2: Untreated ground water intended for drinking	4	57.1	0	0.0	0	0.0	0	0.0	**4**	**50.0**
3: Treatment deficiency	3	42.9	1	100.0	0	0.0	0	0.0	**4**	**50.0**
Total	**7**	**100.0**	**1**	**100.0**	**0**	**0.0**	**0**	**0.0**	**8**	**100.0**

* WBDOs with deficiencies 1–3 and 13 (i.e., surface water contamination, ground water contamination, water treatment deficiency, and untreated chemical contamination of source water) were used for analysis.

TABLE 12. Number and percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = eight),* by predominant illness and type of water system — United States, 2005–2006

	Type of water system§														
	Community			Noncommunity			Individual¶			Mixed system			Total		
Predominant illness†	WBDOs	Cases	(%)	WBDOs	Cases	(%)	WBDOs	Cases	(%)	WBDOs	Cases	(%)	WBDOs	Cases	(%)
ARI	0	0	(0.0)	0	0	(0.0)	0	0	(0.0)	0	0	(0.0)	**0**	**0**	**(0.0)**
AGI	1	32	(100.0)	5	454	(100.0)	1	16	(50.0)	0	0	(0.0)	**7**	**502**	**(96.9)**
Hep	0	0	(0.0)	0	0	(0.0)	1	16	(50.0)	0	0	(0.0)	**1**	**16**	**(3.1)**
Total	**1**	**32**	**(100.0)**	**5**	**454**	**(100.0)**	**2**	**32**	**(100.0)**	**0**	**0**	**(0.0)**	**8**	**518**	**(100.0)**

* WBDOs with deficiencies 1–4 and 13 (i.e., surface water contamination, ground water contamination, water-treatment deficiency, distribution system contamination, and untreated chemical contamination of source water) were used for analysis.
† ARI: acute respiratory illness; AGI: acute gastrointestinal illness; and Hep: viral hepatitis.
§ Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
¶ Excludes commercially bottled water and water not intended for drinking, therefore, not comparable to *Surveillance Summaries* before 2003–2004.

TABLE 13. Number and percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water (n = eight),* by predominant illness and water source — United States, 2005–2006

	Water source														
	Ground water			Surface water			Unknown			Mixed source			Total		
Predominant illness†	WBDOs	Cases	(%)	WBDOs	Cases	(%)	WBDOs	Cases	(%)	WBDOs	Cases	(%)	WBDOs	Cases	(%)
ARI	0	0	(0.0)	0	0	(0.0)	0	0	(0.0)	0	0	(0.0)	0	0	(0.0)
AGI	6	442	(96.5)	1	60	(100.0)	0	0	(0.0)	0	0	(0.0)	7	502	(96.9)
Hep	1	16	(3.5)	0	0	(0.0)	0	0	(0.0)	0	0	(0.0)	1	16	(3.1)
Total	**7**	**458**	**(100.0)**	**1**	**60**	**(100.0)**	**0**	**0**	**(0.0)**	**0**	**0**	**(0.0)**	**8**	**518**	**(100.0)**

* WBDOs with deficiencies 1–3 and 13 (i.e., surface water contamination, ground water contamination, water treatment deficiency, and untreated chemical contamination of source water) were used for analysis.
† ARI: acute respiratory illness; AGI: acute gastrointestinal illness; and Hep: viral hepatitis.

An outbreak of gastroenteritis occurred among two patrons at a golf course (Minnesota, 1979). Acute illness occurred within minutes of consuming water from a water cooler located next to the golf course. The water dispenser had become contaminated after a bucket with detergent residues was used to fill the water container.

During September–November 1995, a hepatitis A outbreak involved eight persons in a community (Tennessee, 1995). All ill persons reported consuming untreated drinking water from ground water sources. Water testing revealed fecal contamination in multiple wells from this community.

One outbreak of gastroenteritis (Tennessee, October 1988) involved an unidentified etiologic agent. The outbreak report implicated water and ice served at a restaurant as the cause of gastroenteritis in 89 persons. Filtered and chlorinated stream water was used for drinking water and ice. Three days before the onset of illnesses, the sewage system at an upstream campground overflowed, which presumably overwhelmed the restaurant's water-treatment system.

One outbreak of *Pseudomonas folliculitis* among 27 persons occurred in an industrial facility (Louisiana, 2002) and was linked with the use of recycled water in the manufacturing process (*37*). Although this closed water system was chemically treated, substantially high concentrations of *P. aeruginosa* were detected in multiple water samples at the facility.

Surveillance Reports Not Classified as Waterborne Disease and Outbreaks

Nine surveillance reports potentially implicating drinking water or WNID were submitted during 2005–2006 but had insufficient epidemiologic and water-quality data to warrant inclusion in this report as WBDOs. For three reports of legionellosis clusters, common-point sources of transmission were not implicated. Three additional outbreak reports described gastroenteritis within minutes of ingesting drinks at restaurants. Apparently, each of these drinking sources had been contaminated with a cleaning product. Because it was unclear whether the water was contaminated before it was mixed into drinks, these outbreaks were classified as foodborne outbreaks. In 2006, members of three families became ill with giardiasis. Subsequent investigations failed to determine whether private wells serving these families were contaminated. An AGI outbreak among rafting company employees was

caused by *Campylobacter jejuni*, and the drinking water system was suspected to be contaminated. However, despite a thorough investigation, other potential locations of exposure could not be ruled out. Finally, four persons became ill with gastroenteritis, and *Aeromonas hydrophila* was isolated from one person. Because no evidence of ground water contamination was detected and the role of *Aeromonas* in causing waterborne disease has not been definitively established, these cases were not included as an outbreak.

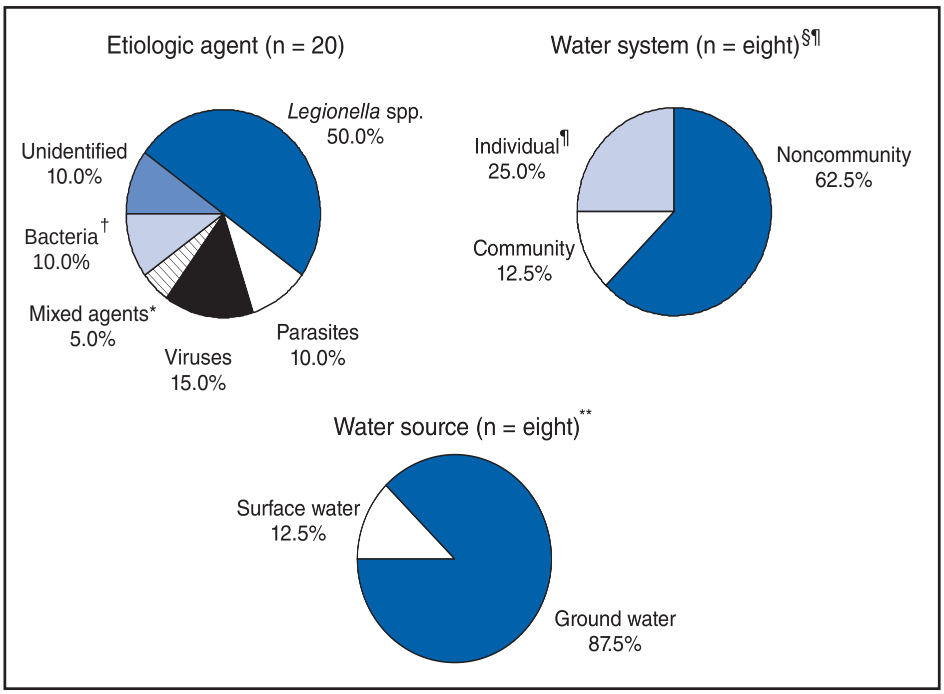
Discussion

Drinking water outbreaks reported to WBDOSS provide important data concerning the etiology and trends of waterborne disease. Analysis of these data can provide insight into the effectiveness of EPA regulations, public health oversight, treatment methods, and risk factors for nonpublic systems and water contaminated outside the jurisdiction of public systems. However, because of incomplete detection, investigation, and reporting of these outbreaks and because the level of surveillance and reporting activity varies in different localities, these data are limited in representing the actual occurrence of waterborne-disease outbreaks. In addition, WBDOSS only captures single, nonoutbreak cases of waterborne disease caused by a limited number of agents (e.g., *Naegleria fowleri* and chemicals demonstrated in water); single cases caused by other waterborne agents are not captured. These factors contribute to the WBDOSS underestimating the burden of endemic waterborne disease related to drinking water.

Multiple factors contribute to the ability of state and local public health agencies to recognize, investigate, and report waterborne-disease outbreaks. These agencies must recognize and link cases of illness to a common water source, which requires appropriate laboratory, epidemiologic, and environmental capacity to conduct appropriate investigations. Outbreaks often are recognized through either case investigations of laboratory-confirmed notifiable diseases or complaints of illness from citizens. This process requires ongoing communication and collaboration between the laboratory, epidemiology and environmental sections of public health agencies. Outbreak reporting might increase as waterborne disease becomes better recognized, water system deficiencies are identified, and state surveillance activities and laboratory capabilities increase (*38–40*). Consequently, recommendations for improving WBDO investigations include enhancing surveillance activities, increasing laboratory support for clinical specimen and water sample testing, and assessing sources of potential bias (*41–43*).

The identification of WBDO etiologic agents depends on multiple factors. Investigators must recognize the WBDO in a timely manner so that appropriate clinical specimens and environmental samples can be collected. Subsequently, the laboratories involved must have the ability to test for the organism, chemical, or toxin in the clinical and water specimens. WBDOSS data suggest that these capabilities are improving, given the reduction in the proportion of reported WBDOs with an unidentified etiology. During 1971–1996, the etiologic agent was unknown in 51% (338/668) of outbreaks; however, during 1997–2006, the etiologic agent was unidentified in 24% (35/146) of outbreaks (Figure 3). Reasons for improved etiologic attribution might include increased testing for viral agents in clini-

FIGURE 6. Percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water, by etiologic agent, water system, and water source — United States, 2005–2006



* Each WBDO involves more than one etiologic agent.
† Other than *Legionella* spp.
§ Deficiencies 1–4. See Table 10.
¶ Does not include commercially bottled water, therefore, not comparable to summaries before 2003–2004.
** Deficiencies 1–3. See Table 11.

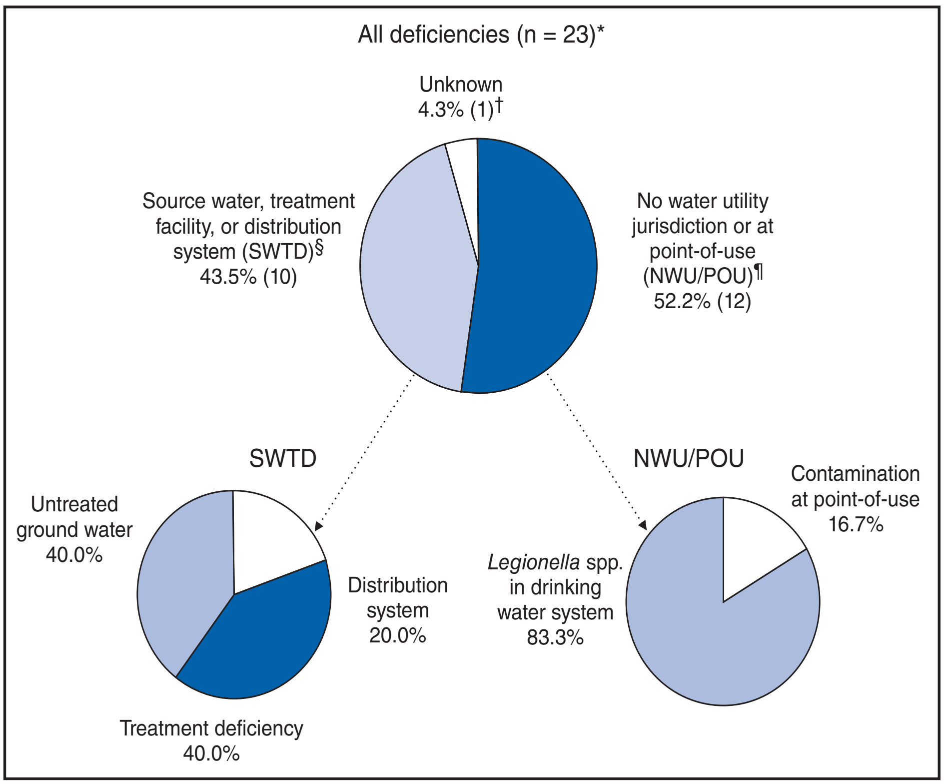
cal and water specimens and refinement in water sampling and testing methods. In previous years, stool specimens were tested routinely for enteric bacterial pathogens and parasites, but testing for viral agents was rarely conducted. Identification of water contamination (by coliform bacteria that might indicate fecal contamination) can provide important information to the epidemiologic investigation and should be attempted when the investigation is conducted in a timely matter. However, collection of water samples also depends on local and state statutory requirements and the availability of investigators who know how to collect the samples. Analyses of specific pathogens and indicators of water contamination depend upon the availability of certified or approved laboratories. Many laboratories are certified to conduct standard analyses for fecal indicators and chemicals, but few laboratories have capabilities for identifying waterborne pathogens, and these tests might be expensive. Collecting water samples for pathogen identification might require sampling large quantities of water or filtering large volumes of water through special membranes. Methods for concentrating large volumes of water for testing are being developed and disseminated to multiple sites in the United States as standard protocols (*44*).

Reporting and surveillance bias might occur because certain local and state public health agencies have enhanced capacity to investigate outbreaks. In addition, determining whether an increase or decrease in reporting reflects either an actual change in the incidence of outbreaks or reflects a change in the sensitivity of surveillance practices is unknown. For example, in states that collaborate with CDC in the Environmental Health Specialist Network's waterborne-disease project (EHS-Net Water), the funding of waterborne disease coordinators improved waterborne disease surveillance and interagency communication, leading to the reporting of previously unreported WBDOs (Table 7) (31). In addition, EHS-Net Water states are also beginning to report more new outbreaks than they have in previous surveillance periods. Increased reporting likely is attributable to better communication, detection, investigation, and reporting and not as a result of more outbreaks occurring.

Another key limitation of the data collected by WBDOSS is that, for the most part, the information pertains only to outbreaks of waterborne illness and not to endemic waterborne illness, including both acute and chronic health effects. The epidemiologic trends and water-quality concerns observed in outbreaks might not necessarily reflect or correspond with trends associated with endemic waterborne illness. In response to the Congressional SDWA Amendments of 1996, EPA and CDC completed and reviewed a series of epidemiologic studies and convened a national workshop in 2005 to assess the magnitude of endemic waterborne AGI associated with consumption of public drinking water. A joint report on the results of these studies is available at http://www.epa.gov/nheerl/articles/2006/waterborne_disease.html. The report includes multiple documents that discuss various methods for estimating the annual number of endemic waterborne-AGI cases associated with public drinking water systems in the United States. Two different but overlapping estimates of the number of endemic AGI cases in the United States were derived: 1) 4.3–11.7 million cases (*45*) and 2) 16.4 million cases associated with public drinking water systems (confidence interval: 5.5–32.8) (*46*).

These estimates, however, only describe a portion of the annual incidence of endemic waterborne-disease cases. To fully

FIGURE 7. Percentage of waterborne-disease outbreaks (WBDOs) associated with drinking water, by deficiency* — United States, 2005–2006



* A total of 20 WBDOs but 23 deficiencies.
† Deficiency 99A. See Table 14.
§ Deficiencies 1–4. See Table 14.
¶ Deficiencies 5A, 6–11, 99B. See Table 14.

TABLE 14. Waterborne-disease outbreaks associated with drinking water (n = 20), by deficiencies (n = 23)* — United States, 2005–2006

Deficiency	No. of deficiencies
Contamination of water at/in the water source, treatment facility, or distribution system (SWTD)†	**10**
1: Untreated surface water intended for drinking	0
2: Untreated ground water intended for drinking	4
3: Treatment deficiency (e.g. temporary interruption of disinfection, chronically inadequate disinfection, or inadequate, or no filtration)	4
4: Distribution system deficiency, including storage (e.g. cross-connection, backflow, and contamination of water mains during construction or repair)	2
13: Current treatment processes not expected to remove a chemical contaminant (e.g., pesticide contamination of groundwater treated with disinfection only)	
A: Surface water	0
B: Ground water	0
Contamination of water at points not under the jurisdiction of a water utility or at the point-of-use (NWU/POU)§	**12**
5: *Legionella* spp. in water system	
A: Water intended for drinking	10
6: Plumbing system deficiency after the water meter or property line (e.g. cross-connection, backflow, and corrosion products)	0
7: Deficiency in building/home-specific water treatment after the water meter or property line	0
8: Deficiency or contamination of equipment using or distributing water (e.g. drink-mix machines)	0
9: Contamination during commercial bottling	0
10: Contamination during shipping, hauling, or storage	
A: Water intended for drinking – Tap water	0
B: Water intended for drinking – Commercially bottled water	0
11: Contamination at point-of-use	
A: Tap	0
B: Hose	1
C: Commercially bottled water	0
D: Container, bottle, or pitcher	1
E: Unknown	0
Unknown/Insufficient Information	**1**
99: Unknown/Insufficient information	
A: Water intended for drinking – Tap water	1
B: Water intended for drinking – Commercially bottled water	0
Total no. of deficiencies*	**23**

* More than one deficiency might have been identified during the investigation of a single waterborne-disease case or outbreak or case.

† Contamination of water and deficiencies occurring in the drinking water system at/in the water source, treatment facility, or distribution system of pipes and storage facilities. For a community water system, the distribution system refers to the pipes and storage infrastructure under the jurisdiction of the water utility before the water meter or property line (if the system is not metered). For noncommunity and nonpublic water systems, the distribution system refers to the pipes and storage infrastructure before entry into a building or house (e.g., in a service line leading to a house or building).

§ Contamination of drinking water and deficiencies occurring in plumbing and pipes that are not part of the distribution system or at other points outside the jurisdiction of a water utility as previously defined. For community systems, this means that after the water meter or property line (if the system is not metered) and for noncommunity and nonpublic systems, this means within the building or house (e.g., in the plumbing inside a house or building) during shipping or hauling, during storage other than in the distribution system, and at the point-of-use).

describe the overall incidence of waterborne disease, estimates also need to include the number of cases of waterborne disease other than AGI and the number of cases associated with nonpublic drinking water systems, commercially bottled water, recreational water, WNID, and WUI. If these other types and sources of waterborne disease were considered, the estimated number of cases of endemic waterborne disease would be higher than the existing estimates of 4–33 million annual cases (*45,46*).

WBDOs Associated with Drinking Water

Etiologic Agents

Since its addition to WBDOSS in 2001, *Legionella* has been the single most commonly reported pathogen associated with drinking water outbreaks. During 2005–2006, a total of 10 (50.0%) of the 20 reported drinking water-associated WBDOs involved *Legionella* spp, which is the first time that the number of reported WBDOs associated with ARI has surpassed those associated with AGI in any surveillance period. These WBDOs all occurred as a result of *Legionella* colonization of plumbing and pipes that are not under the jurisdiction of a water utility and are not specifically subject to EPA regulations. As the predominant drinking water-related pathogen

in WBDOSS, increased attention must be focused on *Legionella* to understand its biology, ecology, and inactivation in parts of the water system not addressed by federal regulation so that appropriate public health action to prevent further WBDOs can be taken.

During the 2005–2006 surveillance period, two drinking water-associated WBDOs involved only bacteria (excluding *Legionella* spp.), compared with five during the 2003–2004 and three during the 2001–2002 surveillance periods. The ongoing occurrence of bacterial WBDOs, despite available and efficacious treatment practices, underscores the continuing need for protection and treatment of drinking water (*47*).

In addition, one mixed-agent type outbreak occurred during the 2005–2006 surveillance period, which included bacteria (*C. jejuni*) and viruses (norovirus G1 and G2). The occurrence of mixed-agent type and multiple agent outbreaks emphasizes the importance of considering more than one etiologic agent in outbreak investigations, collecting appropriate specimens for each agent type, and requesting appropriate diagnostic testing for each agent type. In addition, this outbreak was associated with sewage contamination of a well, underscoring the importance of proper waste management and proper drinking water system and waste water system designs.

Three WBDOs involving only viruses were reported for the 2005–2006 surveillance period. Two involved norovirus G1, and one involved hepatitis A. Based on incubation period, symptoms, and duration of illness, norovirus was also suspected in the two WBDOs where the etiologic agent was unidentified. All of these WBDOs involved contaminated ground water that was either untreated or improperly treated (inadequate or interrupted chlorination as the only treatment provided). EPA's GWR is designed to address vulnerable public ground water systems. However, two of these viral outbreaks occurred in individual nonpublic water systems, and the GWR does not apply to these water systems.

Parasites were identified in two WBDOs during the 2005–2006 surveillance period. The giardiasis outbreak (California, August 2005) was associated with point-of-use contamination. The reason for contamination could not be determined for the *Cryptosporidium* outbreak; however, investigators noted antiquated and piecemeal water plumbing and sewage lines, suggesting that contamination might have entered through water plumbing (Ohio, September 2006). No parasitic outbreaks were associated with contaminated surface water in this surveillance period. Both public surface water systems and public ground water systems under the influence of surface water are regulated under SWTR to protect the public against exposure to *Giardia* and *Cryptosporidium*, among other pathogens. The last parasitic disease outbreak associated with surface water and reported to CDC occurred in 2002 in Palau in an untreated noncommunity system supplied by a river. The dramatic decrease in the number of outbreaks caused by parasites (Figure 3) might be attributable to enhanced EPA regulation of surface water sources.

The etiologic agents of two WBDOs could not be identified, although norovirus was suspected. These two outbreaks represent 10.0% of the 20 drinking water-associated WBDOs reported during 2005–2006 (Figure 6). These two WBDOs represent the lowest number and percentage of outbreaks caused by an unknown etiology in any surveillance period since the beginning of the surveillance system in 1971. This decrease might reflect improved diagnostic capabilities of laboratories and better outbreak investigations, resulting in more rapid and more appropriate specimen collection.

Deficiencies 1–4 and 13: Contamination of Water at/in the Water Source, Treatment Facility, or Distribution System

Typically, EPA regulates the community drinking water supplies from the source water up to the water meter (or up to the property line if the distribution system is not metered). This segment of the drinking water supply system is associated with deficiencies 1–4 and 13 (Table 2): 1) consumption of untreated surface water intended for drinking, 2) consumption of untreated ground water intended for drinking, 3) treatment deficiencies, 4) distribution system deficiencies, and 13) chemical contamination of source water not removed by existing treatment methods. Noncommunity and individual nonpublic systems also might have distribution system deficiencies (i.e., deficiency 4) if problems occur in pipes or storage infrastructure before entry into a building or house. During the 2005–2006 surveillance period, 40.0% of drinking water-related outbreaks (n = 8) and 43.5% of deficiencies (n = 10) involved deficiencies 1–4. A single WBDO can be associated with more than one deficiency. Deficiency 13 was not implicated in any outbreak during the 2005–2006 surveillance period.

Source water. Discussions regarding source water type only include those WBDOs with deficiencies 1–3 because distribution system deficiencies (deficiency 4) are not necessarily dependent upon the source water type. Also excluded from the discussion involving source water types are drinking water-associated WBDOs with unknown or insufficient information (deficiencies 99A) and outbreaks associated with contamination at points not under the jurisdiction of a water utility or at the point-of -use (deficiencies 5A, 6–11, and 99B).

Surface water. Only one (12.5%) of the eight outbreaks with deficiencies 1–3 was associated with consumption of inadequately-treated surface water. In this outbreak (Oregon, 2005), chronically-inadequate chlorination and inadequate

filtration of the river water supplying the camp were cited as the underlying reasons for illness among camp attendees. Since the early 1990s, the percentage of reported WBDOs associated with inadequately treated surface water has been declining. This decrease is likely attributable to EPA regulations mandating treatment of surface water used by public water systems. However, this outbreak underscores that regulations alone do not prevent outbreaks and that attention to proper water system operation and maintenance is still required.

Ground water. Seven (87.5%) of the eight outbreaks with deficiencies 1–3 were associated with consumption of contaminated ground water, either from wells or springs. Among these seven outbreaks, four (57.1%) involved consumption of untreated ground water (deficiency 2), and three (42.9%) involved treatment deficiencies associated with contaminated ground water (deficiency 3). These seven ground water-associated outbreaks indicate that ground water contamination is a continuing problem. Wells and springs must be protected from contamination, even if disinfection is provided, because ground water can become contaminated with pathogens that are not easily disinfected, and source water conditions might overwhelm the disinfection process (e.g., highly turbid water as a result of excessive rain fall).

Five of the seven outbreaks associated with contaminated ground water during the 2005–2006 surveillance period occurred in noncommunity or community water systems that will be subject to EPA's new GWR. Beginning in 2009, the GWR will apply to all public systems that use ground water as a source of drinking water. Although this new rule has not yet been fully implemented, it will establish a risk-based approach to target ground water systems that are vulnerable to fecal contamination. The risk-targeting approach includes four major components: 1) sanitary surveys, 2) source water monitoring to test for the presence of indicators of fecal contamination in the ground water source, 3) corrective action, and 4) compliance-monitoring to ensure that the treatment technology installed to treat drinking water reliably achieves at least 99.99% (4-log) inactivation or removal of viruses. Operators of ground water systems that are identified as being at risk for fecal contamination must take corrective action to reduce the potential for illness from exposure to microbial pathogens.

Because EPA regulations do not apply to individual, nonpublic water systems, WBDOs such as the two involving individual ground water systems reported during 2005–2006 will not be subject to the GWR, which could potentially prevent such outbreaks. The protections offered by the GWR will not extend to individual ground water systems unless they are regulated by state or local authorities. Approximately 17 million persons in the United States rely on private household wells for drinking water each year, and more than 90,000 new wells are drilled annually throughout the United States (*48*). To safeguard the quality of well water, homeowners should seek information on needed protective measures and implement recommended operation and maintenance guidelines for private well usage. Homeowners may also choose to protect their own health by purchasing appropriately designed point-of-use water-treatment devices and by following instructions for their proper operation and maintenance. Although EPA does not regulate individual water systems, EPA recommendations for protecting private wells are available at http://www.epa.gov/safewater/pwells1.html. Additional efforts should be taken by public health officials to educate well owners, users, drillers, and local and state drinking water personnel to encourage practices that best ensure safe drinking water for private well-users.

Water treatment. During 2005–2006, five drinking water-related WBDOs associated with water-treatment deficiencies were reported; all were associated with inadequate chlorination. One WBDO was associated with a malfunctioning chlorine feeder (Indiana, 2006). Two outbreaks occurred because existing water treatment was overwhelmed. Heavy rain might have overwhelmed a camp surface water-treatment system in one outbreak (Oregon, 2005), and remnants of Hurricane Katrina might have created surface water runoff into a spring supplying drinking water to a restaurant in the other outbreak (Ohio, 2005). In addition, this small restaurant served a tour group that was substantially larger than was typically served, and the chlorination system could not keep up with the demand for water. The remaining two WBDOs had inadequate chlorination, but the causes were not specified in the reports. All five outbreaks indicate the need for proper equipment maintenance, adequate capacity of treatment systems to provide potable water during occasional periods of high demand, and education of small water system operators and owners concerning the operation, routine monitoring, and capability of treatment systems under various conditions.

Although treatment deficiencies (deficiency 3) made up the greatest proportion (50.0%) of SWTD deficiencies during the 2005–2006 surveillance period, the majority of (80.0%) of these treatment deficiencies were associated with failures to adequately treat contaminated ground water. When these deficiencies are considered with deficiency 2, contaminated ground water becomes the single largest contributing factor to SWTD-related outbreaks, underscoring the need for the GWR previously described.

Distribution system. Distribution system deficiencies make up the smallest proportion of the SWTD deficiencies during this surveillance period. During 2005–2006, two drinking water-related WBDOs involving distribution system deficien-

cies occurred. Before one outbreak (Indiana, 2006), a new water main was installed without a valid permit. The water main was pressure tested and was left under pressure with nonpotable water, resulting in a cross-contamination hazard. In the second outbreak, backflow prevention devices were absent on water distribution lines to toilet facilities in a camp (Maryland, 2006). Drinking water quality within the distribution systems of public water supplies is regulated under EPA's TCR, which is currently undergoing revisions to better protect public health.

Water systems. Discussions regarding water system types (i.e., community, noncommunity, and individual) include drinking water-associated WBDOs with deficiencies 1–4 and 13. Deficiencies in the distribution system are included in these discussions because distribution system problems might be dependent on the type of water system involved. Among the eight drinking water-associated WBDOs with a deficiency of 1–4, a total of five (62.5%) were associated with noncommunity water systems, two (25.0%) with individual water systems, and one (12.5%) with a community water system. The proportion (12.5%) of drinking water-related WBDOs associated with community water systems represents the lowest proportion of outbreaks that occurred during the last four surveillance periods (i.e., 1999–2000, 2001–2002, 2003–2004, and 2005–2006). This decrease might reflect the success of federal drinking water regulations protecting water quality in public supplies.

Environmental investigation. To better understand the antecedent events resulting in drinking water-associated WBDOs, particularly deficiencies 1–4, a new outbreak investigation tool is being developed by EHS-Net, a collaborative forum of environmental health specialists. These environmental health specialists collaborate with epidemiologists and laboratorians to identify, investigate, and prevent environmental factors contributing to foodborne and waterborne illness and disease outbreaks. In 2000, EHS-Net Food was established with funds from CDC's National Center for Environmental Health, Environmental Health Services Branch, and the FDA and has nine participating state sites that focus on the prevention of foodborne disease. In 2005, EHS-Net Water was piloted with CDC and EPA funds, which support one staff member in each of five states (California, Georgia, Minnesota, New York, and Tennessee) to focus specifically on waterborne-disease investigations. The environmental outbreak investigation tool developed by EHS-Net Water assists with outbreak investigations both by capturing environmental data that are not collected routinely (e.g., assessment of water system operations) and by clarifying the environmental events and situations (e.g., recent precipitation events) that contributed to WBDOs in small ground water systems. This information will assist public health officials and water system operators and owners in addressing the potential sources of contamination that resulted in an outbreak of waterborne disease.

Deficiencies 5A and 6–11: Contamination of Water at Points Not Under the Jurisdiction of a Water Utility or at the Point-of-Use

A distinction can be made between deficiencies that occur at points NWU/POU and SWTD. During the 2005–2006 surveillance period, more WBDOs were associated with NWU/POU (12 [52.2%]) than with SWTD (10 [43.5%]) (Figure 7). Similar proportions were noted in the 2003–2004 surveillance period, which was the first time the distinction was made between NWU/POU and SWTD deficiencies.

Deficiency 5A. *Legionella* in water intended for drinking. Legionellosis includes two clinically distinct syndromes: Legionnaires' Disease (LD), characterized by severe pneumonia, and Pontiac Fever (PF), a febrile, cough illness that does not progress to pneumonia. Legionellosis outbreaks accounted for 50% of all drinking water-associated WBDOs reported during 2005–2006 and 83.3% of all NWU/POU deficiencies, indicating that *Legionella* is a serious public health threat. When outbreaks of legionellosis occur in the setting of contaminated drinking water, they typically manifest as cases of LD rather than PF. Approximately 8,000–18,000 cases of LD occur each year in the United States (*49*). Regardless of the syndrome, the source of legionellosis outbreaks typically share common features (e.g., warm stagnant water, inadequate biocide concentrations, and aerosolization, which provides the mechanism for inhalation).

The outbreaks of legionellosis highlight the challenges related to its detection and prevention. LD is underdiagnosed because the majority of patients with community-acquired pneumonia are treated empirically with broad-spectrum antibiotics (*50*). However, because *Legionella* spp. are not transmitted from person-to-person and are always acquired from an environmental source, even a single case of LD implies the presence of a contaminated aquatic source to which others can be exposed. Certain host factors (e.g., underlying lung disease and immunodeficiencies) influence the development and severity of legionellosis. Typically, the attack rate during documented LD outbreaks is quite low (i.e., <5%). Not everyone who is exposed in a *Legionella*-contaminated building is susceptible to symptomatic illness. Identification of two or more cases of LD in association with a potential source is adequate justification for an investigation. All of the legionellosis outbreaks described in this report involved ten or fewer cases. Nonetheless, in all instances except for one, the epidemiologic and laboratory data were compelling enough to implicate point sources that were subsequently remediated.

During 2005–2006, a total of eight (80%) of 10 legionellosis outbreaks associated with drinking water occurred in health-care settings, demonstrating the propensity for *Legionella* spp. to colonize potable water systems and underscoring the importance of maintaining a high index of suspicion for legionellosis in health-care settings. Seven outbreaks occurred in acute-care hospitals and one in a long-term–care facility. *Legionella* spp. colonize the biofilm layer frequently found inside the large, complex plumbing systems of hospitals (*51*). This biofilm protects *Legionella* from biocides and allows the bacteria to amplify to levels sufficient to be transmitted and/or cause disease. Patients in hospitals or long-term–care facilities typically are older and have underlying illness factors that increase the risk for disease (e.g., chronic lung disease, diabetes, and immunocompromising conditions).

An outbreak of legionellosis in a health-care setting should prompt both an epidemiologic and environmental investigation. Additional cases might point to water exposures that contributed to the outbreak. Environmental sampling of the potable water system and other aerosolized water exposures (e.g., cooling towers) can confirm the source of the outbreak and lead to targeted interventions that prevent additional cases. Superheating and superchlorination are the traditional methods for remediation; however, *Legionella* might regrow in the distribution system (*52*). Other remediation options are under investigation. Monochloramine might be an effective biocide for *Legionella* control; hospitals supplied with drinking water containing monochloramine were less likely to have a reported outbreak of LD than those that used water with free chlorine as a residual disinfectant (*53*). Each health-care facility should develop a plan for legionellosis prevention to address predisposing conditions for *Legionella* growth in the potable water supply. Guidelines for reducing the risk for legionellosis associated with building water systems are available (*52*).

Deficiencies 6–11. Deficiencies involving drinking water that occur at points not under the jurisdiction of a water utility or at the point-of-use have been presented (Table 2). During the 2005–2006 surveillance period, only two reported non-*Legionella* WBDOs involving deficiencies in this category were reported. Both WBDOs involved point-of-use contamination. One outbreak of giardiasis was associated with contamination of a 5-gallon drinking water ceramic crock dispenser at a gym (California, August 2005). Epidemiologic evidence linked all the cases to the dispenser, although the mechanism of contamination of the dispenser could not be determined. The dispenser had a hand-manipulated spigot and the water was typically replenished once a day, although the dispenser was not regularly cleaned during the suspected period of exposure. Investigators thought that either the employee who replenished the water (she was asymptomatic but her boyfriend was a laboratory-confirmed case) or an ill gym patron who used the spigot might have contaminated the water. An outbreak of norovirus G1 at a camp (Maryland 2006) involved water-treatment and distribution-system deficiencies in addition to contamination at the point-of-use. Garden hoses stored improperly on the ground were used to fill large water containers from which campers filled their cups and water bottles. These point-of-use contamination events illustrate the vulnerability of shared water containers and the importance of practicing good hygiene.

Waterborne Disease and Outbreaks Associated with Water Not Intended for Drinking and Water of Unknown Intent

During the 2005–2006 surveillance period, eight WBDOs occurred that were associated with WNID or WUI. Five of these outbreaks were associated with *Legionella* spp. Three of these outbreaks were in health-care settings and attributed to cooling towers. Although the building potable water system is more frequently implicated in health-care–associated outbreaks, community sources should also be considered. Aerosols containing *Legionella* can travel great distances; an investigation of an outbreak among residents of a long-term care facility implicated a cooling tower that was 0.4 km from the facility (*54*).

Legionellosis clusters might signal a wider community outbreak and should prompt an investigation. In addition, legionellosis outbreaks also can occur in the general population outside the health-care setting, as demonstrated by a community outbreak in South Dakota in 2005. The epidemiologic investigation revealed that a restaurant was the common exposure among cases. Targeted environmental testing ultimately confirmed the source as the decorative fountain inside the restaurant (*36*). The source of contaminated water could not be identified for the fifth legionellosis outbreak.

The other three non-*Legionella* WNID/WUI outbreaks were associated with bacterial and parasitic diseases. An outbreak caused by *E. coli* O157:H7 occurred at a sports camp (Tennessee 2005). The primary water exposure associated with illness could not be identified. Illness was associated with swimming in one of the outdoor pools, dining at pool picnic tables, and attending a tennis camp. Unlabeled irrigation faucets drawing water from a nonpotable well were located at multiple points around the tennis courts. Sampling of this water system detected fecal contamination. The remaining two WBDOs involved cases of giardiasis that developed after exposure to WNID. One outbreak involved a family who had canal water piped into their home to use for bathing, dish

washing, house cleaning, and laundry (California, July 2005). The second outbreak involved a school trip to a state forest (Colorado 2006). Six of 26 campers became ill. The epidemiologic data indicated that inadequate treatment of river water before consumption was a risk factor. Adding a sports drink powder to river water while concurrently adding iodine for disinfection was a statistically-significant risk factor for becoming ill. The relative risk for boiling water <3 minutes could not be defined because none of the persons who boiled water longer became ill. Both of these giardiasis outbreaks illustrate the risks associated with consuming untreated surface water, even water that might appear pristine.

Backcountry travel (i.e., travel in wilderness environments) in the United States is an increasingly popular activity. In 2004, approximately 12% of Americans aged ≥16 years (approximately 26 million persons) went backpacking for one or more nights in backcountry areas during the previous 12 months (*55*). Limited information is available concerning the risk factors for illness in the backcountry and about the health outcomes of visitors who use parks in backcountry areas. Several studies indicate that as many as 3.8%–56% of long-distance hikers and backpackers experience gastrointestinal illness during their time in the backcountry (*56–61*). Given the increasing popularity of backcountry use, this burden of illness could have significant medical and economic implications. Although the advice to universally filter and disinfect backcountry drinking water to prevent disease has been debated (*62*), the health consequences of ignoring that standard water treatment advice have been documented in WBDOSS, although they have not been well-defined through research studies.

Previously Unreported Outbreaks

This report discusses information concerning four previously unreported WBDOs. Two of these outbreaks occurred in Tennessee, one in Minnesota, and one in Louisiana. The Tennessee and Minnesota state health departments are partners in EHS-Net Water. Initial surveys by three of the five participating EHS-Net Water states have revealed at least 75 outbreaks or health events previously unreported to CDC, including the three drinking water outbreaks reported in this *Surveillance summary*, nine drinking water outbreaks from New York State included in the previous *Surveillance Summary* (*5*), and 63 recreational water-related outbreaks or health events reported in the recreational water *Surveillance Summary* (*30*). In addition to reporting historical outbreaks, these states are working to improve the sensitivity of their current waterborne-disease outbreak detection. Additional EHS-Net Water projects are underway to improve the practice of environmental health service programs; translate the findings into improved prevention efforts; offer training opportunities to current and future environmental health specialists; and strengthen the collaboration among epidemiology, laboratory, and environmental health programs. The EHS-Net Water activities indicate that increased effort and resources, specifically directed at waterborne-disease reporting, could result in the identification of previously unreported historical outbreaks. As EHS-Net Water refines the process for identifying and investigating current waterborne-disease incidents, these efforts might result in enhanced reporting of waterborne outbreaks from these and other states.

Conclusion

Data collected as part of the national WBDOSS are used to describe the epidemiology of waterborne-disease outbreaks in the United States. Trends regarding water systems and deficiencies implicated in these WBDOs are used to assess whether regulations for water treatment and water-quality monitoring are adequate to protect public health. Trends regarding the etiologic agents responsible for these outbreaks are used to assess the need for different interventions and changes in policies and resource allocations.

Two primary trends can be observed from the 2005–2006 surveillance period data. Since it was first included in WBDOSS in 2001, *Legionella* has become the single most common cause of reported outbreaks in WBDOSS. This does not mean that *Legionella* is a more important cause of waterborne disease than other agents (e.g. norovirus) nor does it mean than legionellosis outbreaks are increasing because they have only been included in the WBDOSS since 2001. Therefore, there is a limited basis for historical comparison. However, outbreaks associated with other agents are not being reported as frequently as outbreaks caused by *Legionella*. Whether this is a result of barriers to laboratory confirmation of non-*Legionella* pathogens in clinical specimens and environmental samples, lack of detection of non-*Legionella* pathogens as a result of different incubation periods or milder illness, use of adequate water-treatment technologies for non-*Legionella* pathogens, or other factors that might be responsible for fewer outbreaks associated with non-*Legionella* is not clear.

The second major trend observed in the 2005–2006 surveillance period is the high proportion of WBDOs associated with contaminated ground water, whether consumed untreated or with inadequate treatment. Until the GWR was finalized in 2006, federal drinking water regulations have concentrated on protecting consumers from contaminated surface water. These rules probably have contributed to the decrease in the number and proportion of reported WBDOs associated with contaminated surface water that have been observed during

the previous twenty years. Similar protections against the consumption of contaminated ground water were absent until the development of the GWR, which was finalized in 2006. This rule, which is expected to be enacted in 2009, might result in a similar decline in the number of ground water–associated WBDOs.

Surveillance for waterborne agents and WBDOs occurs primarily at the local and state levels (including territories and FAS). Public health authorities at these levels are responsible for detecting and recognizing drinking water-associated WBDOs and implementing appropriate prevention and control measures (Box). Improved communication among local and state public health departments, regulatory agencies, and water utilities will aid in the detection and control of WBDOs. Routine reporting or sharing of water-quality data within the health and environmental health departments is recommended. Other means of improving surveillance at the local, state, and federal levels include 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).

A number of efforts have been initiated at the local, state, and national levels to improve the detetection, investigation, and reporting of WBDOs. CSTE passed a position statement at the 2006 annual meeting making WBDOs, as a unit of reporting, nationally notifiable and reportable to CDC starting in 2007. Adoption of this CSTE recommendation at the state level through state-specific legislative action might improve reporting of WBDOs at the state and local levels.

In addition, to improve timeliness and completeness of reporting, CDC and EPA are collaborating with public health jurisdictions to implement electronic reporting of WBDOs

BOX. Organizations that provide assistance in investigations of waterborne disease and outbreaks (WBDOs)

State and territorial health departments can request epidemiologic assistance and laboratory testing from CDC to investigate WBDOs. CDC and the U.S. Environmental Protection Agency (EPA) can be consulted regarding engineering and environmental aspects of drinking water treatment during and after outbreaks and collection of large-volume water samples to identify pathogens that require special protocols for their recovery. EPA and the U.S. Geological Survey can be consulted for assistance with hydrogeologic investigations of outbreaks where untreated ground water is suspected.

- **Environmental Protection Agency Safe Drinking Water Hotline**
  Telephone: 800-426-4791
  E-mail: hotline-sdwa@epa.gov
  Internet: http://www.epa.gov/safewater

- **Testing for Bacterial Enteric Organisms**
  Division of Foodborne, Bacterial, and Mycotic Diseases
  National Center for Zoonotic, Vector-Borne, and Enteric Diseases
  Coordinating Center for Infectious Diseases, CDC
  Telephone: 404-639-1798

- **Request for Information on Testing for *Legionella***
  Division of Bacterial Diseases
  National Center for Immunization and Respiratory Diseases
  Coordinating Center for Infectious Diseases, CDC
  Telephone: 404-639-2215
  Internet: http://www.cdc.gov/legionella

- **Testing for Parasites**
  Division of Parasitic Diseases
  National Center for Zoonotic, Vector-Borne, and Enteric Diseases
  Coordinating Center for Infectious Diseases, CDC
  Telephone: 770-488-7775

- **Testing for Viruses**
  Division of Viral Diseases
  National Center for Immunization and Respiratory Diseases
  Coordinating Center for Infectious Diseases, CDC
  Telephone: 404-639-3607

- **State Reporting of Waterborne Disease and Outbreaks**
  Division of Parasitic Diseases
  National Center for Zoonotic, Vector-Borne, and Enteric Diseases
  Coordinating Center for Infectious Diseases, CDC
  Telephone: 770-488-7775
  Fax: 770-488-7761
  Note: All WBDOs at the local level should be reported to the state health department.

- **CDC Reporting Form CDC 52.12 (rev.01/2003)**
  Internet: http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf

through the National Outbreak Reporting System (NORS). NORS is a more systematic data-collection tool and will provide public health agencies and waterborne-disease researchers with the evidence base they need to identify the causes of WBDOs and understand the environmental factors contributing to these outbreaks.

EHS-Net Water, a collaborative project between EPA, CDC, and five state health departments, is an effort to improve WBDO identification, investigation, response, and reporting. EHS-Net Water sites initially focused on understanding their state-specific surveillance systems, which resulted in the identification and reporting of numerous previously unreported historical outbreaks to WBDOSS. Subsequent efforts are focusing on improving the environmental investigation of drinking water outbreaks, particularly in small groundwater systems.

In May 2007, EPA and CDC convened a workshop to address improving the recognition, investigation, and reporting of waterborne-disease outbreaks. Participants included epidemiologists, environmental engineers, scientists, environmental health specialists, other public health professionals, and water-industry professionals from 44 states, the District of Columbia, and Puerto Rico. Workshop recommendations included 1) improving the communication and coordination between agencies investigating waterborne-disease outbreaks; 2) conducting training for outbreak investigators, laboratory analysts, and water system operators; 3) focusing efforts on outbreak prevention; 4) enhancing surveillance; 5) strengthening outbreak investigations; and 6) improving outbreak reporting.

Efforts to enhance awareness, training, resources, and communication will improve the quality of the data in WBDOSS. These efforts should make public health activities related to waterborne disease more efficient and reduce the burden of WBDOs.

