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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

CENTERS FOR DISEASE CONTROL AND PREVENTION

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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.

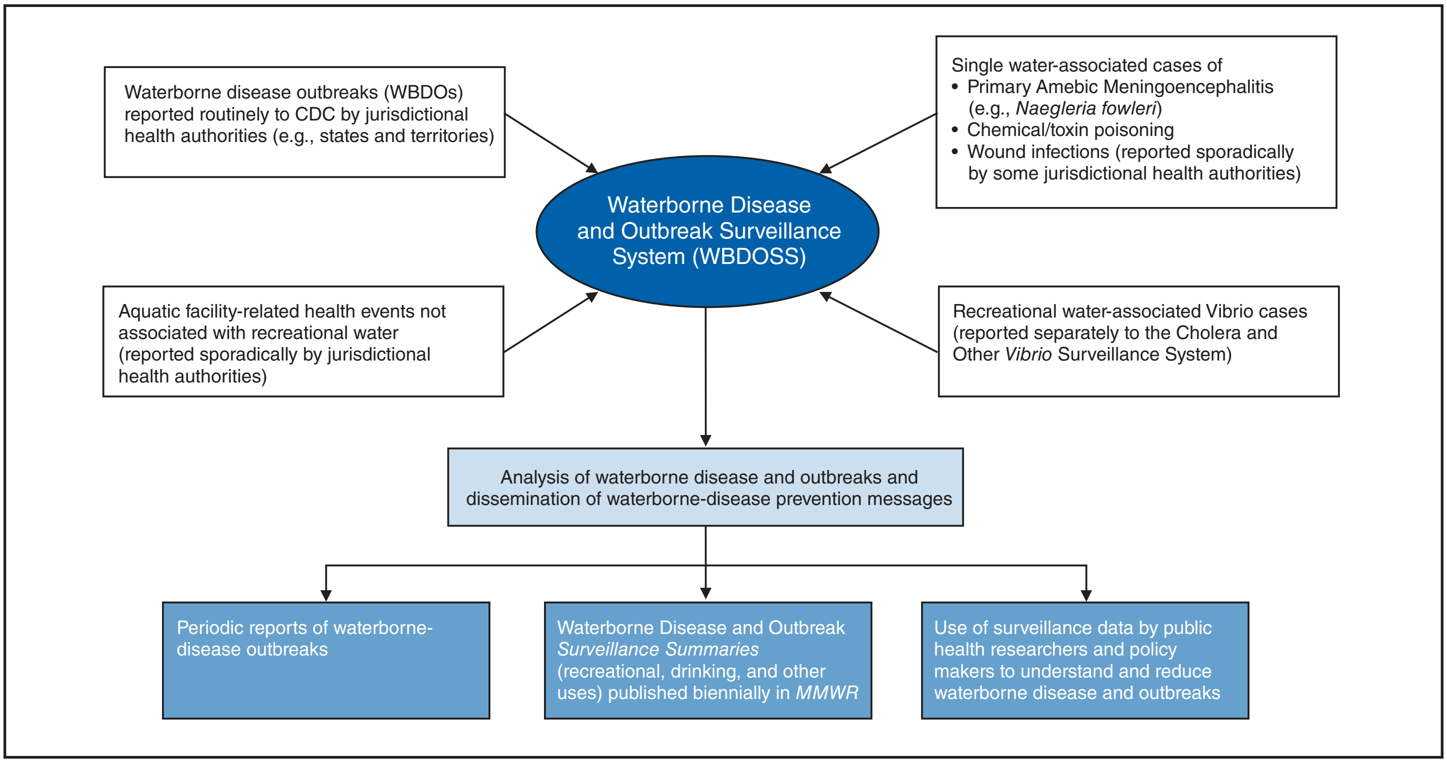
Public Health Actions: CDC uses WBDO surveillance data to 1) identify the etiologic agents, types of aquatic venues, water-treatment systems, and deficiencies associated with outbreaks and case reports; 2) evaluate the adequacy of efforts (i.e., regulations and public awareness activities) to provide 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 ≤33 CFU/100 mL for enterococci or ≤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 ≤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 implicating 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.