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Appendix A

Glossary of Definitions

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.
agent	See etiologic agent.
aquifer	A geologic formation or part of a formation (e.g., gravel, sand, or porous stone) that yields water to wells or springs.
backflow	A hydraulic condition caused by a difference in water pressure that causes nonpotable water or other liquid to enter the potable water system by either backpressure or backsiphonage. See cross-connection.
backpressure	A hydraulic condition that results when pressure from a customer's water system (e.g., potentially nonpotable water) is higher than pressure in the public water system, resulting in backflow of water into the public water system.
backsiphonage	A hydraulic condition caused by negative or subatmospheric pressure within a water system, resulting in backflow.
biofilm	Microbial cells that adhere to a surface through a matrix of primarily polysaccharide materials in which they are encapsulated. Biofilms can grow on piping and surfaces of water systems and can be difficult to remove. They offer protection to microbes from disinfectants (e.g., chlorine) in the water.
boil-water advisory	A statement to the public advising that tap water must be boiled before drinking.
bottled water	Commercially produced bottled water.
class	A categorization given to waterborne disease and outbreaks (WBDOs) indicating to the strength of the epidemiologic and water-quality data implicating water as the source of the disease or outbreak (see Table 3).
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). Coliforms are mostly harmless bacteria that live in soil and water as well as the gut of humans and animals.
community water system	A public water system that has at least 15 service connections used by year-round residents or that regularly serves at least 25-year-round residents. The system might be owned by a private or public entity providing water to a community, subdivision, or mobile home park.
cross-connection	Any actual or potential connection between a drinking water supply and a possible source of contamination or pollution (i.e., nonpotable water). Under this condition, contaminated water might flow back into the drinking water system. See backflow.
deficiency	An antecedent event or situation contributing to the occurrence of a waterborne disease or outbreak.
dermatitis	Inflammation of the skin. In this report, the term dermatitis is used to denote a broad category of skin-related symptoms (e.g., folliculitis, cellulitis, chemical burns, or rash).

disinfection	A treatment that kills microorganisms (e.g., bacteria, viruses, and protozoa); in water treatment, a chemical (commonly chlorine, chloramine, or ozone) or physical process (e.g., ultraviolet light) may be used.
disinfection by-products	Chemicals formed in water by the reaction between organic matter and other waste products and disinfectants.
distribution system	Water pipes, storage reservoirs, tanks, and other means used to deliver drinking water to consumers or to store finished water before delivery to a customer. In community water systems, the distribution system is under the jurisdiction of a water utility and ends at the water meter or at the customer's property line (if the system is not metered). In noncommunity and nonpublic individual water systems, the distribution system ends at the point where water enters the building or house. See plumbing.
etiologic agent	The pathogen, chemical, or toxin causing a waterborne disease or outbreak. Infectious etiologic agents are bacteria, parasites, viruses, or fungi.
fecal coliforms	Coliform bacteria that grow and ferment lactose to produce gas at 112.1°F (44.5°C) in <24 hours. These bacteria are associated with human and animal wastes, and their presence in water might be an indication of recent sewage or animal waste contamination.
filtration	In water treatment, the process of passing water through one or more permeable membranes or media of small diameter (e.g., sand, anthracite, and diatomaceous earth) to remove suspended particles from the water. Filters might be effective in removing pathogens, depending on the type and operation.
finished water	The water (e.g., drinking water) delivered to the distribution system after treatment, if any.
free chlorine	The chlorine in water that is not combined with other constituents, therefore, serving as an effective disinfectant (also referred to as free available chlorine and residual chlorine).
ground water	Water that is contained in interconnected pores in an aquifer.
ground water system	A system that uses water extracted from an aquifer (i.e., a well or spring) as its source.
ground water under the direct influence of surface water	As defined by the U.S. Environmental Protection Agency (EPA), any water beneath the surface of the ground with substantial occurrence of insects or other macrooganisms, algae, or large-diameter pathogens (e.g., *Giardia intestinalis* or *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.
individual water system	A water system that does not meet the EPA definition for a public water system. The system might serve a single family or farm not having access to a public water system, or it might regularly serve as many as 24 persons or 14 connections. States are responsible for regulating these water systems.
karst aquifer	An aquifer characterized by water-soluble limestone and similar rocks in which fractures or cracks have been widened by the dissolution of the carbonate rocks by ground water; the aquifer might contain sinkholes, tunnels, or even caves.
maximum contaminant level	The maximum permissible concentration (i.e., level) of a contaminant in water supplied to any user of a public water system.

mixed-agent outbreak	More than one type of etiologic agent is identified in clinical specimens from affected persons, and each etiologic agent is found in more than 5% of positive clinical specimens (e.g., an outbreak with *Giardia* spp. [parasites] and *Salmonella* spp. [bacteria] with each agent identified in >5% of stool specimens).
mixed-illness outbreak	More than one type of illness is reported by more than 50% of patients in a single outbreak (e.g., a combination of gastroenteritis and dermatitis).
mixed-source outbreak	More than one type of source water is implicated in the outbreak (e.g., a combination of ground water and surface water).
mixed-system outbreak	More than one type of water system is implicated in the outbreak (e.g., a combination of noncommunity and individual water systems).
noncommunity water system	A public water system that is not a community system; it does not serve year-round residents. There are two types: transient and nontransient noncommunity systems.
nontransient noncommunity water system	A public water system that is not a community system and that regularly serves at least 25 of the same persons for more than 6 months per year but not year-round (e.g., a school, a factory, or a business with its own water supply).
plumbing	Water pipes, storage reservoirs, tanks, and other means used to deliver drinking water to consumers inside buildings or houses or to store drinking water inside buildings or houses before consumption. In community water systems, the plumbing begins after the water utility's water meter or at the property line (if the distribution system is not metered). In noncommunity and nonpublic individual water systems, the plumbing begins at the point where water enters the building or house. See distribution system.
predominant illness	The category of illness reported by at least 50% of ill respondents (e.g., gastroenteritis, dermatitis, or acute respiratory illness). When more than one illness category is reported for a single WBDO, they are listed together as predominant illnesses. These mixed illness WBDOs are analyzed separately from WBDOs with single illnesses.
primary water exposure	For use in this report, a classification used for the source of contaminated water not intended for drinking or contaminated water of unknown intent.
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. Such a system must have at least 15 service connections or regularly serve at least 25 persons daily for at least 60 days per year.
raw water	Surface water or ground water that has not been treated in any way.
reservoir, impoundment	An artificially maintained lake, created for the collection and storage of water. This body of water can be available as a source of raw water for drinking purposes and/or recreational use. In certain instances, a finished water storage facility in the distribution system might also be called a reservoir.
setting	Location where exposure to contaminated water occurred (e.g., restaurant, water park, or hotel).
source water	Untreated water (i.e., raw water) used to produce drinking water.
surface water	All water on the surface (e.g., lakes, rivers, reservoirs, ponds, and oceans) as distinguished from subsurface or ground water.

total coliforms	Fecal and nonfecal coliforms that are detected by using a standard test. The extent to which total coliforms are present in water can indicate the general quality of that water and the likelihood that the water is fecally contaminated by animal and/or human sources.
transient noncommunity water system	A public water system that is not a community system and that does not regularly serve at least 25 of the same persons for more than 6 months per year. These systems provide water to places where persons do not remain for long periods (e.g., restaurants, campgrounds, highway rest stations, or parks with their own public water systems).
untreated water	Surface water or ground water that has not been treated in any way (i.e., raw water).
water not intended for drinking	Water that has not been treated for human consumption in conformance with EPA drinking water standards and that is provided for uses other than for drinking. This might include water used in occupational settings; lakes, springs, and creeks used as drinking water by campers and boaters; irrigation water; and other nonpotable water sources with or without taps but does not include exposure to recreational water or flood water.
water of unknown intent	The information about the water is insufficient to determine for what purpose it is being provided or used and whether is has been treated for human consumption in conformance with EPA drinking water standards.
water system	A system for the provision of water for human consumption through pipes or other constructed conduits. This includes any collection, treatment, storage, and distribution facilities used primarily in connection with such a system.

Appendix B

Descriptions of Selected Waterborne Disease Outbreaks Associated with Drinking Water, Water Not Intended for Drinking, and Water of Unknown Intent

Date	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
Bacteria				
February 2006	Indiana	*Campylobacter* spp.	32	Thirty-two county residents who developed gastrointestinal illness were included in a case-control study that implicated municipal water as the source of infection. Seven of nine people who provided stool specimens tested positive for *Campylobacter* species; and routine water samples from the treatment facility tested positive for total coliforms and *Escherichia coli* at the time of the outbreak. The investigation determined that a chlorinator had malfunctioned before the outbreak, resulting in inadequate chlorination of the water supply, and that cross-contamination also might have occurred when a new water main was pressure-tested with non-potable water.
May 2005	Oregon	*Escherichia coli* O157:H7, *C. jejuni, and E. coli* O145	60	Attendees of an outdoor school program at a camp developed gastrointestinal illness with a median duration of four days. Stool samples were collected from 57 cases. Nine persons tested positive for *E. coli* O157:H7, three persons tested positive for *C. jejuni,* two persons tested positive for *E. coli* O145; and three persons tested positive for both *E. coli* O157:H7 and *C. jejuni*. The camp was required to upgrade the surface water-treatment system, which was suspected of providing inadequate treatment after heavy rainfall conditions. Raw water tested positive for fecal coliforms and *E. coli* approximately 1 week after the first case-patient became ill.
May 2005	South Dakota	*Legionella pneumophila* serogroup 1	18 (1)	Eighteen confirmed cases of Legionnaires' disease were reported over a 5-month period in Rapid City, South Dakota. An investigation, including a case-control study and environmental sampling, was conducted. A small, decorative fountain lacking obvious aerosol-generating capacity was implicated. Clinical and environmental *L. pneumophila* serogroup 1 Benidorm isolates had identical sequence-based typing (SBT) patterns. (**Source:** O'Loughlin RE, Kightlinger L, Werpy, M, et al. Restaurant outbreak of Legionnaires' disease associated with a decorative fountain: an environmental and case control study. BMC Infect Dis 2007;7:93).
April 2006	Texas	*L. pneumophila* serogroup 1	10 (3)	Ten confirmed cases of Legionnaires' disease, diagnosed by urine antigen and culture, were reported during spring 2005 after exposure to a hospital in San Antonio, Texas. The potable hot water supply of the newly constructed and recently opened inpatient building was determined to be the most likely source of the outbreak. Multiple *L. pneumophila* serogroup 1 strains were identified from environmental isolates taken from the hospital building; one previously unreported environmental strain matched a case-patient isolate.
May 2002	Louisiana	*Pseudomonas aeruginosa*	27	Thirty-eight employees at a cardboard box manufacturing facility were surveyed regarding recent dermatologic symptoms. Twenty-seven employees reported rashes that were suspected to be work-related and were consistent with *P. aeruginosa* infection. The facility had recently switched to a closed-water system. Water used in manufacturing processes and cleaning was treated and re-used as plant process water. Water samples from multiple sites using this water contained high concentrations of *P. aeruginosa*. Contributing factors noted from the water samples included elevated water temperatures, high organic content, elevated pH levels and varying disinfectant levels. The observation was made that certain areas of the water system were accessed substantially less frequently than others and that the ability of *Pseudomonas* to produce biofilms in hoses or pipes might have limited the effectiveness of the treatment methods. **(Source:** Hewitt DJ., *et al.* Industrial *Pseudomonas* folliculitis. Am J Ind Med 2006; 49:895–9).

Date	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
Viruses				
July 2006	North Carolina	Hepatitis A	16	Private property owners allowed travelers to stay on their property and provided drinking water for public use. The drinking water source for the house and the camping area and the water supply for a limited amount of fruits and vegetables was a spring that the owner had excavated. Water was directed into a plastic reservoir above the spring. Untreated water was pumped to the house through a series of pipes and delivered to the downhill camping area through an overflow hose. Water from a spigot from outside the house tested positive for fecal coliforms, *E. coli,* and hepatitis A. The septic tank located directly upstream from the spring was considered a possible source of water contamination.
July 2006	Maryland	Norovirus G1	148	Attendees of a camp developed gastrointestinal illness. Participants were from England, Canada, Australia, Sweden, and the United States (i.e., California, Connecticut, Delaware, Indiana, Illinois, Massachusetts, Maryland, Michigan, New Jersey, New York, and Pennsylvania). Ten persons submitted stool samples, eight of which tested positive for norovirus G1. General concerns included toilet facilities with plumbing deficiencies and limited handwashing stations throughout the camp. The water distribution system did not contain a detectable level of chlorine. Nine of ten water samples from garden hoses used to provide drinking water contained total coliforms and *E. coli.* Well construction deficiencies were noted (e.g., absence of backflow-prevention devices on the pool bath house water heaters and on water distribution lines to the latrines). The well storage tank and latrine wastewater samples contained Norovirus G1; tracer dye added to latrines was detected in the well.
Parasites				
August 2005	California	*Giardia intestinalis*	3	A child's condition was diagnosed as laboratory-confirmed giardiasis, and a sibling and parent had clinically compatible symptoms. Canal water was piped into a private residence and used for bathing, dishwashing, housecleaning and laundry. Accidental ingestion of contaminated canal water was suspected.
May 2006	Colorado	*G. intestinalis*	6	Participants in a school trip to a state park became ill with gastrointestinal symptoms after consuming inadequately treated river water that was not intended for drinking. Treatment methods included the addition of iodine; filtration; and boiling. No one treatment method was used by the entire group (n=26) and variations in practice were observed among individuals who used each treatment method.
Mixed Agents				
June 2006	Wyoming	Norovirus G1, Norovirus G2, *C. jejuni*	139	Attendees of four week-long camps at a seasonal camp site experienced gastrointestinal illness. Investigators concluded that the camp's two wells, which were drilled into fractured rock aquifers, may have been contaminated by raw sewage released from the main septic system. Water from the wells repeatedly tested positive for fecal and total coliforms; a septic tank sample tested positive for Norovirus G1 and G2. The main tank was documented as poorly located, at capacity and not meeting the state's recommended standards for size or type of construction at the time of the outbreak. Well water was not filtered or chlorinated prior to consumption. (**Source:** CDC, Gastroenteritis among attendees at a summer camp—Wyoming, June-July 2006. MMWR 2007;56(15):368-370)

Date	State in which WBDO occurred	Etiologic agent	No. of cases (deaths)	Description of WBDO
Unidentified				
August 2006	New York	Norovirus suspected	16	Visitors to a bed and breakfast, the owner and his daughter, developed gastrointestinal illness. The incubation period and duration of illness and symptoms were consistent with norovirus infection. The bed and breakfast had its own well and onsite wastewater disposal system, which were located in close proximity. A well water sample was positive for *E. coli* and might have been contaminated from a poorly maintained, leaking sewage system used by nearby cottages. Year-round residents used onsite septic systems or alternate disposal methods for wastewater when the seasonal system was turned off. The geology of the area was primarily fractured bedrock; contamination of the well likely resulted from waste that was released by the leaking seasonal sewage system or onsite wastewater systems, which then traveled through the rock until it reached the groundwater supply.

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and

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U.S. Department of Health and Human Services
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Surveillance for Waterborne Disease Outbreaks and Other Health Events Associated with Recreational Water — United States, 2007–2008

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Abstract

Problem/Condition: Since 1978, CDC, the U.S. Environmental Protection Agency, and the Council of State and Territorial Epidemiologists have collaborated on the Waterborne Disease and Outbreak Surveillance System (WBDOSS) for collecting and reporting data on waterborne disease outbreaks associated with recreational water. This surveillance system is the primary source of data concerning the scope and health effects of waterborne disease outbreaks in the United States. In addition, data are collected on other select recreational water–associated health events, including pool chemical–associated health events and single cases of *Vibrio* wound infection and primary amebic meningoencephalitis (PAM).

Reporting Period: Data presented summarize recreational water–associated outbreaks and other health events that occurred during January 2007–December 2008. Previously unreported data on outbreaks that have occurred since 1978 also are presented.

Description of the System: The WBDOSS database includes data on outbreaks associated with recreational water, drinking water, water not intended for drinking (excluding recreational water), and water use of unknown intent. Public health agencies in the states, the District of Columbia, U.S. territories, and Freely Associated States are primarily responsible for detecting and investigating waterborne disease outbreaks and voluntarily reporting them to CDC using a standard form. Only data on outbreaks associated with recreational water are summarized in this report. Data on other recreational water–associated health events reported to CDC, the Agency for Toxic Substances and Disease Registry (ATSDR), and the U.S. Consumer Product Safety Commission (CPSC) also are summarized.

Results: A total of 134 recreational water–associated outbreaks were reported by 38 states and Puerto Rico for 2007–2008. These outbreaks resulted in at least 13,966 cases. The median outbreak size was 11 cases (range: 2–5,697 cases). A total of 116 (86.6%) outbreaks were associated with treated recreational water (e.g., pools and interactive fountains) and resulted in 13,480 (96.5%) cases. Of the 134 outbreaks, 81 (60.4%) were outbreaks of acute gastrointestinal illness (AGI); 24 (17.9%) were outbreaks of dermatologic illnesses, conditions, or symptoms; and 17 (12.7%) were outbreaks of acute respiratory illness. Outbreaks of AGI resulted in 12,477 (89.3%) cases.

The etiology was laboratory-confirmed for 105 (78.4%) of the 134 outbreaks. Of the 105 outbreaks with a laboratory-confirmed etiology, 68 (64.8%) were caused by parasites, 22 (21.0%) by bacteria, five (4.8%) by viruses, nine (8.6%) by chemicals or toxins, and one (1.0%) by multiple etiology types. *Cryptosporidium* was confirmed as the etiologic agent

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of 60 (44.8%) of 134 outbreaks, resulting in 12,154 (87.0%) cases; 58 (96.7%) of these outbreaks, resulting in a total of 12,137 (99.9%) cases, were associated with treated recreational water. A total of 32 pool chemical–associated health events that occurred in a public or residential setting were reported to WBDOSS by Maryland and Michigan. These events resulted in 48 cases of illness or injury; 26 (81.3%) events could be attributed at least partially to chemical handling errors (e.g., mixing incompatible chemicals). ATSDR's Hazardous Substance Emergency Events Surveillance System received 92 reports of hazardous substance events that occurred at aquatic facilities. More than half of these events (55 [59.8%]) involved injured persons; the most frequently reported primary contributing factor was human error. Estimates based on CPSC's National Electronic Injury Surveillance System (NEISS) data indicate that 4,574 (95% confidence interval [CI]: 2,703–6,446) emergency department (ED) visits attributable to pool chemical–associated injuries occurred in 2008; the most frequent diagnosis was poisoning (1,784 ED visits [95% CI: 585–2,984]). NEISS data indicate that pool chemical–associated health events occur frequently in residential settings. A total of 236 *Vibrio* wound infections were reported to be associated with recreational water exposure; 36 (48.6%) of the 74 hospitalized vibriosis patients and six (66.7%) of the nine vibriosis patients who died had *V. vulnificus* infections. Eight fatal cases of PAM occurred after exposure to warm untreated freshwater.

Interpretations: The 134 recreational water–associated outbreaks reported for 2007–2008 represent a substantial increase over the 78 outbreaks reported for 2005–2006 and the largest number of outbreaks ever reported to WBDOSS for a 2-year period. Outbreaks, especially the largest ones, were most frequently associated with treated recreational water and characterized by AGI. *Cryptosporidium* remains the leading etiologic agent. Pool chemical–associated health events occur frequently but are preventable. Data on other select recreational water–associated health events further elucidate the epidemiology of U.S. waterborne disease by highlighting less frequently implicated types of recreational water (e.g., oceans) and detected types of recreational water–associated illness (i.e., not AGI).

Public Health Actions: CDC uses waterborne disease outbreak surveillance data to 1) identify the types of etiologic agents, recreational water venues, and settings associated with waterborne disease outbreaks; 2) evaluate the adequacy of regulations and public awareness activities to promote healthy and safe swimming; and 3) establish public health priorities to improve prevention efforts, guidelines, and regulations at the local, state, and federal levels.

Introduction

During 1920–1970, data on waterborne disease outbreaks in the United States were collected by multiple researchers and federal agencies (*1*). Since 1971, CDC, the U.S. Environmental Protection Agency (EPA), and the Council of State and Territorial Epidemiologists (CSTE) have collaborated on the Waterborne Disease and Outbreak Surveillance System (WBDOSS), which tracks outbreaks associated with drinking water and other water exposures (*2–12*). Data on outbreaks associated with recreational water have been collected by WBDOSS* since 1978 (*13–15*). Data on 2007–2008 outbreaks associated with drinking water are presented separately (*16*).

Since 1978, surveillance activities have expanded to include multiple types of outbreaks and other health events associated with recreational water. Recreational water–associated outbreaks of Pontiac fever (PF) were first included in the 1981 surveillance summary (*17*); recreational water–associated outbreaks of Legionnaires' disease (LD) were added in the 2001–2002 surveillance summary; however, no LD outbreaks were reported for those years (*15*). Data on single cases of recreational water–associated vibriosis were first added to the 2003–2004 surveillance summary (*14*). Pool chemical–associated health events reported to CDC were first included in the 2005–2006 surveillance summary (*13*). Agency for Toxic Substances and Disease Registry (ATSDR) and U.S. Consumer Product Safety Commission (CPSC) data on pool chemical–associated health events have been added to this 2007–2008 surveillance summary.

The data provided in this report represent only a portion of the burden of illness and injury associated with recreational water. They do not include endemic waterborne disease cases (i.e., sporadic cases not known to be associated with an outbreak), all types of other recreational water–associated health events, nor estimates of the number of unrecognized and unreported waterborne disease outbreaks or other health events.

* Available at http://www.cdc.gov/healthywater/statistics/wbdoss/index.html.

Background

Regulation of Recreational Water Quality

In the United States, state and local governments establish and enforce regulations for protecting recreational water from naturally occurring and human-made contaminants. No federal regulatory agency has authority over treated recreational water (e.g., pools and interactive fountains), and no minimum federal design, construction, operation, disinfection, or filtration standards exist, except the Virginia Graeme Baker Pool and

Spa Safety Act (15 U.S.C. §§ 8001 et seq.), which aims to prevent entrapment. Swimming pool codes are developed and enforced by individual state and local public health agencies, resulting in substantial variation across the country in terms of regulation, compliance, and enforcement.

EPA sets water quality guidelines for natural, untreated recreational water (e.g., lakes, rivers, and oceans). In 1986, EPA developed recommended bacterial water quality criteria for coastal recreational waters (*18*) and, in 2004, established federal standards for those states and territories that had not yet adopted water quality criteria that met or exceeded the 1986 criteria (*19*). For freshwater, full-body contact beaches (e.g., lakes and rivers), EPA recommends that the monthly geometric mean water quality indicator concentration be <33 CFU/100mL for enterococci or <126 CFU/100mL for *Escherichia coli*. For marine water, full-body contact beaches, EPA recommends that the monthly geometric mean water quality indicator concentration be <35 CFU/100mL for enterococci. However, state and local jurisdictions have discretionary authority to adopt specific criteria for a designated use, determine the extent and frequency of monitoring and testing, and choose which interventions should be implemented when state limits are exceeded (e.g., posting signs to alert visitors to water contamination or closing the beach to swimmers). EPA provides grants to eligible coastal and Great Lakes states to help them implement programs to monitor water quality at the beach and to notify the public when problems are detected. Beach Watch, EPA's Action Plan for Beaches and Recreational Waters, was published in 1999 as part of the Clean Water Action Plan. The mission of Beach Watch is to assist state, tribal, and local authorities in strengthening and extending existing programs to protect users of fresh and marine recreational waters. Congress enacted the BEACH Act of 2000 (33 U.S.C. §§ 1346 and 1375a), which directed EPA to update its guidelines for recreational water use on the basis of improved water quality indicators and testing. To this end, since 2002, EPA has been collaborating with CDC on the National Epidemiologic and Environmental Assessment of Recreational (NEEAR) Water Study.

Methods

Data Sources

Public health agencies in the states, the District of Columbia (DC), U.S. territories, and the Freely Associated States (FAS)[†] have the primary responsibility for detecting and investigating waterborne disease outbreaks, which they report voluntarily to CDC using a standard form (CDC 52.12).[§] The form solicits data on characteristics of outbreaks (e.g., number of cases, time, and location), results from epidemiologic and environmental investigations, and results from clinical specimen and water sample testing. CDC annually requests reports of outbreaks from persons designated as waterborne disease coordinators and obtains additional information regarding epidemiologic investigations, water quality, and water treatment to supplement submitted outbreak reports as needed. Data on all of the outbreaks in this summary were collected through paper-based reporting. Numeric and text data are abstracted from outbreak report forms and supporting documents and analyzed by using SAS 9.2 (SAS Institute, Inc. Cary, North Carolina).

National reporting includes only data on waterborne disease outbreaks. Data on pool chemical–associated health events that occurred in a public or residential setting and on single cases of primary amebic meningoencephalitis (PAM) caused by *Naegleria fowleri* also are solicited from coordinators.

To ensure completeness of legionellosis outbreak data, CDC reviewed and compared data from WBDOSS with data from the Travel-Associated Legionellosis in the United States System. In addition, legionellosis outbreak data were abstracted from historic Epidemic Intelligence Service outbreak investigation reports and peer-reviewed publications and entered into the WBDOSS database.

Other data presented in this surveillance summary have been reported to ATSDR's Hazardous Substance Emergency Events Surveillance (HSEES) System,[¶] CPSC's National Electronic Injury Surveillance System (NEISS), and CDC's Cholera and Other *Vibrio* Illness Surveillance (COVIS) System. For this report, the HSEES database was searched for data on hazardous substance events that occurred at aquatic facilities during 2007–2008. To identify such events, comment and synopsis variables were queried for the terms "pool," "Jacuzzi," "spa," "hot tub," "whirlpool," "chlorine," "fountain," and "water park" (*20*). Although "chlorine" was the only chemical term queried, other chemicals were not excluded from the analysis. Only events that occurred on-site at aquatic facilities, regardless of setting (e.g., hotel/motel or waterpark), were included in the analysis. Events that were caused by pool chemicals but did not occur on-site at aquatic facilities (e.g., at a warehouse) were excluded. NEISS captures data on emergency department (ED) visits for injuries associated with consumer products, specifically diagnosis and patient demographic data. The methodology for analysis of NEISS data on pool chemical–associated health events and the findings of a detailed analysis of 2007 NEISS data are presented elsewhere (*21*); this report includes a summary of 2008 NEISS data. Data on cases of

[†] Comprising the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau; formerly part of the U.S.-administered Trust Territory of the Pacific Islands.

[§] Available at http://www.cdc.gov/healthywater/statistics/wbdoss/nors/forms_archive.html.

[¶] Participating states: Colorado, Florida, Iowa, Louisiana, Michigan, Minnesota, North Carolina, New Jersey, New York, Oregon, Texas, Utah, Washington, and Wisconsin.

vibriosis are reported to CDC by use of a COVIS report form.** Vibriosis was added to the list of nationally notifiable diseases in January 2007 and is reportable in 50 states. As described previously, this report summarizes COVIS System data on cases with a reported recreational water exposure but no reported seafood consumption (*14*). Cases reported to have occurred in another jurisdiction were reassigned to the jurisdiction of exposure for analysis.

Definitions

Waterborne Disease Outbreak

Two criteria must be met for a health event to be defined as a waterborne disease outbreak associated with recreational water: 1) two or more persons must be linked epidemiologically by time, location of exposure to water, and illness characteristics, and 2) the epidemiologic evidence must implicate recreational water or volatilization of water-associated compounds into the air surrounding the water as the probable source of illness. Outbreak reports with limited or no environmental data might be included in WBDOSS, but outbreak reports that lack epidemiologic data linking the outbreak to water are excluded. Two outbreak reports that were received are not included in this summary. After swimming in April 2008, a total of 13 members of a swim team in Florida developed AGI caused by norovirus. However, the epidemiologic evidence implicated a restaurant in which they had shared a meal. An outbreak of cryptosporidiosis in Maine in July 2007 among four persons who swam in a residential pool was not included because other common exposures could not be ruled out.

Recreational water venues include but are not limited to pools, interactive fountains, spas (or hot tubs), waterslides, and fresh or marine bodies of water. For this report, outbreaks are categorized by association with treated or untreated recreational water and by location of the water exposure (i.e., not on state of residence of the ill persons). Waterborne disease outbreaks occurring on cruise ships are not reported to WBDOSS; CDC's Vessel Sanitation Program tracks outbreaks of acute gastrointestinal illness (AGI) occurring on cruise ships (*22*).

Other Recreational Water–Associated Health Events

Other recreational water–associated health events that do not meet the definition of an outbreak associated with recreational water are included in this summary because of their implications to the health and safety of the swimming public and aquatics staff. Some pool chemical–associated health events reported to WBDOSS do not meet the outbreak definition (i.e., one case identified or not associated with recreational water). The HSEES System and NEISS do not focus on water exposure, and whether pool chemical–associated health events reported to these systems involved recreational water exposure is not always clear. Consequently, some pool chemical–associated health events reported to WBDOSS, the HSEES System, and NEISS are analyzed and presented separately from outbreak data.

Additional terms used in this report are defined elsewhere (Appendix A).

Strength-of-Evidence Classification for Waterborne Disease Outbreaks

In this report, all outbreaks reported to WBDOSS for 2007–2008 have been classified according to the strength of 1) epidemiologic and clinical laboratory data and 2) environmental data implicating water as the vehicle of transmission (Table 1). The classification (i.e., Classes I–IV) of outbreak investigations in this report is based on the epidemiologic and environmental data reported to WBDOSS. These classes were first delineated in the 1989–1990 surveillance report (*10*) and have since been updated.

Outbreaks and subsequent investigations occur under different circumstances, and not all outbreaks can be investigated rigorously. Classifications of II, III, or IV do not necessarily imply that the investigation was inadequate or incomplete because multiple factors (e.g., timeliness of outbreak detection) contribute to the ability to collect optimal epidemiologic, clinical laboratory, and environmental data.

Changes in 2007–2008 Surveillance Summary

Strength-of-Evidence Classification

Molecular epidemiology is being used increasingly to understand pathogen transmission patterns, detect outbreaks, and identify important risk factors and outbreak sources. The criteria used to determine the strength-of-evidence classifications have been revised to reflect the increasing use of molecular characterization of pathogens identified in clinical specimens and environmental samples collected during outbreak investigations. Molecular data that link multiple persons who had an identical water exposure now are considered adequate epidemiologic data to support a Class I or Class II assignment; previously, epidemiologic study data were required to receive a strength-of-evidence classification of I or II. Molecular data that link at least one person to the implicated water exposure now are considered adequate water quality data to support a Class I or Class III assignment. In this

** Available at http://www.cdc.gov/nationalsurveillance/PDFs/CDC5279_COVISvibriosis.pdf.

TABLE 1. CDC strength-of-evidence classification of investigations of waterborne disease outbreaks — United States

Class	Epidemiologic and clinical laboratory data	Environmental data
I	**Provided and adequate**	**Provided and adequate**
	Epidemiologic data provided about exposed and unexposed persons, with relative risk or odds ratio ≥2 or p-value ≤0.05; or	Laboratory data or historic information (e.g., history of a chlorinator or acid feed pump malfunction, no detectable free-chlorine residual, or a breakdown in circulation system); or
	Molecular characterization of pathogens linked multiple persons who had a single identical exposure	Molecular characteristics of pathogens isolated from water and at least one clinical specimen were identical
II	**Provided and adequate**	**Not provided or inadequate**
	Epidemiologic data provided about exposed and unexposed persons, with relative risk or odds ratio ≥2 or p-value ≤0.05; or	E.g., laboratory testing of water not conducted and no historic information available
	Molecular characterization of pathogens linked multiple persons who had a single identical exposure	
III	**Provided but limited**	**Provided and adequate**
	Epidemiologic data provided that did not meet the criteria for Class I or II or claim made that ill persons had no exposures in common, besides water, but no data provided	Laboratory data or historic information (e.g., history of a chlorinator or acid feed pump malfunction, no detectable free-chlorine residual, or a breakdown in circulation system); or
		Molecular characteristics of pathogens isolated from water and at least one clinical specimen were identical
IV	**Provided but limited**	**Not provided or inadequate**
	Epidemiologic data provided that did not meet the criteria for Class I or II or claim made that ill persons had no exposures in common, besides water, but no data provided	E.g., laboratory testing of water not conducted and no historic information available

report, the previously used categories "epidemiologic data" and "water quality data" have been renamed "epidemiologic and clinical laboratory data" and "environmental data," respectively.

Number of Cases

For this surveillance summary, case counts were based on the estimated number of total cases if sufficient supporting evidence was provided. For example, this might include applying the attack rate found during a cohort study to the entire population exposed to contaminated water to estimate the total number of ill persons associated with an outbreak. If no "estimated ill" number was provided, the actual number of reported cases (e.g., laboratory-confirmed and probable cases as reported by the coordinator) was used. CDC requests that coordinators report only cases with primary exposure to water, so secondary cases (e.g., those resulting from person-to-person transmission among household members) are not included in case counts of waterborne disease outbreaks in WBDOSS.

Results

Waterborne Disease Outbreaks

A total of 134 outbreaks associated with recreational water (84 in 2007 and 50 in 2008) were reported to CDC by 38 states and Puerto Rico (Tables 2–5; Figure 1). These 134 outbreaks resulted in at least 13,966 cases of illness (Table 6); the median number of cases associated with an outbreak was 11 (range: 2–5,697 cases). Minnesota reported 12 outbreaks, Florida reported 11, and New York reported eight. Short narratives on select outbreaks are provided in Appendix B.

Treated recreational water venues were associated with 116 (86.6%) outbreaks (Figure 2), resulting in 13,480 (96.5%) cases; the median number of cases in these outbreaks was 10.5 (range: 2–5,697 persons) (Tables 2 and 3). Of the 116 outbreaks, 50 (43.1%) were associated with exposures in settings in which recreational water was not the focus of activities (i.e., apartment complex, assisted living facility, child care center, farm, hotel/motel, membership club, school, or zoo).

Untreated venues were associated with the remaining 18 (13.4%) outbreaks (Figure 2), resulting in 486 (3.5%) cases; the median number of cases in these outbreaks was 13 (range: 2–200) (Tables 4 and 5). Of these 18 outbreaks, 15 (83.3%) were associated with fresh water and three (16.7%) with marine water.

The 134 outbreaks occurred in every calendar month (Figure 3); 83 (61.9%) started during June, July, or August. The route of entry implicated for each outbreak was ingestion for 81 outbreaks (60.4%), contact for 25 (18.7%), inhalation for 18 (13.4%), combined routes for six (4.5%), and unknown for four (3.0%) (Figure 2).

Illness and Etiologies

Of the 134 outbreaks, 81 (60.4%) were of AGI; 24 (17.9%) of dermatologic illnesses, conditions, or symptoms; 17 (12.7%) of acute respiratory illness (ARI); one (0.7%) of ear-related illnesses, conditions, or symptoms; and one (0.7%) of other

TABLE 2. Waterborne disease outbreaks associated with treated recreational water (n = 74), by state/jurisdiction — Waterborne Disease and Outbreak Surveillance System, United States, 2007

State/ Jurisdiction	Month	Class*	Etiology	Predominant illness†	No. of cases§ (n = 10,749)	Venue	Setting
Alabama	Aug	IV	*Cryptosporidium*	AGI	5	Fill-and-drain pool	Child care center
California	Apr	IV	*Escherichia coli* O157:H7	AGI	11	Temporary waterslide	Private residence
California	Jun	IV	Norovirus genogroup II	AGI	6	Interactive fountain	Community/Municipality
California	Sep	III	*Cryptosporidium*	AGI	2	Pool	Aquatic facility
Florida	Jun	IV	*Cryptosporidium*	AGI	25	Interactive fountain	Community/municipal park
Florida	Jul	IV	Unidentified¶	AGI	6	Interactive fountain	Zoo
Florida	Aug	IV	*Cryptosporidium*	AGI	8	Pool	Neighborhood/Subdivision
Florida	Aug	III	Chlorine gas	ARI	13	Pool	Apartment complex
Florida	Sep	IV	*Cryptosporidium parvum*	AGI	8	Wading pool	Waterpark
Georgia	Apr	IV	Unidentified	Skin	2	Spa	Unknown
Georgia	Aug	IV	*Cryptosporidium*	AGI	6	Pool, temporary waterslide	Neighborhood/Subdivision, private residence
Idaho	May	II	Norovirus genogroup II	AGI	50	Pool, wading pool	Community/Municipality
Idaho	Jun	III	*E. coli* O157:H7	AGI	31	Interactive fountain	Community/Municipality
Idaho	Jul	I	*Cryptosporidium hominis*	AGI	2,000	Interactive fountain	Community/Municipality
Idaho	Aug	II	*C. hominis*	AGI	32	Interactive fountain	Community/Municipality
Illinois	Aug	IV	*Cryptosporidium*	AGI	6	Wading pool	Membership club
Illinois	Aug	IV	*Cryptosporidium*	AGI	4	Pool	Community/Municipality
Indiana	May	IV	Unidentified	ARI, AGI	9	Pool, spa	Private residence
Iowa	Jan	IV	Unidentified	Skin	4	Spa	Hotel/Motel
Iowa	Jan	I	Unidentified**	Skin	20	Pool, spa	Hotel/Motel
Iowa	Feb	IV	Unidentified**	Skin	10	Spa	Hotel/Motel
Iowa	Jun	I	*Cryptosporidium*	AGI	238	Pool, wading pool	Community, membership club
Iowa	Aug	IV	*Cryptosporidium*	AGI	34	Pool	Community/Municipality
Kansas	Mar	IV	Unidentified	Skin	5	Pool	Community/Municipality
Kansas	Jun	IV	*Cryptosporidium*	AGI	79	Pool, interactive fountains	Waterpark, community, private residence, hotel/motel
Kansas	Jul	IV	*Cryptosporidium*	AGI	43	Pools	Community/Municipality
Kentucky	May	IV	*Cryptosporidium*	AGI	131	Pools	Community/Municipality
Maryland	Aug	III	Chlorine gas	ARI	2	Pool	Membership club
Massachusetts	Aug	IV	*Giardia intestinalis*	AGI	10	Pool	Membership club
Michigan	Nov	IV	Unidentified	Skin	2	Pool	Hotel/Motel
Michigan	Dec	III	Unidentified	Skin	2	Pool	Hotel/Motel
Minnesota	May	IV	Unidentified††	Skin, ARI, Eye	4	Pool	Hotel/Motel
Minnesota	Jun	IV	Unidentified††	Skin	7	Wading pool	Community/Municipality
Minnesota	Jul	II	*C. parvum*	AGI	20	Pool	Membership club
Minnesota	Sep	I	*C. hominis*	AGI	58	Pools	Waterpark
Minnesota	Nov	III	*Pseudomonas aeruginosa*	Skin	5	Spa	Hotel/Motel
Minnesota	Nov	I	*P. aeruginosa*	Ear	6	Pool, spa	Hotel/Motel
Minnesota	Nov	II	*C. hominis*	AGI	31	Pool	Membership club
Minnesota	Dec	III	Unidentified††	Skin	3	Spa	Hotel/Motel
Mississippi	Aug	III	*Cryptosporidium*	AGI	11	Pool	Neighborhood/Subdivision
Missouri	Jun	IV	*Cryptosporidium*	AGI	15	Wading pool	Community/Municipality
Nebraska	Jul	IV	*Cryptosporidium*	AGI	2	Pool	Community/Municipality
Nebraska	Jul	IV	*Cryptosporidium*	AGI	3	Pool	Waterpark
Nebraska	Jul	IV	*Cryptosporidium*	AGI	3	Pool	Community/Municipality
Nebraska	Aug	IV	*Cryptosporidium*	AGI	6	Pool	Hotel/Motel
Nebraska	Sep	IV	*Cryptosporidium*	AGI	2	Pool	Private residence
New Hampshire	Feb	IV	Unidentified**	Skin	4	Spa	Hotel/Motel
New York	Jan	IV	Unidentified	Skin	25	Pool	Waterpark
New York	Jul	IV	Unidentified††	ARI	8	Spa	Membership club
Ohio	Jan	I	Chloramines, endotoxins	ARI, Eye	665	Pool, interactive fountain, spa	Waterpark
Ohio	Mar	IV	Unidentified**	Skin	2	Spa	Membership club
Ohio	Mar	II	Unidentified	Skin	31	Pool	Hotel/Motel
Ohio	Oct	III	*Legionella pneumophila* serogroup 1	ARI	2	Pool, spa	Hotel/Motel
Oklahoma	Jul	I	*C. hominis*	AGI	93	Pool	Community§§
Oklahoma	Jul	I	*C. parvum*	AGI	17	Pool	State park
Pennsylvania	Apr	III	*Cryptosporidium*	AGI	76	Pool	Membership club
Pennsylvania	Jun	IV	*C. parvum*	AGI	730	Pool	Community/Municipality
Pennsylvania	Jun	IV	*G. intestinalis*	AGI	3	Fill-and-drain pool	Private residence

See table footnotes on page 7.

TABLE 2. (*Continued*) Waterborne disease outbreaks associated with treated recreational water (n = 74), by state/jurisdiction — Waterborne Disease and Outbreak Surveillance System, United States, 2007

State/ Jurisdiction	Month	Class*	Etiology	Predominant illness†	No. of cases§ (n = 10,749)	Venue	Setting
Pennsylvania	Jul	III	*Cryptosporidium*	AGI	51	Pool	Camp/Cabin
Pennsylvania	Jul	IV	*C. parvum*	AGI	39	Pool	Membership club
Puerto Rico	Aug	II	*C. hominis*	AGI	107	Interactive fountain	Waterpark
Tennessee	May	IV	*L. pneumophila* serogroup 1	ARI	2	Spa	Hotel/Motel
Tennessee	Jul	IV	*Shigella*	AGI	17	Pool, temporary waterslide	Camp/Cabin
Tennessee	Jul	IV	*Cryptosporidium*	AGI	18	Pool	Community/Municipality
Tennessee	Jul	IV	*Cryptosporidium*	AGI	16	Splash pad	Waterpark
Tennessee	Aug	IV	*C. hominis*	AGI	24	Pool	Private residence
Utah	May	I	*Cryptosporidium*	AGI	5,697	Pools	Community/Municipality
Virginia	Jul	IV	*G. intestinalis*	AGI	6	Pool	Community/Municipality
Washington	Aug	IV	*Cryptosporidium*	AGI	14	Pool	Membership club
West Virginia	Apr	II	Unidentified**	Skin	15	Wading pool	Community/Municipality
West Virginia	Nov	IV	Unidentified	Skin	7	Spa	Camp/Cabin
Wisconsin	Aug	IV	*Cryptosporidium*	AGI	35	Pool	Community/Municipality
Wisconsin	Aug	IV	*Cryptosporidium*	AGI	38	Pool	Aquatic facility
Wyoming	Jul	IV	*Cryptosporidium*	AGI	27	Pool	Community/Municipality

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Ear = illnesses, conditions, or symptoms related to the ears; Eye = illnesses, conditions, or symptoms related to the eyes; Skin = illnesses, conditions, or symptoms related to the skin.
* On the basis of epidemiologic and clinical laboratory data, and environmental data (see Table 1) provided to CDC.
† The category of illness reported by ≥50% of ill respondents.
§ No deaths were reported in cases associated with outbreaks reported during 2007.
¶ Etiology unidentified: *Cryptosporidium* suspected on the basis of clinical diagnoses of secondary cases.
** Etiology unidentified: *P. aeruginosa* suspected on the basis of clinical syndrome and setting.
†† Etiology unidentified: contamination from excess chlorine levels, pool disinfection by-products (e.g., chloramines), or altered pool chemistry suspected.
§§ The implicated pool was located at a membership club but functioned as a community pool.

illness (Table 6; Figure 2). The remaining 10 (7.5%) outbreaks were of combined illness types, nine of which included ARI. Outbreaks of AGI accounted for 12,477 (89.3%) of the total outbreak-related cases; 64 (79.0%) of the 81 AGI outbreaks started during June, July, or August (Figures 3 and 4).

The etiologic agent was confirmed for 105 (78.4%) outbreaks (Table 7; Figure 2). Of the outbreaks with a confirmed etiology, 68 (64.8%) were caused by parasites; 22 (21.0%) by bacteria; five (4.8%) by viruses; nine (8.6%) by chemicals or toxins; and one (1.0%) by multiple etiology types. Outbreaks caused by parasites accounted for almost 50 times more cases than those caused by bacteria (12,492 and 254, respectively). Of the 90 outbreaks associated with treated recreational water and caused by an identified etiologic agent: 62 (68.4%) were caused by parasites, 18 (20.0%) by bacteria, eight (8.9%) by chemicals or toxins, and two (2.2%) by viruses (Table 7). Of the 15 outbreaks associated with untreated recreational water and caused by an identified etiologic agent, six (40.0%) were caused by parasites, four (26.7%) by bacteria, three (20.0%) by viruses, one (6.7%) by multiple pathogen types, and one (6.7%) by a toxin.

Parasites

All 62 outbreaks associated with treated recreational water and caused by parasites were outbreaks of AGI. A total of 58 (93.5%) outbreaks were caused by *Cryptosporidium*, resulting in 12,137 cases. Some of the cryptosporidiosis outbreaks were communitywide outbreaks. A communitywide cryptosporidiosis outbreak typically starts as a focal outbreak associated with one recreational water venue and evolves into an outbreak associated with multiple recreational water venues or other settings (e.g., child care centers). As the outbreak progresses, recreational water exposure might decrease in its importance as a risk factor while secondary transmission (i.e., contact with an infected person) might become increasingly important. The statewide cryptosporidiosis outbreak in Utah in 2007 is an example of a communitywide cryptosporidiosis outbreak. Of the remaining four outbreaks of parasitic disease associated with treated recreational water, three were caused by *Giardia intestinalis*, and one was caused by both *Cryptosporidium* and *Giardia*. A July 2007 outbreak associated with a Florida interactive fountain is suspected, on the basis of common exposures to the implicated interactive fountain of persons with primary cases and diagnostic laboratory

TABLE 3. Waterborne disease outbreaks associated with treated recreational water (n = 42), by state — Waterborne Disease and Outbreak Surveillance System, United States, 2008

State	Month	Class*	Etiology	Predominant illness†	No. of cases§ (n = 2,731)	Venue	Setting
Alabama	May	IV	*Legionella pneumophila* serogroup 1	ARI	3	Spa	Hotel/Motel
Arizona	Jun	I	*Cryptosporidium hominis*	AGI	57	Pool	Community/Municipality
Arizona	Jul	III	*C. hominis*	AGI	9	Interactive fountain	Waterpark
Arizona	Jul	I	*Cryptosporidium*	AGI	13	Pool	Community/Municipality
California	Jun	IV	*Cryptosporidium*	AGI	11	Pool	Membership club
California	Aug	IV	*Cryptosporidium*	AGI	5	Pool, interactive fountain	Community/municipal park
Florida	Mar	I	*Legionella*	ARI	5	Spa	Hotel/Motel
Florida	Jun	III	*L. pneumophila* serogroup 1	ARI	3	Spa	Membership club
Florida	Aug	IV	*Cryptosporidium parvum*	AGI	13	Pool	Membership club
Idaho	Jul	IV	*Cryptosporidium*	AGI	2	Pool	Community/Municipality
Illinois	Jan	III	Chlorine	ARI, Skin, Eye	20¶	Wading pool	Waterpark
Illinois	May	I	*L. pneumophila* serogroup 1	ARI	3	Pool, spa	Hotel/Motel
Iowa	Aug	IV	*Cryptosporidium*	AGI	24	Pool	Community/Municipality
Iowa	Nov	III	Unidentified	AGI	10	Pool	Hotel/Motel
Kansas	Jun	IV	*Cryptosporidium*	AGI	6	Pool	Community/Municipality
Kansas	Oct	II	*C. hominis*	AGI	22	Pool	Hotel/Motel
Kentucky	Jul	III	Hydrochloric acid	ARI, AGI	5	Pool	Waterpark
Maryland	Jul	IV	*Shigella sonnei*	AGI	12	Temporary waterslide, dunk tank	Farm
Massachusetts	Mar	IV	Unidentified**	Skin	50	Pool	Waterpark
Michigan	Apr	IV	Unidentified**	ARI, AGI	4	Pool	Hotel/Motel
Michigan	May	IV	Unidentified**	ARI, AGI	5	Pool	Hotel/Motel
Michigan	Aug	IV	*Cryptosporidium*	AGI	3	Pool	Neighborhood/Subdivision
Michigan	Aug	IV	Unidentified**	ARI	2	Pool	Waterpark
Minnesota	Apr	II	*C. parvum*	AGI	12	Pool	Membership club
Minnesota	Aug	II	*C. hominis*	AGI	12	Pools	Waterpark
Minnesota	Sep	II	*C. hominis, Giardia intestinalis*	AGI	19	Pools	Membership club
New Jersey	Jan	IV	*Legionella*	ARI	98	Spa	Community
New Mexico	Jul	III	*C. hominis*	AGI	89	Pool	Community/Municipality
New York	Apr	I	*Pseudomonas aeruginosa*	Skin	23	Spa	Hotel/Motel
New York	Jun	III	Chlorine gas	ARI, Eye	6	Pool	Membership club
New York	Jul	IV	*Cryptosporidium*	AGI	3	Pool	Community/Municipality
New York	Aug	III	Pool chemical††	ARI	19	Wave pool	Waterpark
New York	Aug	III	Chlorine	ARI	2	Pool	School
New York	Aug	III	Unidentified **	ARI, Eye	29	Pool	School
Ohio	Jul	III	*L. pneumophila* serogroup 1	ARI	2	Spa	Hotel/Motel
Ohio	Jul	IV	*Cryptosporidium*	AGI	8	Pool	Community/Municipality
Oklahoma	Aug	II	*Cryptosporidium*	AGI	44	Pool	Camp
South Carolina	Jan	III	*L. pneumophila* serogroup 1	ARI	2	Spa	Hotel/Motel
Texas	Jun	I	*C. hominis*	AGI	2,050	Lake, pool, interactive fountain	Community/Municipality
Virginia	May	IV	Unidentified§§	Skin	6	Pool, spa	Hotel/Motel
Virginia	Nov	III	*L. pneumophila* serogroup 1	ARI	2	Spa	Assisted living facility
Wisconsin	Feb	II	*P. aeruginosa*	Skin	18	Pool, spa	Hotel/Motel

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Eye = illnesses, conditions, or symptoms related to the eyes; Skin = illnesses, conditions, or symptoms related to the skin.

* On the basis of epidemiologic and clinical laboratory data, and environmental data (see Table 1) provided to CDC.

† The category of illness reported by ≥50% of ill respondents.

§ No deaths were reported in cases associated with outbreaks reported during 2008.

¶ The case count reflects the number of persons who were hospitalized; no data were available on the total number of persons who were ill. An unknown number of persons experienced chemical burns, eye irritation, or gastrointestinal symptoms.

** Etiology unidentified: contamination from excess chlorine levels, pool disinfection by-products (e.g., chloramines), or altered pool chemistry suspected.

†† One or more chemicals in the water caused illness; however, it was unclear which chemical(s) led to illness.

§§ Etiology unidentified: *P. aeruginosa* suspected on the basis of clinical syndrome and setting.

TABLE 4. Waterborne disease outbreaks associated with untreated recreational water (n = 10), by state — Waterborne Disease and Outbreak Surveillance System, United States, 2007

State	Month	Class*	Etiology	Predominant† illness	No. of cases§ (n = 321)	Venue	Setting
California	May	IV	*Plesiomonas shigelloides*	AGI	2	River/Stream	Public outdoor area
Colorado	Jun	IV	*Shigella flexneri* type I	AGI	2	Lake/Reservoir	Public outdoor area
Colorado	Jun	III	Schistosomes	Skin	57	Lake/Reservoir	Community/municipal park
Colorado	Aug	IV	Schistosomes	Skin	200	Lake/Reservoir	Public outdoor area
Florida	Jul	III	*Karenia brevis*	ARI	15	Ocean	Public outdoor area
Florida	Aug	IV	Unidentified	AGI, Skin	2	Ocean	Community/municipal park
New Mexico	Jun	III	Schistosomes	Skin	12	Lake/Reservoir	Public outdoor area
North Dakota	Jul	IV	*Cryptosporidium*	AGI	10	Lake/Reservoir	Camp/cabin
Tennessee	Aug	II	Unidentified	AGI	14	River/Stream	Public outdoor area
Washington	Sep	IV	*Cryptosporidium*	AGI	7	Lake/Reservoir	State park

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Skin = illnesses, conditions, or symptoms related to the skin.
* On the basis of epidemiologic and clinical laboratory data, and environmental data (see Table 1) provided to CDC.
† The category of illness reported by ≥50% of ill respondents.
§ No deaths were reported in cases associated with outbreaks reported during 2007.

TABLE 5. Waterborne disease outbreaks associated with untreated recreational water (n = eight), by state — Waterborne Disease and Outbreak Surveillance System, United States, 2008

State	Month	Class*	Etiology	Predominant illness†	No. of cases§ (n = 165)	Venue	Setting
California	Jun	III	Schistosomes	Skin	31	Ocean	State park
Connecticut	Jul	I	Norovirus genogroup I	AGI	16	Lake/Reservoir	Unknown
Florida	Mar	IV	*Shigella*	AGI	2	Spring	County park
Illinois	Jul	II	*Escherichia coli* O157:H7	AGI	3	Lake/Reservoir	Camp/Cabin
Minnesota	Jul	I	Norovirus	AGI	26	Lake/Reservoir	Camp/Cabin
Ohio	Jul	II	*S. sonnei*, norovirus genogroup I, *Yersinia enterolytica*	AGI	54	Lake/Reservoir¶	Waterpark
Vermont	Jul	IV	Unidentified**	Other	10	Lake/Reservoir	Camp/Cabin
Wisconsin	Jul	IV	Norovirus genogroup I	AGI	23	Lake/Reservoir	Camp/Cabin

Abbreviations: AGI = acute gastrointestinal illness; Skin = illnesses, conditions, or symptoms related to skin; Other = undefined illnesses, conditions, or symptoms.
* On the basis of epidemiologic and clinical laboratory data, and environmental data (see Table 1) provided to CDC.
† The category of illness reported by ≥50% of ill respondents.
§ No deaths were reported in cases associated with outbreaks reported during 2008.
¶ A lake with a sand bottom in a freshwater waterpark setting. Some modifications had been made to the lake to support swimming by patrons of the waterpark.
** Etiology unidentified: reported symptoms were consistent with leptospirosis, but clinical specimens tested negative for *Leptospira* infection.

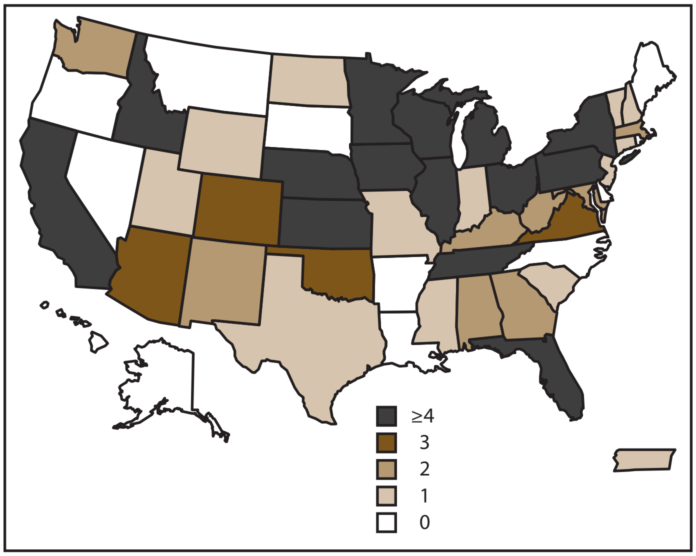
results of persons with secondary cases, to have been caused by *Cryptosporidium*.

Six outbreaks associated with untreated recreational water were caused by parasites including two by *Cryptosporidium*, resulting in 17 cases. Four additional outbreaks of cercarial dermatitis (sometimes called "swimmer's itch") were caused by avian schistosomes; three of these outbreaks were associated with fresh water and one with marine water.

Bacteria

A total of 18 outbreaks were associated with treated recreational water and caused by bacteria. Four were outbreaks of AGI. An April 2007 outbreak, caused by *Escherichia coli* O157:H7 and linked epidemiologically to a temporary inflatable waterslide at a California home, resulted in 11 persons becoming ill. The waterslide was not designed for disinfection or filtration equipment. In June 2007, another outbreak caused by *E. coli* O157:H7 resulted in 31 cases and was linked epidemiologically to an interactive fountain at an Idaho waterpark. An environmental health investigation of the implicated, unregulated recreational water venue noted free chlorine levels <0.5 mg/L (or parts per million [ppm]). A shigellosis outbreak in July 2007 was associated with a pool or temporary inflatable waterslide at a Tennessee camp and resulted in 17 cases. An outbreak in Maryland in July 2008 caused by *Shigella sonnei* that resulted in illness in 12 persons was linked epidemiologically to a waterslide or dunk tank at a farm. Municipal water with no additional disinfection or filtration was used for the recreational water activities. Four outbreaks caused by *Pseudomonas* were each linked epidemiologically to hotel/motel pools or spas and resulted in 52 cases of skin- or ear-related illnesses, conditions, or symptoms. Ten outbreaks

FIGURE 1. Number of waterborne disease outbreaks associated with recreational water (n = 134), by state/jurisdiction — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008*



* Note: These numbers are largely dependent on surveillance and reporting activities in individual states/jurisdictions and do not necessarily indicate the true incidence of waterborne disease outbreaks.

caused by *Legionella* were linked epidemiologically to pools or spas and resulted in 122 persons developing legionellosis (i.e., LD or PF). The largest legionellosis outbreak resulted in 98 cases of PF and was linked epidemiologically to a New Jersey pay-on-entry spa. Exposures leading to seven of the outbreaks occurred in a hotel/motel setting.

Four outbreaks of AGI were caused by bacteria and associated with untreated water. These included two outbreaks caused by *Shigella*, an outbreak caused by *Plesiomonas shigelloides*, and an outbreak caused by *E. coli* O157:H7.

Six additional outbreaks, resulting in a total of 57 cases, had unidentified etiologies but were suspected, on the basis of the clinical symptoms and common exposures to implicated pools or spas, to have been caused by *Pseudomonas*; exposures leading to four of these outbreaks occurred in a hotel/motel setting. An additional outbreak of an unidentified etiology was suspected, on the basis of the clinical symptoms and common exposure to a pond, to have been caused by *Leptospira*.

Viruses

Five outbreaks of AGI had a viral etiology and resulted in 121 cases. Norovirus was identified as the etiologic agent in each of the outbreaks; two were associated with treated water and three with lakes. The two treated venue–associated outbreaks were caused by norovirus genogroup II. One of them occurred in June 2007 and was linked epidemiologically to a California interactive fountain; an environmental health investigation noted inadequacies in facility design. Design plans were not submitted to public health officials for review before construction. Two of the three outbreaks associated with lakes were caused by norovirus genogroup I.

Chemicals/Toxins

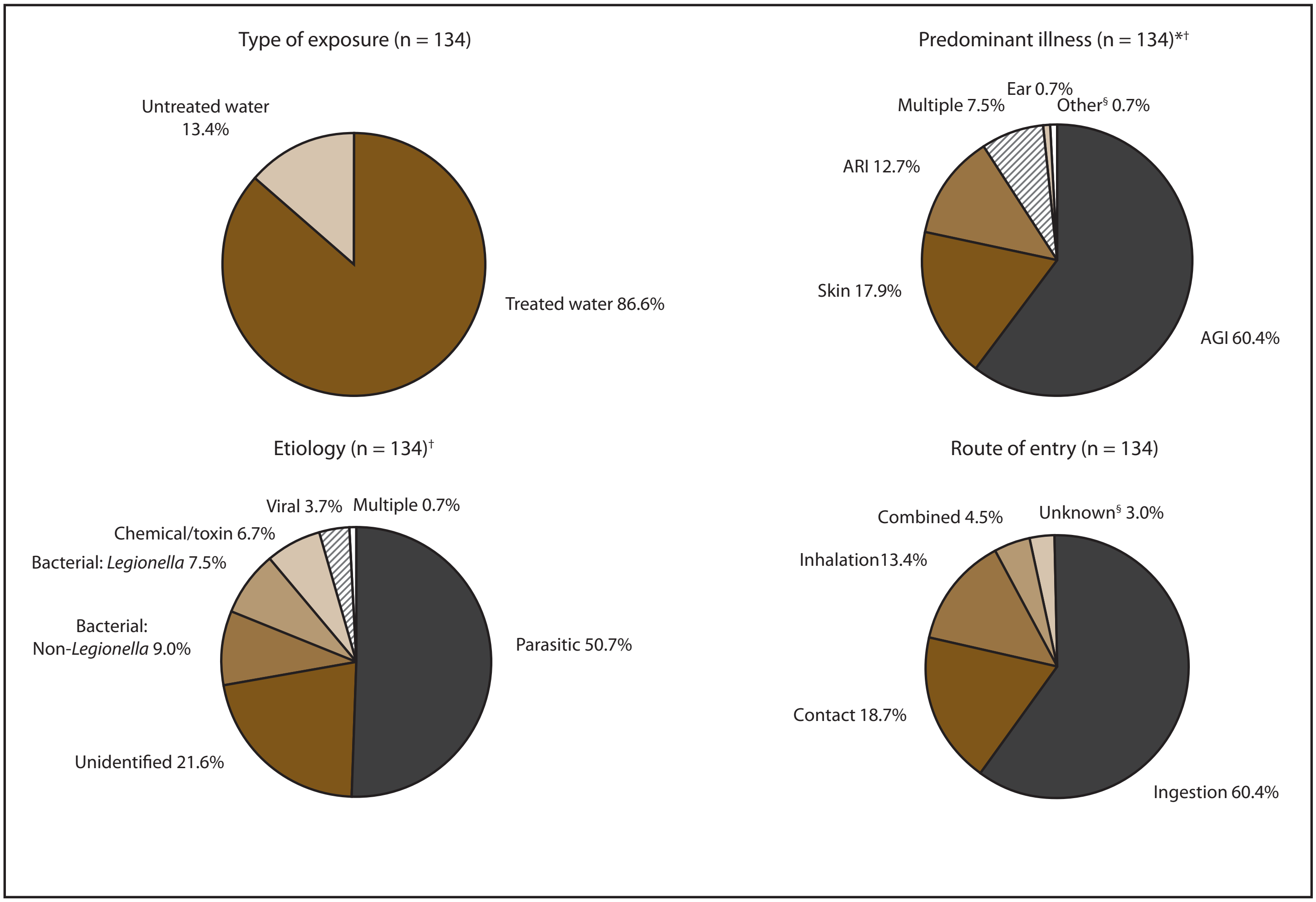
Nine outbreaks associated with chemicals or toxins resulted in a total of 747 cases. The largest outbreak occurred during January–March 2007 and was associated with an indoor Ohio waterpark. Swimmers and employees at the waterpark experienced respiratory and eye irritation. An environmental health investigation revealed elevated trichloramine and endotoxin levels (*23,24*). Three outbreaks were caused by exposure to toxic chlorine gas at pools at one apartment complex and two membership clubs. Environmental health investigations of two of these outbreaks noted that the circulation pump shut down while the chlorine and muriatic (i.e.,

TABLE 6. Number of waterborne disease outbreaks associated with recreational water (n = 134), by predominant illness* and type of water exposure — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008

	Type of exposure					
	Treated		Untreated		Total†	
Predominant illness	Outbreaks	Cases	Outbreaks	Cases	Outbreaks (%)	Cases (%)
AGI	70	12,318	11	159	**81(60.4)**	**12,477 (89.3)**
ARI	16	168	1	15	**17 (12.7)**	**183 (1.3)**
AGI and ARI	4	23	0	0	**4 (3.0)**	**23 (0.2)**
Ear	1	6	0	0	**1 (0.7)**	**6 (0.0)**
Eye and ARI	3	700	0	0	**3 (2.2)**	**700 (5.0)**
Skin	20	241	4	300	**24 (17.9)**	**541 (3.9)**
Skin and AGI	0	0	1	2	**1 (0.7)**	**2 (0.0)**
Skin, ARI, and Eye	2	24	0	0	**2 (1.5)**	**24 (0.2)**
Other	0	0	1	10	**1 (0.7)**	**10 (0.0)**
Total (%)	**116 (86.6)**	**13,480 (96.5)**	**18 (13.4)**	**486 (3.5)**	**134 (100.0)**	**13,966 (100.0)**

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Ear = illnesses, conditions, or symptoms related to the ears; Eye = illnesses, conditions, or symptoms related to the eyes; Skin = illnesses, conditions, or symptoms related to skin; Other = undefined illnesses, conditions, or symptoms.
* The category of illness reported by ≥50% of ill respondents.
† Percentages do not add up to 100.0% due to rounding.

FIGURE 2. Recreational water–associated outbreaks, by type of exposure, predominant illness,* etiology, and route of entry — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008



Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Ear = illnesses, conditions, or symptoms related to the ears; Skin = illnesses, conditions, or symptoms related to the skin; Multiple = a combination of predominant illnesses; Other = undefined illnesses, conditions, or symptoms.

* The category of illness reported by ≥50% of ill respondents.

† Percentages do not add up to 100.0% due to rounding.

§ Etiology was not identified for one outbreak. Reported symptoms were consistent with leptospirosis but clinical specimens tested negative for *Leptospira* infection. Route of transmission was unclear.

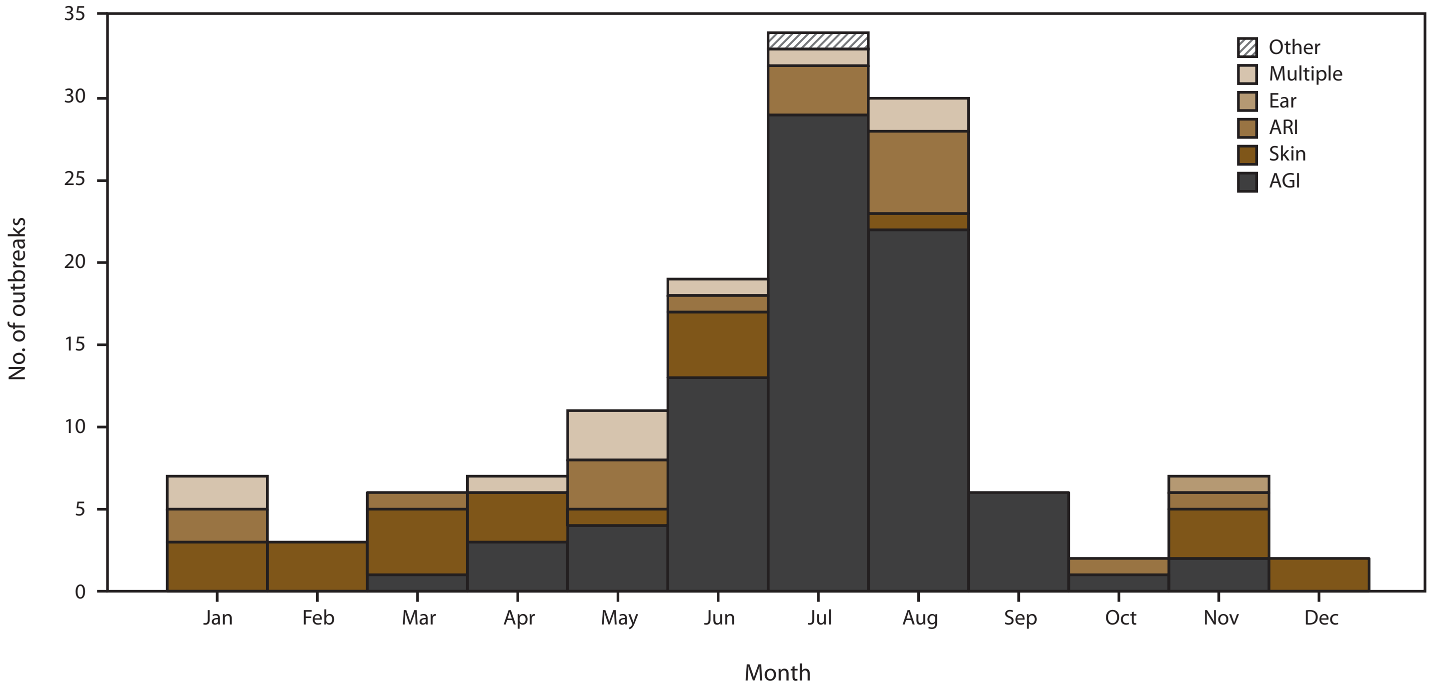
hydrochloric) acid feed pumps continued to run, allowing the chlorine and acid to mix within the circulation system plumbing without dilution, thus generating toxic chlorine gas. When the circulation pumps were restarted, the gas was released into the pools and caused respiratory distress in swimmers. Two outbreaks were attributed to release of excess chlorine caused by issues related to the automatic chemical controllers and poolside water testing. In addition, one outbreak was caused by the release of excess muriatic acid during filter backwash. Another outbreak was caused by one or more pool chemicals; however, which chemical(s) caused the outbreak was unclear. Both outbreaks occurred at outdoor waterparks. The remaining outbreak was linked epidemiologically to untreated water and was caused by exposure to brevetoxins released by algae, specifically *Karenia brevis* (*25*).

Nine additional outbreaks, resulting in 112 cases, of unidentified etiologies were suspected, on the basis of clinical symptoms and common exposures to implicated pools or spas, to have been caused by excessive levels of chlorine, pool disinfection by-products, or altered pool chemistry. Exposures leading to four of these outbreaks occurred in a hotel/motel setting. Two outbreaks, resulting in 79 cases, were suspected to have been caused by chloramines and were associated with an indoor Massachusetts waterpark and an indoor New York school pool.

Previously Unreported Outbreaks

Data on five previously unreported recreational water–associated outbreaks were received (Table 8). Four children at a residential school became ill with AGI after using a

FIGURE 3. Number of waterborne disease outbreaks associated with recreational water (n = 134), by predominant illness* and month — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008



Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Ear = illnesses, conditions, or symptoms related to the ears; Skin = illnesses, conditions, or symptoms related to the skin; Multiple = a combination of predominant illnesses; Other = undefined illnesses, conditions, or symptoms.
* The category of illness reported by ≥50% of ill respondents.

fill-and-drain pool. All four tested positive for *Campylobacter*. Published and unpublished data on four legionellosis outbreaks that were associated with recreational water and occurred during 1993–1999 were added to the WBDOSS database (*26,27*). Three of the legionellosis outbreaks resulted in four deaths; these deaths are included in the respective outbreak case counts. Data on these five outbreaks are summarized but not included in the analysis for this report.

Pool Chemical–Associated Health Events

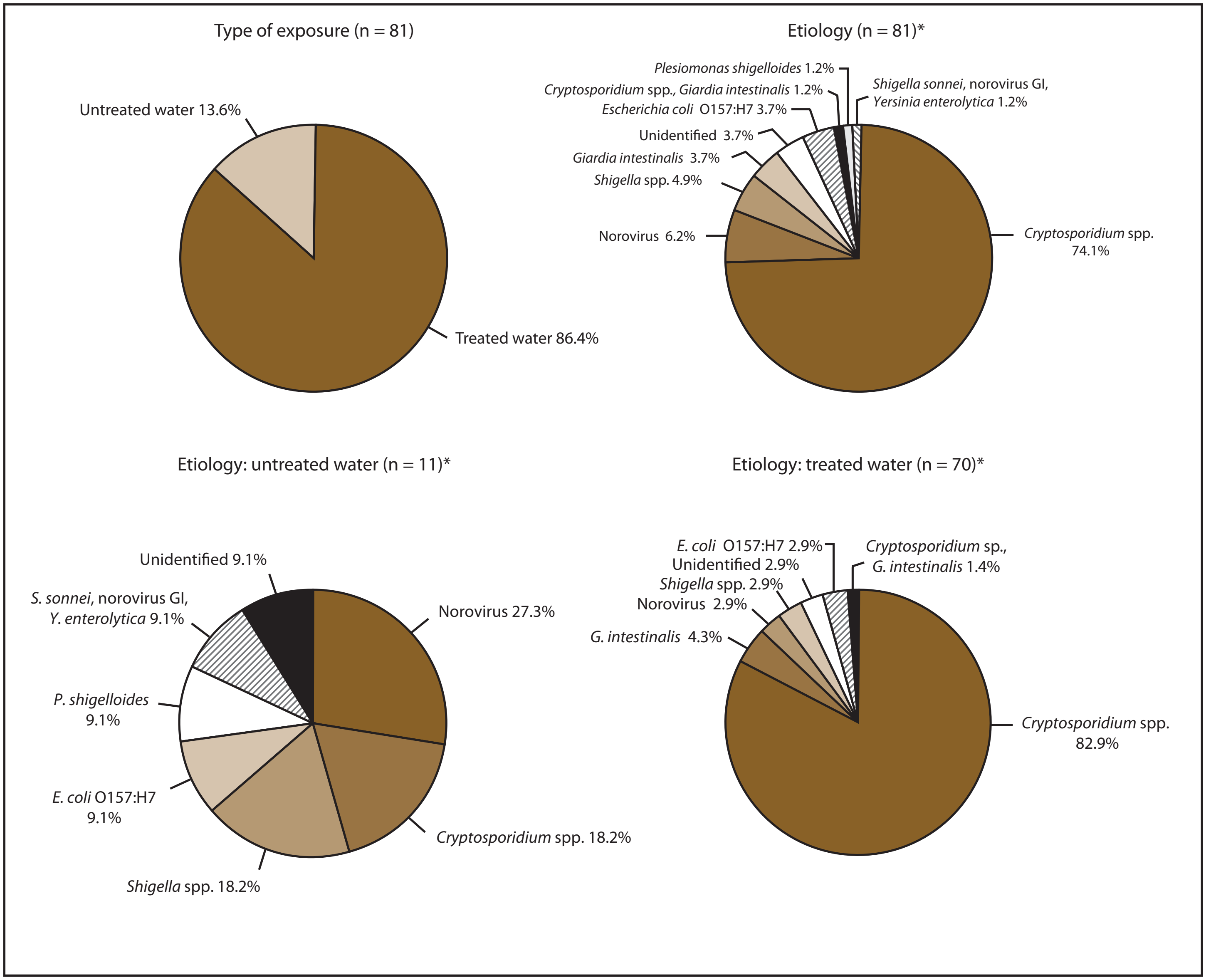
Maryland and Michigan reported 32 pool chemical–associated health events that did not meet the definition of an outbreak associated with recreational water and occurred during 2007–2008 (Table 9). These health events resulted in 48 cases of illness or injury; the median number of cases associated with an event was one (range: 1–15 cases). No deaths were reported. Nineteen (59.3%) of the events resulted in ARI, six (18.8%) in ocular symptoms, three (9.4%) in AGI, and four (12.5%) in ARI and other illness. Almost half (15 [46.9%]) of the events occurred at a private residence. Six (18.8%) occurred at a public setting and 11 (34.4%) at an unknown setting. All six events affecting a single child aged ≤13 years occurred at private residences. Of the 32 events, 26 (81.3%) were the result of pool chemical–exposures that occurred in June, July, or August. Twenty-six (81.3%) events could be attributed at least in part to chemical handling errors, such as mixing incompatible chemicals (e.g., acid and chlorine or different chlorines) and not using personal protective equipment (PPE).

Hazardous Substances Emergency Events Surveillance Associated With Aquatic Facilities

For 2007–2008, a total of 12 state health departments[††] reported 92 hazardous substance events involving aquatic facilities, 55 (59.8%) of which involved injured persons. The 92 events led to 663 persons being evacuated, 231 being injured (median number of persons injured in an event with injuries: one; range: 1–44), and 111 persons (84 [75.7%] of whom were injured) being decontaminated (Table 10). No deaths were reported.The majority of injured persons (132 [57.1%]) were members of the general public; 50 (21.6%) were students. Over half of the injured persons (140 [60.6%]) had injuries/symptoms requiring hospital treatment but not admission. Although injured persons primarily reported respiratory irritation or gastrointestinal injuries/symptoms, they also reported suffering from a wide range of injuries/symptoms (Table 11). A total of 33 (35.9%) of the overall events and 22 (40.0%) of the events with injured persons occurred in residential areas (Table 12).

[††] Florida, Iowa, Louisiana, Michigan, Minnesota, North Carolina, New Jersey, New York, Oregon, Texas, Utah, and Wisconsin.

FIGURE 4. Recreational water–associated outbreaks of acute gastrointestinal illness, by type of exposure and etiology — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008



* Percentages do not add up to 100.0% due to rounding.

A primary contributing factor was reported for 88 (95.7%) of events overall and 52 (94.5%) of events with injured persons (Figure 5). Among this subset of events, human error was the leading primary contributing factor for events overall and those with injured persons (51 [58.0%] and 36 [69.2%], respectively). Equipment failure was also frequently reported to be the primary contributing factor of events overall and those with injured persons (31 [35.2%] and 16 [30.8%], respectively).

National Electronic Injury Surveillance System

During 1999–2008, the median estimated number of annual ED visits for pool chemical–associated injuries was 4,120 (range: 3,315–5,216) (Figure 6). In 2008, an estimated 4,574 persons (1.5 per 100,000 population [95% confidence interval (CI): 0.9–2.1]) visited an ED for pool chemical–associated injuries (Table 13). The most common injury diagnoses were poisoning, which includes ingestion of pool chemicals as well as inhalation of their vapors, fumes, or gases (1,784 [95% CI: 585–2,984]) and dermatitis/conjunctivitis (1,452 [95% CI: 936–1,969]); more than half of the injuries occurred at a residence (2,870; [95% CI: 1,363–4,377]). Almost three quarters of the injuries occurred during June, July, or August. No deaths were documented.

TABLE 7. Number of waterborne disease outbreaks associated with recreational water (n = 134), by etiology and type of water exposure — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008

	Type of exposure					
	Treated		Untreated		Total	
Etiology	Outbreaks	Cases	Outbreaks	Cases	Outbreaks (%)*	Cases (%)*
Bacterium	**18**	**245**	**4**	**9**	**22 (16.4)**	**254 (1.8)**
Esherichia coli O157:H7	2	42	1	3	**3**	**45**
Legionella spp.	10	122	0	0	**10**	**122**
Plesiomonas shigelloides	0	0	1	2	**1**	**2**
Pseudomonas aeruginosa	4	52	0	0	**4**	**52**
Shigella spp.	2	29	2	4	**4**	**33**
Parasite	**62**	**12,175**	**6**	**317**	**68 (50.7)**	**12,492 (89.4)**
Schistosomes	0	0	4	300	**4**	**300**
Cryptosporidium spp.	58	12,137	2	17	**60**	**12,154**
Cryptosporidium hominis, Giardia intestinalis	1	19	0	0	**1**	**19**
G. intestinalis	3	19	0	0	**3**	**19**
Virus	**2**	**56**	**3**	**65**	**5 (3.7)**	**121 (0.9)**
Norovirus	2	56	3	65	**5**	**121**
Chemical/Toxin	**8**	**732**	**1**	**15**	**9 (6.7)**	**747 (5.3)**
Chloramines and endotoxins	1	665	0	0	**1**	**665**
Chlorine	2	22	0	0	**2**	**22**
Chlorine gas	3	21	0	0	**3**	**21**
Hydrochloric acid	1	5	0	0	**1**	**5**
Karenia brevis	0	0	1	15	**1**	**15**
Pool chemical(s)†	1	19	0	0	**1**	**19**
Multiple§	**0**	**0**	**1**	**54**	**1 (0.7)**	**54 (0.4)**
S. sonnei, norovirus genogroup I, *Yersinia enterolytica*	0	0	1	54	**1**	**54**
Unidentified	**26**	**272**	**3**	**26**	**29 (21.6)**	**298 (2.1)**
Suspected chemical exposure¶	7	33	0	0	**7**	**33**
Suspected chloramines	2	79	0	0	**2**	**79**
Suspected *Cryptosporidium*	1	6	0	0	**1**	**6**
Suspected *P. aeruginosa*	6	57	0	0	**6**	**57**
Unidentified	10	97	3	26	**13**	**123**
Total (%)	**116 (86.6)**	**13,480 (96.5)**	**18 (13.4)**	**486 (3.5)**	**134 (100.0)**	**13,966 (100.0)**

* Percentages do not add up to 100.0% due to rounding.
† One or more chemicals in the water caused illness; which chemical(s) caused the outbreak was unclear.
§ Outbreaks with multiple etiologies are defined as outbreaks in which more than one type of etiologic agent is identified in clinical specimens from affected persons, and each etiologic agent is found in ≥5% of positive clinical specimens (e.g., the outbreak caused by *Shigella sonnei* and *Yersinia enterolytica* [bacteria] and norovirus genogroup I [virus], in which each agent was identified in ≥5% of stool specimens).
¶ Etiology unidentified: for nine outbreaks, the etiologies were suspected on the basis of clinical symptoms to be excessive levels of chlorine, pool disinfection by-products, or altered pool chemistry.

TABLE 8. Previously unreported outbreaks associated with recreational water (n = five), by state — Waterborne Disease and Outbreak Surveillance System, United States, 1993–2005*

State	Month	Year	Class†	Etiology	Predominant illness§	No. of cases [deaths] (n = 65 [4])¶	Venue	Setting
Florida	Apr	1993	IV	*Legionella pneumophila*	ARI	3 [1]	Spa	Hotel/Motel
Georgia	Apr	1999	I	*L. pneumophila* serogroup 6	ARI	24 —**	Spa	Hotel/Motel
Iowa	Jan	1995	II	*L. pneumophila* serogroup 1	ARI	11 [1]	Spa	Hotel/Motel
Maryland	Jun	2005	III	*Campylobacter*	AGI	4 —	Fill-and-drain pool	Residential school
Virginia	Sep	1996	I	*L. pneumophila* serogroup 1	ARI	23 [2]	Spa	Store

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness.
* Previously unreported legionellosis outbreaks included in this table were identified through a review of the published literature on *Legionella* as well as reports from past CDC-led investigations occurring during 1971–2000. Data presented are based on review and interpretation of available outbreak investigation reports and published articles.
† On the basis of epidemiologic and clinical laboratory data, and environmental data (see Table 1) provided to CDC.
§ The category of illness reported by ≥50% of ill respondents.
¶ Deaths are included in the overall case count.
** No deaths were reported.

TABLE 9. Number of pool chemical–associated health events (n = 32), by state — Hazardous Substance Emergency Events Surveillance System, Maryland and Michigan, 2007–2008*

State	Month	Year	Etiology	Predominant illness†	No. of cases (n = 48)	Venue	Setting
Maryland	May	2008	Chlorine gas§	ARI	1	Pool	Apartment/Condominium
Michigan	May	2007	Chlorine¶	ARI	1	Pool	Waterpark
Michigan	Jun	2007	Chlorine gas§	ARI	1	Pool	Private residence
Michigan	Jun	2007	Chlorine¶	ARI	1	Pool	Unknown
Michigan	Jun	2007	Unidentified**	ARI	1	Pool	Private residence
Michigan	Jun	2007	Unidentified**	ARI	1	Pool	Private residence
Michigan	Jul	2007	Chlorine¶	ARI, AGI	1	Pool	Unknown
Michigan	Jul	2007	Sodium hypochlorite	Eye	1	Pool	Neighborhood/Subdivision
Michigan	Jul	2007	Chlorine gas§	ARI	1	Pool	Unknown
Michigan	Aug	2007	Chlorine gas§	ARI, AGI	1	Pool	Unknown
Michigan	Aug	2007	Chlorine¶	ARI	1	Pool	Waterpark
Michigan	Nov	2007	Algaecide	AGI	1	Pool	Private residence
Michigan	Mar	2008	Unidentified**	ARI	15	Pool	Hotel/Motel
Michigan	Jun	2008	Chlorine¶	ARI	1	Pool	Private residence
Michigan	Jun	2008	Unidentified††	ARI	1	Pool	Private residence
Michigan	Jun	2008	Chlorine powder	ARI	1	Pool	Private residence
Michigan	Jun	2008	Unidentified††	Eye	1	Pool	Private residence
Michigan	Jun	2008	Chlorine gas	AGI	1	Pool	Private residence
Michigan	Jun	2008	Chlorine powder	ARI	1	Pool	Private residence
Michigan	Jun	2008	Chlorine¶	ARI	1	Pool	Private residence
Michigan	Jun	2008	Chlorine¶	Eye	1	Pool	Community/Municipility
Michigan	Jun	2008	Chlorine¶	ARI	1	Pool	Private residence
Michigan	Jun	2008	Unidentified††	AGI	1	Pool	Unknown
Michigan	Jun	2008	Unidentified††	ARI, Eye	2	Pool	Private residence
Michigan	Jul	2008	Chlorine liquid	Eye	1	Pool	Unknown
Michigan	Jul	2008	Chlorine powder	ARI	2	Pool	Private residence
Michigan	Jul	2008	Chlorine liquid	ARI	1	Pool	Unknown
Michigan	Jul	2008	Chlorine¶	ARI, AGI	1	Pool	Unknown
Michigan	Aug	2008	Chlorine¶	ARI	1	Pool	Unknown
Michigan	Aug	2008	Chlorine gas§	ARI	1	Pool	Unknown
Michigan	Sep	2008	Sodium hypochlorite	Eye	1	Pool	Private residence
Michigan	Nov	2008	Unidentified††	Eye	1	Pool	Unknown

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Eye = illnesses, conditions, or symptoms related to the eyes; Skin = illnesses, conditions, or symptoms related to the skin.

* Reports submitted by individual states were based on data from injury surveillance activities within those states. Events reported to the Hazardous Substances Emergency Events Surveillance (HSEES) system were omitted from this list and are discussed in aggregate with HSEES data (see Table 10).

† The category of illness reported by ≥50% of ill respondents.

§ Chlorine gas was generated after inappropriate chemical mixing (e.g., liquid chlorine bleach and acid).

¶ Unknown if chlorine was in a gaseous, liquid, or powder form when exposure occurred.

** Etiology unidentified: chlorine gas suspected on basis of event summary and symptoms.

†† Etiology unidentified: one or more person(s) were handling pool chemical(s) used to "shock" swimming pools.

TABLE 10. Number of persons injured in pool chemical–associated health events (n = 55), by treatment category — Hazardous Substance Emergency Events Surveillance System, 12 states,* 2007–2008

Injured person type	No. of injured persons	No. of persons decontaminated	Predominant symptoms†	No. treated					
				On scene (first aid)	At hospital (not admitted)	At hospital (admitted)	At hospital (not treated)	By private physician within 24 hrs	Injury reported by an official§
General public¶	132**	26	Respiratory irritation	20	63	28	1	4	15
Student††	50	42	Respiratory irritation	1	48	1	0	0	0
Employee§§	42	16	Respiratory irritation	2	22	3	0	14	1
Responder¶¶	7	0	Gastrointestinal	0	7	0	0	0	0
Total	**231****	**84**		**23**	**140**	**32**	**1**	**18**	**16**

* Florida, Iowa, Louisiana, Michigan, Minnesota, North Carolina, New Jersey, New York, Oregon, Texas, Utah, and Wisconsin.

† At least 50% of persons had the symptom.

§ Injuries reported within 24 hours of event by officials (e.g., fire department, emergency medical technician, police, or poison control center).

¶ Includes persons who were neither employees of a company when the event occurred nor either responders or students.

** Data on public health consequences were missing for one injured person.

†† Includes a child or an adult who was a student when the event occurred at a school (includes elementary, middle, high, or vocational school or colleges).

§§ Includes injured persons who worked at the company where the event occurred, including owners.

¶¶ A person whose job is to bring the chemical release under control, provide medical assistance to injured persons, or conduct crowd control.

TABLE 11. Number and percentage of injuries/symptoms attributed to pool chemical–associated health events, by injury/symptom type — Waterborne Disease Outbreak Surveillance System, 12 states,* 2007–2008

Type	No.†	(%)§
Respiratory irritation	187	(56.8)
Gastrointestinal	59	(17.9)
Eye irritation	32	(9.7)
Shortness of breath	20	(6.1)
Dizziness/central nervous system	12	(3.6)
Headache	9	(2.7)
Skin irritation	6	(1.8)
Burn	2	(0.6)
Heart problem	1	(0.3)
Other	1	(0.3)
Total	**329**	**(100.0)**

* Florida, Iowa, Louisiana, Michigan, Minnesota, North Carolina, New Jersey, New York, Oregon, Texas, Utah, and Wisconsin.
† The total number of injuries/symptoms is higher than the total number of victims because injured persons could report more than one injury/symptom.
§ Percentages do not add up to 100.0% due to rounding.

Vibriosis

During 2007–2008, a total of 236 individual vibriosis cases associated with recreational water exposure were reported by 25 states, representing 20.6% (236/1,148) of the total number of vibriosis cases reported for these years (*28,29*). Of the 236 patients, 74 (31.4%) were hospitalized, and nine (3.8%) patients died (Table 14). The most frequently isolated *Vibrio* species was *Vibrio alginolyticus*, which was isolated from clinical specimens from 106 (44.9%) patients overall, 11 (14.9%) of those hospitalized, and two (22.2%) of those who died. *V. vulnificus* was isolated from clinical specimens from 48 (20.3%) patients overall, 36 (48.6%) of those hospitalized, and six (66.7%) of those who died. Recreational water–associated *Vibrio* infections occurred most commonly during summer months (Figure 7).

Nearly all vibriosis patients reported that they were exposed to recreational water in coastal states (Figure 8). The most frequently reported exposure location was the Atlantic coastal states (86 [36.4%]; followed by the Gulf Coast states, which include Florida (81 [34.3%]); Pacific coastal states (59 [25.0%]); and noncoastal states (10 [4.2%]) (Table 15). Florida, Hawaii, California, and Texas had the highest number of reported exposures in their jurisdictions (31, 29, 27, and 27, respectively).

Primary Amebic Meningoencephalitis

Eight individual fatal cases of PAM caused by *Naegleria fowleri* were reported for 2007–2008 (Table 16). Illness occurred after exposure to warm untreated freshwater in Florida (three cases), Texas (two cases), Arizona (one case), California (one case), and Oklahoma (one case). The median age at death was 13 years (range: 9–22 years); seven (87.5%) patients were male.

Discussion

Overview of Outbreaks

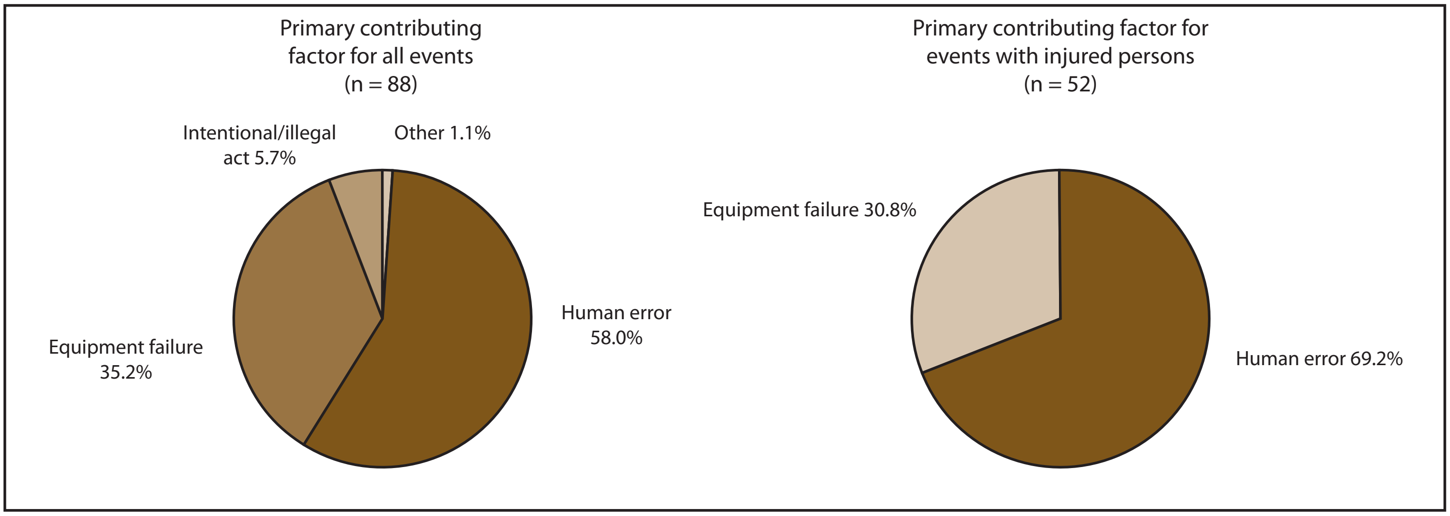
A total of 134 recreational water–associated outbreaks were reported to CDC for 2007–2008. They occurred year-round, but almost two thirds of them started during the traditional summer swim season (Memorial Day through Labor Day). The 2007–2008 outbreak count represents a 71.8% increase over that for 2005–2006 (n = 78) and the largest number of outbreaks ever reported for a 2-year period (Figure 9). The number of drinking water–associated outbreaks reported to

TABLE 12. Number of pool chemical–associated health events (n = 91), by substance category and setting — Hazardous Substance Emergency Events Surveillance System, 12 states,* 2007–2008†

	All events			Events including injured persons		
Substance category	Residential§	Nonresidential¶	Both**	Residential	Nonresidential	Both
Chlorine	19	15	22	12	11	10
Acids	6	3	3	6	2	1
Other inorganic substances††	3	2	1	0	0	0
Mixture across chemical category§§	3	5	4	3	5	2
Pesticides	1	1	0	0	0	0
Oxy/Organics	0	0	1	0	0	1
Volatile organic compounds	0	0	1	0	0	0
Other¶¶	1	0	0	1	0	0
Total	**33**	**26**	**32**	**22**	**18**	**14**

* Florida, Iowa, Louisiana, Michigan, Minnesota, North Carolina, New Jersey, New York, Oregon, Texas, Utah, and Wisconsin.
† Data on setting were missing for one event involving one injured person.
§ Includes land that predominantly consists of housing.
¶ Includes commercial, recreational, and industrial areas.
** Includes events that occurred in both residential and nonresidential areas.
†† Includes all inorganics except for acids, bases, ammonia, and chlorine.
§§ Includes substances from different categories that were mixed or formed from a reaction.
¶¶ Includes substances that do not belong to one of the existing categories.

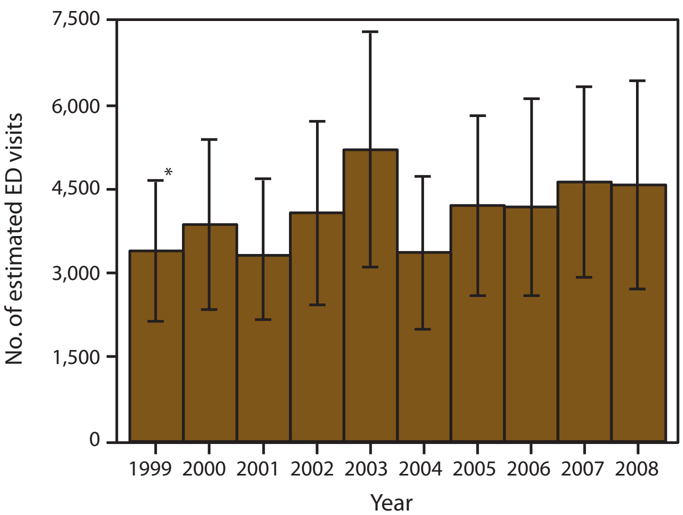
FIGURE 5. Distribution of primary contributing factors reported for pool chemical–associated health events — Hazardous Substance Emergency Events Surveillance System, 12 states,* 2007–2008



* Florida, Iowa, Louisiana, Michigan, Minnesota, North Carolina, New Jersey, New York, Oregon, Texas, Utah, and Wisconsin.

CDC concurrently increased 80%, from 20 for 2005–2006 to 36 for 2007–2008 (*16*). Overall, the number of recreational water–associated outbreaks reported annually has increased substantially since reporting to CDC began in 1978. Possible contributing factors to the increased recreational water–associated outbreak reporting include but are not limited to 1) changes in detection, investigation, and reporting of waterborne disease outbreaks and 2) the emergence of *Cryptosporidium*.

FIGURE 6. Number of estimated emergency department (ED) visits for injuries attributed to pool chemicals (n = 40,803), by year — National Electronic Injury Surveillance System (NEISS), United States, 1999–2008



Source: NEISS. Estimates Query Builder. Bethesda, Maryland: U.S. Consumer Product Safety Commission. 1999–2008. Code 938, swimming pool chemicals. Available at http://cpsc.gov/cgibin/NEISSQuery/home.aspx.
* 95% confidence interval.

Dedicating human resources to waterborne disease detection, investigation, and reporting could be contributing to the observed increase. In late 2006, CDC and its state, DC, territorial, and FAS partners began developing a waterborne disease network and identified points of contact for water-related issues in each reporting jurisdiction, and CDC hired a permanent full-time surveillance coordinator dedicated to running WBDOSS. Having staff dedicated to water-related complaints and inquiries has been reported to be key in optimizing waterborne disease surveillance (*30*). This network allows CDC and its partners to share outbreak investigation tools (e.g., water testing, *Cryptosporidium* subtyping, questionnaires, and press releases) and lessons learned (e.g., via webinars and newsletters). In addition, CDC, EPA, and state partners have been collaborating to strengthen waterborne disease outbreak detection, investigation, response, and reporting under the umbrella of the Environmental Health Specialists Network (EHS-Net) Water program, which provides funding for waterborne disease staff and projects in state public health agencies. One EHS-Net Water project that involved conducting a retrospective review of state-specific waterborne disease outbreak data at the states and at CDC identified outbreaks that had not been reported previously to CDC (*13*).

The increasing number of outbreaks of AGI is driving the overall increase in outbreak reporting (Figures 9 and 10). Since the first reported U.S. recreational water–associated cryptosporidiosis outbreak was identified in 1988 (*31*), *Cryptosporidium* has emerged as the single most important etiologic agent of recreational water–associated outbreaks (Figure 11). In 2007–2008, of 81 outbreaks of AGI, 60 (74.0%) were caused by *Cryptosporidium*; all but two were associated

TABLE 13. Estimated number, percentage, and rate of pool chemical–associated injuries treated in hospital emergency departments — National Electronic Injury Surveillance System (NEISS), United States, 2008*†

Characteristic	No.	Weighted estimate§¶	95% CI	%**	Annual rate††	95% CI
Injury diagnosis						
Poisoning§§	38	1,784	585–2,984	39.0	—¶¶	—
Dermatitis/conjunctivitis	38	1,452	936–1,969	31.7	0.5	0.3–0.6
Other (e.g., chemical burns)	35	1,338	725–1,951	29.3	0.4	0.2–0.6
Affected body part						
All parts of the body (>50% of body)***	48	2,181	862–3,500	47.7	—	—
Eyeball	39	1,452	838–2,066	31.7	0.5	0.3–0.7
Other (e.g., hand) or not recorded (n = three)	24	942	447–1,436	20.6	—	—
Patient disposition						
Treated and released, or examined and released without treatment	101	4,214	2,903–5,526	92.1	1.4	1.0–1.8
Other†††	10	360	0–731	7.9	—	—
Incident location						
Residence	60	2,870	1,363–4,377	62.7	—	—
Public location (e.g., school or place of recreation or sports)	16	352	71–632	7.7	—	—
Unknown	35	1,352	580–2,124	29.6	—	—
Patient age (yrs)						
0–17	55	2,051	1,168–2,934	44.8	2.8	1.6–3.9
18–45	35	1,698	1,012–2,384	37.1	1.4	0.9–2.0
≥46	21	825	90–1,561	18.0	—	—
Patient sex						
Male	60	2,403	1,313–3,493	52.5	1.6	0.9–2.3
Female	51	2,171	1,374–2,969	47.5	1.4	0.9–1.9
Patient race/ethnicity						
White	60	3,039	1,713–4,364	66.4	—	—
Other	14	365	76–655	8.0	—	—
Unknown	37	1,170	404–1,937	25.6	—	—
Total	**111**	**4,574**	**2,703–6,446**	**100.0**	**1.5**	**0.9–2.1**

Abbreviation: CI = confidence interval.

* **Source:** NEISS. Estimates Query Builder. Bethesda, Maryland: U.S. Consumer Product Safety Commission. 1999–2008. Code 938, swimming pool chemicals. Available at http://www.cpsc.gov/cgibin/NEISSQuery/home.aspx.

† For 2007 NEISS summary data, refer to CDC. Pool chemical–associated health events in public and residential settings—United States, 1983–2007. MMWR, 2009; 58:489–93. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5818a1.htm.

§ Each injured person was weighted based on the inverse probability of the hospital being selected, and the weights were summed to produce national estimates.

¶ Categorical weighted counts might not add up to 4,574 due to rounding.

** Categorical percentages might not add up to 100.0% due to rounding.

†† Rates per 100,000 population were calculated using U.S. Census Bureau population estimates accessed September 10, 2010; 95% confidence intervals were calculated by using SAS survey procedures that accounted for the sample weights and complex sampling design.

§§ Poisoning includes ingestion and inhalation of vapors, fumes, or gases.

¶¶ If the sample count was <20, weighted count was <1,200, or the coefficient of variation >30%, the estimate was considered unstable and rates were not reported. Rates by location and race are not reported because of the high percentage of unreported location and race.

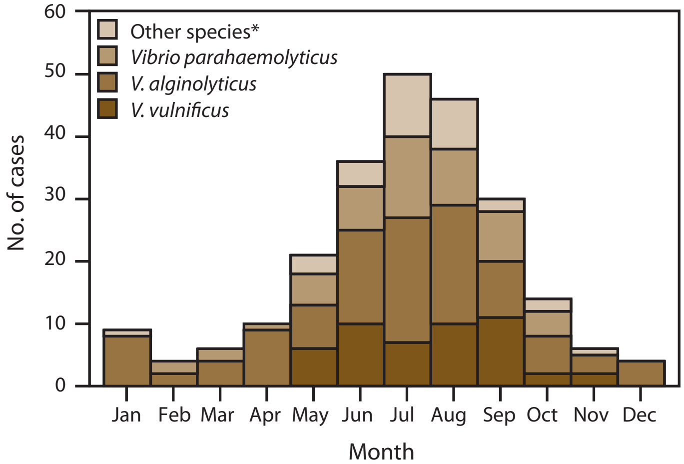
*** For a poisoning injury diagnosis, NEISS requires that affected body part be coded as "all parts of the body (more than 50% of body)."

††† Treated and transferred to another hospital (n = three), treated and admitted for hospitalization (within same facility) (n = four), or left without being seen/left against medical advice (n = three).

TABLE 14. Number of vibriosis cases associated with recreational water (n = 236), by species, hospitalization, death, and year — Cholera and Other *Vibrio* Illness Surveillance System, United States, 2007–2008

	Year								
	2007			2008			Total		
Species	Cases	Hospitalized	Deaths	Cases	Hospitalized	Deaths	Cases	Hospitalized	Deaths
Vibrio alginolyticus	57	3	1	49	8	1	**106**	**11**	**2**
V. cholerae non-O1, non-O139	5	1	0	6	1	1	**11**	**2**	**1**
V. damsela	2	0	0	0	0	0	**2**	**0**	**0**
V. fluvialis	1	0	0	2	0	0	**3**	**0**	**0**
V. parahaemolyticus	29	11	0	22	9	0	**51**	**20**	**0**
V. vulnificus	24	21	3	24	15	3	**48**	**36**	**6**
Vibrio spp.	6	1	0	7	3	0	**13**	**4**	**0**
Multiple	0	0	0	2	1	0	**2**	**1**	**0**
Total (%)	**124**	**37 (29.8%)**	**4 (3.2%)**	**112**	**37 (33.0%)**	**5 (4.5%)**	**236**	**74 (31.4%)**	**9 (3.8%)**

FIGURE 7. Number of vibriosis cases associated with recreational water exposure (n = 236), by species and month — Cholera and Other *Vibrio* Illness Surveillance System, United States, 2007–2008



* Includes *V. cholerae* (non-O1, non-O139) (n = 11), *V. damsela* (n = two), *V. fluvialis* (n = three), unidentified *Vibrio* co-infection (n = two), and *Vibrio* species not identified (n = 13).

with treated recreational water venues. The percentage of outbreaks of AGI caused by *Cryptosporidium* and associated with treated recreational water was 82.9% (Figure 4) for both 2007–2008 (58/70) and 2005–2006 (29/35) (*13*). In contrast, it was 68.2% (15/22), 50.0% (9/18), and 55.6% (10/18) in 1999–2000, 2001–2002, and 2003–2004, respectively (*5,14,15*). Its predominance as an etiologic agent, particularly among outbreaks associated with treated recreational water venues, is related to its chlorine tolerance, which allows it to survive in properly chlorinated recreational water >10 days (*32*). Since 2004, the number of cases of cryptosporidiosis reported to CDC annually has more than tripled (*33*). Although the reasons for increased cryptosporidiosis case and outbreak reporting are not understood completely, treated recreational water venues continue to play a key role in *Cryptosporidium* transmission.

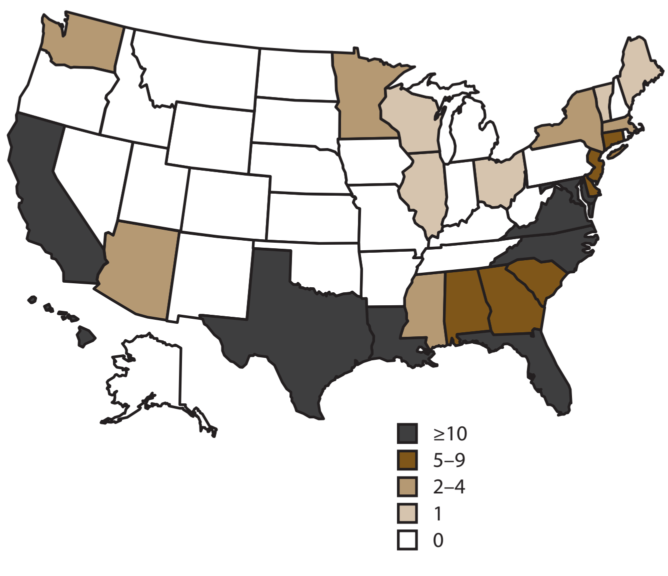
Treated Recreational Water Venues and Pathogens

In treated recreational water venues, chlorine and bromine are the primary barriers to pathogen transmission. Maximizing disinfectant effectiveness requires maintaining appropriate pH levels and circulating the water through a filter to remove particulates that deplete disinfectants. Chlorine- and bromine-susceptible pathogens (e.g., *Shigella*, norovirus, and *Giardia*) caused 23 (25.6%) of 90 treated recreational water–associated outbreaks of known etiology and indicate lapses in operation. Such lapses also are identified frequently on routine inspection. An analysis of data from >121,000 pool inspections conducted across the United States in 2008 indicated that 10.7% of inspections identified disinfectant level violations, and 12.1% of inspections resulted in immediate closure because of violations that threatened public health or safety (*34*). Implementation of proper pool operation practices (e.g., adequate disinfection) has been demonstrated to stop transmission of chlorine-susceptible pathogens effectively and quickly (*35*), which underscores the need for improved operator training.

Molecular epidemiology data from investigations of the 2007–2008 outbreaks caused by norovirus suggested a possible association between recreational water type and genogroup. This led to a review of 19 reports of outbreaks (1990–2006) confirmed to be caused by norovirus, a chlorine-susceptible pathogen (*36*). The investigation of one (20.0%) of five treated recreational water–associated outbreaks included molecular typing of isolates, which belonged to genogroup II. Investigations of three (21.4%) of 14 untreated recreational water–associated outbreaks included molecular typing of isolates. Two of the outbreaks were caused by norovirus genogroup I and one by norovirus genogroup II. Data on further characterization by genotyping were not available. Only genogroup II was isolated from implicated treated recreational water venues; however, the limited number of outbreaks with genogroup data precludes further interpretation of these data and underscores the need for molecular typing to elucidate the epidemiology of waterborne disease outbreaks caused by norovirus (*37*).

In contrast to chlorine-susceptible pathogens, *Cryptosporidium* requires extended contact time for inactivation at typically required or recommended free chlorine levels (1–3 mg/L). Thus, *Cryptosporidium* transmission can occur even in well-maintained treated recreational water venues. During 1999–2008, the parasite caused 74.4% (122/164) of treated recreational water–associated outbreaks of AGI (Figure 10). During 2007–2008, treated recreational water–associated outbreaks of cryptosporidiosis accounted for 86.9% (12,137/13,966) of cases overall; the communitywide cryptosporidiosis outbreak in Utah in 2007 alone accounted for 40.8% (5,697/13,966). Such communitywide cryptosporidiosis outbreaks can occur for the following reasons: *Cryptosporidium* can survive in properly chlorinated recreational water >10 days (*32*); it has a protracted incubation period (approximately 7 days) (*38*), which prolongs the amount of time that elapses between infection and epidemiologic implication of the outbreak source; and swimmers who continue to swim while ill can introduce the parasite to multiple recreational water venues. By the time reported cryptosporidiosis cases are linked epidemiologically to a particular venue, transmission already might be occurring at another venue in the community despite public health efforts to control the outbreak. An investigation of a communitywide cryptosporidiosis outbreak in Utah indicated that 20% of case-patients swam while ill

FIGURE 8. Number of vibriosis cases associated with recreational water exposure (n = 236) — Cholera and Other *Vibrio* Illness Surveillance System, United States, 2007–2008*



* These numbers are largely dependent on surveillance and reporting activities in individual states and do not necessarily indicate the true incidence of vibriosis cases.

with diarrhea and identified approximately 450 potentially contaminated recreational water venues (*39*).

Modifying swimmer behavior is a critical component of reducing recreational water–associated outbreaks, particularly those caused by chlorine-tolerant *Cryptosporidium*. Fecal-oral transmission associated with recreational water can occur when swimmers ingest contaminated water. The water can be contaminated by pathogens that cause AGI when a person has a fecal incident in the water or fecal material washes off of a swimmer's body. Diarrhea-exclusion policies for all patrons should be established, implemented, and enforced at all recreational water venues and particularly for young children and visitors from high-risk settings (e.g., child care centers), which have diarrhea-exclusion policies but might not always enforce them (*40*). In addition, policies for restricting staff who are ill with diarrhea from entering the water, similar to those restricting ill foodhandlers from food preparation, should be established, implemented, and enforced (*41*).

For water contamination to be minimized, good swimmer hygiene is imperative. Swimmers should wash with soap, especially the perianal area, before entering the water; washing young children thoroughly with soap and water before they enter the water is particularly important (*42*). An adequate number of clean, functioning, well-stocked (e.g., with soap) and easily accessible facilities with showers, toilets, and handwashing sinks located near the water might promote good swimmer hygiene. Taking frequent bathroom breaks, particularly for young children, and checking swim diapers every 30–60 minutes also might help minimize water contamination. Diaper-changing facilities with handwashing stations should be located close to the water to encourage hygienic diaper-changing and handwashing. Increased awareness of the risk for recreational water–associated illness, its potential severity, and the efficacy and the simplicity of the prevention steps (e.g., not swimming while ill with diarrhea and not swallowing water) (*43,44*) might make the public more likely to adopt healthy swimming behaviors.

The increasing number of reports of treated recreational water–associated outbreaks of cryptosporidiosis and their potential to evolve into communitywide outbreaks also call for prevention measures beyond conventional chlorination and filtration (*45*). Ultraviolet (*46–48*) and ozone (*49,50*) disinfection systems can effectively inactivate *Cryptosporidium* and are available for use at treated recreational water venues. Remedial biocidal treatment (i.e., hyperchlorination: 20 mg/L free chlorine for 12.75 hours or the equivalent at water pH ≤7.5 and temperature at ≥77°F [25°C] in the absence of stabilized chlorine [*32*] or 40 mg/L free chlorine for approximately 30 hours at water pH 6.5 and temperature at ≥77°F [25°C] in the presence of stabilized chlorine [*51*]) is another potential risk-reduction option. Increased circulation flow rates and occupancy-dependent water replacement might also help reduce risk (*45*).

Finally, *Cryptosporidium*'s ability to cause communitywide outbreaks underscores the need for more rapid implementation of control measures once an increase in case reporting is noted rather than waiting for an outbreak investigation to implicate a specific source of transmission. A response plan should include 1) establishing a strong communication network with community partners likely to be affected by a cryptosporidiosis outbreak (e.g., operators of treated recreational water venues and child care centers), 2) setting a pre-outbreak disease action threshold (e.g., a two- to threefold increase in number of cases over baseline), and 3) rapid mobilization of community partners to implement intensified control measures (e.g., communitywide hyperchlorination of treated recreational water venues) once the threshold is exceeded (*52*). To address the concerns of communitywide cryptosporidiosis outbreaks, Salt Lake County, Utah, and Idaho each developed a cryptosporidiosis prevention campaign before the 2008 summer swim season. Both campaigns engaged community partners and educated the public about healthy swimming behaviors. For 2008, Utah reported no waterborne cryptosporidiosis outbreaks, and Idaho reported only one outbreak with two identified cases.

TABLE 15. Number of vibriosis cases (n = 236) and deaths (n = nine) associated with recreational water, by region/state and species — Cholera and Other *Vibrio* Illness Surveillance System, United States, 2007–2008

	Species									
	Vibrio alginolyticus		*V. parahaemolyticus*		*V. vulnificus*		Other/unknown species*		Total	
Region/State	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Atlantic Coast	**33**	**1**	**23**	**0**	**19**	**1**	**11**	**1**	**86**	**3**
Connecticut	1	0	7	0	0	0	0	0	**8**	**0**
Delaware	4	0	0	0	0	0	1	0	**5**	**0**
Georgia	2	0	0	0	1	0	2	0	**5**	**0**
Maine	1	0	0	0	0	0	0	0	**1**	**0**
Maryland	4	0	3	0	3	0	1	0	**11**	**0**
Massachusetts	1	0	2	0	0	0	0	0	**3**	**0**
North Carolina	6	0	2	0	5	0	3	0	**16**	**0**
New Jersey	2	0	2	0	2	1	1	0	**7**	**1**
New York	1	1	0	0	1	0	0	0	**2**	**1**
South Carolina	3	0	3	0	2	0	1	1	**9**	**1**
Virginia	8	0	4	0	5	0	2	0	**19**	**0**
Gulf Coast	**22**	**0**	**22**	**0**	**27**	**5**	**10**	**0**	**81**	**5**
Alabama	1	0	3	0	3	0	1	0	**8**	**0**
Florida	14	0	8	0	5	0	4	0	**31**	**0**
Louisiana	1	0	2	0	8	1	0	0	**11**	**1**
Mississippi	0	0	1	0	1	0	2	0	**4**	**0**
Texas	6	0	8	0	10	4	3	0	**27**	**4**
Noncoastal	**5**	**1**	**1**	**0**	**0**	**0**	**4**	**0**	**10**	**1**
Arizona	2	0	0	0	0	0	0	0	**2**	**0**
Illinois	1	1	0	0	0	0	0	0	**1**	**1**
Minnesota	0	0	1	0	0	0	3	0	**4**	**0**
Ohio	1	0	0	0	0	0	0	0	**1**	**0**
Vermont	1	0	0	0	0	0	0	0	**1**	**0**
Wisconsin	0	0	0	0	0	0	1	0	**1**	**0**
Pacific Coast	**46**	**0**	**5**	**0**	**2**	**0**	**6**	**0**	**59**	**0**
California	22	0	1	0	1	0	3	0	**27**	**0**
Hawaii	23	0	3	0	1	0	2	0	**29**	**0**
Washington	1	0	1	0	0	0	1	0	**3**	**0**
Total (%)	**106 (44.9)**	**2 (22.2)**	**51 (21.6)**	**0 (0)**	**48 (20.3)**	**6 (66.7)**	**31 (13.1)**	**1 (11.1)**	**236 (100.0)**	**9 (3.8)**

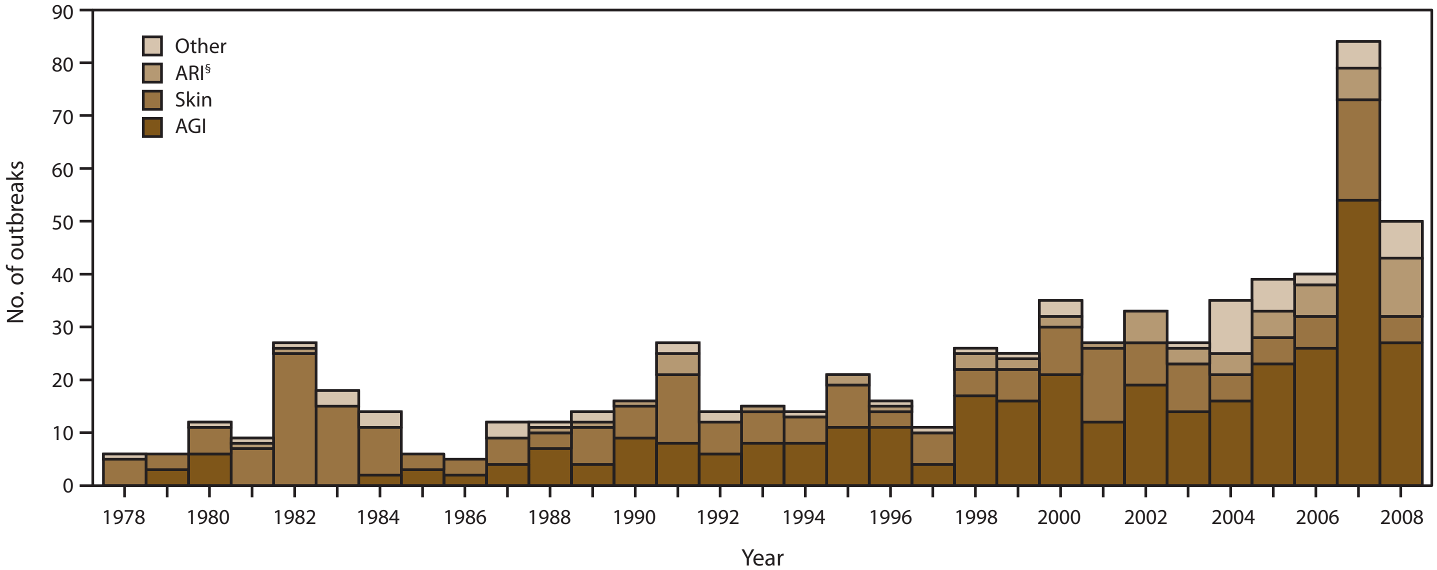
* Includes *V. cholerae* (non-O1, non-O139), *V. damsela*, *V. fluvialis,* unidentified *Vibrio* coinfection, and *Vibrio* unknown species.

TABLE 16. Single cases of primary amebic meningoencephalitis associated with untreated recreational water (n = eight), by state — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008

State	Month	Year	Etiology	Predominant illness*	No. of cases [deaths] (n = 8 [8])†	Venue	Setting
Arizona	Sep	2007	*Naegleria fowleri*	Neuro	1 [1]	Lake	State park
California	Jul	2008	*N. fowleri*	Neuro	1 [1]	Lake	Community
Florida	Jun	2007	*N. fowleri*	Neuro	1 [1]	Unknown	Neighborhood/Subdivision
Florida	Aug	2007	*N. fowleri*	Neuro	1 [1]	Lake	Community/Municipality
Florida	Aug	2007	*N. fowleri*	Neuro	1 [1]	Lake	Community/Municipality§
Oklahoma	Aug	2008	*N. fowleri*	Neuro	1 [1]	Lake	Camp/Cabin
Texas	Aug	2007	*N. fowleri*	Neuro	1 [1]	Lake	Public outdoor area¶
Texas	Aug	2007	*N. fowleri*	Neuro	1 [1]	Lake	Public outdoor area¶

Abbreviation: Neuro = neurologic illnesses, conditions, or symptoms (e.g., meningitis).
* The category of illness reported by ≥50% of ill respondents.
† Deaths are included in the overall case count.
§ Epidemiologic and environmental health investigation identified county lakes and a lake at a water sports park as potential exposure sites for this case.
¶ The same lake in Texas was implicated as the source of water exposure for both cases with exposure occurring at different parts of the lake weeks apart.

FIGURE 9. Number of waterborne disease outbreaks associated with recreational water (n = 696),* by predominant illness† and year — Waterborne Disease and Outbreak Surveillance System, United States, 1978–2008



Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Skin = illnesses, conditions, or symptoms related to the skin; Other = includes bronchitis; illnesses, conditions, or symptoms related to the ears; illnesses, conditions, or symptoms related to the eyes; hepatitis; leptospirosis; meningitis; meningoencephalitis; and multiple predominant illnesses.

* Single cases of primary amebic meningoencephalitis are not included in this figure, which therefore is not comparable with figures included in summaries prior to the 2005–2006 report.

† The category of illness reported by ≥50% of ill respondents.

§ All outbreaks of legionellosis (i.e., Legionnaires' disease and Pontiac fever) are classified as ARI.

Venue-Specific Challenges to Prevention of Pathogen Transmission in Treated Recreational Water Venues

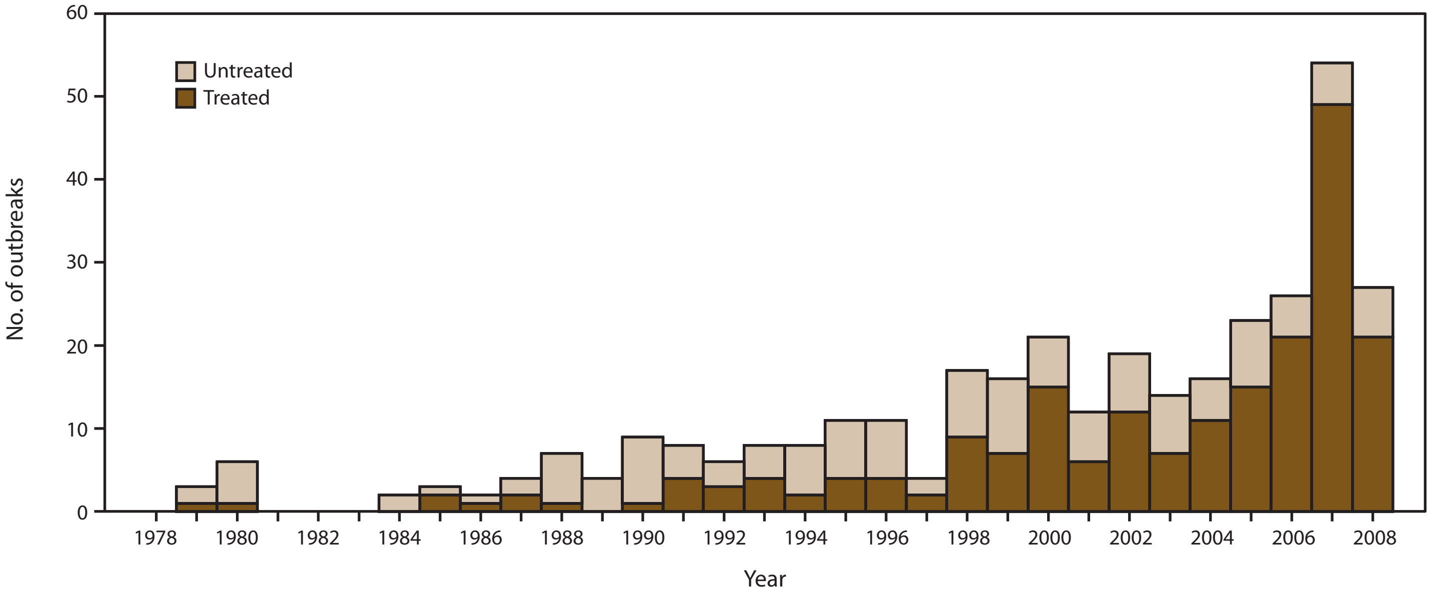
Spas and interactive fountains present particular challenges to prevention of recreational water–associated illness. They typically hold smaller volumes of water than pools, resulting in a relatively high bather load to water volume ratio, and aeration of the water depletes disinfectants.

Spas (hot tubs). The higher water temperatures of spas make it difficult to maintain proper disinfectant levels. As a result, poorly maintained spas are ideal for amplification of naturally occurring thermophilic environmental contaminants (e.g., *Pseudomonas aeruginosa* and *Legionella*). Common recurring themes in outbreaks of *P. aeruginosa* and *Legionella* infection include 1) epidemiologically implicating both the pool and spa in a given setting; 2) exposure occurring in a hotel/motel setting, in which spa operation is not a full-time job; 3) exposure occurring in the context of a group event (e.g., a wedding or birthday party), which can lead to the rapid depletion of disinfectant levels; and 4) the group event taking place on a weekend, when trained staff might not be on duty.

Frequent co-location and use of both spas and pools can make it difficult epidemiologically to implicate one or the other. However, *Pseudomonas* and *Legionella* are most likely to multiply in the higher water temperatures in spas (*53,54*). Group events might lead multiple participants to use a given spa simultaneously, possibly leading to a substantial number of bathers, which can rapidly overwhelm its disinfection capacity and spur bacterial amplification. Group events also might facilitate detection of an outbreak. Conversely, the repeated identification of these outbreaks in the hotel/motel setting highlights the role of travel in pathogen transmission and the potentially decreased likelihood of outbreak detection when travelers disperse to their resident states or countries.

To prevent spa-associated outbreaks, operators must understand the factors that contribute to bacterial amplification and take steps to limit contamination and prevent infection, particularly by thermophilic pathogens. Proper chlorination or bromination are effective in killing *Pseudomonas* and other skin-infecting bacteria. A review of 18 outbreaks caused by *Pseudomonas* demonstrated that the implicated spas with recorded chlorine levels all had levels ≤0.5 mg/L (*55*). Maintaining free chlorine or bromine levels at 2–6 mg/L and pH levels in a range of 7.2–7.8 can minimize bacterial amplification and biofilm build-up, although pathogens might not be eliminated completely from the water. *Pseudomonas* and *Legionella* can persist in spa biofilms, even in the presence of adequate disinfectant, and proliferate rapidly if the disinfectant level drops (*54,56*). A review of data from >5,200 spa inspections conducted across the United States in 2002 revealed that 17.1%

FIGURE 10. Number of outbreaks of acute gastrointestinal illness associated with recreational water (n = 341), by type of exposure and year — Waterborne Disease and Outbreak Surveillance System, United States, 1978–2008



of inspections identified improper disinfectant levels, and 11.0% of inspections resulted in immediate closure because of violations that threatened public health or safety, again underscoring the need for improved operator training (*57*).

The greater frequency of outbreaks of *Pseudomonas* and *Legionella* infections associated with hotel/motel spas underscores the importance of proper operation in these settings. Hotels and motels should consider having only trained employees operate and maintain pools and spas, particularly on weekends, when usage might increase, and enhance water quality monitoring when large groups or events are scheduled.

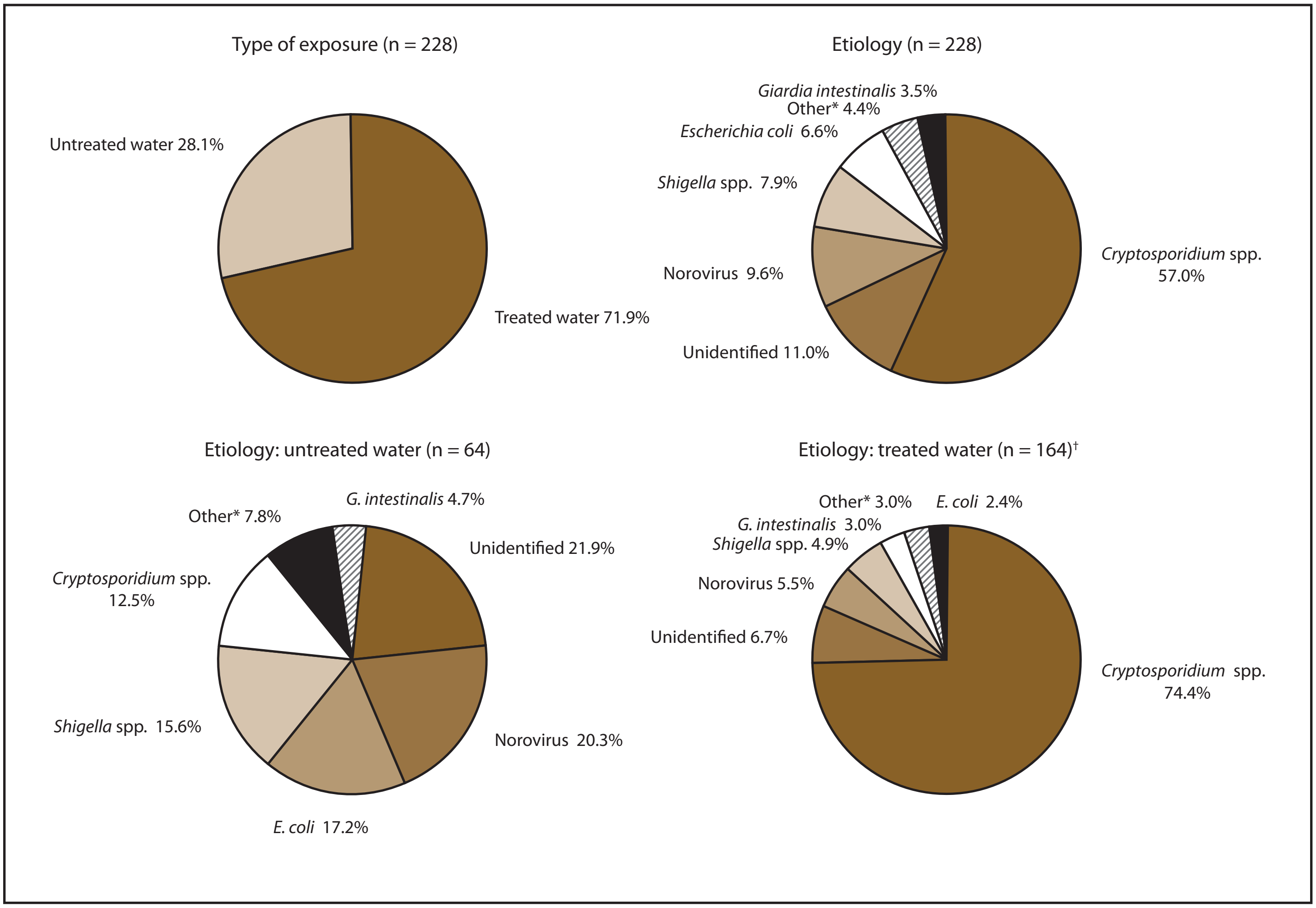
Interactive fountains (splash pads or water play areas). Interactive fountains are particularly prone to contamination by fecal material, vomit, and particulates because of open access to young users, persons in street clothes and shoes, and animals. Contaminants can drain into the water reservoir and be recirculated (i.e., sprayed back on users), increasing the likelihood of ingestion of contaminated water. Because interactive fountains typically do not have standing water above ground, they might be inadvertently exempt from pool codes. The lack of public health oversight in some jurisdictions might increase the likelihood of improper design, maintenance, or operation of these venues. An investigation of a 2008 Texas cryptosporidiosis outbreak epidemiologically linked multiple laboratory-confirmed cases to interactive-fountain exposures. At the time, interactive fountains were not regulated under the Texas state pool code; consequently, emergency regulations for interactive fountains were enacted in 2009, and the 2010 pool code was amended to include interactive fountains (Tex. Health & S § 341.0645 and Tex. Health & S § 0695).

Fill-and-drain pools/temporary water slides. The use of tap water to fill temporary venues used by young children continues to be a public health challenge. Lack of additional disinfection and filtration has resulted in multiple outbreaks being associated with use in residential and public settings (*58*). The potential risk for infection associated with using temporary venues filled with tap water without additional disinfection and filtration should be considered before use in residential settings. To reduce the risk for pathogen transmission, in addition to exclusion of persons with AGI, these pools should be emptied and cleaned at least daily. CDC recommendations on cleaning fill-and-drain pools are available at http://www.cdc.gov/healthywater/swimming/pools/inflatable-plastic-pools.html. On the basis of documented outbreaks such as the previously unreported campylobacteriosis outbreak associated with a fill-and-drain pool at a Maryland residential school (Table 8), these temporary venues should be eliminated from public use (e.g., at child care centers).

Treated Recreational Water Venues and Chloramines

Three outbreaks of ARI or eye irritation, two of which occurred in January, were caused or suspected to be caused by an accumulation of chloramines in the water and air of two indoor waterparks and an indoor school pool. Chloramines are disinfection by-products that result from chlorine oxidation of nitrogenous compounds (e.g., perspiration, saliva, urine, and body oils) commonly shed into the water by swimmers. Chloramines are generated in the water and can volatilize into the surrounding air. Swimmers' water activities and features

FIGURE 11. Recreational water–associated outbreaks of acute gastrointestinal illness, by type of exposure and etiology — Waterborne Disease and Outbreak Surveillance System, United States, 1999–2008



* These include outbreaks caused by *Salmonella, Campylobacter, Plesiomonas* and outbreaks caused by multiple etiologies.
† Percentages do not add up to 100.0% due to rounding.

that splash, spray, and aerate water disturb the water surface and promote the dispersion of chloramines into the atmosphere surrounding indoor treated recreational water venues (*59,60*). Air in these enclosed settings might be recycled more often in the winter to minimize heating costs, limiting the amount of fresh, cold air that is introduced and the amount of warm chloramine-polluted air that is exhausted. The resulting high levels of chloramines can cause ocular, respiratory tract, and mucous membrane irritation and also might be linked to asthma (*61*). As swimming in the United States evolves from a summertime into a year-round activity, indoor air-quality issues are likely to increase, and chloramines could become an increasingly important etiologic agent of treated recreational water–associated outbreaks. Two of the three outbreaks occurred at indoor waterparks. Such waterparks might be more prone to accumulation of chloramines in the air than traditional indoor recreational water venues with one or two pools because of larger bather loads (i.e., more nitrogenous compounds are introduced into the water); more features such as wave pools, fountains, and slides that splash, spray, and aerate the water; and increased cost of maintaining the air temperature of an increased number of enclosed cubic square feet. An investigation of an outbreak associated with the indoor Ohio waterpark revealed that the high placement of air supply and return ducts caused chloramines to accumulate in the air at the pool surface and deck level (*23*). After the ventilation system was reconstructed considerably, no new cases of respiratory and ocular symptoms were detected.

The variability in indoor air quality and shortage of laboratories that perform analyses for airborne chloramines impedes investigators' ability to respond to reports of ocular and respiratory distress. The length of time required for testing makes it difficult to obtain rapid and quantitative measurements of contamination of the air surrounding implicated indoor

treated recreational water venues. Using the water's measured total chlorine (i.e., the sum of free and combined chlorine levels) and free chlorine levels to calculate the level of combined chlorine, of which chloramines are a subset, might be useful for evaluating indoor air quality. Levels that exceed test kit capacity should be remeasured by making dilutions using distilled water. These outbreaks underscore the need to train pool operators to routinely monitor combined chlorine levels to protect the health of patrons and staff and the need for public health authorities to include the calculation of the water's combined chlorine level as a standard part of pool inspections.

Accumulation of chloramines in the air surrounding indoor treated recreational water can be prevented by improving water treatment, swimmer hygiene, and air ventilation. Studies suggest that installation of ultraviolet or ozone treatment devices in circulation systems can reduce chloramine levels in the water (*62–64*) and also can effectively inactivate pathogens, including chlorine-tolerant *Cryptosporidium*. Because the nitrogenous compounds introduced into the water by swimmers are precursors to chloramine formation, swimmers must be engaged in any chloramine-reduction plan. Such an effort should raise public awareness about the role of urine and sweat in creating the ocular and respiratory irritants at treated recreational water venues. Plans to improve air quality also can be aided by working with the public to improve swimmer hygiene. Aquatics staff should encourage swimmers to at least rinse before entering the water and facilitate frequent bathroom breaks, particularly for young children (e.g., instituting adult-only swim times or short closures for water quality testing). Showering for 17 seconds has been demonstrated to decrease by 35%–60% the load of sweat and other pollutants that wash off of swimmers' bodies (*65*).

Pool Chemical–Associated Outbreaks and Health Events

Nine pool chemical–associated outbreaks and 32 additional pool chemical–associated health events were reported to WBDOSS by Florida, Illinois, Kentucky, Maryland, Michigan, and New York. Data on additional pool chemical–associated health events are captured by the HSEES System and NEISS. Pool chemical–associated health events not only have the potential to impact individual and public health adversely but also have a negative financial impact. Approximately 60% of the injured individuals in the HSEES cohort and 100% of those in the NEISS cohort sought treatment in hospital EDs. Pool chemical–associated health events also might require responses from multiple government agencies and officials (e.g., fire fighters, police officers, paramedics, and hazardous materials personnel).

Analysis of HSEES data examined factors contributing to hazardous substance releases of pool chemicals. The most frequently reported factors contributing to HSEES events were human error and equipment failure. A review of the reports of 2007–2008 pool chemical–associated outbreaks and other health events reported to WBDOSS revealed common themes, including mixing of incompatible chemicals, improper handling of chemicals, and overreliance on automatic controllers. These findings indicate that pool chemical–associated health events are preventable through engineering, education, and enforcement. Examples of engineering-based prevention measures include electric interlocks and flow switch sensors, which shut down the chemical feed pumps when the circulation pump shuts down or during filter backwash and thus prevent concentrated chlorine and acid from mixing and generating toxic chlorine gas. Previous studies underscore that requiring pool operator training can reduce the number of water quality violations (*66,67*). Thus, future prevention efforts should require training for all public pool operators on preventive maintenance and how to read pool chemical labels and material safety data sheets, which include information on which chemicals are incompatible and proper chemical handling. Education efforts need to include operators in settings in which recreational water is not the primary focus (e.g., schools or hotels/motels). Given that pool chemical–associated health events frequently occur in the residential setting, messages about safe chemical handling (e.g., not handling chemicals in the presence of children) should also target residential pool owners.

Untreated Recreational Water Venues

The proportion of AGI outbreaks associated with untreated venues relative to treated venues decreased over the previous decade. However, the number of outbreaks associated with untreated venues has remained relatively constant. During 2007–2008, a total of 11 outbreaks of AGI associated with untreated freshwater venues were reported; all of these were linked to a lake, river, stream, or spring. Untreated venues have a higher proportion of outbreaks caused by chlorine-susceptible pathogens compared with treated venues.

Studies have determined the utility of monitoring (*18*) and testing for fecal indicator bacteria to assess the risk for recreational water–associated gastrointestinal illness (*68–70*) in large bodies of water (e.g., the Great Lakes and oceans). The NEEAR study is being conducted to evaluate rapid water quality testing methods that can produce results in <2 hours and to correlate these indicators with health effects among beachgoers. Results from freshwater Great Lakes beaches have demonstrated an association between an increasing signal detected by a quantitative polymerase chain reaction–based test method for enterococci and human health effects (*68,71*). Children aged <10 years were at greater

risk for AGI following exposure to water with elevated levels of enterococci. The small inland water bodies associated with the outbreaks described in this report do not have consistent or identified external sources of contamination (e.g., sewage releases or overflows), suggesting that swimmers might be an important source of water contamination and pathogen transmission.

As with treated recreational water, human behavior plays a key role in the transmission of pathogens in untreated recreational water. Modification of swimmer behavior is critical in untreated water given the lack of disinfection and filtration barriers to pathogen transmission. Recommendations for swimmer hygiene in untreated recreational waters are the same as those discussed previously for treated recreational water. In addition, beach managers and swimmers should be aware that shallow, poorly circulated swimming areas, which are particularly desirable for young children learning toileting skills or wearing diapers, might pose a higher risk for exposure to swimmer-introduced pathogens compared with deeper, well-circulated swimming areas. Potential methods to improve circulation of water through beach areas should be explored to reduce the longevity of focal, swimmer-derived contamination and thus risk for pathogen transmission. In addition to improved swimmer hygiene, exposure to high bacteria levels also can be reduced by avoiding swimming after heavy rainfall at sites affected by runoff to reduce exposure to any increase in contaminants and by not swimming near storm drains or pipes that might release contamination into water bodies (*72*).

Chlorine was added routinely to both an Ohio lake associated with an outbreak of multiple infectious etiologies and a man-made lake associated with a 2008 Texas cryptosporidiosis outbreak. The Ohio beach manager reported adding chlorine to the water to improve water clarity, not to disinfect. Public health and environmental concerns about the addition of chlorine to untreated recreational water include swimmers believing mistakenly that the water is microbiologically safe.

Four outbreaks of confirmed and suspected cercarial dermatitis caused by avian schistosomes were reported during 2007–2008. Three were associated with fresh water and one with marine water. This self-limited disease is known to occur among persons exposed to lakes in which infected birds contaminate water inhabited by the intermediate host snail (*73*). The risk for acquiring cercarial dermatitis might be reduced by avoiding potentially contaminated lakes, avoiding shallow swimming areas in which infected snails reside, instituting a snail control program, and not attracting birds that transmit the schistosomes into swimming areas (e.g., not feeding them).

Marine Water

Three outbreaks were associated with exposure to contaminated marine recreational water. Since 1978, only six such outbreaks have been reported to WBDOSS. Although outbreaks associated with marine waters are reported infrequently, evidence from multiple sources demonstrates that contamination of marine waters is common and that swimming in marine waters is associated with increased risk for AGI (*69,70*). States and territories report water quality testing results and notification data for their coastal and Great Lakes recreational water to EPA. In 2009, one or more advisories or closure notices were issued for 1,642 (43.0%) of the 3,819 monitored coastal beaches because monitoring results for bacteria exceeded state or EPA standards (*74*). This represents an increase over previous years that might be attributable to increased monitoring, increased precipitation during the summer swim season in some coastal states, or the inclusion of preemptive closings made because of rainfall. Multiple studies have linked these water quality indicators with increased risk for recreational water–associated illnesses (*69,70,75*) although such pathogen transmission also can occur when water quality indicators are within established limits (*76*). The reasons for the infrequency of reported marine-associated outbreaks might include the wide geographic dispersion of residences of beachgoers and the fact that illnesses might not be attributed to swimming in marine waters. Prospective epidemiologic studies indicate that these beaches can be associated with illness despite an absence of reported outbreaks (*68,71,77*).

Algae toxicity. Toxin- or chemical-associated outbreaks can occur naturally. One outbreak that was caused by exposure to brevetoxins released by *Karenia brevis* near the Florida coast in 2007 resulted in at least 15 cases of illness (*25*). The outbreak investigation focused on dredging company workers, who reported symptoms such as throat and ocular irritation and coughing. The effects of this red-tide event on other populations are unknown. A study of the economic impact of *Karenia brevis* in one Florida county during 2001–2006 estimated the marginal costs of illness to be between $500,000 and $4 million dollars (*78*). Closure or restricted recreational use of marine beaches and freshwater lakes and ponds because of algal blooms might also result in concerns about lost revenue at the local or regional level (*79*). No U.S. federal regulations or official EPA guidelines specify allowable concentrations of toxins related to harmful algal blooms in water.

Other Recreational Water–Associated Health Events

Vibriosis

The number of *Vibrio* infections associated with water exposures during 2007–2008 (n = 236) was higher than the number reported in 2005–2006 (n = 189) (*28,29*). The majority of deaths and hospitalizations were caused by *V. vulnificus* infection, which occurs predominantly in the Gulf Coast. *V. vulnificus* wound infection can cause severe illness and

sequelae, including septicemia, and require amputation. Disease is more common and severe among persons with preexisting wounds and chronic medical conditions (e.g., diabetes, heart disease, or liver disease) (*80,81*). In general, swimmers with open wounds or sores should refrain from swimming.

Primary Amebic Meningoencephalitis

Eight fatal cases of PAM caused by *Naegleria fowleri* were reported for 2007–2008 (Table 16). This rare disease is of public health importance because of the high (>99%) fatality rate associated with infection (*82*) and the public alarm it raises about the recreational use of freshwater. *N. fowleri* is a free-living ameba that proliferates in warm freshwater and hot springs. Disease occurs when the ameba coincidentally enters the nasal passages, travels to the olfactory lobe of the brain, and infects brain tissue. The eight cases all resulted from warm freshwater exposures in southern states during the summer.

The limited number of PAM cases makes it difficult to determine why certain persons become infected. As a result, the efficacy of existing risk-reduction strategies is uncertain. Lake water surveys conducted in southern states have frequently detected *Naegleria (83–85*), and PAM case reports demonstrate recent exposure to swimming in warm, freshwater lakes, rivers, or hot springs. Swimmers might reduce their risk for *Naegleria* infection by avoiding water-related activities in warm freshwater during periods of high water temperature and low water levels; holding the nose shut or using nose clips when taking part in water-related activities in bodies of warm freshwater; and refraining from digging in or stirring up sediment while swimming in shallow, warm, freshwater areas (*86*). CDC is collaborating with CSTE and individual states to improve case investigations by collecting exposure, symptom, treatment, and environmental data. Systematic collection of these data could help refine current risk-reduction measures and guidance.

Prevention

Recreational water–associated illness can be prevented through concerted efforts by public health professionals, recreational water venue operators, and the general public. Given the different stakeholders required to promote healthy and safe swimming, good communication among these groups is imperative.

Public health professionals regulate recreational water facilities and investigate outbreaks as a multidisciplinary team (e.g., including laboratorians, environmental health specialists, and epidemiologists within and among jurisdictions). They also function as an important source of information for operators and the swimming public. Public health professionals should

- have opportunities to maintain and build upon current knowledge about recreational water–associated illness and operation,
- update and improve codes to stay current with changing designs and needs demonstrated by findings of outbreak investigations,
- lead and collaborate with the aquatics industry to educate the general public,
- use inspection and beach monitoring data as surveillance data to inform public health decision-making and program planning, and
- develop expertise in detecting and investigating recreational water–associated outbreaks and other health events.

Various tools are available to operators of treated recreational water venues to protect the health and safety of swimmers and aquatics staff. The traditional paradigm of two barriers (disinfection and filtration) to pathogen transmission in treated recreational water needs to shift to include in-line (i.e., usually installed after filtration and before disinfection) secondary or supplemental treatment (e.g., ultraviolet treatment or ozonation). Ultraviolet and ozone treatment not only will increase the level of protection against chlorine-tolerant *Cryptosporidium* but also will break down chloramines. Because these systems depend on circulation, they alone will not eliminate outbreaks; a commitment to monitoring and maintaining water quality and educating the public (e.g., including healthy swimming messages in posters in bathrooms, on the back of ticket stubs, and in contracts for group events) also is critical. To maximize their ability to protect the health and safety of swimmers and aquatics staff, pool operators working in all public settings should complete training that includes such topics as disinfection, water chemistry, preventive maintenance, chemical safety, and illness and injury prevention. In response to the lack of protective barriers at untreated recreational water venues (e.g., lakes and oceans), beach managers and public health officials should implement water quality testing programs and educate swimmers about prevention measures specific to untreated recreational water venues (e.g., not swimming after heavy rainfall) and for illnesses unlikely to be prevented by current water quality guidelines (e.g., vibriosis, PAM, and otitis externa).

Swimmers are an important source of recreational water contamination (i.e., pathogens and nitrogenous compounds); thus, it is imperative to educate the public about healthy swimming behaviors. The general public also can participate in the healthy swimming effort by checking chlorine and pH levels before getting into treated recreational water, asking operators of treated recreational water venues about the latest inspection score, encouraging operators to take steps known to kill *Cryptosporidium*, educating other swimmers about healthy swimming, and reporting operational issues, if not corrected, to public health agencies.

Limitations

The findings in this report are subject to at least four main limitations. First, differences in the numbers of outbreaks reported by different jurisdictions might be attributable to factors such as the variable requirements for notifiable diseases and variable public health capacity to detect, investigate, and report recreational water–associated outbreaks. Thus, the jurisdictions reporting outbreaks most frequently might not be the jurisdictions in which the outbreaks most frequently occur (*87*). Second, factors such as incubation period, size and location of the outbreak exposure, severity of illness, and geographic dispersion of ill swimmers also likely influence the detection, investigation, and reporting of recreational water–associated outbreaks. Larger outbreaks are more likely to be identified by public health authorities. In contrast, smaller outbreaks (e.g., those associated with residential pools and spas) might go undetected because fewer persons are ill, and they might attribute illness to other common exposures. In addition, outbreaks associated with venues that draw from a wide geographic range (e.g., large lakes and marine beaches or hotel/motel pools or spas) might be difficult to detect because potentially infected persons disperse widely from the site of exposure and, therefore, cases of illness might be less likely to be identified as part of an outbreak. Prospective epidemiology studies, such as EPA's NEEAR Water Study (*68*), have revealed elevated rates of AGI in swimmers compared with nonswimmers at all beaches studied. Multiple other prospective studies of AGI associated with beach swimming have also indicated elevated rates of illness associated with swimming in lakes and oceans, though few outbreaks have been detected (*69,76*). Data on endemic recreational water–associated illnesses are not captured by WBDOSS, highlighting the need for more studies to estimate the magnitude of risk for illness for routine, nonoutbreak-associated exposures at recreational water venues. Third, the incidence of recreational water–associated outbreaks of cryptosporidiosis in 2007 might be overestimated in this report. The statewide outbreak in Utah and the individual outbreaks in neighboring Idaho and Wyoming might have been a single multistate outbreak. Of note, Colorado also detected a statewide increase in cryptosporidiosis cases in the summer of 2007 that was determined to be associated with multiple risk factors in multiple counties (*88*). In 2007, had *Cryptosporidium* isolates from each health event been available for subtyping, investigators might have been able to determine if they were linked to each other. Finally, few outbreak reports included findings from environmental health investigations of the implicated venue. It is unclear whether environmental health investigations were not conducted or the findings were not included in reports. Whereas epidemiologic investigations provide data that characterize outbreaks, data from environmental health investigations can be used to identify factors that contributed to the outbreak to help prevent future outbreaks.

This is the first surveillance summary to present pool chemical–associated health event data from multiple surveillance systems, and the data provided in this report regarding such events are subject to at least six additional limitations. First, injuries, illness, or pool chemical spills might not be serious enough to require outside assistance and thus are not detected. Second, because communication channels might not be established between public health agencies and emergency responders, certain pool chemical–associated health events might not be reported. Such communication is important because the outbreaks and other health events caused by pool chemicals might be more likely to involve first responders and hazardous materials personnel than waterborne disease coordinators, who voluntarily report outbreaks to WBDOSS. This in part might be the reason why pool chemical–associated outbreaks and other health events were reported to WBDOSS by only six states. Third, water chemistry can change quickly and contaminated air can be ventilated rapidly, making it difficult to determine the etiology of a pool chemical–associated health event. This might explain why the etiologies of nine outbreaks were not determined but are suspected to have been caused by excess chlorine, disinfection by-product levels, or altered pool chemistry. Fourth, the approximately 100 hospitals participating in NEISS and the 12 states participating in HSEES and reporting events might not be representative of the United States, and therefore the findings might not be generalizable. Fifth, the fact that "chlorine" was the only chemical term used to search the HSEES system database might have created a bias for not identifying events caused by other pool chemicals. Finally, no one surveillance system collects data on all events, but, rather, each collects data on a subset of the events. This leads to the possibility of not collecting data on events that do not meet the case definition of any of the systems but could also lead to duplicate reporting. For example, health event data reported to NEISS also might be reported to either WBDOSS or the HSEES System. NEISS location data are limited to type of setting (e.g., residence or school) and do not include information such as the state or county in which the event occurred; this precludes de-duplication of reports across all surveillance datasets.

Conclusion

CDC and ATSDR can lead the effort to prevent recreational water–associated outbreaks and other health events by 1) spearheading the efforts to set minimum national standards to protect the health and safety of swimmers and aquatics staff at treated recreational water venues; 2) providing data to advocate for waterborne disease prevention and control efforts; 3) continuing to provide web-based and other healthy swimming resources for public health partners, the public, and the aquatics industry; and

4) coordinating efforts among agencies to prevent pool chemical–associated health events. Multiple federal organizations provide assistance with investigations of recreational water–associated outbreaks and other health events (Box).

In 2005, at the request of CSTE, experts from local, state, and federal public health agencies and representatives from the aquatics industry met in Atlanta at a CDC-sponsored workshop on preventing recreational water–associated illnesses at treated recreational water venues. Setting uniform national aquatic standards was determined to be a key prevention and control measure.

Since 2007, the New York State Department of Health and CDC have spearheaded an all-stakeholder effort to develop a Model Aquatic Health Code (MAHC) (available at http://www.cdc.gov/healthywater/swimming/pools/mahc). MAHC has two primary objectives: 1) to be a free, science-based health code that reduces risk for illness and injury at treated recreational water venues, and 2) to serve as a model available for voluntary adoption by state and local public health agencies to facilitate an evolution from disparate pool regulations across the country into a set of national uniform standards. The 12 MAHC modules cover such topics as disinfection and water quality, operator training, hygiene facilities, and ventilation and air quality; it is anticipated that the modules will be made publicly available in 2012.

To help support waterborne disease detection, investigation, and reporting, CDC should collect and report on data through research initiatives that underscore the importance of waterborne disease in the United States. Estimates of the magnitude and cost of waterborne disease and magnitude of recreational water exposure can be used to advocate for prevention and control measures. In addition, bolstering waterborne disease surveillance can promote prevention and control. For example, given that *Cryptosporidium* is the predominant etiologic agent of recreational water–associated outbreaks and has the ability to cause communitywide outbreaks, CDC should systemically collect stool specimens and utilize molecular epidemiology tools to subtype isolates to help elucidate the epidemiology of cryptosporidiosis (*89*).

Since 2001, CDC has posted healthy swimming messages and resources on its Healthy Swimming website.[§§] This communication tool allows CDC to share outbreak investigation resources and lessons learned with public health partners, educate the public about healthy swimming, and provide recommendations to the aquatics industry. The website highlights Recreational Water Illness and Injury Prevention Week, which is the week before Memorial Day and represents a health communications opportunity to educate the public about healthy swimming behaviors.

§§ Available at http://www.cdc.gov/healthywater/swimming.

Finally, ATSDR and CDC collect data on pool chemical–associated health events. The data suggest that such events are both common and preventable. The data also indicate the need for a coordinated effort to establish the magnitude of these health events, more completely characterize their epidemiology, refine prevention and spill response recommendations, and develop prevention tools. To optimize health communication to operators, residential pool owners, and pool chemical manufacturers, ATSDR/CDC messages should balance the needs to chemically disinfect to prevent and control pathogen transmission and to reduce the incidence pool chemical–associated health events.

In 2009, CDC transitioned to electronic reporting through the National Outbreak Reporting System (NORS)[¶¶] for waterborne disease outbreaks occurring on or after January 1, 2009. As waterborne disease outbreak reporting to CDC transitions from a paper-based to an electronic system, the number of reported recreational water–associated outbreaks might increase. Efforts to improve the quality and completeness of WBDOSS data include activities such as NORS webinars for and e-mail updates to epidemiology, environmental health, and laboratory partners at the local, state, and federal levels; web-accessible training materials for public health staff responsible for voluntary reporting; and collaboration across CDC programs to streamline reporting, provide technical support, and develop new NORS reporting tools. One of the key improvements in NORS reporting is the inclusion of more standardized fields to report environmental health investigation data. All of these efforts aim to generate surveillance data that better inform the development and implementation of more effective waterborne disease prevention and control guidelines and standards such as the MAHC and ultimately reduce the burden of recreational water–associated illness and injury.

¶¶ Available at http://www.cdc.gov/healthywater/statistics/wbdoss/nors/index.html.

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BOX. Federal organizations that provide assistance with investigations of recreational water–associated outbreaks and other health events

State health departments and other reporting jurisdictions can request epidemiologic assistance and laboratory testing from CDC. CDC also can be consulted regarding engineering and environmental health aspects of recreational water treatment and collection of proper water samples to identify pathogenic viruses, bacteria, and parasites.

Requests for assistance with waterborne disease outbreak investigations (e.g., epidemiologic assistance, water testing, diagnosis of free-living ameba infection, or molecular characterization of *Cryptosporidium* and *Giardia*)

Waterborne Disease Prevention Branch
Division of Foodborne, Waterborne, and Environmental Diseases
National Center for Emerging and Zoonotic Infectious Diseases, CDC
Telephone: 404-639-1700
Email: healthywater@cdc.gov
Internet: http://www.cdc.gov/healthywater

Requests for diagnostic testing for viral pathogens

Division of Viral Diseases
National Center for Immunization and Respiratory Diseases, CDC
Telephone: 800-232-4636

Requests for diagnostic testing for enteric bacterial pathogens

Enteric Diseases Laboratory Branch
Division of Foodborne, Waterborne, and Environmental Diseases
National Center for Emerging and Zoonotic Infectious Diseases, CDC
Telephone: 404-639-3334

Requests for information or diagnostic testing for parasites (except for *Cryptosporidium*, *Giardia*, or free-living amebas)

Division of Parasitic Diseases and Malaria
Center for Global Health, CDC
Telephone: 404-718-4745
Internet: http://www.cdc.gov/parasites

Requests for information or testing for *Legionella*

Division of Bacterial Diseases
National Center for Immunization and Respiratory Diseases, CDC
Telephone: 404-639-2215
Internet: http://www.cdc.gov/legionella

Resources for pool chemical–associated health events

ATSDR National Toxic Substances Incidents Program (NTSIP)
Internet: http://www.atsdr.cdc.gov/ntsip
24 hours/7 days chemical spill hotlines
—To report chemical spills, telephone the National Response Center (NRC) at 800-424-8802 or report via the Internet: www.nrc.uscg.mil
—For medical advice, telephone the National Poison Center at 800-222-1222
—For public health assistance during a chemical emergency, telephone the CDC Emergency Operations Center at 770-488-7100.

Resources for harmful algal blooms

Health Studies Branch
Division of Environmental Hazards and Health Effects
National Center for Environmental Health, CDC
Telephone: 866-556-0544

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Appendix A

Glossary of Definitions

backwash	Flow of water through filter element(s) or media in a reverse direction to dislodge and remove accumulated dirt, debris, or filter aid from the filter tank.
bather load	The number of bathers using a swimming pool or spa at any one time. The maximum bather load is usually determined by a state or local pool code and is based on surface area and depth of the pool or spa.
biofilm	Microbial cells that adhere to a moist or water-covered surface through a matrix of primarily polysaccharide materials in which they are encapsulated. Biofilms can grow on piping and surfaces of aquatic venues and can be very difficult to remove. They protect microbes from disinfectants (e.g., chlorine) in the water.
cercarial dermatitis	Dermatitis caused by contact with or direct invasion through the skin or a break in the skin by the cercariae (larval stage) of certain species of schistosomes. The normal hosts of these species are birds and non-human mammals. Dermatitis is an allergic response to contact with cercariae and 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 clinical laboratory data, and environmental data implicating recreational water as the source of the outbreak (see Table 1).
chloramines	A group of disinfection by-products or weak disinfectants formed when free chlorine combines with nitrogen-containing compounds (e.g., urine or perspiration) in the water. Tri- and di-chloramine can cause eye and respiratory (e.g., lung and throat) irritation and can accumulate in the water and air surrounding treated recreational water venues. In drinking water treatment, monochloramine is used for disinfection to reduce formation of disinfection by-products created when using chlorine as a disinfectant (see combined chlorine level).
combined chlorine	Chlorine that has combined with organic or inorganic compounds in the water and is no longer an effective disinfectant for recreational water. The combined chlorine level is derived by subtracting the water's free chlorine test level from its total chlorine test level. This level is likely to include combined compounds in addition to chloramines (see chloramines).
communitywide outbreak	This outbreak typically starts as a focal outbreak associated with one recreational water venue and evolves into an outbreak associated with multiple recreational water venues or other settings, such as child care centers in a community.
contact time	The length of time that recreational water and any pathogens in the water are exposed to a disinfectant, usually measured in minutes (e.g., chlorine contact time).
disinfection	A treatment that kills microorganisms (e.g., bacteria, viruses, and parasites); in water treatment, a chemical (commonly chlorine, chloramine, or ozone) or physical process (e.g., ultraviolet radiation) can be used.
disinfection by-products	Chemicals formed in water through reactions between organic or inorganic matter and disinfectants. Examples include chloramines, also known as combined chlorines. These chemicals might have acute or chronic health effects.
etiology	The pathogen, chemical, or toxin causing a waterborne disease outbreak or other health event. Infectious etiologies include bacteria, parasites, and viruses.
fill-and-drain pools	Small pools or slides that often are constructed of plastic and that might be inflatable. These pools and slides are filled with tap water without any ongoing chemical disinfection or filtration.
filtration	In water treatment, the process of passing water through one or more permeable membranes or media of small diameter (e.g., sand, anthracite, or diatomaceous earth) to remove suspended particles from the water. Filters might be effective in removing pathogens, depending on the type and operation.

free chlorine	Chlorine in water (found as an aqueous mixture of hypochlorous acid and hypochlorite anion) that has not combined with other constituents; therefore, it is able to serve as an effective disinfectant (also referred to as free available chlorine or residual chlorine). Measuring the free chlorine level is a common water quality test.
freshwater	Untreated, nonmarine surface water (e.g., water from lakes, rivers, or ponds).
interactive fountain	A fountain or water spray device that is either intended for or accessible for recreational use and typically does not have standing water aboveground; recirculated water typically is stored in an underground holding tank. These fountains are sometimes called spray pads, splash pads, wet decks, or spray grounds. In contrast, a noninteractive (ornamental or decorative) fountain intended for public display rather than recreational use is often located in front of buildings and monuments, and the water is not easily accessible for public use.
jurisdiction	An inclusive term for the U.S. states, District of Columbia, territories, and Freely Associated States (FAS) (e.g., the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau) that report waterborne disease outbreaks to the Waterborne Disease and Outbreak Surveillance System (WBDOSS). Waterborne disease outbreaks investigated by local public health agencies are reported to the state, territorial, or FAS public health agency. Jurisdictions can also report select recreational water–associated health events to WBDOSS.
marine water	Untreated recreational water at an ocean or estuarine setting.
pool chemical–associated health events	Injuries or illnesses resulting from exposure to pool chemicals (e.g., halogens or disinfection by-products) used to maintain quality of treated recreational water. These events might not meet the criteria for a waterborne disease outbreak depending on whether they involve exposure to recreational water or two or more persons. These events must be associated with treated recreational water venues.
recreational water venue	A body of water used for recreation (e.g., swimming, soaking, or athletics), including any structure that encloses this water. It can include a lake, pond, river, spring, ocean, or a man-made venue (e.g., swimming pool and spa); some recreational water venues do not include standing water (e.g., interactive fountains).
reservoir, impoundment	An artificially maintained lake or other body of water used for the collection and storage of water. It can be available as a source of raw water for drinking purposes or recreational use.
setting	Location where exposure to contaminated water occurred.
spa	Any structure, basin, chamber, or tank (located either indoors or outdoors) containing a body of water that is intended to be used for recreational or therapeutic purposes and that usually contains a waterjet or aeration system. It is operated at high temperatures and usually is not drained, cleaned, or refilled after each use. It also is referred to as a hot tub or whirlpool.
spray park	A recreational water venue consisting of multiple interactive fountains.
total chlorine	A common water quality test that measures the chlorine in water that is free for disinfection (see free chlorine) plus that combined with organic or inorganic materials (see combined chlorine level). The water's combined chlorine level is derived by subtracting the free chlorine test level from the total chlorine test level.
treated water	Water that has undergone a systematic disinfection process (e.g., chlorination and filtration) to maintain good microbiologic quality for recreation. Typically, this refers to any recreational water in an enclosed, manufactured structure. This includes water in swimming or wading pools, fountains, and spas but might also include water in fill-and-drain pools filled with treated tap water or untreated water (e.g., mineral spring water) that receives no further treatment.
untreated water	Water that has not undergone a disinfection or treatment process to maintain good microbiological quality for recreation (e.g., lakes, rivers, oceans, and reservoirs).
user	Any person or bather entering recreational water. Might also be referred to as a patron at some membership clubs or recreational water venues.

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. Standards might vary based on type and degree of water exposure associated with different water uses. Ideally, density or concentration correlates with health effects. Examples include turbidity, coliform counts, fecal coliforms, *Escherichia coli*, enterococci, and free chlorine level.

Appendix B

Descriptions of Select Waterborne Disease Outbreaks Associated with Recreational Water Use

Month	Year	State	Etiology	No. of cases	Outbreak description
Bacteria					
February	2008	Wisconsin	*Pseudomonas aeruginosa*	18	After spending time in a hotel/motel pool and spa, 17 persons reported having a rash and one person reported an ear infection. A swab of one person's skin lesion yielded *P. aeruginosa*. A case-control study found a statistically significant association between using the spa on a given Saturday and the development of symptoms. An environmental health investigation noted that no water quality readings were recorded on the Saturday that case-patients used the spa.
March	2008	Florida	*Legionella*	5	The results of a matched case-control study epidemiologically linked five travel-associated cases of legionellosis to spa exposure at a hotel/motel. The spa had two cartridge filters and an automatic chlorine feeder. The environmental health investigation noted that the pool and spa had free chlorine levels of $\leq$0.5 mg/L (or parts per million [ppm]) and the cartridge filters were insufficient for the size of the spa. The maintenance logs for the spa were not available. Environmental water samples from the spa, hotel boilers, and a room air conditioner all tested negative for *Legionella*.
Viruses					
May	2007	Idaho	Norovirus genogroup II	50	After exposure to a community pool and wading pool, six persons submitted stool specimens that tested positive for norovirus genogroup II. The pools had a combined filtration system. An investigation identified multiple contributing factors, including high bather load, inaccessible bathroom facilities, and lack of oversight by management to handle fecal incidents.
July	2008	Connecticut	Norovirus genogroup I	16	After exposure to a lake that was used by diaper-aged children, six persons submitted stool specimens that tested positive for norovirus genogroup I. A fecal incident and stagnant water were suspected as contributing factors in the outbreak. A case-control study found that the odds of developing gastrointestinal symptoms were significantly higher for persons who swam in the lake on a particular day, swam in the water for more than an hour, or swallowed lake water compared with persons who did not report these exposures. Swimming $\geq$12 feet from shore also was associated with an increased odds of illness (p=0.0004).
Parasites					
June	2007	New Mexico	Schistosomes	12	A medical provider's office reported multiple individuals seen for rashes diagnosed as cercarial dermatitis ("swimmer's itch") after spending time at a freshwater lake. The outbreak investigation included: case interviews, environmental assessment, and testing. Cases occurred among individuals who entered the water from the shoreline and did not occur in individuals who entered the water directly from a boat. Cercariae were isolated from snails collected along the shoreline. Low water levels 2 years earlier supported increased vegetation and large snail populations along the shoreline. Warning signs posted at the lake in English and Spanish listed allergic reaction symptoms and prevention measures.
July	2007	Oklahoma Oklahoma	*C. hominis* *C. parvum*	93 17	Molecular subtyping of *Cryptosporidium* isolates led public health officials to determine that two distinct outbreaks of cryptosporidiosis had occured in neighboring counties during the same month. Persons affected by the first outbreak reported swimming in a pool that was the only publicly accessible swimming pool in the community, and none of the persons with laboratory-confirmed cases reported swimming in another pool. *Cryptosporidium* oocysts isolated from stool specimens of 11 patients and four liters of pool filter backwash were subtyped as *C. hominis*. Persons affected by the second outbreak stayed in state park cabins during a week-long period in mid-July. A retrospective cohort study implicated the park's pool. Molecular typing of stool specimens and pool backwash identified *C. parvum* and provided strong supporting evidence that the cases were not part of the first outbreak.

Month	Year	State	Etiology	No. of cases	Outbreak description
August	2007	Iowa	*Cryptosporidium*	34	County public health staff responded quickly to prevent a focal cryptosporidiosis outbreak from becoming communitywide following notification of two laboratory-confirmed cases in children with recent swimming pool exposures. Public health staff immediately initiated case investigations and active cryptosporidiosis surveillance. Local health-care providers were sent a health alert containing information about how to diagnose and report cryptosporidiosis cases. Child care providers were sent guidance about disease prevention and control measures. The environmental health staff worked closely with local pools, starting on the day that the first two cases were reported. Multiple pools were hyperchlorinated immediately. A fact sheet also was shared with several neighboring counties for distribution to pool operators.
July	2008	New Mexico	*C. hominis*	89	Confirmed cases of cryptosporidiosis were identified among competitive swimmers who swam at a community aquatic facility. At least one patient swam while symptomatic and participated in competitions with hundreds of swimmers. Working closely with state and local partners, the New Mexico Department of Health coordinated the health communications, epidemiologic investigation, and environmental health response to the outbreak. This included hyperchlorination of all pools in the aquatic facility as well as any other pools that infectious swimmers had used. A total of 34% of ill persons (including competitive swimmers, lifeguards, or swim team coaches) reported recreational water activity while symptomatic or in the 2 weeks following symptom resolution. Stool specimens from multiple persons and recreational water tested positive for *C. hominis*. Clinical isolates were of the same subtype.
July	2008	Arizona	*C. hominis*	9	Four laboratory-confirmed cases of *C. hominis* infection were linked to the same interactive fountain. The interactive fountain was not found to have any violations upon initial inspection. Staff complied with health department recommendations. Water from the interactive fountain tested positive for *Cryptosporidium* both before and after disinfection guidelines were applied; follow-up testing is not recommended by CDC because nonviable oocysts present in the treated water might lead to a positive test result via molecular testing. Molecular subtyping determined that this outbreak was unique from two concurrent recreational water–associated outbreaks in Arizona. An ultraviolet disinfection system was added to supplement the bromine disinfection system.
Chemicals/Toxins					
January	2008	Illinois	Chlorine	20	At least 20 persons were hospitalized and an unknown number of people were injured after exposure to chlorine at an indoor waterpark. Case counts and symptom data were based on fire department records. The automatic controller that managed pool disinfectant and pH levels failed. Pool staff did not recognize the problem during routine testing. The free chlorine and pH levels of the wading pool measured 18 mg/L and 8.3, respectively, on the day that the event occurred.

Surveillance for Waterborne Disease Outbreaks Associated with Drinking Water—United States, 2007–2008

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Abstract

Problem/Condition: Since 1971, CDC, the Environmental Protection Agency (EPA), and the Council of State and Territorial Epidemiologists have collaborated on the Waterborne Disease and Outbreak Surveillance System (WBDOSS) for collecting and reporting data related to occurrences and causes of waterborne disease outbreaks associated with drinking water. This surveillance system is the primary source of data concerning the scope and health effects of waterborne disease outbreaks in the United States.

Reporting Period: Data presented summarize 48 outbreaks that occurred during January 2007–December 2008 and 70 previously unreported outbreaks.

Description of System: WBDOSS includes data on outbreaks associated with drinking water, recreational water, water not intended for drinking (WNID) (excluding recreational water), and water use of unknown intent (WUI). Public health agencies in the states, U.S. territories, localities, and Freely Associated States are primarily responsible for detecting and investigating outbreaks and reporting them voluntarily to CDC by a standard form. Only data on outbreaks associated with drinking water, WNID (excluding recreational water), and WUI are summarized in this report. Outbreaks associated with recreational water are reported separately.

Results: A total of 24 states and Puerto Rico reported 48 outbreaks that occurred during 2007–2008. Of these 48 outbreaks, 36 were associated with drinking water, eight with WNID, and four with WUI. The 36 drinking water–associated outbreaks caused illness among at least 4,128 persons and were linked to three deaths. Etiologic agents were identified in 32 (88.9%) of the 36 drinking water–associated outbreaks; 21 (58.3%) outbreaks were associated with bacteria, five (13.9%) with viruses, three (8.3%) with parasites, one (2.8%) with a chemical, one (2.8%) with both bacteria and viruses, and one (2.8%) with both bacteria and parasites. Four outbreaks (11.1%) had unidentified etiologies. Of the 36 drinking water–associated outbreaks, 22 (61.1%) were outbreaks of acute gastrointestinal illness (AGI), 12 (33.3%) were outbreaks of acute respiratory illness (ARI), one (2.8%) was an outbreak associated with skin irritation, and one (2.8%) was an outbreak of hepatitis. All outbreaks of ARI were caused by *Legionella* spp.

A total of 37 deficiencies were identified in the 36 outbreaks associated with drinking water. Of the 37 deficiencies, 22 (59.5%) involved contamination at or in the source water, treatment facility, or distribution system; 13 (35.1%) occurred at points not under the jurisdiction of a water utility; and two (5.4%) had unknown/insufficient deficiency information. Among the 21 outbreaks associated with source water, treatment, or distribution system deficiencies, 13 (61.9%) were associated

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with untreated ground water, six (28.6%) with treatment deficiencies, one (4.8%) with a distribution system deficiency, and one (4.8%) with both a treatment and a distribution system deficiency. No outbreaks were associated with untreated surface water. Of the 21 outbreaks, 16 (76.2%) occurred in public water systems (drinking water systems under the jurisdiction of EPA regulations and water utility management), and five (23.8%) outbreaks occurred in individual systems (all of which were associated with untreated ground water). Among the 13 outbreaks with deficiencies not under the jurisdiction of a water system, 12 (92.3%) were associated with the growth of *Legionella* spp. in the drinking water system, and one (7.7%) was associated with a plumbing deficiency. In the two outbreaks with unknown deficiencies, one was associated with a public water supply, and the other was associated with commercially bottled water. The 70 previously unreported outbreaks included 69 *Legionella* outbreaks during 1973–2000 that were not reportable previously to WBDOSS and one previously unreported outbreak from 2002.

Interpretation: More than half of the drinking water–associated outbreaks reported during the 2007–2008 surveillance period were associated with untreated or inadequately treated ground water, indicating that contamination of ground water remains a public health problem. The majority of these outbreaks occurred in public water systems that are subject to EPA's new Ground Water Rule (GWR), which requires the majority of community water systems to complete initial sanitary surveys by 2012. The GWR focuses on identification of deficiencies, protection of wells and springs from contamination, and providing disinfection when necessary to protect against bacterial and viral agents. In addition, several drinking water–associated outbreaks that were related to contaminated ground water appeared to occur in systems that were potentially under the influence of surface water. Future efforts to collect data systematically on contributing factors associated with drinking water outbreaks and deficiencies, including identification of ground water under the direct influence of surface water and the criteria used for their classification, would be useful to better assess risks associated with ground water.

During 2007–2008, *Legionella* was the most frequently reported etiology among drinking water–associated outbreaks, following the pattern observed since it was first included in WBDOSS in 2001. However, six (50%) of the 12 drinking water–associated *Legionella* outbreaks were reported from one state, highlighting the substantial variance in outbreak detection and reporting across states and territories. The addition of published and CDC-investigated legionellosis outbreaks to the WBDOSS database clarifies that *Legionella* is not a new public health issue. During 2009, *Legionella* was added to EPA's Contaminant Candidate List for the first time.

Public Health Actions: CDC and EPA use WBDOSS surveillance data to identify the types of etiologic agents, deficiencies, water systems, and sources associated with waterborne disease outbreaks and to evaluate the adequacy of current technologies and practices for providing safe drinking water. Surveillance data also are used to establish research priorities, which can lead to improved water quality regulation development. Approximately two thirds of the outbreaks associated with untreated ground water reported during the 2007–2008 surveillance period occurred in public water systems. When fully implemented, the GWR that was promulgated in 2006 is expected to result in decreases in ground water outbreaks, similar to the decreases observed in surface water outbreaks after enactment of the Surface Water Treatment Rule in 1974 and its subsequent amendments. One third of drinking water–associated outbreaks occurred in building premise plumbing systems outside the jurisdiction of water utility management and EPA regulations; *Legionella* spp. accounted for >90% of these outbreaks, indicating that greater attention is needed to reduce the risk for legionellosis in building plumbing systems. Finally, a large communitywide drinking water outbreak occurred in 2008 in a public water system associated with a distribution system deficiency, underscoring the importance of maintaining and upgrading drinking water distribution system infrastructure to provide safe water and protect public health.

Introduction

Data on waterborne disease outbreaks in the United States have been collected since 1920. Researchers reported these statistics during 1920–36 (*1*), 1938–1945 (*2*), 1946–1960 (*3*), and 1961–1970 (*4*). Since 1971, CDC, the U.S. Environmental Protection Agency (EPA), and the Council of State and Territorial Epidemiologists (CSTE) have collaborated on the Waterborne Disease and Outbreak Surveillance System (WBDOSS), which tracks the occurrences and causes of outbreaks associated with drinking water and other water exposures. The history of surveillance for waterborne disease outbreaks in the United States has been summarized previously (*5*). Previously reported data from drinking water–associated outbreaks have been reclassified systematically and analyzed for trends (*6*). This report presents data on 48 outbreaks that occurred during 2007–2008 and were reported to CDC by public health departments in U.S. states, territories, and localities as well as a previously unreported outbreak that occurred in 2002 and 69 legionellosis outbreaks associated with drinking water, water not intended for drinking (WNID), and water of unknown intent (WUI) that occurred before 2001. Since 2001,

legionellosis outbreaks associated with drinking water have been reported to WBDOSS. Legionellosis outbreaks that occurred before 2001 have been added retrospectively to WBDOSS to provide a more complete representation of legionellosis outbreaks associated with drinking water, WNID, and WUI. The data provided in this report represent only a portion of the burden of illness associated with exposure to drinking water. They do not include either endemic waterborne disease cases (sporadic cases not known to be associated with an outbreak) or the estimated number of unrecognized and unreported outbreaks.

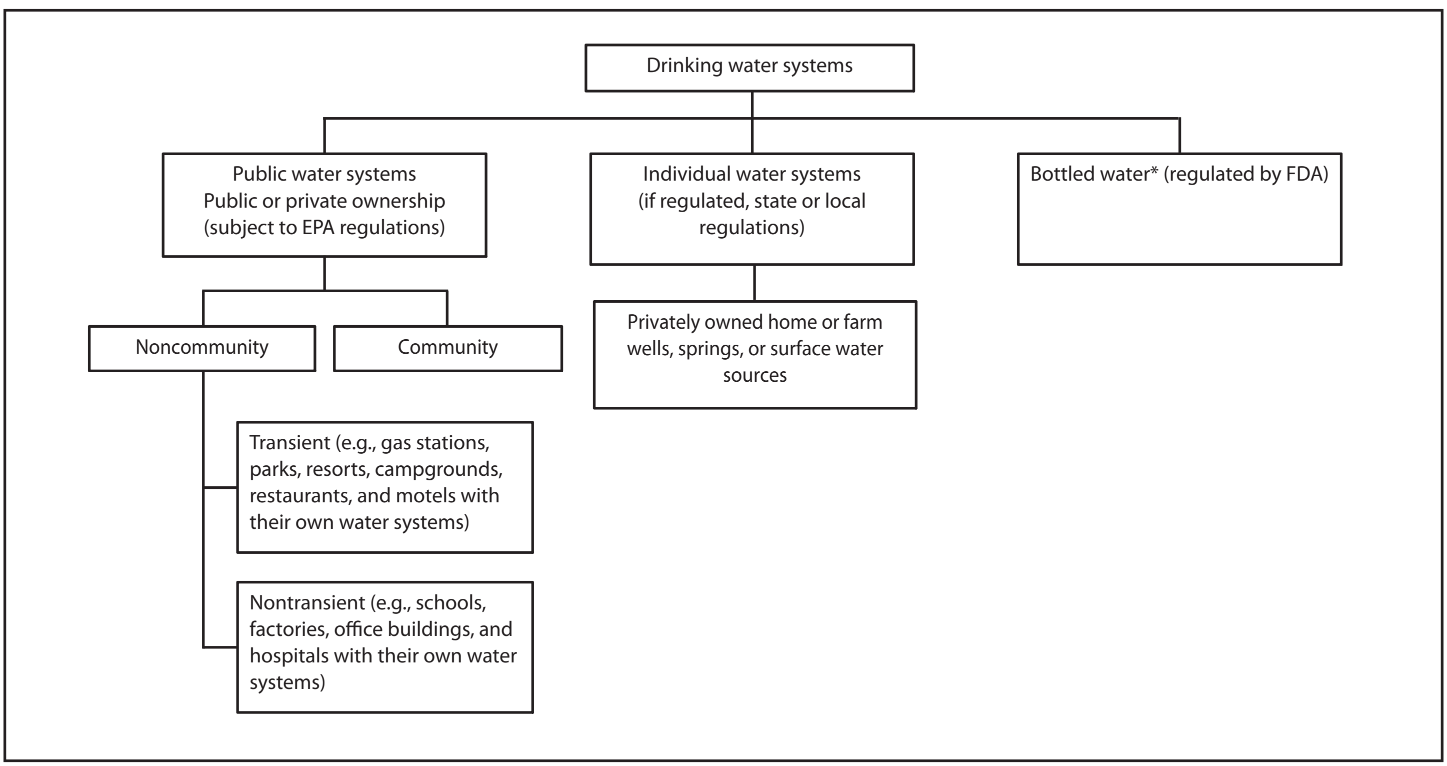
Background

Environmental Protection Agency Drinking Water Regulations

The majority of outbreaks described in this report occurred in public drinking water systems (Figure 1). The Safe Drinking Water Act (SDWA) of 1974 and its subsequent 1986 and 1996 amendments authorized EPA to set national standards to protect public drinking water and its sources against naturally occurring or man-made contaminants (*7–9*). These standards include health-based maximum levels for microbiologic, chemical, and other contaminants in drinking water and water treatment performance criteria for the removal or inactivation of contaminants (Table 1). If needed, EPA can issue guidance or a health advisory instead of a regulation. EPA regulations do not apply to private, individual water supplies. However, certain states and localities might set standards for individual water supplies (e.g., driller licensing and registration, well permitting, and water testing processes). Standards and requirements for private wells vary among states and localities. Commercially bottled water is regulated by the Food and Drug Administration (FDA) (Figure 1).

Additional rules that protect against exposure to waterborne pathogens include the Surface Water Treatment Rule (SWTR) and its amendments (*10–15*), the Total Coliform Rule (TCR) (*16,17*), and the 2006 Ground Water Rule (GWR) (*18,19*). The SWTR and amendments specify water-treatment techniques (e.g., filtration and disinfection), monitoring, and performance criteria for systems that use surface water sources to protect against *Giardia* and *Cryptosporidium* contamination. EPA has established criteria to assess whether ground water sources are under the direct influence of surface water, and, if so, these systems are required to meet provisions of the SWTR and amendments. The TCR requires public water systems to monitor for indicators of fecal contamination and take corrective action when they are found. In 2007, EPA established an advisory committee to provide recommendations on revisions to the TCR and on

FIGURE 1. Types of drinking water systems — United States



Abbreviations: EPA = Environmental Protection Agency; FDA = Food and Drug Administration.
* In certain instances, bottled water is used in lieu of a community supply or by noncommunity systems.

TABLE 1. Selected U.S. Environmental Protection Agency listings and regulations regarding drinking water, by year enacted — United States, 1974–2009

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 (TCR)	1989
Chemical Contaminant Rules Phase I	1989
Lead and Copper Regulations	1990
Chemical Contaminant Rules Phase II	1992
Chemical Contaminant Rules Phase IIB	1993
Chemical Contaminant Rules Phase V	1994
SDWA Amendments	1996
Information Collection Rule	1996
Interim Enhanced SWTR	1998
Stage 1 - Disinfectants and Disinfection By-Products (D-DBP) Regulation	1998
Drinking Water Contaminant Candidate List	1998
Unregulated Contaminant Monitoring Regulations	1999
Radionuclides Rule	2000
Lead and Copper Rule — action levels	2000
Filter Backwash Recycling Rule	2001
Long Term 1 Enhanced SWTR	2002
Unregulated Contaminant Monitoring Regulations	2002
Drinking Water Contaminant Candidate List 2	2005
Long Term 2 Enhanced SWTR	2006
Stage 2 D-DBP Rule	2006
Ground Water Rule	2006
Drinking Water Contaminant Candidate List 3	2009

information needed to understand better the public health risks associated with the degradation of water quality in pipes, storage tanks, and other appurtenances used to distribute drinking water to consumers (*20*). The GWR specifies when corrective action, including disinfection, is required for wells and springs to protect against bacteria and viruses (Table 1). In addition to the rules described above, a program established in the 1986 SDWA amendments, the Wellhead Protection Program, requires states to develop plans to delineate and manage wellhead protection areas and to actively reduce the potential for contamination of all public ground water systems (*18*).

The SDWA amendments of 1996 require EPA to publish periodically a list of contaminants that must be evaluated for potential regulatory action (*21,22*) and to establish criteria for a program to monitor unregulated contaminants (*23–26*). Contaminant Candidate Lists (CCL1, 2 and 3) were published in 1998, 2005, and 2009 (*21,22,27*). Microbial contaminants are selected for inclusion on the CCL on the basis of three criteria: 1) that the contaminant might have an adverse effect on human health, 2) that the contaminant is known to occur or there is a substantial likelihood that it will occur in public water systems with a frequency and at levels of public health concern, and 3) that regulation of the contaminant presents a meaningful opportunity to reduce health risk (*28*). In 2009, *Legionella pneumophila* was added to CCL3 for the first time (*22*).

Methods

Data Sources

Public health agencies in the states, U.S. territories, localities, and Freely Associated States* (FAS) have primary responsibility for detecting and investigating outbreaks, which they report voluntarily to CDC using a standard form (CDC 52.12, available at http://www.cdc.gov/healthywater/statistics/wbdoss/nors/forms_archive.html). The form solicits data on characteristics of outbreaks (e.g., number of cases, time, and location), results from epidemiologic and environmental investigations, and results from clinical-specimen and water-sample testing. CDC annually requests reports of outbreaks from persons designated as waterborne disease surveillance coordinators and obtains additional information regarding epidemiologic investigations, water quality, and water treatment to supplement submitted outbreak reports as needed. Numeric and text data are abstracted from outbreak report forms and supporting documents and entered into a database for analysis. All of the outbreaks that occurred during 2007–2008 were reported through the paper-based reporting system and analyzed by using SAS 9.2 (SAS Institute, Inc. Cary, North Carolina). To ensure completeness of legionellosis outbreak data for 2007–2008, CDC compared data from WBDOSS with data from the Travel-Associated Legionellosis in the United States System. In addition, data on outbreaks of legionellosis that occurred before 2001 were added to the WBDOSS database.

Definitions

Waterborne Disease Outbreak

Two criteria must be met for an event to be defined as an outbreak associated with drinking water, WNID (excluding recreational water), or WUI: 1) two or more persons must be linked epidemiologically by time, location of exposure to water, and illness characteristics; and 2) the epidemiologic evidence must implicate water as the probable source of illness. Outbreak reports with limited or no environmental data might be included in WBDOSS, but outbreak reports that lack epidemiologic data linking the outbreak to water are excluded.

Reported outbreaks associated with contaminated drinking water, commercially bottled water, ice, beverages made with contaminated water, and water contaminated by malfunctions in equipment or devices in which water is used or distributed (e.g., beverages contaminated by plumbing failures in drink mix/soda machines) are classified as drinking water–associated

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

outbreaks. Outbreaks involving the consumption of beverages containing contaminated ingredients (i.e., other than water) or ice contaminated through human handling are reported to CDC as foodborne disease outbreaks, not waterborne disease outbreaks. WBDOSS report data are categorized on the basis of the location of the water exposure, not the ill person's state of residence. Outbreaks occurring on cruise ships are not reported to WBDOSS; CDC's Vessel Sanitation Program tracks outbreaks of acute gastrointestinal illness (AGI) related to cruise ships (*29*).

Single Cases

Single cases of illness or injury associated with water exposure are not classified or analyzed as outbreaks but might be reported directly to WBDOSS or through other national surveillance systems. Cases that might be reported directly to WBDOSS include laboratory-confirmed primary amebic meningoencephalitis (PAM) as a result of *Naegleria fowleri* infection and single cases of chemical or toxin poisoning.

Water Systems

WBDOSS includes data on outbreaks occurring in public and individual water systems. EPA defines a public water system as a system for the provision of water for human consumption through a distribution system that has at least 15 service connections or that regularly serves at least 25 persons (*30*). An individual system is one that does not meet EPA's definition of a public water system. It typically serves a single family or farm; individual systems are not subject to EPA regulations but might be regulated at the state or local level. Public water systems include community water systems (serving the same persons year round) and noncommunity water systems (which serve the public but generally do not serve the same persons year round). Noncommunity water systems include transient noncommunity systems (serving different persons for >6 months of the year, such as those in parks and restaurants) and nontransient, noncommunity systems (serving the same persons for >6 months out of the year, such as those in schools and factories) (Figure 1). Of the approximately 153,530 public water systems in the United States, 51,651 (33.6%) are community systems, and 101,879 (66.4%) are noncommunity systems, including 83,484 (81.9%) transient systems and 18,395 (18.1%) nontransient systems (Figure 1) (*31*). Community systems serve 294.3 million persons; of the 51,651 community water systems, 4,156 (8%) are classified by EPA as "large" (serving 10,001–100,000 persons) or "very large" (serving >100,000 persons) and provide water to 77% of the U.S. population. Nontransient, noncommunity systems provide water to 6.2 million persons, and transient noncommunity systems provide water to 13.3 million persons (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 78% of community water systems are supplied by ground water, more persons (70%) are supplied year-round by community water systems that use surface water (*31*). Approximately 15% of the U.S. population (15.8 million households) relies on individual water systems that are owned privately (*32,33*). Private wells that serve <25 persons are not regulated by EPA under SDWA (*34*).

Water Sources

Drinking water–associated outbreaks are categorized in WBDOSS as having ground water, surface water, or mixed water sources. Ground water sources include springs, aquifers, and wells. Surface water refers to all water found on the surface (e.g., river, lake, or pond) as distinguished from subsurface or ground water. A drinking water system that uses both a ground water and a surface water source is defined by WBDOSS as having a mixed source. Ground water sources that have the potential for surface water contamination and are used to supply drinking water systems may be categorized as ground water under the direct influence of surface water (GWUDI). EPA has specified criteria to identify potential GWUDI, and state and local environmental health agencies conduct site-specific evaluations of water quality, construction characteristics, and geology to determine treatment requirements.

Deficiencies

To understand the circumstances and water system breakdowns that lead to outbreaks, each outbreak is classified as having one or more deficiencies (e.g., in water treatment and operation, water storage and delivery, or premise plumbing) (Table 2). Analyses of outbreak deficiencies provide important information about how the water became contaminated, water system characteristics, and factors leading to waterborne disease outbreaks.

Strength-of-Evidence Classification for Waterborne Disease Outbreaks

All outbreaks reported to WBDOSS for 2007–2008 have been classified according to the strength of 1) epidemiologic and clinical laboratory evidence and 2) environmental evidence implicating water as the vehicle of transmission (Table 3). The classification (i.e., Classes I–IV), which was first used in the 1989–1990 surveillance report (*35*), is based on the epidemiologic and environmental data reported to WBDOSS.

Outbreaks and subsequent investigations occur under different circumstances, and not all outbreaks can be investigated

TABLE 2. CDC deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent

Contamination of water at/in the water source, treatment facility, or distribution system*

1: Untreated surface water intended for drinking
2: Untreated ground water intended for drinking
3: Treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, or inadequate or no filtration)
4: Distribution system deficiency, including storage (e.g., cross-connection, backflow, contamination of water mains during construction or repair)
13: Current treatment processes not expected to remove a chemical contaminant (e.g., pesticide contamination of ground water treated with disinfection only)
  A: Surface water
  B: Ground water

Contamination of water at points not under the jurisdiction of a water utility or at the point of use†

5: *Legionella* spp. in water system
  A: Water intended for drinking
  B: Water not intended for drinking (excluding recreational water)
  C: Water of unknown intent
6: Plumbing system deficiency after the water meter or property line (e.g., cross-connection, backflow, or corrosion products)
7: Deficiency in building/home-specific water treatment after the water meter or property line
8: Deficiency or contamination of equipment using or distributing water (e.g., drink-mix machines)
9: Contamination or treatment deficiency during commercial bottling
10: Contamination during shipping, hauling, or storage
  A: Water intended for drinking – tap water
  B: Water intended for drinking – commercially bottled water
11: Contamination at point of use
  A: Tap
  B: Hose
  C: Commercially bottled water
  D: Container, bottle, or pitcher
  E: Unknown
12: Drinking or contact with water not intended for drinking (excluding recreational water)

Unknown/Insufficient Information

99: Unknown/Insufficient information
  A: Water intended for drinking – tap water
  B: Water intended for drinking – commercially bottled water
  C: Water not intended for drinking (excluding recreational water)
  D: Water of unknown intent

* For a community water system, the distribution system refers to the pipes and storage infrastructure under the jurisdiction of the water utility prior to the water meter or property line (if the system is not metered). For noncommunity and nonpublic individual water systems, the distribution system refers to the pipes and storage infrastructure before entry into a building or house.

† Contamination of drinking water and deficiencies occurring in plumbing and pipes that are not part of the distribution system as defined previously. For community systems, this means occurring after the water meter or outside the jurisdiction of a water utility; for noncommunity and nonpublic systems, this means occurring within the building or house (e.g., in a service line leading to a house or building, in the plumbing inside a house or building, during shipping or hauling, during storage other than in the distribution system, or at point of use).

rigorously. Classifications that do not meet the highest level (I) do not necessarily imply that the investigation was inadequate or incomplete because multiple factors (e.g., timeliness of outbreak detection) contribute to the ability to collect optimal epidemiologic, clinical laboratory, and environmental data.

Additional terms used in this report have been defined elsewhere (Appendix A).

Changes in the 2007–2008 Surveillance Summary

Strength-of-Evidence Classification

Molecular epidemiology is used increasingly to understand pathogen transmission patterns, detect outbreaks, and identify important risk factors and outbreak sources. The criteria used to determine the strength-of-evidence classifications have been revised to reflect the increasing use of molecular characterization of pathogens identified in clinical specimens and environmental samples collected during outbreak investigations. Molecular data that link multiple persons who had an identical water exposure now are considered adequate epidemiologic data to support a Class I or Class II assignment; molecular data that link at least one person to the implicated water exposure now are considered adequate water quality data to support a Class I or Class III assignment. Previously, epidemiologic study data were required to receive a strength-of-evidence classification of I or II. The "epidemiologic data" and "water quality data" categories have been renamed "epidemiologic and clinical laboratory data" and "environmental data," respectively (Table 3).

Number of Cases

Case counts provided in this report were based on the estimated number of total cases if sufficient supporting evidence

TABLE 3. CDC classification of investigations of waterborne disease outbreaks on the basis of strength of evidence implicating water as a vehicle of transmission — United States, 2007–2008

Class	Epidemiologic and clinical laboratory data	Environmental data
I	**Provided and adequate**	**Provided and adequate**
	Epidemiologic data provided about exposed and unexposed persons, with relative risk or odds ratio ≥2 or p-value ≤0.05; or	Laboratory data or historic information (e.g., reports of chlorinator malfunction, a water main break, no detectable free-chlorine residual, or the presence of coliforms in the water); or
	Molecular characterization of pathogens linked multiple persons who had a single identical exposure	Molecular characteristics of pathogens isolated from water and at least one clinical specimen were identical
II	**Provided and adequate**	**Not provided or inadequate**
	Epidemiologic data provided about exposed and unexposed persons, with relative risk or odds ratio ≥2 or p-value ≤0.05; or	E.g., laboratory testing of water not conducted and no historic information available
	Molecular characterization of pathogens linked multiple persons who had a single identical exposure	
III	**Provided but limited**	**Provided and adequate**
	Epidemiologic data provided that did not meet the criteria for Class I or II or claim made that ill persons had no exposures in common, besides water, but no data provided	Laboratory data or historic information (e.g., reports of chlorinator malfunction, a water main break, no detectable free-chlorine residual, or the presence of coliforms in the water); or
		Molecular characteristics of pathogens isolated from water and at least one clinical specimen were identical
IV	**Provided but limited**	**Not provided or inadequate**
	Epidemiologic data provided that did not meet the criteria for Class I or II or claim made that ill persons had no exposures in common, besides water, but no data provided	E.g., laboratory testing of water not conducted and no historic information available

was provided. For example, this might include applying the attack rate found during a cohort study to the entire population exposed to contaminated water to estimate the total number of ill persons associated with an outbreak. If no "estimated ill" number was provided, the actual number of reported cases (e.g., laboratory-confirmed and probable cases as reported by the state) was used. CDC requests that states report only cases in which primary exposure to water occurs, so secondary cases (e.g., person-to-person transmission among household members) are not included in case counts of waterborne disease in WBDOSS.

Analysis of Deficiencies

Previous WBDOSS surveillance reports limited the descriptive analyses to focus on drinking water–associated outbreaks with source water, treatment, or distribution system deficiencies (i.e., deficiencies 1–4 and 13) (Table 2). However, tables and figures in this report present data for all of the drinking water–associated outbreaks and deficiencies, including those associated with *Legionella* spp. and building premise plumbing deficiencies (i.e., deficiencies 1–13 and 99).

Legionnaires' Disease Outbreaks Before 2001

Data concerning previously unreported legionellosis outbreaks that occurred before 2001 have been added to the WBDOSS database. These data were abstracted from Epidemic Intelligence Service outbreak investigation reports and peer-reviewed publications. Previously, only Legionnaires' disease (LD) outbreaks that occurred after 2001 were included in WBDOSS.

Results

During 2007–2008, a total of 24 states and Puerto Rico reported 48 outbreaks, including 29 for 2007 and 19 for 2008. Of these, 36 outbreaks were associated with drinking water, eight with WNID, and four with WUI. Outbreaks are tabulated by year and state (Tables 4–6). One outbreak that occurred in 2002 and 69 *Legionella* outbreaks from 1973–2000 also were included as previously unreported outbreaks (Table 7).

Waterborne Disease Outbreaks Associated with Drinking Water

Since the surveillance system first started in 1971, drinking water–associated outbreaks have been reported every year (Figure 2). The 36 outbreaks described in this report (including 20 in 2007 and 16 in 2008) occurred in 23 states and Puerto Rico (Figure 3). Outbreaks occurred predominantly in the spring through fall, with only three outbreaks reported during November–February. Multiple etiologic agents were implicated in the 36 outbreaks (Table 8). Descriptions of selected outbreaks have been summarized (Appendix B).

The 36 outbreaks reported during 2007–2008 caused illness among at least 4,128 persons and resulted in three deaths. The median number of persons affected in an outbreak was 14 (range: 2–1,663). Four predominant illnesses were reported: 22 (61.1%) outbreak reports of AGI, 12 (33.3%) outbreak reports of acute respiratory illness (ARI), one (2.8%) outbreak report

TABLE 4. Waterborne disease outbreaks associated with drinking water (n = 20) — Waterborne Disease and Outbreak Surveillance System, United States, 2007

State	Month	Class*	Etiology	Predominant illness†	No. of cases§ (n = 2,456)	Type of system¶	Deficiency**	Water source	Setting
California	Jul	III	*Giardia intestinalis*	AGI	46	Ncom	3	Spring	Camp/Cabin
Colorado	Jun	III	Norovirus genogroup II	AGI	77	Ncom	3	Well	Camp/Cabin
Florida	Sep	I	Unidentified	AGI	1,663	Com	3	Reservoir	Community
Idaho	Jun	I	*Campylobacter*	AGI	15	Ncom	2	Spring††	Camp/Cabin
Massachusetts	Apr	III	Sodium hydroxide§§	Skin	145	Com	3	Well	Community
Maryland	Jun	I	Norovirus genogroup II	AGI	94	Ncom	3	Well	Membership club
Missouri	May	I	Unidentified	AGI	51	Com	3	Well	Community
New Hampshire	Aug	I	*G. intestinalis*	AGI	35	Com	2	Well	Neighborhood/Subdivision
Nevada	Oct	I	*Legionella pneumophila* serogroup 1	ARI	7	Com	5A	Reservoir	Condominium
New York	Oct	III	*L. pneumophila* serogroup 1	ARI	3	Com	5A	Reservoir	Nursing home
New York	Oct	IV	*L. pneumophila* serogroups 1, 5	ARI	3	Com	5A	Reservoir	Hospital/Health-care facility
New York	Jun	III	*L. pneumophila* serogroup 1	ARI	2	Com	5A	Reservoir	Nursing home
Ohio	Mar	IV	Unidentified	AGI	3	Bottled	99B	Reservoir¶¶	Private residence
Ohio	Nov	III	*L. pneumophila* serogroup 1	ARI	3	Com	5A	Lake	Hospital/Health-care facility
Tennessee	May	I	*Salmonella* Newport	AGI	2	Ind	2	Well	Private Residence
Vermont	Oct	III	*L. pneumophila* serogroup 1	ARI	3	Ncom	5A	Well	Hotel/Motel
Washington	Jan	I	Norovirus	AGI	32	Ncom	2	Well	Restaurant
Wisconsin	May	I	Norovirus genogroup I, *Campylobacter*, *Salmonella*	AGI	229	Ncom	2	Well	Restaurant
West Virginia	Oct	III	*Campylobacter*	AGI	4	Ind	2	Spring	Private residence
Wyoming	Jan	I	Unidentified***	AGI	39	Ncom	2	Well	Lodge

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Skin = illnesses, conditions, or symptoms related to skin; Com = community; Ncom = noncommunity; Ind = individual; Bottled = commercially bottled water.

* On the basis of epidemiologic, clinical laboratory, and environmental data (e.g., water quality data) provided to CDC.

† The category of illness reported by ≥50% of ill respondents.

§ No deaths were reported in cases associated with outbreaks reported during 2007.

¶ Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.

** Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).

†† The spring associated with this outbreak was vulnerable to surface water contamination and is regulated as a surface water source by the state.

§§ A chemical overfeed of sodium hydroxide at the water-treatment facility raised the pH of the water in the distribution system.

¶¶ Water from a community water system that used surface water was distilled before distribution.

*** Etiology unidentified; norovirus suspected based upon incubation period, symptoms, and duration of illness.

of hepatitis and one (2.8%) outbreak report of skin irritation associated with a chemical exposure. Although the 22 AGI outbreaks were caused by a variety of pathogens, all 12 ARI outbreaks were caused by *Legionella* (i.e., LD or Pontiac fever [PF]) (Figure 4).

Of the 36 drinking water–associated outbreaks, 17 (47.2%) were assigned a strength-of-evidence rank of Class I, two (5.6%) were ranked as Class II, 14 (38.9%) were ranked as Class III, and three (8.3%) were ranked as Class IV. Drinking water–associated outbreaks were tabulated by etiology, type of water system, and water source (Table 8); deficiency and type of water system (Table 9); and deficiency and water source (Table 10).

Etiology

Of the 36 drinking water–associated outbreaks, 21 (58.3%) were caused by bacteria, five (13.9%) were caused by viruses, three (8.3%) were caused by parasites, and one (2.8%) was caused by a chemical. Two (5.6%) outbreaks had multiple etiologies: one (2.8%) was caused by bacteria and viruses, and one (2.8%) was caused by bacteria and parasites. Four (11.1%) had unidentified etiologies: one was suspected to be caused by norovirus (Table 8; Figure 5).

Bacteria. A total of 21 outbreaks were associated with bacterial agents and resulted in 1,520 cases of illness: 12 outbreaks, 75 cases of illness, and two deaths were caused by *Legionella*; four outbreaks and 77 cases of illness were caused by *Campylobacter*; three outbreaks, 1,307 cases of illness, and one death were caused by *Salmonella*; one outbreak and six cases of illness were caused by *E. coli* O157:H7; and one outbreak with 55 cases of illness was caused by *Providencia* spp. (Table 8). An estimated 1,300 cases of illness were related to *Salmonella* contamination during a single outbreak in Colorado (Table 5; Appendix B).

Viruses. Five outbreaks were associated with viral agents and resulted in 274 cases of illness: four outbreaks with 265 cases of illness were caused by norovirus, and one outbreak with nine cases of illness was caused by hepatitis A.

Parasites. Three outbreaks were associated with parasitic agents and resulted in 163 cases of illness and no reported deaths. Two of these outbreaks with 81 cases of illness were caused by *Giardia intestinalis*, and one outbreak with 82 cases of illness was caused by *Cyclospora cayetanensis*.

Chemicals. One outbreak involved a chemical exposure and resulted in an estimated 145 cases of illness following exposure

TABLE 5. Waterborne disease outbreaks associated with drinking water (n = 16), by state/jurisdiction — Waterborne Disease and Outbreak Surveillance System, United States, 2008

State/ Jurisdiction	Month	Class*	Etiology	Predominant illness†	No. of cases [deaths] (n = 1,672 [3]§)		Type of system¶	Deficiency**	Water source	Setting
Colorado	Mar	I	*Salmonella* Typhimurium	AGI	1,300	[1]	Com	4	Well	Community
Connecticut	Aug	I	*Providencia*††	AGI	55	—§§	Com	2	Well	Apartment complex
Georgia	Sep	III	*Legionella pneumophila* serogroup 1	ARI	6	—	Com	5A	Reservoir	Hospital/Health-care facility
Illinois	Jun	III	*L. pneumophila* serogroup 1	ARI	4	—	Com	5A	Well	Hospital/Health-care facility
Illinois	Oct	II	*Escherichia coli* O157:H7	AGI	6	—	Ind	2	Well	Farm
Illinois	Sep	I	*Shigella sonnei, Cryptosporidium, Giardia*	AGI	41	—	Com	6	Lake	Boat
New Jersey	Aug	III	*L. pneumophila* serogroup 1	ARI	9	—	Com	5A	Reservoir	Hospital/Health-care facility
New York	Jul	III	*L. pneumophila* serogroup 1	ARI	13	[1]	Com	5A	Well, river	Seniors housing complex
New York	Aug	IV	*L. pneumophila* serogroup 1	ARI	19	—	Com	5A	Lake	Assisted living facility
New York	Sep	III	*L. pneumophila* serogroup 1	ARI	3	[1]	Com	5A	Lake	Nursing home
Oklahoma	Jun	I	Norovirus genogroup 1.4	AGI	62	—	Com	3,4	Well	Neighborhood/Subdivision
Puerto Rico	Apr	II	*Cyclospora cayetanensis*	AGI	82	—	Com	99A	River	Community/Municipality
Tennessee	Mar	I	Hepatitis A virus	Hep	9	—	Ind	2	Well	Community/Municipality
Tennessee	Aug	I	*Salmonella* serotype I 4,5,12:*i*:-	AGI	5	—	Ncom	2	Spring	Private residence
Utah	Jun	III	*Campylobacter*	AGI	50	—	Ncom	2	Spring	Camp/Cabin
West Virginia	May	I	*C. jejuni*	AGI	8	—	Ind	2	Well	Private residence

Abbreviations: AGI = acute gastrointestinal illness, ARI = acute respiratory illness; Hep = hepatitis; Com = community; Ncom = noncommunity; Ind = individual; Bottle = commercially bottled water.

* On the basis of epidemiologic, clinical laboratory, and environmental data (e.g., water quality data) provided to CDC.

† The category of illness reported by ≥50% of ill respondents.

§ Deaths are included in the overall case count.

¶ Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.

** Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).

†† Six of nine stool specimens tested positive for *Providencia*. Extensive testing concluded that stool specimens were negative for *Salmonella*, *Shigella*, *Campylobacter*, *Escherichia coli*, ova and parasites, and norovirus.

§§ No deaths were reported.

TABLE 6. Waterborne disease outbreaks (n = 12) associated with water not intended for drinking (WNID) (excluding recreational water) and water of unknown intent (WUI) , by state — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008

State	Water type	Month	Year	Class*	Etiology	Predominant illness†	No. of cases [deaths] (n = 79 [4]§)		Deficiency¶	Water source	Setting
Colorado	WUI	Aug	2007	III	*Giardia intestinalis*	AGI	13	—**	99D	Unknown	Park
Florida	WUI	Mar	2007	IV	*Legionella pneumophila* serogroup 1	ARI	2	—	5C	Unknown	Membership club
Iowa	WNID	May	2007	IV	Unidentified††	AGI	10	—	12	Stream	State forest
Maryland	WNID	Oct	2007	I	*L. pneumophila* serogroup 1§§	ARI	2	—	5B	Ornamental fountain	Hospital/Health-care facility
Maryland	WNID	Jul	2008	IV	*L. pneumophila* serogroup 1	ARI	18	—	5B	Unknown¶¶	Community/Municipality
New Jersey	WUI	Jul	2008	IV	*L. pneumophila* serogroup 1	ARI	2	—	5C	Unknown	Senior housing facility
New York	WNID	Jun	2007	III	*L. pneumophila* serogroup 1	ARI	2	—	5B	Cooling tower	Community/Municipality
New York	WNID	Jun	2007	III	*L. pneumophila* serogroup 1	ARI	2	—	5B	Recycled water	Vehicle-washing station***
New York	WUI	Aug	2007	IV	*L. pneumophila* serogroup 1 *L. pneumophila* serogroup 7	ARI	2	[2]	5C	Unknown†††	Nursing home
New York	WNID	Sep	2007	III	*L. pneumophila* serogroup 1	ARI	4	[1]	5B	Cooling tower	Assisted living facility
New York	WNID	Jun	2008	I	*L. pneumophila* serogroup 1	ARI	12§§§	[1]	5B	Cooling tower	Community/Municipality
Wyoming	WNID	Apr	2007	IV	Unidentified	AGI	10	—	12	Hydrant, hose	Youth facility

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness.

* On the basis of epidemiologic, clinical laboratory, and environmental data (e.g., water quality data) provided to CDC.

† The category of illness reported by ≥50% of ill respondents.

§ Deaths are included in the overall case count.

¶ Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).

** No deaths were reported.

†† Etiology unidentified; norovirus suspected based upon incubation period, symptoms, and duration of illness.

§§ Outbreak occurred at a federal facility and was investigated independently by the facility.

¶¶ Environmental testing found positive results in samples collected at a cooling tower and a decorative fountain.

*** The outbreak was associated with a mass-transit vehicle washing station.

††† The investigation identified the drinking water system and a cooling tower as possible water exposures in this outbreak.

§§§ Eleven persons received a diagnosis of Legionnaires' disease, and one person received a diagnosis of Pontiac fever.

TABLE 7. Previously unreported outbreaks (n = 70) associated with drinking water, water not intended for drinking, and water of unknown intent, by state — Waterborne Disease and Outbreak Surveillance System, United States, 1973–2002*

State	Month/Year	Class[†]	Etiology	Predominant illness[§]	No. of cases [deaths] (n = 1,522 [237[¶]])	Deficiency**	Setting
Virginia	Jun 1973	IV	*Legionella pneumophila*	ARI	12 —[††]	5B	Factory/Industrial facility
Virginia	Jul 1973	IV	*L. pneumophila*	ARI	10 —	5B	Factory/Industrial facility
Pennsylvania	Sep 1974	II	*L. pneumophila*	ARI	11 —	5C	Hotel/Motel
Kansas	Aug 1975	IV	*Legionella*	ARI	3 [3]	5C	Hospital/Health-care facility
Connecticut	Nov 1976	I	*L. pneumophila* serogroup 1	ARI	28 [12]	5B	Community/Municipality
Pennsylvania	Jul 1976	II	*Legionella*	ARI	182 [29]	5C	Hotel/Motel
California	May 1977	II	*Legionella*	ARI	49 [15]	5C	Hospital/Health-care facility
Indiana	May 1977	IV	*Legionella*	ARI	39 [4]	5C	Hotel/Motel/Lodge
Ohio	Jul 1977	II	*Legionella*	ARI	14 [1]	5C	Community/Municipality
Tennessee	Aug 1977	IV	*Legionella*	ARI	33 [3]	5C	Community/Municipality
Vermont	May 1977	IV	*Legionella*	ARI	69 [17]	5C	Community/Municipality
Virginia	Jun 1977	IV	*L. micdadei*	ARI	16 [2]	5A	Hospital/Health-care facility
Georgia	Jul 1978	III	*L. pneumophila*	ARI	8 —	5B	Membership club
New York	Aug 1978	IV	*L. pneumophila* serogroup 1	ARI	57 [3]	5B	Factory/Industrial facility
Tennessee	Aug 1978	I	*L. pneumophila* serogroup 1	ARI	39 [7]	5B	Hospital/Health-care facility
Texas	Aug 1978	II	*L. pneumophila* serogroup 1	ARI	18 [2]	5B	Hotel/Motel
Illinois	Dec 1979	III	*L. pneumophila* serogroup 6	ARI	3 —	5A	Hospital/Health-care facility
New York	Jul 1979	III	*L. pneumophila*	ARI	6 [1]	5B	Factory/Industrial facility
Pennsylvania	Feb 1979	IV	*L. pneumophila*	ARI	27 [12]	5C	Hospital/Health-care facility
Wisconsin	Jun 1979	I	*L. pneumophila* serogroup 1	ARI	13 [4]	5B	Hotel/Motel
California	Mar 1980	III	*L. pneumophila* serogroup 1	ARI	14 —	5B	Office
California	Dec 1980	III	*L. pneumophila* serogroup 1, *L. dumoffi*	ARI	20 —	5C	Hospital/Health-care facility
Connecticut	Dec 1980	IV	*L. pneumophila*	ARI	36 [5]	5C	Hospital/Health-care facility
Vermont	May 1980	II	*L. pneumophila* serogroup 1	ARI	85 [16]	5B	Community/Municipality
Washington	Nov 1980	IV	*L. dumoffi*	ARI	9 [4]	5C	Hospital/Health-care facility
Iowa	Oct 1981	IV	*L. pneumophila* serogroup 1	ARI	12 [1]	5C	Community/Municipality
New York	Feb 1982	I	*L. pneumophila* serogroup 1	ARI	11 —	5A	Hospital/Health-care facility
New York	Jun 1982	IV	*L. pneumophila*	ARI	3 —	5A	Hospital/Health-care facility
Washington	Oct 1982	I	*L. pneumophila* serogroup 3	ARI	15 [2]	5A	Hospital/Health-care facility
Rhode Island	Jun 1983	I	*L. pneumophila* serogroup 1	ARI	15 [10]	5B	Hospital/Health-care facility
California	Jan 1984	IV	*L. pneumophila, L. dumoffi, L. micdadei*	ARI	14 [1]	5A	Hospital/Health-care facility
New York	Apr 1984	III	*L. pneumophila* serogroup 1	ARI	86 —	5B	Office
Ohio	Apr 1984	IV	*L. pneumophila* serogroup 1	ARI	7 —	5C	Hospital/Health-care facility
Utah	May 1984	I	*L. pneumophila* serogroup 1	ARI	4 [1]	5B	Hospital/Health-care facility
Michigan	May 1985	IV	*L. pneumophila* serogroup 1	ARI	14 [3]	5C	Temporary event
South Dakota	Apr 1985	I	*L. pneumophila* serogroup 1	ARI	26 [10]	5A	Hospital/Health-care facility
Wisconsin	Aug 1986	I	*L. pneumophila* serogroup 1	ARI	32 [2]	5B	Community/Municipality
California	Mar 1986	IV	*L. pneumophila* serogroups 1, 4, 6	ARI	7 [5]	5A	Hospital/Health-care facility
Maryland	May 1986	IV	*L. pneumophila* serogroup 1	ARI	27 [2]	5C	Store
Arizona	Jan 1987	I	*L. pneumophila* serogroups 1, 5, 6, 10	ARI	25 [12]	5A	Hospital/Health-care facility
Florida	Jan 1987	III	*L. pneumophila* serogroup 1	ARI	2 [1]	5A	Hospital/Health-care facility
Washington	May 1987	II	*L. micdadei, L. feelei, L. pneumophila* serogroup 3	ARI	7 [5]	5A	Hospital/Health-care facility
Michigan	Jul 1987	IV	*L. pneumophila* serogroup 1	ARI	7 —	5B	Prison/Jail
Pennsylvania	Jul 1987	III	L. *pneumophila* serogroup 1	ARI	2 [1]	5B	Factory/Industrial facility
Vermont	Oct 1987	IV	*L. pneumophila* serogroup 1	ARI	27 [3]	5C	Hotel/Motel
California	Apr 1988	III	*L. anisa*	ARI[††]	34 —	5B	Hotel/Motel
California	Jun 1988	IV	*L. pneumophila* serogroup 1	ARI	3 —	5C	Retirement home
Ohio	Jul 1989	III	*L. pneumophila* serogroup 1	ARI	38 [11]	5A	Hospital/Health-care facility
Louisiana	Oct 1989	I	*L. pneumophila* serogroup 1	ARI	33 [2]	5A	Store
New York	Jun 1989	II	*L. pneumophila* serogroups 1, 6	ARI	7 —	5C	Hospital/Health-care facility
Texas	Apr 1989	II	*L. pneumophila* serogroup 1	ARI	14 [6]	5A	Hospital/Health-care facility
California	Mar 1991	II	*L. pneumophila* serogroups 4, 5, 6	ARI	5 —	5C	Hospital/Health-care facility
California	Aug 1991	IV	*L. pneumophila* serogroup 1	ARI	10 [1]	5C	Office
Utah	Aug 1991	I	*L. pneumophila* serogroup 1	ARI	11 —	5A	Indoor place of work
Florida	Jan 1992	I	*L. pneumophila* serogroup 1	ARI	5 —	5B	Hotel/Motel
Ohio	Jun 1992	II	*L. pneumophila* serogroups 1, 3, 7, *L. longbeachae*	ARI	52 [2]	5C	Community/Municipality
Pennsylvania	Feb 1992	II	*L. pneumophila* serogroup 1	ARI	2 —	5C	Factory/Industrial Facility
Massachusetts	Jul 1993	I	*L. pneumophila* serogroup 1	ARI	11 [3]	5B	Community/Municipality
Rhode Island	Aug 1993	I	*L. pneumophila* serogroup 1	ARI	17 [2]	5B	Community/Municipality
Connecticut	Apr 1994	I	*L. pneumophila* serogroup 1	ARI	20 —	5A	Hospital/Health-care facility
Delaware	Jul 1994	I	*L. pneumophila* serogroup 1	ARI	29 [2]	5B	Hospital/Health-care facility
New York	Jan 1995	I	*L. micdadei*	ARI	19 [4]	5A	Hospital/Health-care facility
Pennsylvania	Jul 1995	I	*L. pneumophila* serogroup 1	ARI	22 [3]	5B	Hospital/Health-care facility
Missouri	Sep 1996	III	*L. pneumophila* serogroup 1	ARI	3 —	5C	Restaurant/Cafeteria
Rhode Island	Aug 1996	III	*L. pneumophila* serogroup 1	ARI	18 [1]	5B	Community/Municipality
Texas	Apr 1996	III	*L. pneumophila*	ARI	4 —	5C	Hospital/Health-care facility

See table footnotes on page 48

TABLE 7. (*Continued*) Previously unreported outbreaks (n = 70) associated with drinking water, water not intended for drinking, and water of unknown intent, by state — Waterborne Disease and Outbreak Surveillance System, United States, 1973–2002*

State	Month	Year	Class†	Etiology	Predominant illness§	No. of cases[deaths] (n = 1,522 [237¶])	Deficiency**	Setting
California	Nov	1997	II	*L. pneumophila* serogroup 1	ARI	8 [1]	5C	Community/Municipality
Missouri	Jul	1997	III	*L. pneumophila* serogroup 1, *L. bozemanii*	ARI	4 —	5B	Hospital/Health-care facility
Pennsylvania	May	1998	IV	*L. pneumophila* serogroup 1	ARI	7 —	5B	Community/Municipality
Georgia	Sep	2002	III	*Mycobacterium mageritense*	Skin	2 —	12	Nail salon

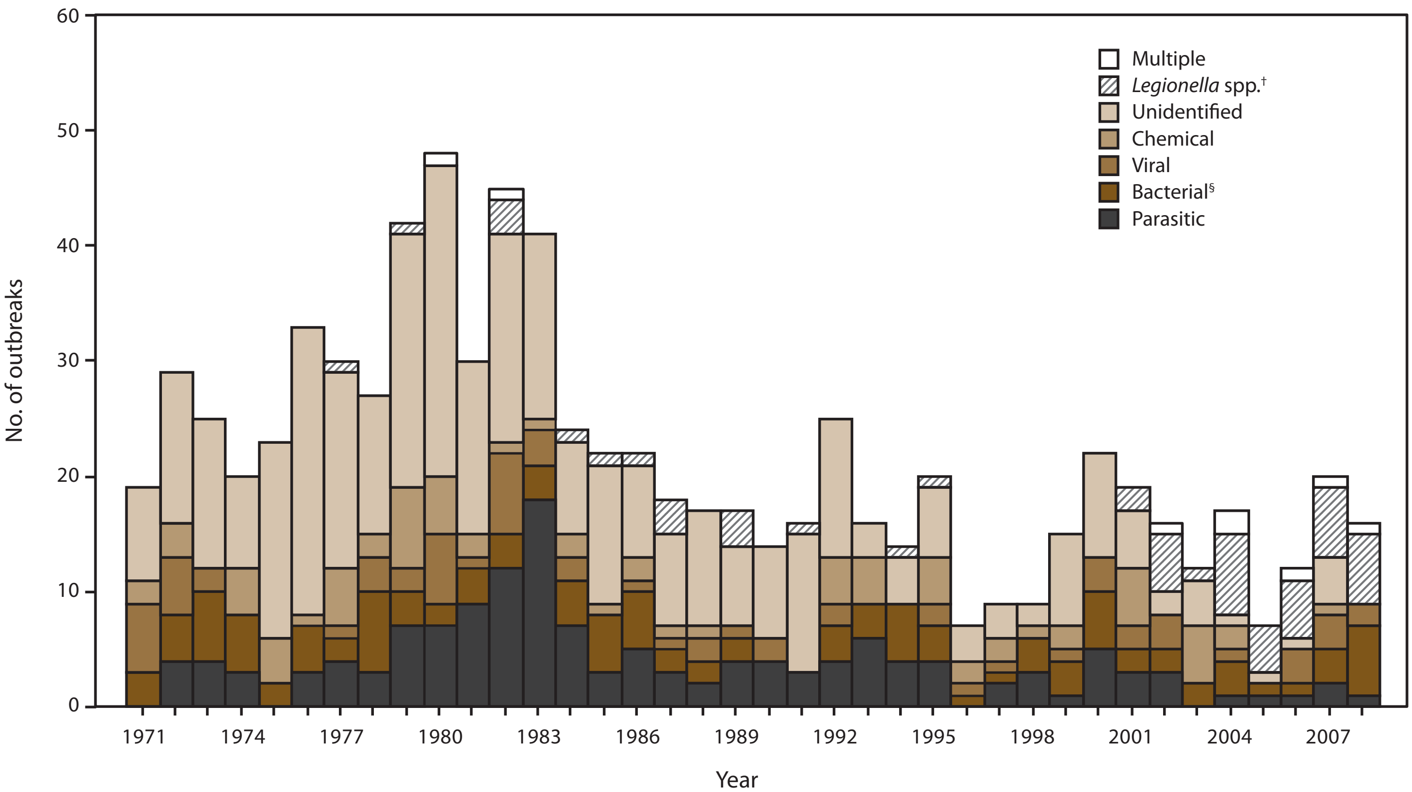
Abbreviations: ARI = acute respiratory illness; Skin = illnesses, conditions, or symptoms related to skin.
* Previously unreported legionellosis outbreaks included in this table were identified through a review of the published literature on *Legionella* as well as reports from past CDC-led investigations occurring during 1971–2000. Data are presented on the basis of a review and interpretation of available outbreak investigation reports and published articles.
† On the basis of epidemiologic, clinical laboratory, and environmental data (e.g., water quality data) provided to CDC.
§ The category of illness reported by ≥50% of ill respondents.
¶ Deaths are included in the overall case count.
** Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).
†† No deaths were reported.
§§ Some or all cases might have been Pontiac fever.

to water containing high levels of sodium hydroxide. No deaths were reported.

Multiple etiologies. Two outbreaks were associated with multiple etiologies and resulted in 270 cases of illness; one outbreak with viral and bacterial agents caused by norovirus genogroup I, *Campylobacter,* and *Salmonella* resulted in 229 cases of illness; one outbreak with parasitic and bacterial agents caused by *Shigella sonnei, Giardia intestinalis,* and *Cryptosporidium* resulted in 41 cases of illness. No deaths were reported.

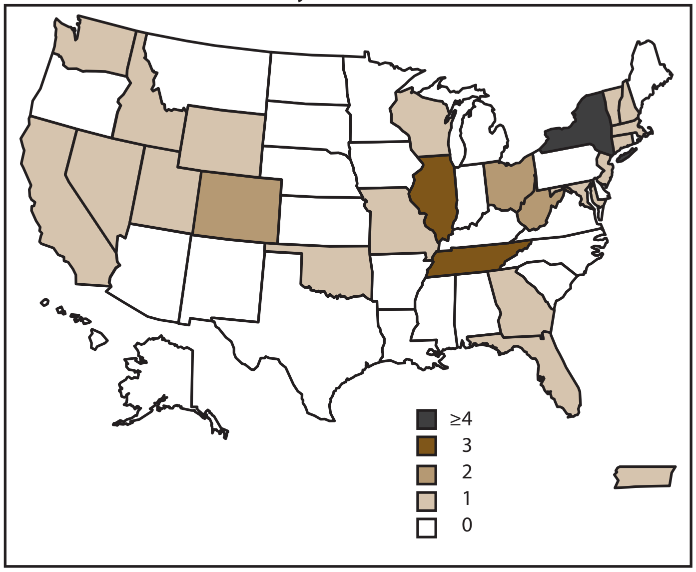
Unidentified etiologies. In four outbreaks an etiologic agent was not identified; however, one outbreak had a suspected

FIGURE 2. Number of waterborne disease outbreaks associated with drinking water (n = 818),* by year and etiology — Waterborne Disease and Outbreak Surveillance System, United States, 1971–2008



* Some outbreaks from prior reporting periods were added, reclassified, or excluded during an extensive review (Craun GF, Brunkard JM, Yoder JS, et al. Causes of outbreaks associated with drinking water in the United States from 1971 to 2006. Clin Microbiol Rev 2010;23:507–28); therefore, data are not comparable to figures in previous reports.
† Legionnaires' disease (LD) was reported to the Waterborne Disease and Outbreak Surveillance System (WBDOSS) beginning in 2001. A review of publications and CDC-led investigations during 1971–2000 resulted in the addition of 17 historic LD drinking water outbreaks to WBDOSS.
§ Includes all bacteria except *Legionella*.

FIGURE 3. Number of waterborne disease outbreaks associated with drinking water (n = 36), by state/jurisdiction — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008*



* These numbers are largely dependent on reporting and surveillance activities in individual states/jurisdictions, and do not necessarily indicate the true incidence of waterborne disease outbreaks.

etiology of norovirus. These four outbreaks resulted in 1,756 cases of AGI; no deaths were reported (Table 8).

Deficiencies

A total of 37 deficiencies were cited in 36 drinking water–associated outbreaks. Of these, 22 (59.5%) involved the source water, treatment facility, or distribution system (eight in community, nine in noncommunity, and five in individual systems), including 13 associated with untreated ground water (deficiency 2), seven associated with treatment deficiencies (deficiency 3), and two associated with distribution system deficiencies (deficiency 4) (Table 9). No outbreaks associated with untreated surface water (deficiency 1) or current treatment processes that are not expected to remove a chemical contaminant (deficiency 13) were reported during this surveillance period (Table 11). Of the 37 deficiencies, 13 (35.1%) occurred in public water systems at points not under the jurisdiction of a water utility, including 12 deficiencies associated with *Legionella* (deficiency 5A) and one associated with a plumbing system deficiency (deficiency 6); two outbreaks had an unknown deficiency (deficiency 99A, B) (Table 9; Figure 6). No outbreaks reported during 2007–2008 were associated with deficiencies in treatment after the property line or meter; contamination of equipment using or distributing water; contamination during commercial bottling, shipping, hauling, or storage; or contamination at point of use (deficiencies 7–11) (Table 11).

Contamination of Water at/in the Water Source, Treatment Facility, or Distribution System

A total of 21 outbreaks were assigned a deficiency classification of 2–4 (untreated ground water, treatment, and distribution system deficiencies, respectively), including one outbreak that was assigned two deficiency classifications (treatment and distribution system deficiencies). No outbreaks with a deficiency classification of 1 (untreated surface water) or 13 (current treatment processes not expected to remove a chemical contaminant) were reported (Table 11).

Etiology

Nine (42.9%) of these 21 outbreaks were associated with bacteria, five (23.8%) with viruses, three (14.3%) with unidentified etiologies, two (9.5%) with parasites, one with a chemical (4.8%), and one (4.8%) with multiple etiologies (both bacterial and viral agents). Cases in one outbreak with an unidentified etiology had an incubation period, symptoms, and duration of illness that were consistent with norovirus infection.

Water Quality Data

All but one of the 21 outbreaks with a deficiency classification of 2–4 (Tables 2–4) had current water quality data (e.g., laboratory data regarding the presence of coliform bacteria, pathogens, or chemical contaminants) or historic data (e.g., levels of disinfectants) available.

Water Systems

Nine (42.9%) of the 21 outbreaks with deficiencies 2–4 involved noncommunity water systems, five (23.8%) involved individual water systems, and seven (33.3%) involved community water systems (Table 9). Among the nine outbreaks involving noncommunity water systems, six (66.7%) were associated with untreated ground water, and three (33.3%) were associated with a treatment deficiency. All five outbreaks involving individual water systems were associated with untreated ground water. Among the seven outbreaks involving a community water system, eight deficiencies were assigned. Two (28.6%) outbreaks were associated with untreated ground water, three (42.9%) were associated with a treatment deficiency, one (14.3%) was associated with a distribution system deficiency, and one (14.3%) was associated with both a treatment deficiency and a distribution system deficiency (Table 9).

Water Sources

A total of 20 (95.2%) of the 21 outbreaks with deficiencies 2–4 were associated with ground water sources (i.e., wells or springs); one (4.8%) outbreak was associated with surface water derived from a reservoir (Table 10). Among the 20 outbreaks and 21

TABLE 8. Number of waterborne disease outbreaks associated with drinking water (n=36), by etiology, type of water system, and water source* — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008

	Type of water system											
	Public water systems†						Individual water systems		Commercially bottled water systems			
	Ground		Surface		Other§		Ground		Surface		Total	
Etiology	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases
Bacterium	**7**	**1,432**	**9**	**55**	**1**	**13**	**4**	**20**	**0**	**0**	**21**	**1,520**
Campylobacter spp.	2	65	0	0	0	0	2	12	0	0	**4**	**77**
Escherichia coli O157	0	0	0	0	0	0	1	6	0	0	**1**	**6**
Legionella pneumophila	2	7	9	55	1	13	0	0	0	0	**12**	**75**
Providencia	1	55	0	0	0	0	0	0	0	0	**1**	**55**
Salmonella spp.	2	1,305	0	0	0	0	1	2	0	0	**3**	**1,307**
Virus	**4**	**265**	**0**	**0**	**0**	**0**	**1**	**9**	**0**	**0**	**5**	**274**
Hepatitis A virus	0	0	0	0	0	0	1	9	0	0	**1**	**9**
Norovirus	4	265	0	0	0	0	0	0	0	0	**4**	**265**
Parasite	**2**	**81**	**1**	**82**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**163**
Cyclospora cayetanensis	0	0	1	82	0	0	0	0	0	0	**1**	**82**
Giardia intestinalis	2	81	0	0	0	0	0	0	0	0	**2**	**81**
Chemical	**1**	**145**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**145**
Sodium hydroxide	1	145	0	0	0	0	0	0	0	0	**1**	**145**
Multiple¶	**1**	**229**	**1**	**41**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**270**
Unidentified**	**2**	**90**	**1**	**1,663**	**0**	**0**	**0**	**0**	**1**	**3**	**4**	**1,756**
Total	**17**	**2,242**	**12**	**1,841**	**1**	**13**	**5**	**29**	**1**	**3**	**36**	**4,128**

* Only categories of water sources in which outbreaks occurred are presented in this table.
† Includes community and noncommunity water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and 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, and parks). Individual water systems are defined as small systems not owned or operated by a water utility that have <15 connections or serve <25 persons. Individual water systems are not under the jurisdiction of the EPA; however, there may be additional regulations or operational guidelines that fall under state jurisdiction, depending on the state and size of the water system.
§ Includes outbreaks with mixed or unknown water sources. One outbreak of legionellosis was associated with a mixed public water system.
¶ Defined as outbreaks in which more than one type of etiologic agent is identified in clinical specimens from affected persons, and each etiologic agent is found in ≥5% of positive clinical specimens (e.g., an outbreak with *Giardia intestinalis* [parasites] and *Salmonella* spp. [bacteria] with each agent identified in ≥5% of stool specimens). Two outbreaks occurred: one with 229 cases was associated with Norovirus GI, *Campylobacter* spp., and *Salmonella* spp, and one with 41 cases was associated with *Shigella sonnei*, *Giardia*, and *Cryptosporidium*.
** For one outbreak with an unidentified etiology, norovirus was suspected on the basis of incubation period, symptoms, and duration of illness.

deficiencies related to ground water sources, 13 (65.0%) outbreaks were associated with consumption of untreated ground water. Well water sources were used by systems in nine of these outbreaks, and springs were water sources in four outbreaks. In one of the outbreaks associated with the use of untreated spring water, the spring was classified by the State as GWUDI and thus subject to EPA regulations for surface water (SWTR and amendments) (*10–15*). In several other outbreaks, evidence of contamination suggested that the well or spring was under the direct influence of surface water; however, information was not provided on the surveillance form about GWUDI testing and classification.

Six (30.0%) ground water outbreaks were associated with treatment deficiencies, including inadequate disinfection or filtration, interruption of disinfection, and deficiencies in other treatment processes. Two outbreaks in systems using well water were associated with distribution system deficiencies. One large communitywide outbreak was associated with contamination of a distribution system storage tank, and a second outbreak had both distribution system and treatment deficiencies, including cross-connections and inadequate disinfection (Table 10; Appendix B).

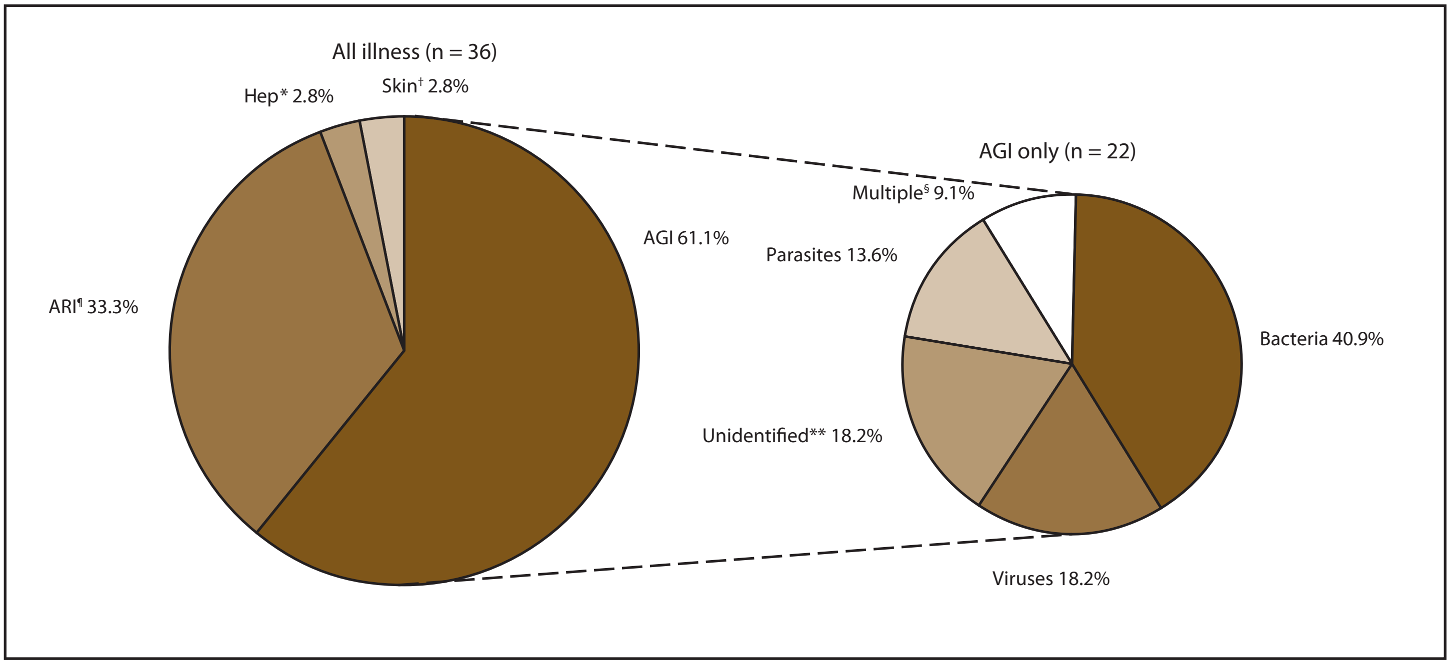
Contamination of Water at Points Not Under the Jurisdiction of a Water Utility or at the Point of Use

A total of 13 outbreaks were given a deficiency classification of 5A (*Legionella* spp. in drinking water systems) or 6 (plumbing system deficiency). Of these 13 outbreaks, 12 (92.3%) were associated with *Legionella* spp., and one (7.7%) outbreak with multiple etiologies was associated with a plumbing system deficiency (Table 11). No outbreaks reported for 2007–2008 were associated with a deficiency classification of 7–11 (deficiencies in treatment after the property line or meter; contamination of equipment using or distributing water [e.g., drink-mix machines]; and contamination during commercial bottling; shipping, hauling, or storage; and at point of use) (Table 11).

Water Quality Data

Water quality data were available for all 13 outbreaks with a deficiency of 5A or 6. *Legionella* spp. were isolated from the implicated water source in all of the 12 legionellosis outbreaks.

FIGURE 4. Percentage of waterborne disease outbreaks asscociated with drinking water, by predominant illness and etiology — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008



Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Hep = viral hepatitis; Skin = illnesses, conditions, or symptoms related to skin.
* All hepatitis infections were attributed to hepatitis A virus.
† One outbreak was associated with exposure to water that contained elevated levels of sodium hydroxide.
§ One outbreak involved bacterial and viral agents. A second outbreak involved bacterial and parasitic agents.
¶ All acute respiratory illness was attributed to *Legionella* spp.
** Three outbreaks. Norovirus was suspected in one outbreak on the basis of incubation period, symptoms, and duration of illness.

Legionella in Drinking Water

A total of 12 outbreaks were related to multiplication of *Legionella* spp. in building plumbing systems. Five (41.7%) of the 12 drinking water–associated legionellosis outbreaks occurred in hospitals, three in nursing homes (25.0%), two in residential buildings (16.7%), one in a hotel (8.3%), and one in an assisted living facility (8.3%). The majority of cases of legionellosis were diagnosed by urinary antigen testing, which is specific for *L. pneumophila* serogroup 1 (*36*).

Deficiencies 6–11. One outbreak that had multiple etiologies (both bacterial and parasitic agents were identified) was associated with a plumbing system deficiency (deficiency 6).

Deficiency 99A–B. The deficiency involved in two (5.6%) of the 36 outbreaks could not be identified because the cause of water contamination was unknown. One of the outbreaks occurred in a rural community in Puerto Rico in which persons became ill with *Cyclospora cayetanensis*. Although an epidemiologic investigation implicated drinking water as the source of exposure in the outbreak, the point at which water was contaminated was not determined, and a deficiency could not be assigned. The second outbreak was associated with commercially bottled water and was assigned a deficiency of 99B. A private residence used a five-gallon water dispenser to supply drinking water. Three persons who replaced an empty container and consumed water from the new container developed gastrointestinal symptoms. Water from the container was not tested, and no etiologic agent was identified. An FDA inspection of the water facility did not find any problems with the bottling process.

Waterborne Disease Outbreaks Associated with Water Not Intended for Drinking (WNID) and Water of Unknown Intent (WUI)

A total of 12 outbreaks were associated with either WNID (n = eight) or WUI (n = four) (Table 6). The 12 WNID/WUI outbreaks caused illness among ≥79 persons, resulting in four deaths, all of which were associated with legionellosis. Of the 12 outbreaks, nine (75.0%) were categorized as ARI and three (25.0%) as AGI. Two (16.7%) of the 12 outbreaks were assigned a strength-of-evidence Class I ranking. No outbreaks were ranked as Class II, four (33.3%) were ranked as Class III, and six (50.0%) were ranked as Class IV.

Etiology

Nine (75.0%) of the 12 WNID/WUI outbreaks were attributed to *L. pneumophila* serogroup 1, with one of these

TABLE 9. Number and percentage of waterborne disease outbreaks associated with drinking water (n = 36), by type of deficiency (n = 37)* and type of water system — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008

	Type of water system†§									
	Community		Noncommunity		Individual		Bottled		Total	
Type of deficiency	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
2: Untreated ground water intended for drinking	2	(9.5)	6	(60)	5	(100.0)	0	(0)	**13**	**(35.1)**
3: Treatment deficiency	4	(19.0)	3	(30)	0	(0)	0	(0)	**7**	**(18.9)**
4: Distribution system deficiency, includes storage	2	(9.5)	0	(0)	0	(0)	0	(0)	**2**	**(5.4)**
5A: *Legionella* in drinking water system	11	(52.4)	1	(10)	0	(0)	0	(0)	**12**	**(32.4)**
6: Plumbing system deficiency	1	(4.8)	0	(0)	0	(0)	0	(0)	**1**	**(2.7)**
99A: Unknown/insufficient information	1	(4.8)	0	(0)	0	(0)	0	(0)	**1**	**(2.7)**
99B: Unknown/insufficient information (bottled water)	0	(0)	0	(0)	0	(0)	1	(100.0)	**1**	**(2.7)**
Total (%)	**21**	**(100.0)**	**10**	**(100.0)**	**5**	**(100.0)**	**1**	**(100.0)**	**37**	**(100.0)**

* Includes all deficiencies for drinking water–associated outbreaks reported for 2007–2008. Some outbreaks have multiple deficiencies that are tabulated separately. This table reports 37 deficiencies from 36 outbreaks.
† Community and noncommunity water systems are public water systems that have ≥15 service connections or serve 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. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and 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 and 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, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
§ No outbreaks associated with mixed drinking water systems were reported for 2007–2008.

outbreaks also being attributed to *L. pneumophila* serogroup 7; the nine legionellosis outbreaks affected 46 persons and resulted in four deaths. One (8.3%) of the WNID/WUI outbreaks was attributed to *G. intestinalis*. Of the two outbreaks that did not have an identified etiology, one outbreak was suspected to be caused by norovirus (Table 6).

Deficiencies

Each of the 12 WNID/WUI outbreaks was assigned one deficiency: six (50.0%) WNID outbreaks involved *Legionella* spp. in the water system (deficiency 5B), three (25.0%) WUI outbreaks involved *Legionella* spp. (deficiency 5C), two (16.7%) WNID outbreaks of AGI involved unidentified etiologies (deficiency 12), and one (8.3%) WUI outbreak involved contamination of an unknown water source (deficiency 99D) (Tables 2 and 6).

Previously Unreported Outbreaks

A total of 70 previously unreported outbreaks that occurred from 1973–2002 were added to WBDOSS during 2010. One previously unreported WNID (deficiency 12) outbreak of *Mycobacterium mageritense* occurred in 2002 (Table 7). Two patients were diagnosed with *M. mageritense* infections on their feet following separate visits to a nail salon. Environmental samples from the nail salon isolated *M. mageritense* in foot bath, drain, and hand sink samples. *M. goodii* and *M. smegma* also were isolated in foot bath samples (*37*).

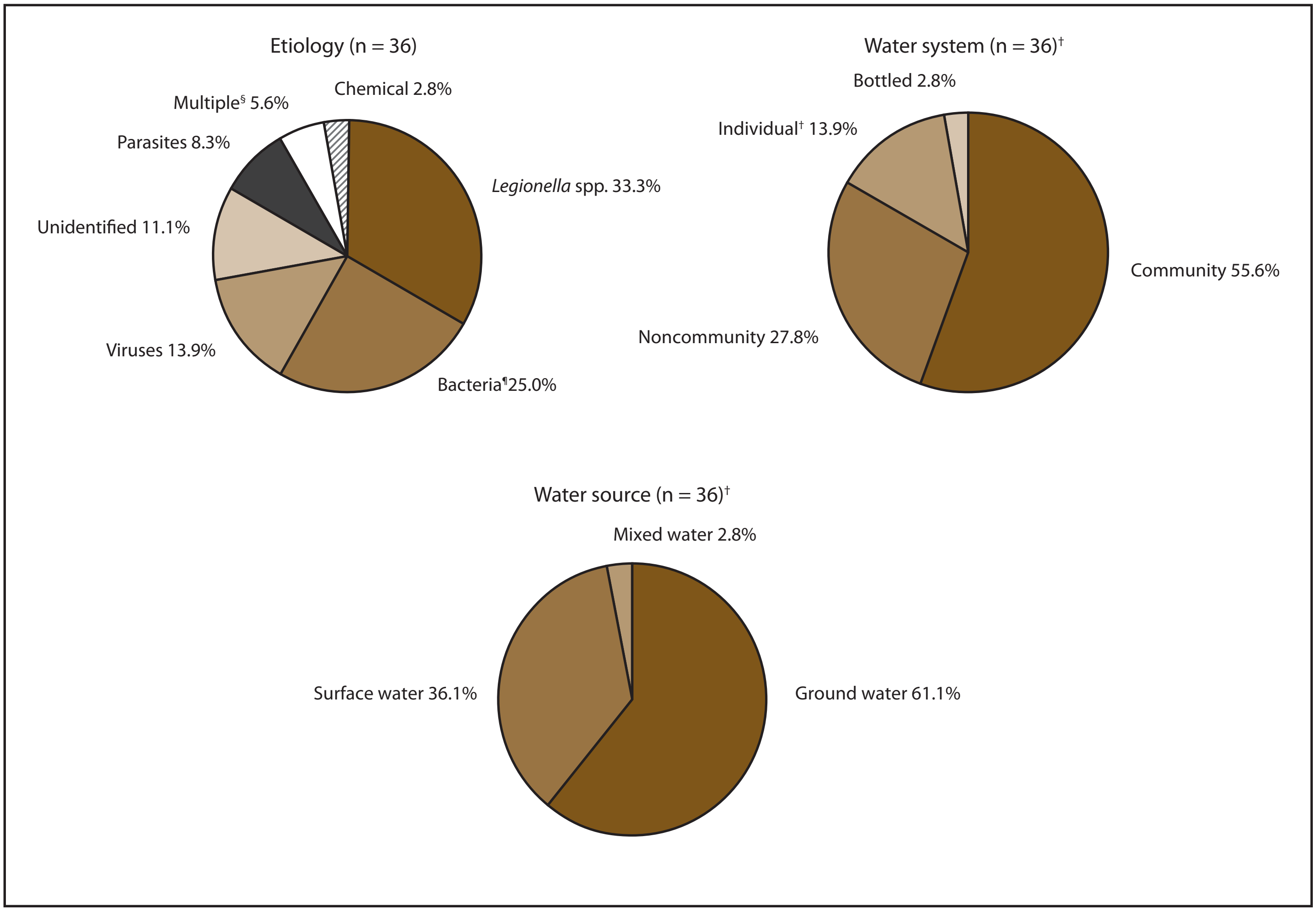
A total of 69 legionellosis outbreaks that occurred during 1973–2000 were added to the surveillance system in 2010 (Table 7). These data were abstracted from Epidemic Intelligence Service outbreak investigation reports and peer-reviewed publications (*38–75*). Seventeen outbreaks were associated with drinking water, 26 with WNID, and 26 with

TABLE 10. Number and percentage of waterborne disease outbreaks associated with drinking water (n = 36), by type of deficiency (n = 37) and water source — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008*

	Water source†							
	Ground water		Surface water		Mixed source		Total	
Type of deficiency	No.	(%)	No.	(%)	No.	(%)	No.	(%)
2: Untreated ground water intended for drinking	13	(56.5)	0	(0)	0	(0)	**13**	**(35.1)**
3: Treatment deficiency	6	(26.1)	1	(7.7)	0	(0)	**7**	**(18.9)**
4: Distribution system deficiency, includes storage	2	(8.7)	0	(0)	0	(0)	**2**	**(5.4)**
5A: *Legionella* in drinking water system	2	(8.7)	9	(69.2)	1	(100.0)	**12**	**(32.4)**
6: Plumbing system deficiency	0	(0)	1	(7.7)	0	(0)	**1**	**(2.7)**
99A: Unknown/insufficient information	0	(0)	1	(7.7)	0	(0)	**1**	**(2.7)**
99B: Unknown/insufficient information (bottled water)	0	(0)	1	(7.7)	0	(0)	**1**	**(2.7)**
Total (%)	**23**	**(100.0)**	**13**	**(100.0)**	**1**	**(100.0)**	**37**	**(100.0)**

* Includes all deficiencies for drinking water–associated outbreaks reported for 2007–2008. Some outbreaks have multiple deficiencies that are tabulated separately. This table reports 37 deficiencies from 36 outbreaks.
† No water outbreaks associated with unknown or unidentified drinking water sources were reported for 2007–2008.

FIGURE 5. Percentage of waterborne disease outbreaks associated with drinking water, by etiology, water system, and water source — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008*



* Not limited to deficiencies 1–4, and therefore figure is not comparable to those in previous summaries.
† Percentages do not add up to 100% due to rounding.
§ One outbreak involved bacterial and viral agents. A second involved bacterial and parasitic agents.
¶ Other than *Legionella* spp.

WUI (Figure 7). Among these 69 outbreaks, 1,520 cases and 237 deaths were reported from 27 states.

Surveillance Reports Not Classified as Waterborne Disease Outbreaks

Two outbreak reports about occupational exposures did not meet the criteria for inclusion in the surveillance system because either water did not appear to be the source of exposure or evidence was insufficient. In one event, five persons were injured at a water treatment plant; chlorine gas was released following an accidental mixing of sodium hypochlorite and hydrofluorosilicic acid. The second event involved two housecleaners who poured ammonia into a toilet suspected to have contained water with high concentrations of chlorine. One person later called a local poison control center (PCC) to report eye pain and respiratory irritation; however, insufficient epidemiologic and water quality data were available to warrant inclusion of this report as a waterborne disease outbreak. Six additional single case reports that were associated with known or suspected chemical exposures occurring primarily at the point of water use also were excluded because single cases do not meet the case definition for an outbreak. These single cases were identified by one state that conducted an independent review of supplemental data sources for occupational diseases and chemical poisonings, including PCC inquiries and reports submitted to the Hazardous Substances Emergency Events Surveillance (HSEES) system. Although single cases are not classified as outbreaks, the case reports highlight the potential to detect waterborne illness and injury at a state level through collaboration with other existing surveillance systems.

TABLE 11. Waterborne disease outbreaks associated with drinking water (n = 36), by type of deficiency (n = 37)* — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008

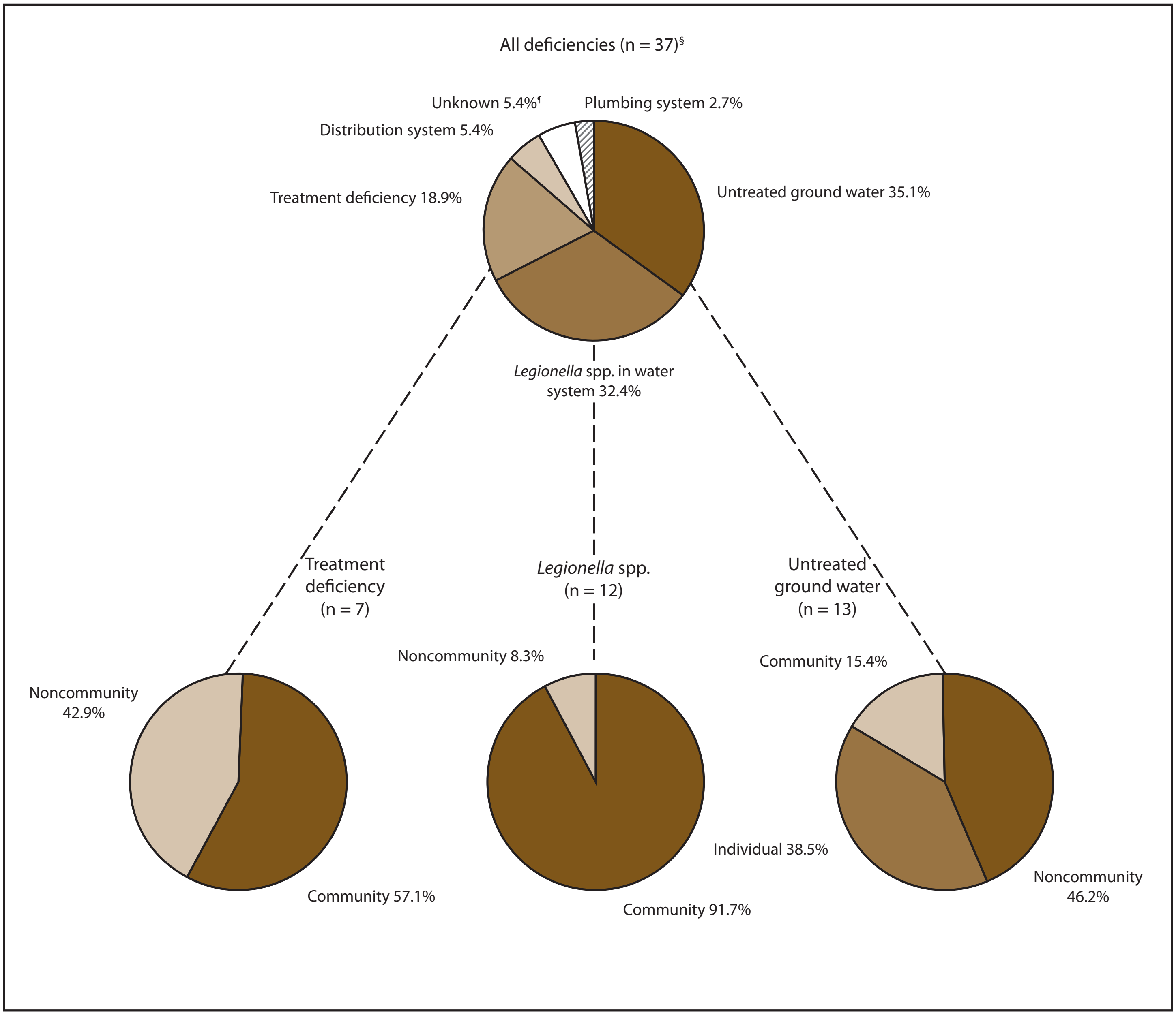
Contamination of water at/in the water source, treatment facility, or distribution system†	**22**
1: Untreated surface water intended for drinking	0
2: Untreated ground water intended for drinking	13
3: Treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, or inadequate or no filtration)	7
4: Distribution system deficiency, including storage (e.g., cross-connection, backflow, contamination of water mains during construction or repair)	2
13: Current treatment processes not expected to remove a chemical contaminant (e.g., pesticide contamination of ground water treated with disinfection only)	
A: Surface water	0
B: Ground water	0
Contamination of water at points not under the jurisdiction of a water utility or at the point of use§	**13**
5: *Legionella* spp. in water system	
A: Water intended for drinking	12
6: Plumbing system deficiency after the water meter or property line (e.g., cross-connection, backflow, or corrosion products)	1
7: Deficiency in building/home-specific water treatment after the water meter or property line	0
8: Deficiency or contamination of equipment using or distributing water (e.g., drink-mix machines)	0
9: Contamination or treatment deficiency during commercial bottling	0
10: Contamination during shipping, hauling, or storage	
A: Water intended for drinking – tap water	0
B: Water intended for drinking – commercially bottled water	0
11: Contamination at point of use	
A: Tap	0
B: Hose	0
C: Commercially bottled water	0
D: Container, bottle, or pitcher	0
E: Unknown	0
Unknown/Insufficient Information	**2**
99: Unknown/Insufficient information	
A: Water intended for drinking – tap water	1
B: Water intended for drinking – commercially bottled water	1
Total	**37**

* More than one deficiency might have been identified during the investigation of a single waterborne disease outbreak.
† For a community water system, the distribution system refers to the pipes and storage infrastructure under the jurisdiction of the water utility prior to the water meter or property line (if the system is not metered). For noncommunity and nonpublic water systems, the distribution system refers to the pipes and storage infrastructure prior to entry into a building or house.
§ Contamination of drinking water and deficiencies occurring in plumbing and pipes that are not part of the distribution system as previously defined. For community systems, this means after the water meter or outside the jurisdiction of a water utility, and for noncommunity and nonpublic systems, this means within the building or house (e.g., in a service line leading to a house or building, in the plumbing inside a house or building, during shipping or hauling, during storage other than in the distribution system, or at point of use).

Discussion

The outbreaks reported during this surveillance period highlight several important public health challenges associated with drinking water in the United States. The large proportion of outbreaks associated with untreated or inadequately treated ground water in particular indicate that additional efforts are needed to monitor and protect ground water sources from contamination and to ensure that adequate, continuous treatment is provided when it is needed. *Legionella* continues to be the most frequently reported etiology among drinking water–associated outbreaks and was also the predominant etiology among WNID and WUI outbreaks. However, more than half of the legionellosis outbreaks reported during 2007–2008 were from one state, demonstrating the substantial variance in outbreak detection, investigation and reporting across states. All deaths except one reported during this surveillance period were associated with *Legionella*, underscoring the need for improved methods of elimination and control of *Legionella*, particularly in settings with vulnerable populations. In addition, a large communitywide outbreak associated with contamination of a storage tank underscores the importance of protecting and maintaining drinking water distribution system infrastructure. This report also includes the addition of data concerning 69 legionellosis outbreaks, providing a more complete representation of legionellosis outbreaks in the United States before 2001.

FIGURE 6. Percentage of waterborne disease outbreaks associated with drinking water, by deficiency* and water system† — Waterborne Disease and Outbreak Surveillance System, United States, 2007–2008



* There were 36 waterborne disease outbreaks but 37 deficiencies. See Table 2 for a list of all deficiencies.
† For deficiencies 2, 3, and 5A only. See Table 9 for a summary of all 37 outbreak deficiencies by water system.
§ Percentages do not add up to 100.0% due to rounding.
¶ Deficiencies 99A and 99B.

Outbreaks Associated with Drinking Water

Illness and Etiology

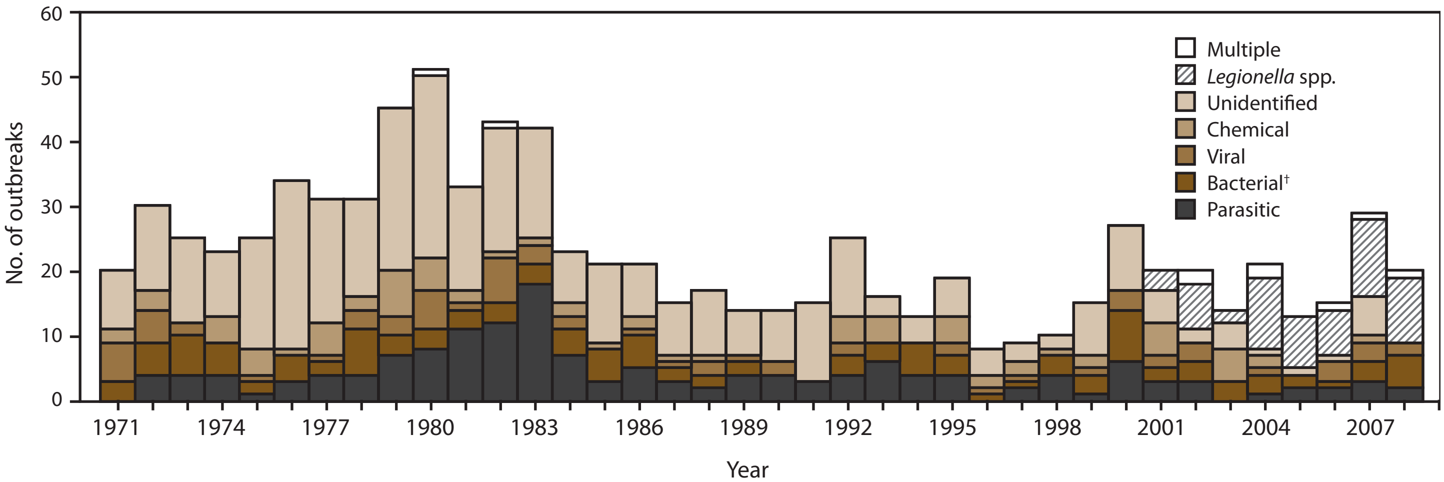
During 2007–2008, AGI was the dominant illness type (associated with 61% of drinking water–associated outbreaks) in contrast with the prior surveillance period (2005–2006) in which half of drinking water–associated outbreaks were associated with ARI (*78*). Of the 36 outbreaks, 24 (67%) were caused by bacteria, five (14%) by viruses, three (8%) by parasites, one (3%) by a chemical, and two (6%) by multiple etiologies. Four (11%) outbreaks had unidentified etiologies.

Bacteria

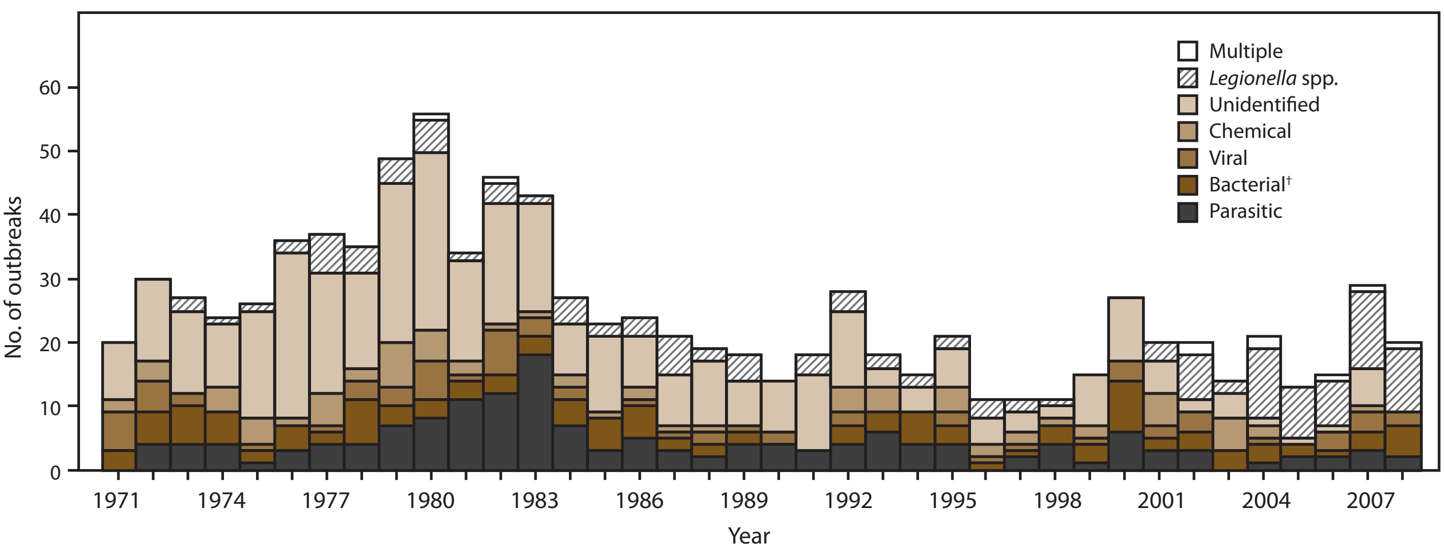
Since its addition to WBDOSS in 2001, *Legionella* has been the single most commonly reported pathogen identified in drinking water–associated outbreaks. During 2007–2008,

FIGURE 7. Number of waterborne disease outbreaks associated with drinking water, water not intended for drinking (WNID) (excluding recreational water), and water use of unknown intent (WUI), by year and etiology — Waterborne Disease and Outbreak Surveillance System, United States, 1971–2008

Before the addition of pre-2001 legionellosis outbreaks (n = 867)*



After the addition of pre-2001 legionellosis outbreaks (n = 936)*



* Since 2001, legionellosis outbreaks associated with drinking water, WNID, and WUI have been reported to WBDOSS by public health jurisdictions, and *Legionella* is presented as its own bacterial etiologic category. Outbreaks that occurred before 2001 were identified through a literature review of journal publications and CDC-led investigation reports.

† Includes all bacteria except *Legionella*.

a total of 12 (33.3%) of the 36 reported drinking water–associated outbreaks involved *Legionella* spp.; half of these outbreaks were reported by one state (New York). Unlike other waterborne bacterial outbreaks that also might be foodborne, zoonotic, or spread person-to-person, legionellosis outbreaks are almost exclusively associated with exposure to colonized water; therefore, *Legionella* spp. might be more likely than other waterborne pathogens to be associated successfully with a water source during outbreak investigations. All legionellosis outbreaks reported herein occurred as a result of colonization of premise plumbing and pipes (i.e., infrastructure that neither is under the jurisdiction of a water utility nor is regulated by EPA). EPA has no contaminant level specific to *Legionella* spp. but believes that if parasites and viruses are removed or inactivated according to the treatment techniques in the SWTR and amendments, *Legionella* will be controlled at

the water source (*10*). However, this does not ensure control within the water distribution system. Because *Legionella* is the predominant drinking water–related pathogen in WBDOSS, increased attention is needed to understand its ecology, the characteristics contributing to its pathogenicity, the need for improved diagnostics (e.g., molecular tests) and national laboratory testing capacity, and the interventions that are most effective to prevent ongoing disease transmission (*6,76–78*). EPA's recent inclusion of *Legionella* in CCL3 might lead to additional research that improves risk-reduction interventions.

During the 2007–2008 surveillance period, nine drinking water–associated outbreaks involved only bacteria (excluding *Legionella* spp.) compared with two during 2005–2006, five during 2003–2004, and three during 2001–2002. The nine bacterial outbreaks involved chlorine-sensitive pathogens (e.g., *Campylobacter, Salmonella, Providencia*, and *E. coli*), including five outbreaks associated with ground water sources in public water systems, highlighting the importance of protecting ground water sources and providing adequate treatment and filtration where needed. The ongoing occurrence of bacterial outbreaks, despite available and efficacious treatment practices, underscores the need for source water protection and adequate disinfection when needed for ground water systems (*79*) in community, noncommunity, and individual water systems. A large outbreak of *Salmonella* Typhimurium occurred in a community water system using untreated ground water. The outbreak was associated with contamination in a storage reservoir and emphasizes the importance of protecting water quality in the distribution system, particularly in systems that use untreated ground water sources or have other system vulnerabilities.

The outbreak of *Providencia* is the first documented drinking water outbreak of this bacterium known to be reported in the United States. An epidemiologic investigation indicated that 55 persons developed gastroenteritis associated with drinking water from a community water system served by a well. Six of nine stool samples from ill persons tested positive for *Providencia* and negative for other bacteria (*Campylobacter, Shigella,* and *E. coli*), norovirus, and parasites. Previously thought to be nonpathogenic (*80*), *Providencia* was identified as the cause of a large foodborne outbreak in Japan in 1996 (*81*) and is thought to be a potential source of travelers' diarrhea (*82*). Whether *Providencia* is a true human pathogen or an indicator of exposure to fecally contaminated water or food remains unclear (*83*).

Viruses

Five outbreaks involving only viruses were reported during 2007–2008, four involving norovirus and one involving hepatitis A virus. All five outbreaks involved contaminated ground water that was either untreated or treated improperly (inadequate or interrupted chlorination as the only treatment provided). These types of events are anticipated to decrease as the GWR is fully implemented. However, one of these viral outbreaks occurred in an individual water system, and the GWR does not apply to private systems.

Parasites

Parasites were identified in three outbreaks reported during 2007–2008. An outbreak linked epidemiologically to a drinking water system in Puerto Rico was caused by *C. cayetanensis* (*84*), a rarely reported source of drinking water outbreaks in developed countries. This is the first known reported outbreak of cyclosporiasis associated with drinking water in the United States or associated territories since 1990. A previous outbreak of cyclosporiasis that occurred in Chicago in 1990 was suspected to be associated with water exposure (*85*). In the 2008 outbreak, residents reported recent interruptions in the community water supply and changes in water quality. A pumping station was determined to be damaged, and a water tanker had been used to haul treated water from a neighboring system to fill a water tank during the same time period. In addition to the *C. cayetanensis* outbreak, two outbreaks of giardiasis occurred in public water systems using ground water; one outbreak was associated with the improper installation of a filter (*86*) and the other with a well that was possibly GWUDI (*87*).

Chemicals

Only one outbreak during 2007–2008 involved a chemical exposure. The outbreak occurred within a public water system after a sodium hydroxide overfeed occurred at the water-treatment facility, raising the pH level of the drinking water supply and injuring an estimated 145 persons. Although a mechanism was in place to monitor pH levels at the treatment plant, the system was not designed to provide automatic notification of offsite staff regarding the problem. The response effort required collaboration among local and state agencies to flush the contaminated water from the distribution system, provide guidance to the community, and make safe drinking water available to local residents. This event highlights the need for appropriate remote monitoring systems in water treatment facilities when staff members are not onsite and the value for public water systems of developing comprehensive incident response plans with involvement from state and local agencies.

Multiple Etiologies and Unidentified Etiologies

Two outbreaks involving multiple etiologies occurred during 2007–2008; one outbreak was caused by norovirus genogroup I, *Campylobacter* spp. and *Salmonella* spp., and the other was caused by *S. sonnei*, *G. intestinalis*, and *Cryptosporidium*. The occurrence of multiple etiologic agent outbreaks emphasizes the importance of considering more than one etiology

in outbreak investigations, collecting appropriate clinical and environmental specimens, and requesting appropriate diagnostic testing for each agent type. One outbreak was associated with sewage contamination of a well, underscoring the importance of proper waste management and water system protection, and the other outbreak was associated with a plumbing system and cross-connection deficiency. A dinner cruise boat connected to a municipal water supply from a dock had a cross-connection that might have allowed backsiphonage of lake water contaminated with sewage into the boat's potable water supply (*88*). The outbreak occurred after a period of heavy rainfall and flooding that resulted in the release of a large volume of storm water containing highly diluted sewage into the lake in which the boats were located.

The etiologies of four outbreaks could not be identified, although norovirus was suspected in one outbreak on the basis of symptoms, incubation period, and duration of illness. These four outbreaks represent 11.1% of the 36 drinking water–associated outbreaks reported during 2007–2008, which is among the lowest proportion of outbreaks caused by an unidentified etiology since the beginning of the surveillance system in 1971. This continues a decreasing trend in the proportion of outbreaks caused by an unidentified etiology (*6*).

The identification of etiologic agents depends on the ability of investigators to recognize the outbreak in a timely manner and for appropriate clinical and environmental samples to be collected and analyzed for the organism, chemical, or toxin of interest. WBDOSS data suggest that these capabilities are improving. During 1971–1996, the etiologic agent was unidentified in 48% (312/645) of drinking water–associated outbreaks whereas during 1997–2008, the etiologic agent was unidentified in 23% (40/174) of outbreaks. This decrease likely reflects improved diagnostic capabilities of laboratories and improvements in outbreak investigations, resulting in more rapid and appropriate specimen collection. Reasons for improved etiologic attribution might also include increased testing and testing capabilities for viral agents in clinical specimens and water samples and improved water sampling and testing methods.

Deficiencies

Outbreaks associated with untreated or inadequately treated source water and distribution system contamination are assigned deficiencies 1–4 and 13. EPA regulations associated with the Safe Drinking Water Act are applicable to public water systems from the water source up to the water meter, the property line, or entry into the building or house, and these deficiencies are important in assessing regulatory strategies. Although individual water systems are not regulated by EPA, the same problems might affect these systems including contamination of pipes or storage infrastructure.

During 2007–2008, 58.3% of all drinking water–related outbreaks (n = 21) and 59.5% of deficiencies (n = 22) involved deficiencies 2–4. One outbreak was associated with more than one deficiency (deficiencies 3 and 4). Deficiencies 1 and 13 were not implicated in any outbreak during the 2007–2008 surveillance period. No outbreaks in public water systems have been associated with the use of untreated surface water since 1990.

Untreated Ground Water

Of the 36 drinking water–associated outbreaks reported during 2007–2008, a total of 13 (36.1%) were associated with contaminated ground water, indicating that contamination of ground water remains a public health problem. Eight (61.5%) of these 13 outbreaks occurred in public water systems, including six in noncommunity water systems and two in community water systems. Factors potentially contributing to these outbreaks included improperly constructed or sited wells, improperly maintained or placed septic systems, contamination by wild or domestic animals, periods of heavy rainfall, and contamination of wells through limestone or fissured rock. Included in the outbreaks associated with improper well construction was a large outbreak of giardiasis in which 35 persons in New Hampshire reported becoming ill after their community drinking water system's well became contaminated with *G. intestinalis*. The well was approximately 40 feet from a brook that had evidence of beaver habitation and was likely under the influence of surface water (*87*). New Hampshire Department of Environmental Services regulations require that wells be placed ≥50 feet from sources of surface water (*89*), but the well owner had not sought a permit before construction. Following an investigation, the well was disconnected from the water system.

In another outbreak, five persons who drank from a noncommunity water system using untreated, contaminated spring water became ill with salmonellosis (*Salmonella* serotype I 4,5,12:*i*:-) (*90*). Although this serotype has been identified in foodborne disease outbreaks reported to CDC, this is the first report to WBDOSS of an outbreak with this serotype. Several factors potentially contributed to the outbreak, including the poor protection of the spring from contamination (including by runoff and wildlife) and lack of disinfection. Pulsed-field gel electrophoresis patterns for a patient's stool and tap water collected from the patient's residence and another distribution system sample were identical. In addition, investigators noted that the geology of the area (porous limestone [karst]) might have increased the likelihood that the spring was under the influence of surface water (*90*). The spring water tested positive for *E. coli* (it was not tested for *Salmonella*), which suggested that the spring was the source of the contamination.

Outbreaks can occur even when wells and septic systems are built according to existing codes. An extensive investigation of a multiple pathogen (norovirus, *Campylobacter,* and

Salmonella) outbreak that sickened 229 persons in Wisconsin revealed that these pathogens were likely introduced into a noncommunity water system through fissures in the underlying dolomite rock that made the system particularly vulnerable to interconnections between the septic system and the well. The investigators noted that the septic system and well were built in accordance with state codes, so it is unlikely that the source of the outbreak would have been identified had the investigators not conducted a rigorous multifaceted investigation (including epidemiologic, laboratory, and hydrologic examinations). As a result of the outbreak, the well water now is being treated with a combination of UV and chlorination (*91*).

Eight of thirteen outbreaks associated with contaminated ground water during 2007–2008 occurred in noncommunity or community water systems that are subject to EPA's GWR. In 2006, the GWR was promulgated for all public systems that use ground water as a source of drinking water. The GWR establishes a risk-based approach to target ground water systems that are vulnerable to fecal contamination and comprises four major components: 1) sanitary surveys, 2) source water monitoring to test for the presence of indicators of fecal contamination in the ground water source, 3) corrective action, and 4) compliance monitoring to ensure that the treatment technology installed to treat drinking water reliably achieves ≥99.99% (4 log) inactivation and/or removal of viruses (*92*). States are required to perform initial sanitary surveys on the majority of community water systems by 2012; the remainder of the community water systems (the best performing systems) and all noncommunity drinking water systems must be surveyed by the end of 2014 (*92*). Operators of ground water systems that are identified as being at risk for fecal contamination must take corrective action to reduce the potential for illness from exposure to microbial pathogens.

The remaining five outbreaks associated with untreated ground water deficiencies occurred in individual water systems. Potential contributing factors in these outbreaks included septic system problems, contamination of wells by domestic or wild animals, flooding and heavy rain, and cracks in the well casing. These systems are not subject to the GWR. Approximately 15 million households in the United States have private wells (*33*). To safeguard the quality of well water, homeowners should seek information on protective measures and implement recommended operation and maintenance guidelines for private well usage. Recommendations for protecting private wells have been published previously (*93–95*).

Ground Water Under the Direct Influence of Surface Water

In several outbreaks associated with the use of untreated ground water or treatment deficiencies, the water source appeared to be GWUDI (e.g., microscopic particulate analysis testing identified algae and diatoms, the well was located <50 feet from a surface water source, or the spring was not protected from surface runoff). If a drinking water source is determined to be GWUDI, it is subject to SWTR requirements and amendments and may be classified as a surface water source by the state. Systems using GWUDI must disinfect their water and either provide filtration or meet criteria for avoiding filtration. EPA has developed a consensus method for assessing whether ground water is under the direct influence of surface water (*98*). However, WBDOSS currently does not collect information on whether ground water systems are under the influence of surface water, nor do states have standard case definitions and criteria for categorizing a system as GWUDI. Establishing a more standardized system for capturing data on GWUDI will be particularly important in better understanding the potential contributing factors and risks between ground water systems and those that have unique challenges associated with surface water influence.

Treatment Deficiencies

Seven outbreaks (19.4%) were associated with treatment deficiencies (deficiency 3) during 2007–2008. Six (85.7%) of these treatment deficiencies were associated with failures to treat contaminated ground water adequately. Multiple treatment-related factors potentially contributed to these outbreaks, including temporary interruption of disinfection, chronically inadequate disinfection, lack of disinfection, and inadequate filtration. When these deficiencies are considered with deficiency 2, contaminated ground water was determined to be the single largest contributing factor in outbreaks associated with drinking water in 2007–2008, underscoring the need for source water protection and adequate disinfection of ground water sources.

Two outbreaks were reported in public systems that provided filtration and disinfection, but both systems experienced treatment failures preceding the outbreak. One outbreak was reported in a noncommunity system using contaminated spring water and was responsible for 46 cases of giardiasis (*86*). This spring was classified as GWUDI and therefore subject to EPA's SWTR and amendments. Although the system had installed a slow sand filter and chlorinator, inadequate time was allowed for formation of a schmutzdecke[†] biologic layer on the surface of the filter, which is important for effective treatment performance of slow sand filters. When a slow sand filter is first constructed, the bed of clean sand cannot, strictly speaking, be called a filter because the vital living organisms on which

[†] Gelatinous biologic layer on the surface of a slow sand filter, consisting of a complex microbial community (including bacteria, fungi, protozoa, and rotifera and other aquatic organisms) and organic particulate matter.

effective filtration depends are not yet present. Building up the biologic content of a new filter is a slow but necessary process. Until the filter is sufficiently "ripened," the filter should not be put into service. Water samples collected 1 week after the filter was put into operation indicated considerably higher levels of total coliforms and turbidity in filtered water samples than in the spring water samples. On the basis of these samples, this system did not meet the treatment requirements of the TCR and SWTR and amendments (*97*). However, 6 weeks after operation of the filter, a schmutzdecke layer formed, and water samples met requirements.

The second outbreak was reported in a community water system that used surface water from a reservoir. The water was treated conventionally with coagulation, settling, filtration, and disinfection; however, operator error and the interruption of chlorination for 1–2 hours allowed partially disinfected water to enter the distribution system directly through a bypass pipe. During this time, the system did not meet the treatment requirements for disinfection as defined by the SWTR and amendments. The system was recycling filter backwash water as required by EPA (*98*); however, before the outbreak, the backwash water erroneously bypassed the recovery basin and ozonation before filtration, thereby adversely affecting filter performance. This investigation combined monitoring data with modeling of the distribution system to identify potential system vulnerabilities and sources of contamination. In conjunction with a boil water order notice, the health department asked that residents in the affected area report symptoms of gastrointestinal illness. A cross-sectional, randomly selected household survey was conducted in the affected area to assess potential associations between tap water consumption and gastrointestinal illness. The study identified increased risk for gastrointestinal illness among households that consumed tap water during the period before the boil water notice and also identified substantial dose-response effects and statistically significant trends, with higher rates of illness associated with increased tap water consumption. An extensive list of short- and long-term recommendations was provided through an independent investigation to address system deficiencies and operational issues at the treatment plant.

Distribution System Deficiencies

During 2007–2008, two drinking water–related outbreaks involving distribution system deficiencies occurred, including a large communitywide outbreak of salmonellosis that required local, regional, state, and federal emergency response. An estimated 1,300 persons became ill; 122 infections were laboratory-confirmed, and one person died. The likely source of the outbreak was animal contamination of a storage tank that had numerous cracks and entry points (*99*). The post outbreak inspection of the water system also identified >100 possible cross-connections in the distribution system, although these were not thought to contribute directly to the outbreak (*99*). This was one of the largest outbreaks in a community water system in recent years and highlights the critical importance of robust inspection of storage facilities, identification of potential cross-connections during required sanitary surveys, and the staffing and resources for adequate follow-up to ensure that deficiencies have been addressed. The other outbreak associated with a distribution system deficiency was related to a cross-connection between a well serving a residential community and a noncommunity water system. Additional deficiencies and contributing factors included inadequate disinfection and filtration along with a sewage lift that was out of service; this was the only outbreak reported during this surveillance period with two deficiencies noted.

Cross-connections and backsiphonage represented the largest underlying contributing factors among distribution system deficiencies identified in drinking water outbreaks reported during 1971–2006 (*6*), indicating that greater attention should be focused on cross-connection and backflow prevention and on maintaining the integrity of the distribution system. Drinking water quality within the distribution systems of public water supplies is assessed by monitoring requirements under EPA's Total Coliform Rule. The 2010 revisions to the TCR include a focus on research and information collection needs in the distribution system to protect public health (*100*). Seven high-priority areas needing additional focus (cross-connections, storage, water main breaks and pressure transients, intrusion, nitrification, contaminant accumulation, and biofilms) were identified by a steering committee selected by EPA and the Water Research Foundation as part of the Research and Information Collection Partnership (*101*).

Legionella

Legionellosis includes two clinically distinct syndromes: LD, characterized by severe pneumonia, and PF, a febrile illness that includes cough and does not progress to pneumonia. Legionellosis outbreaks accounted for 33.3% of all drinking water–associated outbreaks reported during 2007–2008 and 91.7% of all deficiencies occurring outside the jurisdiction of regulations or water utility management, indicating that legionellosis is a serious public health issue. Approximately 8,000–18,000 cases of LD occur each year in the United States (*102*), and incidence appears to be increasing (*103*). Cases typically manifest as LD rather than PF, but regardless of the syndrome, the source of legionellosis outbreaks typically share common features (e.g., warm stagnant water, inadequate biocide concentrations, and aerosolization, which provides the mechanism for inhalation).

The outbreaks of legionellosis reported during this surveillance period highlight the challenges related to its detection and prevention. Surveillance for legionellosis is passive, and the approach to surveillance, outbreak response, and reporting varies substantively by state. For example, six of 12 LD outbreaks associated with drinking water during this surveillance period were reported from one state, emphasizing the variance in outbreak detection, investigation, and reporting across states. However, there appear to be true differences in disease incidence across the United States, with the highest rates of disease reported in the northeast (*103*). LD is underdiagnosed because the majority of patients with community-acquired pneumonia are treated empirically with broad-spectrum antibiotics (*104*). However, because *Legionella* spp. are not transmitted from person-to-person and are always acquired from an environmental source, even a single case of LD implies the presence of a contaminated water source to which others can be exposed. Certain host factors (e.g., underlying lung disease and immunodeficiencies) influence the development and severity of legionellosis. As a result of underdiagnosis and underreporting, identification of two or more cases of LD in association with a potential source is adequate justification for conducting an investigation.

During 2007–2008, nine (75.0%) of 12 legionellosis outbreaks associated with drinking water occurred in health-care or long-term–care settings, demonstrating the propensity for *Legionella* spp. to colonize potable water systems and underscoring the importance of maintaining a high index of suspicion for legionellosis in health-care settings and in other settings with vulnerable populations. Although *Legionella* spp. can live in a free state, they often colonize biofilms and free-living protozoa frequently found inside large, complex hospital plumbing systems (*79,105*). This protects *Legionella* from biocides and temperature extremes and allows the bacteria to amplify to levels sufficient to be transmitted and cause disease. Persons in hospitals or elderly living facilities are at increased risk as a result of advanced age and a high prevalence of underlying chronic medical conditions.

An outbreak of legionellosis in a health-care setting should prompt both epidemiologic and environmental investigations. Additional cases might point to water exposures that contributed to the outbreak. Environmental sampling of the potable water system and devices that aerosolize water (e.g., cooling towers) can confirm the source of the outbreak and lead to targeted interventions that prevent additional cases. Each health-care facility should develop a plan for legionellosis prevention to address conditions that support *Legionella* growth in the potable water supply. Guidelines for reducing the risk for legionellosis associated with building water systems are available (*106*).

Waterborne Disease Outbreaks Associated with Water Not Intended for Drinking and Water of Unknown Intent

During 2007–2008, a total of 12 outbreaks occurred that were associated with WNID or WUI. Nine (75.0%) of these outbreaks were associated with *Legionella* spp., three (33.3%) with cooling towers, one (11.1%) with an ornamental fountain, and one (11.1%) with recycled water from a vehicle washing station. Four (44.4%) legionellosis outbreaks had an unidentified source of exposure. Of the nine legionellosis outbreaks associated with WNID/WUI, two occurred in long-term–care or assisted living facilities, two occurred at hospitals, and one occurred at an apartment complex for seniors. As noted previously, it is important to address *Legionella* colonization in and near buildings that house high-risk populations. Although potable water systems within buildings are implicated frequently in health-care–associated outbreaks, other sources of aerosolized water on site and in the surrounding community (e.g., cooling towers and decorative fountains) also should be considered. Aerosols containing *Legionella* can travel great distances; an investigation of an outbreak among residents of a long-term–care facility implicated a cooling tower that was 0.4 km from the facility (*107*).

Previously Unreported Outbreaks

This report incorporates 69 outbreaks of legionellosis from 27 states during 1973–2000 that were added to the surveillance system in 2010 and one previously unreported outbreak of *M. mageritense* from 2002. Legionellosis outbreaks associated with drinking water, WNID, and WUI were not included in WBDOSS before 2001. During 2009–2010, CDC conducted a comprehensive search of the peer-reviewed scientific literature and CDC outbreak investigation reports to capture the historic record of legionellosis outbreaks since the disease was first recognized in 1976; additional legionellosis outbreaks occurring before 1976 were identified later. Legionellosis outbreaks that occurred after 1971 were included in the analysis to correspond with the period when the surveillance system was started (Table 7). The legionellosis outbreaks identified (covering 1971–2000) are likely an underestimate of legionellosis outbreaks that occurred during this period, and caution should be used when interpreting the reported data (Figures 2 and 7). For example, because reporting mechanisms have changed over time (e.g., only published outbreaks and Epi-Aids are included before 2001, whereas all outbreaks reported by state health departments are included as of 2001), comparisons over time cannot be made, and these data might not be representative of the number of outbreaks over time. However, the addition of the pre-2001

outbreaks to WBDOSS underscores the point that legionellosis outbreaks have occurred consistently over the past 3 decades.

Limitations

WBDOSS and waterborne disease outbreak reporting is subject to at least four main limitations. First, the level of surveillance and reporting activity varies across states and localities. Therefore, determining whether an increase or decrease in reporting reflects an actual change in the incidence of outbreaks or reflects a change in the sensitivity of surveillance practices is unknown. Outbreak reporting might increase as waterborne disease becomes better recognized, water system deficiencies are identified, and state surveillance activities and laboratory capabilities increase (*108–110*). Environmental testing and laboratory capacity also vary substantially across states and localities.

Second, detection, investigation, and reporting of outbreaks are incomplete. Multiple factors contribute to the ability of state and local public health agencies to recognize, investigate, and report outbreaks. Public health agencies must have the financial and personnel resources to investigate outbreaks; they must recognize and link cases of illness to a common water source, which requires appropriate epidemiologic, environmental, and laboratory capacity to conduct investigations. For example, analyses for specific pathogens and indicators of water contamination depend upon the availability of certified or approved laboratories. Although many laboratories are certified to conduct standard analyses for fecal indicators and chemicals, few laboratories have capabilities for identifying waterborne pathogens, and these tests can be expensive. Collecting water samples for pathogen identification often requires sampling large quantities of water or filtering large volumes of water through special membranes. Methods for concentrating large volumes of water for testing are being developed and implemented for use in outbreak investigations (*89,111–113*).

Third, outbreaks associated with drinking water are inherently difficult to detect because most persons have daily exposure to tap water. For this reason, case-control and other epidemiologic studies are less likely to find statistically significant associations unless the outbreaks are communitywide or environmental investigations provide supporting data to identify deficiencies in water treatment or distribution systems that can help identify drinking water as the potential exposure.

Finally, gaps exist in the types of data that are systematically collected and reported during outbreak investigations. In particular, data from environmental investigations on contributing factors associated with outbreaks (e.g., distribution system vulnerabilities, classification of GWUDI systems including testing criteria, or details on septic system placement and maintenance) are often not collected or reported to CDC. Water samples also often are not collected or are collected late in an investigation, limiting the ability to link clinical and environmental data to establish a water-related exposure through molecular epidemiologic or other laboratory testing. Success in the detection of a pathogen in water samples is highly dependent on a timely investigation and sample collection before contamination is flushed from the water system or inactivated by a disinfectant.

Conclusion

Data collected as part of the national WBDOSS are used to describe the epidemiology of waterborne disease outbreaks in the United States. Trends regarding water systems and deficiencies implicated in these outbreaks are used to assess whether regulations for water treatment and water quality monitoring are adequate to protect public health. Trends regarding the etiologic agents responsible for these outbreaks are used to assess the need for different interventions and changes in policies and resource allocations.

The data provided in this report highlight two primary findings. The first is the high proportion of outbreaks associated with contaminated ground water, whether consumed untreated or with inadequate treatment. This is consistent with data from 1971–2006 indicating that ground water outbreaks comprised the majority of drinking water outbreaks and showed no decrease over time (*6*). The second finding is that *Legionella* was again the most frequently reported etiology among drinking water–associated outbreaks, following the pattern observed since it was first included in WBDOSS in 2001 (*6*). The addition of published and CDC-investigated legionellosis outbreaks to the database demonstrates that legionellosis is not a new public health issue.

Federal drinking water regulations have focused on protecting consumers from contaminated surface water, in part because of previous outbreaks and analyses that suggested needed improvements for surface water systems and the large percentage of the population served by surface water (70% of those using community water systems) (*31*). These regulations have likely contributed to the decrease in the number and proportion of reported outbreaks associated with contaminated surface water during the previous twenty years. Similar protections for ground water were absent until promulgation of the GWR in 2006. The GWR focuses on identification of deficiencies, protection of wells and springs from contamination, and providing disinfection where necessary to protect against bacterial and viral agents. Outbreaks in disinfected ground water systems emphasize the importance of maintaining adequate, continuous disinfection. Outbreaks

in untreated ground water systems underscore the importance of assessing contamination sources to determine if the ground water source is at risk of contamination from fecal sources or is under the direct influence of surface water where additional treatment is needed to protect against parasites. When fully implemented, the GWR is expected to reduce ground water-associated outbreaks, as seen in surface water outbreaks after promulgation of the SWTR and its amendments.

Surveillance, prevention, and control activities for outbreaks occur primarily at the local and state levels (including territories and FAS). CDC and other federal agencies provide technical assistance with laboratory testing and epidemiologic and environmental investigations when requested by states and territories (Box 1). Efforts to improve the detection, investigation, and reporting of outbreaks at the local, state, and national levels include the 2006 CSTE position statement that made waterborne disease outbreaks, as a unit of reporting, nationally notifiable and reportable to CDC starting in 2007. To improve timeliness and completeness of outbreak reporting, in 2009, CDC transitioned to electronic outbreak reporting through the National Outbreak Reporting System (NORS) for outbreaks occurring on or after January 1, 2009 (*114,115*). NORS is a collaborative project that is currently used for national surveillance of waterborne disease outbreaks, foodborne disease outbreaks, and enteric disease outbreaks associated with zoonotic, person-to-person, environmental, and undetermined exposures. Efforts to develop and enhance NORS functionality focus on the need to support public health agencies and researchers working to identify the causes of outbreaks and to understand the environmental factors contributing to these outbreaks.

Adequate programmatic funding and human resources to investigate outbreaks are essential for an effective surveillance system. Improved communication among local and state public health departments, regulatory agencies, and water utilities, along with routine reporting or sharing of water quality data within the health and environmental departments will aid in the detection and control of outbreaks. Additional data are needed to better understand some of the contributing factors associated with many drinking water outbreaks (e.g., a GWUDI classification with details on criteria used to determine the influence of surface water). Further research and exploration of other contributing factors and antecedent events associated with untreated ground water outbreaks are needed, including systematic documentation and reporting of the role of septic system contamination, extreme precipitation events, improper well construction, main breaks, cross-connections, and treatment failures.

Measures to reduce the occurence of drinking water outbreaks in the United States have been outlined (Box 2).

Additional efforts are needed to improve outbreak detection and investigations. Such efforts include enhancing surveillance activities, increasing laboratory support for clinical specimen and water sample testing, conducting environmental investigations to assess outbreak deficiencies and contributing factors, and providing adequate resources and staff to state and local health departments to monitor, detect, and prevent outbreaks.

BOX 1. Federal organizations that provide assistance with investigations of waterborne disease outbreaks

State and territorial health departments can request epidemiologic assistance, water quality assessment, and laboratory testing from CDC during waterborne disease outbreaks. Collection of large-volume water samples might be required to identify pathogens that require special protocols for their recovery. The EPA Safe Drinking Water Hotline can be consulted for information about drinking water rules, guidance, and regulations or to identify state and local laboratories certified for drinking water quality testing. The U.S. Geological Survey can be consulted for assistance with hydrogeologic investigations of outbreaks when untreated ground water is suspected.

Requests for assistance with outbreak investigations (e.g., epidemiologic assistance, water testing, diagnosis of free-living amebas, or molecular characterization of *Cryptosporidium* and *Giardia*)

Waterborne Disease Prevention Branch
Division of Foodborne, Waterborne, and Environmental Diseases
National Center for Emerging and Zoonotic Infectious Diseases, CDC
Telephone: 404-639-1700
Email: healthywater@cdc.gov
Internet: http://www.cdc.gov/healthywater

Requests for diagnostic testing for viral organisms

Division of Viral Diseases
National Center for Immunization and Respiratory Diseases, CDC
Telephone: 800-232-4636

Requests for diagnostic testing for enteric bacterial organisms

Enteric Diseases Laboratory Branch
Division of Foodborne, Waterborne, and Environmental Diseases
National Center for Emerging and Zoonotic Infectious Diseases, CDC
Telephone: 404-639-3334

Requests for information for diagnostic testing for parasites (except for *Cryptosporidium*, *Giardia*, or free-living amebas)

Division of Parasitic Diseases and Malaria
Center for Global Health, CDC
Telephone: 404-718-4745
Internet: http://www.cdc.gov/parasites

Requests for information or testing for *Legionella*

Division of Bacterial Diseases
National Center for Immunization and Respiratory Diseases, CDC
Telephone: 404-639-2215
Internet: http://www.cdc.gov/legionella

Information regarding drinking water and public health

CDC
Internet: http://www.cdc.gov/healthywater/drinking
- Drinking water health communication and education resources for the general public
- Information on maintaining individual wells and effectively disinfecting water when camping, hiking, or traveling
- Outbreak investigation toolkit and technical information concerning laboratory diagnostics

Safe Drinking Water Hotline

Environmental Protection Agency
Telephone: 800-426-4791
E-mail: hotline-sdwa@epa.gov
Internet: http://www.epa.gov/safewater

Microbiological and chemical exposure assessment

Environmental Protection Agency
Microbiological and Chemical Exposure Assessment Research Division
National Exposure Research Laboratory
Telephone: 513-569-7303

Information about groundwater resources

U.S. Geological Survey
Internet: http://water.usgs.gov/ogw

Box 2. Measures to reduce the occurrence of drinking water outbreaks in the United States

- Increase monitoring and prevention efforts to reduce the risk for outbreaks in public ground water systems, particularly unchlorinated ground water systems.
- Conduct research to improve understanding of the ecology of *Legionella*, the characteristics contributing to its pathogenicity, and the interventions that are most effective for controlling growth of *Legionella* and reducing outbreaks of legionellosis.
- Systematically collect and analyze data on contributing factors associated with drinking water outbreaks and deficiencies, including identification of ground water under the direct influence of surface water (GWUDI) systems and the criteria (e.g., microscopic particulate analysis testing) used for their classification to better assess risks associated with ground water and GWUDI systems and to enable comparison across geographic regions.
- Increase efforts to reduce the risk for outbreaks associated with drinking water distribution system vulnerabilities (e.g., water main breaks, cross-connections, storage issues, and biofilm proliferation).
- Provide guidance and technical assistance to help prevent outbreaks in unregulated drinking water systems (e.g., private wells and premise plumbing).
- Maintain efforts focused on water systems operations and management, water quality, and effective regulations to sustain gains made over the past four decades in safe drinking water provision.
- Provide additional resources and capacity building for outbreak detection, investigation and reporting of waterborne disease (particularly environmental investigation, laboratory testing, and data management) at local, state, territorial, tribal, and national levels.

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Appendix A

Glossary of Definitions

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	A geologic formation or part of a formation (e.g., gravel, sand, or porous stone) that yields water to wells or springs.
backflow	A hydraulic condition caused by a difference in water pressure that causes nonpotable water or other liquid to enter the potable water system by either backpressure or backsiphonage. See cross-connection.
backsiphonage	A hydraulic condition caused by negative or subatmospheric pressure within a water system, resulting in backflow.
biofilm	Microbial cells that adhere to a moist or water-covered surface through a matrix of primarily polysaccharide materials in which they are encapsulated. Biofilms can grow on piping and surfaces of water systems and can be very difficult to remove. They protect microbes from disinfectants (e.g., chlorine) in the water.
boil water advisory	A statement to the public advising that tap water must be boiled before drinking.
bottled water	Commercially produced bottled water.
class	Waterborne disease outbreaks are classified according to the strength of the epidemiologic and clinical laboratory data, and environmental data implicating water as the source of the outbreak (see Table 3).
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). Coliforms are mostly harmless bacteria that live in soil and water as well as the gut of humans and animals.
community water system	A public water system that has at least 15 service connections used by year-round residents or that regularly serves at least 25 year-round residents. The system might be owned by a private or public entity providing water to a community, subdivision, or mobile home park.
cross-connection	Any actual or potential connection between a drinking water supply and a possible source of contamination or pollution (i.e., nonpotable water). Under this condition, contaminated water might flow back into the drinking water system. See backflow and backsiphonage.
deficiency	An antecedent event or situation contributing to the occurrence of a waterborne disease or outbreak. Outbreaks associated with water intended for drinking, water not intended for drinking and water of unknown intent are assigned deficiency codes, as categorized in Table 2.
dermatitis	Inflammation of the skin. In this report, dermatitis denotes a broad category of skin-related symptoms (e.g., folliculitis, cellulitis, chemical burns, or rash).
disinfection	A treatment that kills microorganisms (e.g., bacteria, viruses, and protozoa); in water treatment, a chemical (commonly chlorine, chloramine, or ozone) or physical process (e.g., ultraviolet light) can be used.
disinfection by-products	Chemicals formed in water through reactions between organic or inorganic matter and disinfectants. Examples include chloramines, also known as combined chlorines. These chemicals might have acute or chronic health effects.

distribution system	Water pipes, storage reservoirs, tanks, and other means used to deliver drinking water to consumers or to store finished water before delivery to a customer. In community water systems, the distribution system is under the jurisdiction of a water utility and ends at the water meter or at the customer's property line (if the system is not metered). In noncommunity and nonpublic individual water systems, the distribution system ends at the point where water enters the building or house. See plumbing.
etiology	The pathogen, chemical, or toxin causing a waterborne disease or outbreak or other health event. Infectious etiologic agents include bacteria, parasites, and viruses.
fecal coliforms	Coliform bacteria that grow and ferment lactose to produce gas at 112.1°F (44.5°C) within 24 hours. These bacteria are associated with human and animal wastes, and their presence in water might be an indication of recent sewage or animal waste contamination.
filtration	In water treatment, the process of passing water through one or more permeable membranes or media of small diameter (e.g., sand, anthracite, and diatomaceous earth) to remove suspended particles from the water. Filters might be effective in removing pathogens, depending on the type and operation.
finished water	The water (e.g., drinking water) delivered to the distribution system after treatment (if any treatment occurred).
free chlorine	Chlorine in water (found as an aqueous mixture of hypochlorous acid and hypochlorite anion) that has not combined with other constituents; therefore, it is able to serve as an effective disinfectant (also referred to as free available chlorine or residual chlorine). Measuring the free chlorine level is a common water quality test.
ground water	Water that is contained in interconnected pores in an aquifer.
ground water system	A drinking water system that uses water extracted from an aquifer (i.e., a well or spring) as its source.
ground water under the direct influence of surface water (GWUDI)	As defined by the U.S. Environmental Protection Agency (EPA): Any water beneath the surface of the ground with: 1) significant occurrence of insects or other macroorganisms such as algae or large-diameter pathogens such as *Giardia lamblia* or, 2) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatologic or surface water conditions. Direct influence must be determined for individual sources in accordance with criteria established by the state. The state determination of direct influence may be based on site-specific measurements of water quality and/or documentation of well construction characteristics and geology with field evaluation. **Source:** http://water.epa.gov/aboutow/ogwdw/glossary_technical.cfm#G.
individual water system	A water system that does not meet the EPA definition for a public water system. The system might regularly serve as many as 24 persons or 14 connections or as few as a single person or connection (e.g., a single family or farm not having access to a public water system). States are responsible for regulating these water systems.
karst aquifer	An aquifer characterized by water-soluble limestone and similar rocks in which fractures or cracks have been widened by the dissolution of the carbonate rocks by ground water; the aquifer might contain sinkholes, tunnels, or even caves.
mixed water source outbreak	More than one type of source water is implicated in the outbreak (e.g., a combination of ground water and surface water).
noncommunity water system	A public water system that is not a community system; it does not serve year-round residents. There are two types: transient and nontransient noncommunity systems.

nontransient noncommunity water system	A public water system that regularly supplies water to ≥25 of the same persons for ≥6 months per year but not year-round (e.g., schools, factories, office buildings, or hospitals with their own water systems).
plumbing	Water pipes, storage reservoirs, tanks, and other means used to deliver drinking water to consumers inside buildings or houses or to store drinking water inside buildings or houses before consumption. In community water systems, the plumbing begins after the water utility's water meter or at the property line (if the distribution system is not metered). In noncommunity and nonpublic (i.e., individual) water systems, the plumbing begins at the point where water enters the building or house. See distribution system.
predominant illness	The category of illness reported by ≥50% of ill respondents (e.g., acute gastroenteritis, dermatitis, or acute respiratory illness). When more than one illness category is reported for a single outbreak, they are listed together as predominant illnesses. These mixed illness outbreaks are analyzed separately from outbreaks with single illnesses.
primary water exposure	For use in this report, a classification used for the source of contaminated water in outbreaks involving water not intended for drinking or water of unknown intent.
public water system	A system that provides piped water to the public for human consumption and is regulated under the Safe Drinking Water Act. Such a system must have at least 15 service connections or regularly serve at least 25 persons daily for at least 60 days per year. Each public water system is further classified as either a community water system or a noncommunity water system.
raw water	Surface water or ground water that has not undergone a disinfection or treatment process for the purpose of making it safer for consumption in any way. See untreated water.
reservoir, impoundment	An artificially maintained lake or other body of water used for the collection and storage of water. This body of water can be available as a source of raw water for drinking purposes or recreational use. In certain instances, a finished water storage facility in the distribution system might also be called a reservoir.
schmutzdecke	Gelatinous biologic layer on the surface of a slow sand filter, consisting of a complex microbial community (including bacteria, fungi, protozoa, and rotifera and other aquatic organisms) and organic particulate matter.
setting	Location in which exposure to contaminated water occurred (e.g., restaurant, hospital, or hotel).
source water	Untreated ground or surface water (i.e., raw water) used to produce drinking water. Source water may or may not be treated prior to human consumption.
surface water	All water on the surface of the earth (e.g., lakes, rivers, reservoirs, ponds, and oceans) as distinguished from subsurface or ground water.
total coliforms	The combined count of fecal and nonfecal coliforms that are detected in water using a standard test. The extent to which total coliforms are present in water can indicate the general quality of that water and the likelihood that the water is contaminated fecally by animal and/or human sources.
transient noncommunity water system	A public water system that provides water in a place such as a gas station or campground where persons do not remain for long periods.
untreated water	Water that has not undergone a disinfection or treatment process for the purpose of making it safer for consumption (i.e., raw water).

water not intended for drinking (WNID)	Water that has not been treated for human consumption in conformance with EPA drinking water standards and that is provided for uses other than for drinking. This category includes water used in industrial settings; untreated water from lakes, springs, and creeks used as drinking water by campers and boaters; irrigation water; and other nonpotable water sources with or without taps. This category does not include exposure to recreational water or flood water.
water of unknown intent (WUI)	Water for which there is insufficient information to determine for what purpose it is being provided or used and whether it has been treated for human consumption in conformance with EPA drinking water standards.
water system	A system for the provision of water for human consumption through pipes or other constructed conduits. This includes any collection, treatment, storage, and distribution facilities used primarily in connection with such a system.

Appendix B

Descriptions of Selected Waterborne Disease Outbreaks Associated with Drinking Water, Water Not Intended for Drinking, and Water of Unknown Intent

Month	Year	State/Jurisdiction in which outbreak occurred	Etiology	No. of cases (deaths)	Description of outbreak
Bacteria					
October	2007	Nevada	*Legionella pneumophila* serogroup 1	7	During November and December of 2007, two cases of Legionnaire's disease (LD) occurring at the same timeshare condominium were identified through CDC's surveillance system for travel-associated LD; two additional cases were identified in 2008. A subsequent review identified a single case in 2006, and a previous outbreak of legionellosis in 2001 at the same condominium. Seven laboratory-confirmed cases were reported during 2007–2008. The condominium has three towers with individual low- and high-rise potable water systems. Water samples were collected from guest rooms, water heaters, cooling towers, decorative features and recreational facilities, as well as the municipal water source at the water meter, prior to the implementation of extensive remediation efforts. Environmental samples from showerheads and sinks in one of the towers were found to have *L. pneumophila* that was an identical molecular match to the single clinical isolate available in 2001. Laboratory findings, combined with evidence of sporadic transmission between the first and second outbreak, indicated that long-term colonization of the drinking water system with *L. pneumophila* had likely occurred at the complex and highlights the importance of travel-associated surveillance systems in linking disease occurrence among geographically-dispersed travelers. No cases were reported at the time-share condominium in 2009 following completion of the second remediation attempt.
July	2008	New York	*L. pneumophila* serogroup 1	13 (1)	Thirteen residents of an apartment complex for seniors received a diagnosis of Legionnaires' disease. Several water samples from apartment bathroom taps and a hot water cartridge were culture positive for *L. pneumophila* serogroup 1. The environmental isolates matched patient clinical isolates via pulse-field gel electrophoresis (PFGE). No single event was determined to have led to the outbreak. Potential contributing factors included a previous water main break and subsequent loss in water pressure, disruption and mobilization of an existing biofilm colonized with *Legionella*, and a hot water heater temperature setting that may have been supportive of *Legionella* growth.
August	2008	Connecticut	*Providencia*	55	Fifty-five persons in an apartment complex supplied by water from a community water system became ill with gastrointestinal symptoms. Six of nine stool specimens tested positive for *Providencia*. None of the stool specimens tested positive for *Salmonella*, *Shigella*, *Campylobacter*, *E. coli*, parasites, or norovirus. The investigation found a statistically significant association between tap water consumption and illness. Seven well water samples tested negative for *Providencia* and six of the samples tested positive for *E. coli*. Raw sewage was visible on the ground after two septic pumps located uphill of the water system wells failed and the septic tank overflowed. Contributing factors in the outbreak included the downhill movement of sewage towards the wells by rainfall and a cracked well casing.
March	2008	Colorado	*Salmonella* Typhimurium	1,300 (1)	An estimated 1,300 persons became ill when a community drinking water system became contaminated with *Salmonella* Typhimurium. At the time of the outbreak, a state waiver allowed the distribution of untreated ground water. Twenty persons were hospitalized and one person died. Epidemiologic and environmental findings implicated the community water system. Clinical specimens and tap water tested positive for identical subtypes of *S.* Typhimurium using pulse-field gel electrophoresis. The likely source of the outbreak was animal contamination of a storage tank that had numerous cracks and entry points. The outbreak response required local, regional, state, and federal emergency assistance over a period of three weeks during which bulk water was distributed by the National Guard while the distribution system was hyperchlorinated. At the time of the outbreak, a new water-treatment plant was under construction, primarily for the purpose of abating naturally high levels of arsenic. Since the outbreak, water is now continuously disinfected at this new plant.

Month	Year	State/Jurisdiction in which outbreak occurred	Etiology	No. of cases (deaths)	Description of outbreak
August	2008	Tennessee	*Salmonella* serotype I 4,5,12:*i*:-	5	Five persons were infected with *Salmonella* serotype I 4,5,12:*i*:- following consumption of untreated water from a local spring that supplied five homes and a church. The initial case was an infant who was seen by a physician for bloody diarrhea. The regional health department investigated the illness and determined that tap water used to mix powdered formula was the primary risk factor. Tap water collected from the infant's home tested positive for total coliforms and *E. coli*. The water also tested positive for *Salmonella* and was a pulse-field gel electrophoresis (PFGE) match to isolates from the infant's stool. A subsequent water sample from the church matched the clinical and tap water samples by PFGE. As a result of the investigation, the Tennessee Department of Environment and Conservation (TDEC) and the regional health department then worked with the affected homes, church and spring owner to provide education and bring the drinking water system into compliance.
Viruses					
March	2008	Tennessee	Hepatitis A virus	9	Nine persons tested positive and four persons were hospitalized for infection with hepatitis A virus after spending time at a lakeside residential and vacation community without municipal water or sewer services. Cases were identified among relatives and friends of two resident families. The index case occurred in early March, and the cluster of secondary cases occurred >6 weeks later, in April. The epidemiologic study indicated that person-to-person transmission did not occur. Water samples collected in May from two wells, one supplying the residence of three persons with secondary cases, detected hepatitis A virus by PCR that was the same strain as that in the persons from whom virus specimens were collected. The untreated well water was likely contaminated by a faulty septic system used by the index case-patient, who lived in a mobile home nearby. The public health response included provision of vaccine at three vaccination clinics and provision of postexposure immunoglobulin to >1,500 residents and visitors. Education regarding karst geology and the risks of drinking water from shallow private wells without disinfection was provided to homeowners in the area, and local and state government offices were encouraged to consider extending water utility services to the affected area.
Parasites					
April	2008	Puerto Rico	*Cyclospora cayetanensis*	82	The Puerto Rico Department of Health investigated an outbreak of recurrent diarrhea in a rural community. Of 82 case-patients that were identified, seven were hospitalized. Clinical testing identified *Cyclospora cayetanensis* in 20 of 26 case-patient stool specimens. An epidemiologic study showed that interruptions in the water service during the past six months, changes in drinking water quality and appearance, and food purchases at a local supermarket were associated with illness; no increased risk was associated with consumption of fruits or vegetables. Interruptions in water service occurred prior to the outbreak, including one interruption during the estimated exposure period when a pumping station was found to be damaged and water was delivered in trucks from another water system and stored in a water tank. Breaks in water supply and changes in water quality were reported by the community during the same time period. Although the source of contamination was not identified, this is the first outbreak of *C. cayetanensis* in Puerto Rico in which water consumption is considered the probable source of transmission.
July	2007	California	*Giardia intestinalis*	46	A giardiasis outbreak at a camp that used a spring as its water source resulted in 46 cases of illness. The spring was classified as ground water under the direct influence of surface water and therefore subject to the Environmental Protection Agency's Surface Water Treatment Rule and amendments. An epidemiologic study conducted implicated eating a garden salad and showering as risk factors for illness. Although a slow sand filter and chlorinator had been installed, inadequate time was allowed for formation of a *schmutzdecke* biological layer on the surface of the filter, which is important for effective treatment performance of slow sand filters. Water samples collected one week after the filter was put into operation showed considerably higher levels of total coliforms and turbidity in filtered water samples than in the spring water samples. Six weeks after operation of the filter a *schmutzdecke* layer formed and water samples met requirements.

Month	Year	State/Jurisdiction in which outbreak occurred	Etiology	No. of cases (deaths)	Description of outbreak
Chemicals					
April	2007	Massachusetts	Sodium hydroxide	145	An estimated 145 persons experienced chemical burns after a sodium hydroxide overfeed altered the pH balance of water passing through a water treatment facility. The pH imbalance occurred overnight when treatment lines were left on a manual setting after routine maintenance. The event activated an onsite alarm system but the facility did not have an automatic notification system for off-site staff. Detection and remediation of the problem at the water treatment facility occurred early the following morning. The emergency response was a coordinated effort that included the local health department and multiple emergency response agencies. Response measures included a Do Not Use order, community education and outreach, consultation with local healthcare facilities and inspection of food and retail establishments prior to re-opening.
Multiple etiologies					
May	2007	Wisconsin	Norovirus genogroup I, *Campylobacter*, *Salmonella*	229	Gastrointestinal illness in 229 persons was associated with drinking water exposure at a local restaurant; three stool specimens were positive for enteric pathogens: one for norovirus genogroup 1, one for *Campylobacter*, and one for *Salmonella*. Well water tested positive for *E. coli* and a boiled/bottled water advisory was issued. Subsequent tests found norovirus genogroup I in the water that was identical to the strain in clinical specimens. The restaurant and surrounding residences were located in an area with karst geological features. Tracer dye testing implicated a septic tank as a source of contamination. Underground seepage of sewage and contamination through limestone or fissured rock were thought to contribute to the outbreak.
September	2008	Illinois	*Shigella sonnei*, *Cryptosporidium*, *Giardia*	41	Of 72 persons who gathered for weekend activities that included a dinner cruise on a lake, 41 developed illness attributed to infections with *S. sonnei*, *Giardia*, and *Cryptosporidium* beginning the following day. Environmental inspection revealed conditions and equipment that could have contributed to lake water contaminating the hose used to load potable water onto the boat. Heavy rainfall and flooding the same weekend resulted in the release of a large volume of storm water containing rainwater and highly diluted sewage into the lake. Ice consumption was epidemiologically linked with illness. *S. sonnei* was isolated from a surface swab of an ice container.
Unidentified etiology					
September	2007	Florida	Unidentified	1,663	An estimated 1,663 cases of gastrointestinal illness occurred in a community water system supplied by surface water and conventionally treated with coagulation, settling, filtration, and disinfection. A boil water advisory was issued two days after fecal coliforms and *E. coli* were initially found in the water during routine testing. A cross-sectional, random telephone survey of households affected by the boil water advisory found statistically significant associations between water consumption and illness. An independent assessment identified numerous operation and maintenance deficiencies in water disinfection and filtration processes, as well as a segment of outdated pipe that bypassed disinfection steps because it was not known to still be connected to the distribution system. The system was recycling filter backwash water as required by EPA; however, before the outbreak, the backwash water bypassed the recovery basin and ozonation before filtration, thereby adversely affecting filter performance.

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- 2009-2010 Supplemental Figures

2009-2010 Recreational Water-associated Outbreak Surveillance Report Supplemental Tables

These tables provide supplemental information not published in Recreational Water–Associated Disease Outbreaks — United States, 2009–2010 (http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6301a2.htm?s_cid=mm6301a2_w) (MMWR Weekly).

TABLE 1. Waterborne Disease Outbreaks Associated with Treated Recreational Water (n = 57) and Untreated Recreational Water (n = 24), by Year and Jurisdiction — Waterborne Disease and Outbreak Surveillance System, United States, 2009–2010

Treated Recreational Water

Treated Recreational Water

Jurisdiction	Month	Year	Class*	Etiology	Predominant Illness†	No. cases§	No. hospitalizations¶	Venue	Setting
Alabama	Aug	2010	4	*Cryptosporidium* sp.	AGI	9	0	Pool, wave pool	Waterpark
Alabama	Aug	2010	4	*Cryptosporidium* sp.	AGI	9	1	Pool, spa	Waterpark
Arizona	Aug	2010	3	Unidentified	AGI	4	0	Pool	Waterpark
California	Mar	2009	3	*Legionella* sp.	ARI	2	2	Spa	Apartment/Condo
California	Jul	2009	3	*Legionella* sp.	ARI	2	2	Pool, spa	Membership club
California	Dec	2010	4	*Cryptosporidium* sp.	AGI	2		Pool	Long-term care facility
Florida	Aug	2009	3	*Cryptosporidium* sp.	AGI	5	0	Pool	Hotel/Motel
Florida	Aug	2009	3	*Cryptosporidium* sp.	AGI	4	0	Pool	Community/Municipality
Florida	Aug	2009	3	*Cryptosporidium* sp.	AGI	5	0	Pool	Waterpark
Florida	Aug	2009	4	*Cryptosporidium* sp.	AGI	8	0	Pool	Apartment/Condo
Florida	Mar	2010	3	*Legionella pneumophila*	ARI	2	2	Spa	Membership club
Idaho	Apr	2010	3	Unidentified**	Skin	7	0	Pool, spa	Hotel/Motel
Illinois	Jul	2010	3	*Cryptosporidium* sp.††	AGI	43	3	Pool	Community/Municipality
Illinois	Jul	2010	4	*Cryptosporidium* sp.	AGI	4	0	Pool	Waterpark
Illinois	Aug	2010	4	*Cryptosporidium* sp.	AGI	4	1	Pool	Waterpark
Illinois	Aug	2010	4	*Cryptosporidium* sp.	AGI	4	2	Pool	Subdivision/Neighborhood
Illinois	Aug	2010	4	*Cryptosporidium* sp.	AGI	3	0	Pool	Waterpark
Indiana	Jun	2010	4	*Cryptosporidium* sp.	AGI	5	2	Pool	Waterpark
Iowa	Jul	2010	4	*Cryptosporidium* sp.	AGI	7	0	Pool	Community/Municipality
Iowa	Aug	2010	4	*Cryptosporidium* sp.	AGI	13	0	Fill-and-drain pool	Private residence
Iowa	Aug	2010	4	*Cryptosporidium* sp.	AGI	15	0	Pool	Waterpark
Kansas	Mar	2010	4	Unidentified**	Skin§§	26	0	Pool, spa	Hotel/Motel
Kentucky	Jun	2010	3	Unidentified¶¶	ARI	20		Pool	Community/Municipal park
Kentucky	Aug	2010	2	*Cryptosporidium* sp.	AGI	21	1	Pool	Hotel/Motel
Maine	Mar	2009	3	Unidentified***	ARI; Eye	280	0	Pool	School/College/University

Michigan	Mar	2009	4	Unidentified***	ARI	2	0	Pool	Unknown
Michigan	Apr	2009	4	Unidentified***	Skin	2	0	Pool	Hotel/Motel
Michigan	Jun	2009	3	Unidentified¶¶	ARI	6	1	Pool	School/College/University
Michigan	Jan	2010	4	Unidentified***	Skin	2	0	Pool	Hotel/Motel
Michigan	Feb	2010	4	Unidentified***	ARI; Eye; Skin	12	0	Pool	Waterpark
Minnesota	Feb	2009	3	*Pseudomonas aeruginosa*	Skin	8	0	Pool	Hotel/Motel
Minnesota	Jul	2009	2	*Cryptosporidium hominis* IbA10G2	AGI	33	0	Pool	Waterpark
Minnesota	Aug	2010	1	*Cryptosporidium hominis* IbA10G2	AGI	2	0	Pool	Waterpark
Missouri	Jul	2010	1	*Cryptosporidium hominis* IaA28R4†††	AGI	126	4	Pool, wading pool	Community/Municipality
New Mexico	May	2009	3	Unidentified***	Skin	5		Pool	Public outdoor area
New Mexico	Sep	2009	4	Unidentified§§§	AGI	23	0	Pool	Hotel/Motel
New Mexico	Mar	2010	3	Unidentified¶¶	Skin	3	0	Pool	Community/Municipality
New York	Feb	2009	3	*Pseudomonas* sp.	Skin	2	0	Spa	Hotel/Motel
New York	Feb	2009	3	Unidentified**	Skin	5	0	Pool	Hotel/Motel
New York	Mar	2009	3	Unidentified***	Eye; Skin	31	0	Pool, spa	Hotel/Motel
New York	Oct	2009	3	Unidentified**	AGI; Ear; Skin	7	0	Spa	Hotel/Motel
New York	Nov	2010	3	*Legionella* pneumophila serogroup 1	ARI	2	1	Spa	Hotel/Motel
Ohio	Apr	2009	1	*Pseudomonas aeruginosa*	Eye; Skin	23	0	Pool, spa	Hotel/Motel
Ohio	Mar	2010	3	Unidentified***	ARI	4	0	Pool	School/College/University
Ohio	Mar	2010	1	*Pseudomonas aeruginosa*	Skin¶¶¶	17	0	Pool, spa	Hotel/Motel
Ohio	Jul	2010	3	*Cryptosporidium* sp.	AGI	23	0	Pool	Waterpark
Oregon	Aug	2010	4	*Cryptosporidium* sp.	AGI	18	0	Pool	Hotel/Motel
Oregon	Oct	2010	4	*Cryptosporidium* sp.	AGI	12	0	Pool	Community/Municipality
Puerto Rico	Jun	2009	1	Unidentified§§§	AGI	68	13	Interactive fountain(s)	Community/Municipal park
South Carolina	Jul	2010	1	*Cryptosporidium hominis* IbA10G2	AGI	31	0	Interactive fountain(s)	Community/Municipality
Tennessee	May	2009	4	*Shigella sonnei*	AGI	3	0	Fill-and-drain pool	School/College/University
Tennessee	Jul	2009	2	Unidentified	Skin	11	0	Pool, spa	Hotel/Motel
Tennessee	Jun	2010	1	*Escherichia coli* O157:H7	AGI	14	4	Pool	Membership club
Virginia	Apr	2009	4	Unidentified**	Skin	10		Spa	Hotel/Motel
West Virginia	May	2010	4	Unidentified	Skin	6	0	Spa	Vacation rental house
Wyoming	Mar	2009	3	Unidentified	Skin	8	0	Pool, spa	Hotel/Motel
Wyoming	Aug	2010	4	*Giardia intestinalis*	AGI	7	1	Pool (hot spring)****	Waterpark

Untreated Recreational Water

Jurisdiction	Month	Year	Class*	Etiology	Predominant Illness†	No. cases§	No. hospitalizations¶	Venue	Setting
Alabama	May	2010	1	Norovirus genogroup II	AGI	69	2	Lake/Reservoir	State park
Arkansas	Jun	2010	4	*Escherichia coli* O157:H7	AGI	5	3	River/Stream	Public outdoor area
California	Jul	2010	4	Unidentified††††	Skin	9	0	Pond	Public outdoor area
Florida	Aug	2009	4	*Cryptosporidium* sp.	AGI	6	0	Lake/Reservoir	State park
Massachusetts	Jul	2009	1	*Shigella sonnei*	AGI	68	6	Lake/Reservoir	Public beach

Michigan	Jun	2010	3	*Campylobacter jejuni*	AGI	6	4	Lake/Reservoir	Public beach
Michigan	Jun	2010	4	Unidentified§§§§	Skin	3	0	Lake/Reservoir	Unknown
Minnesota	Jul	2010	2	*Escherichia coli* O157:H7	AGI	5	4	Lake/Reservoir	Public beach
Minnesota	Aug	2010	2	*Cryptosporidium hominis* IbA10G2	AGI	3	0	Lake/Reservoir	Public beach
New York	Jun	2009	3	Unidentified¶¶¶¶	ARI; Eye	2		Lake/Reservoir	Unknown
New York	Jun	2009	3	Unidentified¶¶¶¶	Skin	2	0	Lake/Reservoir	Public beach
New York	Aug	2009	3	Cyanobacterial toxin(s)*****	Skin	2	0	Lake/Reservoir	State park
New York	Oct	2010	4	Unidentified††††	Skin	2	0	Ocean	Membership club
Ohio	Jun	2010	3	Cyanobacterial toxin(s)†††††	AGI; ARI; Skin	8	1	Lake/Reservoir	State park
Ohio	Jul	2010	3	Cyanobacterial toxin(s)§§§§§	AGI	19	0	Lake/Reservoir	Camp/Cabin
Ohio	Jul	2010	3	Unidentified¶¶¶¶¶	Skin	7	0	Lake/Reservoir	State park
Ohio	Jul	2010	3	Cyanobacterial toxin(s)*****	Skin	9	0	Lake/Reservoir	Public outdoor area
Ohio	Aug	2010	3	Unidentified******	AGI; ARI; Neuro; Skin††††††	3	0	Lake/Reservoir	State park
Ohio	Aug	2010	3	Unidentified§§§§§§	AGI	2	0	Lake/Reservoir	State park
Oklahoma	May	2009	3	*Campylobacter jejuni,* norovirus genogroup I, *Shigella* sp.	AGI	45	0	River/Stream	Public outdoor area
Tennessee	Mar	2009	4	*Cryptosporidium* sp.	AGI	7		Lake/Reservoir, river/stream	Camp/Cabin
Washington	Jun	2009	4	Unidentified¶¶¶¶	AGI	4	1	Lake/Reservoir	State park
Washington	Jul	2009	4	Unidentified¶¶¶¶¶¶	AGI	3	0	Lake/Reservoir	State park
Wisconsin	Jun	2009	2	*Escherichia coli* O157:H7	AGI	7	1	Lake/Reservoir	State park

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Ear = illnesses, conditions, or symptoms related to the ears; Eye = illnesses, conditions, or symptoms related to the eyes; Neuro = neurologic illnesses, conditions, or symptoms (e.g., meningitis); Skin = illnesses, conditions, or symptoms related to the skin.

* Based on epidemiologic, clinical laboratory, and environmental data (e.g., water quality data) reported to CDC. For more information, refer to the strength-of-evidence classification table. (http://www.cdc.gov/healthywater/surveillance/recreational/outbreak-classifications.html)

† The category of illness reported by ≥50% of ill respondents. All legionellosis outbreaks were categorized as ARI.

§ No outbreak-related deaths were reported.

¶ Value was set to missing in reports when zero hospitalizations were reported and the reported number of people for whom these data were available was also zero.

** Etiology unidentified: *Pseudomonas aeruginosa* suspected based on reported venue(s) of exposure and clinical signs and symptoms.

†† *Cryptosporidium* was detected in stool specimens from multiple case-patients. Isolate from one case-patient was identified as *Cryptosporidium hominis* IaA28R4.

§§ Eleven case-patients reported earaches in addition to dermatologic symptoms.

¶¶ Etiology unidentified: chlorine (i.e., toxic chlorine gas or extremely elevated chlorine levels) suspected based on reported events.

*** Etiology unidentified: disinfection by-products (e.g., chloramines), altered water chemistry, or extremely elevated chlorine levels suspected based on reported data.

††† Isolates from stool specimens of six case-patients were identified as *C. hominis* IaA28R4; the isolate from another case-patient was identified as *C. hominis* IaA24R4; and the isolate from another case-patient was identified as *C. hominis* IdA15G1.

§§§ Etiology unidentified: norovirus suspected based on reported incubation period, symptoms, or duration of illness.

¶¶¶ Eight case-patients reported earaches in addition to dermatologic symptoms.

**** Pool is a manufactured venue that is filled with filtered but otherwise untreated hot spring water.

†††† Etiology unidentified: avian schistosomes suspected based on reported clinical diagnosis of cercarial dermatitis and environmental data.

§§§§ Etiology unidentified: copper suspected based on reported use of chemical treatment for algae.

¶¶¶¶ Etiology unidentified: cyanobacterial toxin(s) suspected based on reported clinical signs and symptoms, environmental data (e.g., confirmed algal bloom), and venue of exposure.

***** Microcystin toxin (≥20 ppb) detected in water samples collected during or within 1 day of dates of exposure. Other cyanobacterial toxin(s) suspected based on reported clinical signs and symptoms.

††††† Microcystin toxin (≥20 ppb), anatoxin-a, saxitoxin, and cylindospermopsin detected in water samples collected during or within 1 day of dates of exposure.

§§§§§ Microcystin toxin (≥20 ppb) detected in water samples collected during or within 1 day of dates of exposure.

¶¶¶¶¶ Etiology unidentified: microcystin toxin, saxitoxin, and other cyanobacterial toxin(s) suspected based on reported clinical signs and symptoms, environmental data (e.g., confirmed algal bloom), and venue of exposure. Microcystin toxin (<20 ppb) and saxitoxin detected in water samples collected during or within 1 day of dates of exposure.

****** Etiology unidentified: microcystin toxin, anatoxin-a, and other cyanobacterial toxin(s) suspected based on reported clinical signs and symptoms, environmental data (e.g., confirmed algal bloom), and venue of exposure. Microcystin toxin (<20 ppb) and anatoxin-a detected in water samples collected during or within 1 day of dates of exposure.

†††††† One or more case-patients reported symptoms in each illness category; however, no illness category was definitively reported by ≥50% of ill respondents. Therefore, all reported illness categories have been included.

§§§§§§ Etiology unidentified: microcystin toxin, anatoxin-a, and cylindrospermopsin suspected based on reported clinical signs and symptoms, environmental data (e.g., confirmed algal bloom), and venue of exposure. Microcystin toxin (<20 ppb), anatoxin-a, and cylindrospermopsin detected in water samples collected during or within 1 day of dates of exposure.

¶¶¶¶¶¶ Etiology unidentified: microcystin toxin based on reported clinical signs and symptoms, environmental data (e.g., confirmed algal bloom), and venue of exposure. Microcystin toxin (<20 ppb) detected in water samples collected during or within 1 day of dates of exposure.

Note: For more detailed information on harmful algal bloom–associated outbreaks, refer to Algal Bloom–Associated Disease Outbreaks Among Users of Freshwater Lakes — United States, 2009–2010 (http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6301a3.htm?s_cid=mm6301a3_w) **(MMWR Weekly).**

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Table 2. Number of Waterborne Disease Outbreaks Associated with Recreational Water (n = 81*), by Predominant Illness† and Type of Water Exposure — Waterborne Disease and Outbreak Surveillance System, 2009–2010

	Type of Water Exposure												
	Treated			Untreated			Total						
Predominant Illness	Outbreaks	Cases	Hospitalized	Outbreaks	Cases	Hospitalized	Outbreaks	%	Cases	%	Hospitalized	%
AGI	30	525	32	14	249	21	44	54.3%	774	58.4%	53	85.5%
AGI, ARI, Neuro, and Skin§	0	0	0	1	3	0	1	1.2%	3	0.2%	0	0.0%
AGI, ARI, and Skin	0	0	0	1	8	1	1	1.2%	8	0.6%	1	1.6%
AGI, Ear, and Skin	1	7	0	0	0	0	1	1.2%	7	0.5%	0	0.0%
ARI	8	40	8	0	0	0	8	9.9%	40	3.0%	8	12.9%
ARI and Eye	1	280	0	1	2	0	2	2.5%	282	21.3%	0	0.0%
ARI, Eye, and Skin	1	12	0	0	0	0	1	1.2%	12	0.9%	0	0.0%
Eye and Skin	2	54	0	0	0	0	2	2.5%	54	4.1%	0	0.0%
Skin	14	112	0	7	34	0	21	25.9%	146	11.0%	0	0.0%
Total (%)	57 (70.4%)	1,030 (77.7%)	40 (64.5%)	24 (29.6%)	296 (22.3%)	22 (35.5%)	81	100.0%	1,326	100.0%	62	100.0%

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Ear = illnesses, conditions, or symptoms related to the ears; Eye = illnesses, conditions, or symptoms related to the eyes; Neuro = neurologic illnesses, conditions, or symptoms (e.g., meningitis); Skin = illnesses, conditions, or symptoms related to the skin.

* No outbreak-related deaths were reported.

† The category of illness reported by ≥50% of ill respondents. All legionellosis outbreaks were categorized as ARI.

§ One or more case-patients reported symptoms in each illness category; however, no illness category was definitively reported by ≥50% of ill respondents. Therefore, all reported illness categories have been included.

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Supplemental Tables & Figures

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2011–2012 Recreational Water–associated Outbreak Surveillance Report Supplemental Tables

These tables provide supplemental information not published in Outbreaks of illness associated with recreational water — United States, 2011–2012 (http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6424a4.htm?s_cid=mm6424a4_w) (MMWR Weekly).

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- Untreated Recreational Water
- Recreational Water Outbreaks, by Predominant Illness and Type of Water Exposure

Table 1. Waterborne Disease Outbreaks* Associated with Treated Recreational Water and Untreated Recreational Water, by Year and Jurisdiction — Waterborne Disease and Outbreak Surveillance System, United States, 2011–2012

Treated Recreational Water

Jurisdiction	Month	Year	Class*	Etiology	Predominant Illness†	No. cases§	No. hospitalizations¶	Venue	Setting
Alabama	Jun	2011	I	*Escherichia coli* O157:H7 (C)	AGI	19	3	Interactive fountain(s), pool	Recreational facility
Arizona	Apr	2012	IV	Norovirus (S)	AGI	3	0	Pool	Resort
Colorado	Jul	2011	II	*Cryptosporidium hominis* IaA28R4 (C)	AGI	33	0	Pool	Waterpark
Colorado	Jun	2012	IV	*Cryptosporidium* sp. (C)	AGI	5	0	Interactive fountain(s), pools, spas	Membership club
Georgia	May	2011	IV	*Shigella sonnei* subgroup D (C)	AGI	5	1	Pool	Waterpark
Georgia	Oct	2012	III	*Legionella pneumophila* serogroup 1 (C)	ARI	2	2	Pool, spas	Recreational facility
Idaho	Sep	2011	III	*Escherichia coli* O157:H7 (C)	AGI	2	2	Fill-and-drain pool††	Private residence
Idaho	Jun	2012	III	*Cryptosporidium* sp. (C)	AGI	82	3	Pools	Community/Municipal park, membership club, waterpark
Idaho	Aug	2012	IV	*Cryptosporidium* sp. (C)	AGI	2	0	Pool	Community/Municipality
Illinois	Jun	2011	IV	*Cryptosporidium* sp. (C)	AGI	23	0	Temporary water slide	Community/Municipal park
Iowa	Mar	2012	III	Norovirus genogroup I (C)	AGI	75	0	Pool, spa, wading pool, water slide	Hotel/Motel, indoor waterpark
Iowa	Aug	2012	IV	*Cryptosporidium* sp. (C)	AGI	24	0	Wading pool	Community/Municipal park
Kansas	Jul	2011	III	*Cryptosporidium* sp. (C)	AGI	144	10	Pool	Apartment/Condo
Kansas	Aug	2011	IV	*Cryptosporidium* sp. (C)	AGI	9	1	Pool	Community/Municipality
Kansas	Apr	2012	III	*Legionella* sp. (C)	ARI	3	§§	Spa	Hotel/Motel
Kentucky¶¶	May	2011	III	*Cryptosporidium* sp. (C)	AGI	130	13	Pool	Unknown
Louisiana	Dec	2012	IV	*Legionella pneumophila* (C)	ARI	4	4	Unknown	Unknown
Maryland	Jul	2011	IV	*Giardia intestinalis* (C)	AGI	21	0	Wading pool	Membership club
Michigan	Jun	2012	IV	*Legionella pneumophila* serogroup 2 (C)	ARI	9	4	Pool, spa	Private residence
Michigan	Jul	2012	IV	Chemical (pool chemical) (S)***	ARI	3	§§	Pool	Unknown
Michigan	Jul	2012	I	*Cryptosporidium* sp. (C)	AGI	27	0	Pool	Private residence
Michigan	Aug	2012	III	*Cryptosporidium parvum* IIaA15G2R1 (C)	AGI	9	0	Interactive fountain(s)	County park
Minnesota	Mar	2011	I	*Legionella* sp. (S)	ARI	48	1	Spa	Recreational facility
Minnesota	Aug	2011	I	*Cryptosporidium hominis* IaA15R3 (C)	AGI	11	0	Pool	Recreational facility, school/college/university

Minnesota	Mar	2012	I	*Cryptosporidium parvum* IIaA15G2R1 (C)	AGI	97	1	Pool	Hotel/Motel, indoor waterpark
Minnesota	Mar	2012	I†††	*Cryptosporidium parvum* IIaA16G3R1 (C)	AGI	43	1	Pool	Hotel/Motel, indoor waterpark
Minnesota	Apr	2012	III	*Pseudomonas aeruginosa* (S)	Skin	7	0	Pool, spa	Hotel/Motel
Minnesota	Jun	2012	III	*Cryptosporidium* sp. (C)	AGI	7	2	Pool	Community/Municipality
Minnesota	Jul	2012	II	*Cryptosporidium parvum* IIaA15G2R1 (C)	AGI	5	1	Swim pond§§§	Community/Municipal park
Minnesota	Jul	2012	II	*Cryptosporidium parvum* IIaA16G2R2 (C)	AGI	2	0	Interactive fountain(s)	Community/Municipal park
Minnesota	Jul	2012	II	*Cryptosporidium parvum* IIaA16G2R2 (C)	AGI	2	0	Interactive fountain(s)	Community/Municipality
Minnesota	Aug	2012	II	*Cryptosporidium parvum* IIaA15G2R1 (C)	AGI	6	0	Pool	Community/Municipality
Minnesota	Aug	2012	I	*Cryptosporidium parvum* IIaA15G2R1 (C)	AGI	2	1	Pool	Community/Municipality
Minnesota	Nov	2012	III	*Legionella* sp. (S)	ARI	4	0	Spa	Private residence
Missouri	Jul	2011	III	*Cryptosporidium* sp. (C)	AGI	38	3	Pool	Waterpark
Missouri	Jul	2011	III	Chloramines (S)	ARI	9	0	Pool, spa	Hotel/Motel
Missouri	Jun	2012	III	*Legionella pneumophila* serogroup 1 (C)	ARI	3	3	Interactive fountain(s), pool, spa	Resort
Nevada	Oct	2011	III	Chlorine (S)	Skin	12	0	Spa	Hotel/Motel
New Hampshire	Aug	2011	IV	*Pseudomonas aeruginosa* (C)	Skin	9	0	Spa	Private residence
New York	Jan	2011	III	Chloramines (S)	Skin	4	0	Interactive fountain(s), pool	Indoor waterpark
New York	Apr	2011	III	Chlorine gas (C)	ARI; Eye; Skin	11	0	Pool	Membership club
New York	May	2011	III	Chlorine gas (S)¶¶¶	ARI; Eye	3	0	Pool	Recreational facility
New York	Jun	2012	III	Chlorine (C)****	Eye; Skin	30	§§	Wading pool	Community/Municipal park
North Carolina	Sep	2012	I	Norovirus genogroup I (C)	AGI	47	0	Pool	Recreational facility
Ohio	Jan	2011	IV	*Cryptosporidium* sp. (C)	AGI	87	3	Pool	Hotel/Motel, indoor waterpark
Ohio	Jul	2011	IV	*Cryptosporidium* sp. (C)††††	AGI	3	1	Pool	Apartment/Condo
Ohio	Jul	2011	IV	*Cryptosporidium* sp. (C)††††	AGI	2	0	Pool	Membership club
Ohio	Jul	2011	III	*Cryptosporidium* sp. (C)††††	AGI	7	1	Interactive fountain(s)	Community/Municipal park
Ohio	Jul	2011	IV	*Cryptosporidium* sp. (C)††††	AGI	19	0	Pool	Amusement park
Ohio	Aug	2011	IV	*Cryptosporidium* sp. (C)††††	AGI	2	0	Pool	Waterpark
Ohio	Aug	2011	IV	*Cryptosporidium* sp. (C)	AGI	2	0	Pool	Recreational facility
Ohio	Aug	2011	IV	*Cryptosporidium* sp. (C)††††	AGI	4	0	Pool	Recreational facility
Ohio	Aug	2011	IV	*Cryptosporidium* sp. (C)††††	AGI	8	0	Pool	Recreational facility
Ohio	Aug	2011	IV	*Cryptosporidium* sp. (C)††††	AGI	4	1	Interactive fountain(s)	Community/Municipal park
Ohio	Aug	2011	IV	*Cryptosporidium* sp. (C)††††	AGI	3	0	Interactive fountain(s)	Community/Municipal park
Ohio	Aug	2011	IV	*Cryptosporidium* sp. (C)	AGI	2	1	Pool, wading pool	Recreational facility
Ohio	Sep	2011	I	*Pseudomonas aeruginosa* (C)	Skin§§§§	7	0	Pool, spa	Hotel/Motel
Ohio	Dec	2011	III	*Legionella pneumophila* serogroup 1 (C)	ARI	2	2	Pool, spa	Membership club
Ohio	Apr	2012	IV	*Pseudomonas aeruginosa* (S)	Skin§§§§	40	0	Spa	Hotel/Motel
Ohio	Jun	2012	III	Chlorine (C)	Eye; Skin	16	0	Interactive fountain(s), pool, wading pool	Recreational facility

Ohio	Jul	2012	III	*Cryptosporidium* sp. (C)	AGI	12	1	Pool	Waterpark
Ohio	Dec	2012	IV	*Pseudomonas aeruginosa* (S)	Skin	4	0	Spa¶¶¶¶	Hotel/Motel
Pennsylvania	Sep	2011	III	*Legionella pneumophila* serogroup 1 (C)	ARI	6	0	Spa	Hotel/Motel
Pennsylvania	Jan	2012	III	*Legionella pneumophila* serogroup 1 (C)	ARI	2	2	Spa	Hotel/Motel
Puerto Rico	Dec	2012	III	Norovirus (S)	AGI	18	4	Interactive fountain(s)	Community/Municipal park
South Carolina	Jun	2012	IV	*Legionella* sp. (C)	ARI	2	1	Pool, spa	Apartment/Condo
Utah	Aug	2012	IV	*Cryptosporidium* sp. (C)	AGI	2	0	Pool	Waterpark
Virginia	Mar	2012	IV	*Pseudomonas aeruginosa* (S)	Skin	5	0	Spa	Private residence
Wisconsin	Jul	2011	IV	*Cryptosporidium* sp. (C)	AGI	16	0	Pool	Community/Municipality

Untreated Recreational Water

Jurisdiction	Month	Year	Class†	Etiology (C/S)§	Predominant Illness¶	No. cases**	No. hospitalizations	Venue	Setting
California	Apr	2012	IV	Avian schistosomes (S)	Skin	2	§§	Lake/Reservoir	Beach
Colorado	Jul	2012	II	*Shigella sonnei* subgroup D (C)	AGI	31	2	Lake/Reservoir	Public beach
Connecticut	Jul	2012	II	Norovirus genogroup I (C)	AGI	24	0	Lake/Reservoir	Amusement park
Florida	Apr	2011	I	Norovirus genogroup II (C)	AGI	29	0	Lake/Reservoir	Park
Illinois	Aug	2011	IV	*Giardia intestinalis* (C)	AGI	10	0	Lake/Reservoir	Membership club
Illinois	Jul	2012	IV	Avian schistosomes (S)	Skin	4	1	Lake/Reservoir	Beach
Illinois	Jul	2012	II	*Escherichia coli* O111 (C)	AGI	7	0	Lake/Reservoir	Private beach
Illinois	Jul	2012	III	Adenovirus (C)	Eye*****	32	1	Lake/Reservoir	Private beach
Massachusetts	Jul	2011	I	*Escherichia coli* O157:H7 (C)	AGI	8	3	Ocean†††††	Public beach
Minnesota	Jul	2012	II	*Cryptosporidium hominis* IbA10G2 (C)	AGI	16	0	Lake/Reservoir	Camp/Cabin
New York	May	2011	III	Avian schistosomes (C)	Skin§§§§§	43	0	Lake/Reservoir	Public beach
New York	Jul	2011	III	Cyanobacterial toxin(s) (C)¶¶¶¶¶	Eye	8	§§	Lake/Reservoir	Private beach, public beach
New York	Jul	2012	IV	Avian schistosomes (S)	Skin	16	§§	Lake/Reservoir	Public beach
North Dakota	Jul	2012	IV	*Giardia intestinalis* (C)	AGI	3	0	Lake/Reservoir	Public outdoor area
Pennsylvania	Jul	2011	II	*Escherichia coli* O157:H7 (C)	AGI	16	9	Lake/Reservoir	State park
Texas	Jun	2011	IV	*Escherichia coli* (C), *Plesiomonas shigelloides* (C), *Shigella sonnei* subgroup D (C)	AGI	56	1	Lake/Reservoir	Public outdoor area
Vermont	Jul	2012	IV	Norovirus (S)	AGI	35	0	Lake/Reservoir	State park
Washington	Jul	2012	IV	*Shigella sonnei* subgroup D (C)	AGI	3	1	Pond	Community/Municipality
Wisconsin	Jul	2011	I	*Escherichia coli* O111 (C)	AGI	4	0	Lake/Reservoir	Public beach, public outdoor area
Wisconsin	Jul	2012	I	*Giardia intestinalis* (C), norovirus genogroup I GI_3 (C)	AGI	125	1	Lake/Reservoir	State park
Wisconsin	Jul	2012	II	*Escherichia coli* O157:H7 (C)	AGI	7	3	Lake/Reservoir	Lake-sandbar

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Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Eye = illnesses, conditions, or symptoms related to the eyes; Skin = illnesses, conditions, or symptoms related to the skin.

* n=90; treated water, n=69; untreated water, n=21

† Based on epidemiologic, clinical laboratory, and environmental data (e.g., water quality data) reported to CDC. For more information, refer to the strength-of-evidence classification table. (http://www.cdc.gov/healthywater/surveillance/recreational/outbreak-classifications.html)

§ Provides information about etiologies and whether these were confirmed—denoted as "etiology (C)"—or suspected—denoted as "etiology (S)".

¶ The category of illness reported by 50% of ill respondents. All legionellosis outbreaks were categorized as ARI.

** One outbreak-related death was reported.

†† Pool was a manufactured venue that is filled with untreated irrigation water.

§§ No information reported

¶¶ Exposures to recreational water venues in Ohio were also documented for this outbreak.

*** Etiology unidentified: disinfection by-products (e.g., chloramines), altered water chemistry, or extremely elevated chlorine levels suspected based on reported data.

††† Replacement of burned out bulbs for the UV disinfection system was considered a treatment deficiency since there was a chance of the problem being fixed prior to the outbreak.

§§§ Pond was a manufactured venue that is filled with filtered and chlorinated water.

¶¶¶ Aerosolized disinfectant was also a possible etiology for this outbreak.

**** Free chlorine (5ppm) and combined chlorine (10ppm) detected in water samples collected during or within 1 day of dates of exposure.

†††† These nine *Cryptosporidium* outbreaks in Ohio during the summer of 2011 may have been part of a community-wide/state-wide outbreak.

§§§§ Case-patients reported earaches in addition to dermatologic symptoms

¶¶¶¶ Spa was a portable venue.

***** One or more case-patients reported fever, headache, cough, vomiting or diarrhea in addition to eye-related symptoms.

††††† Venue is a creek that flows into an ocean.

§§§§§ One or more case-patients reported wound infections and respiratory, gastrointestinal, ear and eye symptoms in addition to skin symptoms.

¶¶¶¶¶ Microcystin toxin (20 ppb) detected in water samples collected during or within 1 day of dates of exposure. *Anabaena, Aphanizomenon, Gloetrichia, Microcystis, Oscillatoria, Lyngbya* spp. detected from algal samples.

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- Line List - Recreational Water Outbreaks, 2011-2012 [PDF - 5 pages]

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Table 2. Number of Waterborne Disease Outbreaks Associated with Recreational Water, by Predominant Illness* and Type of Water Exposure — Waterborne Disease and Outbreak Surveillance System, 2011–2012

	Type of Water Exposure															
	Treated				Untreated				Total							
Predominant Illness	Outbreaks	Cases	Hospitalized	Died	Outbreaks	Cases	Hospitalized	Died	Outbreaks	%	Cases	%	Hospitalized	%	Died	%
AGI	44	1,064	54	0	15	374	20	0	59	65.6%	1,438	80.4%	74	77.9%	0	0.0%
ARI	13	97	19	1	0	0	0	0	13	14.4%	97	5.4%	19	20.0%	1	100.0%
ARI and Eye	1	3	0	0	0	0	0	0	1	1.1%	3	0.2%	0	0.0%	0	0.0%
ARI, Eye, and Skin	1	11	0	0	0	0	0	0	1	1.1%	11	0.6%	0	0.0%	0	0.0%
Eye	0	0	0	0	2	40	1	0	2	2.2%	40	2.2%	1	1.1%	0	0.0%
Eye and Skin	2	46	0	0	0	0	0	0	2	2.2%	46	2.6%	0	0.0%	0	0.0%
Skin	8	88	0	0	4	65	1	0	12	13.3%	153	8.6%	1	1.1%	0	0.0%
Total (%)	69 (76.7%)	1,309 (73.2%)	73 (76.8%)	1 (100.0%)	21 (23.3%)	479 (26.8%)	22 (23.2%)	0 (0.0%)	90	100.0%	1788	100.0%	95	100.0%	1	100.0%

Abbreviations: AGI = acute gastrointestinal illness; ARI = acute respiratory illness; Eye = illnesses, conditions, or symptoms related to the eyes; Skin = illnesses, conditions, or symptoms related to the skin.

*n=90; The category of illness reported by 50% of ill respondents. All legionellosis outbreaks were categorized as ARI.

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- Number of Waterborne Disease Outbreaks Associated with Recreational Water, by Predominant Illness and Type of Water Exposure, 2011-2012 [PDF - 1 page]

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