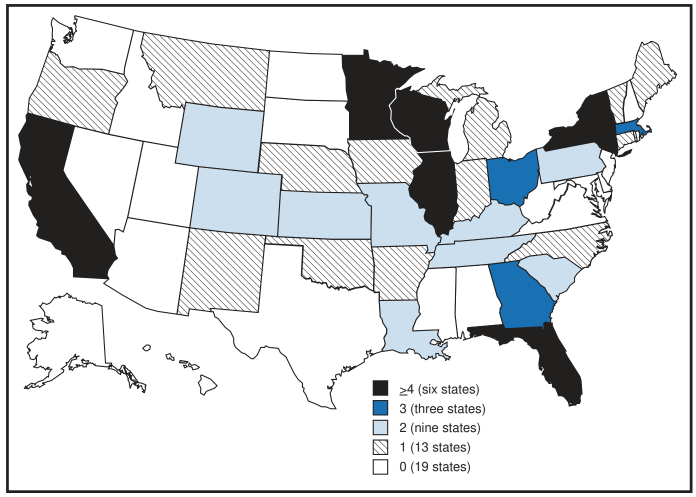
Bacteria

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.

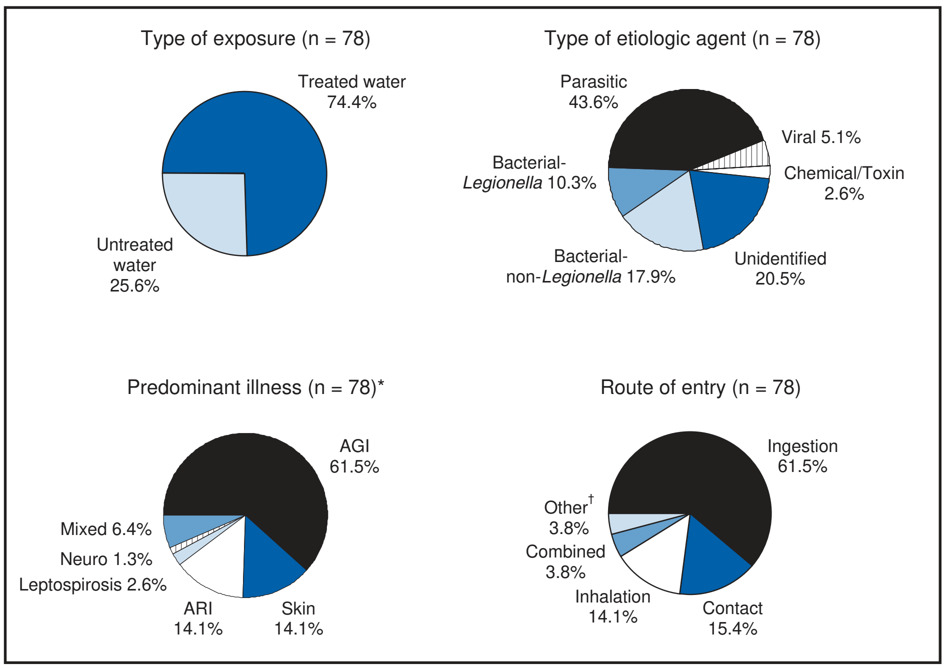
Eight outbreaks caused by *Legionella* were associated with treated recreational water venues during 2005–2006, causing 124 cases of legionellosis (i.e., LD and PF) and resulted in three deaths. The largest

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).

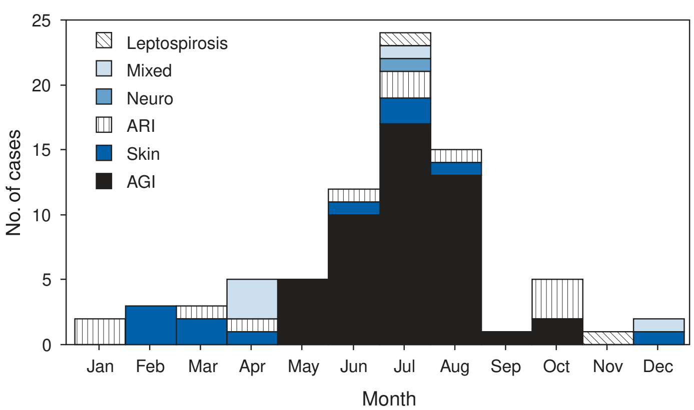
† Infection with *Naegleria* was categorized as other because of the nasal, noninhalational route of infection. Infection with *Leptospira* was categorized as other because the route of infection is typically through contact with mucous membrane or broken or abraded skin.

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					
	Treated		Untreated		Total	
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.

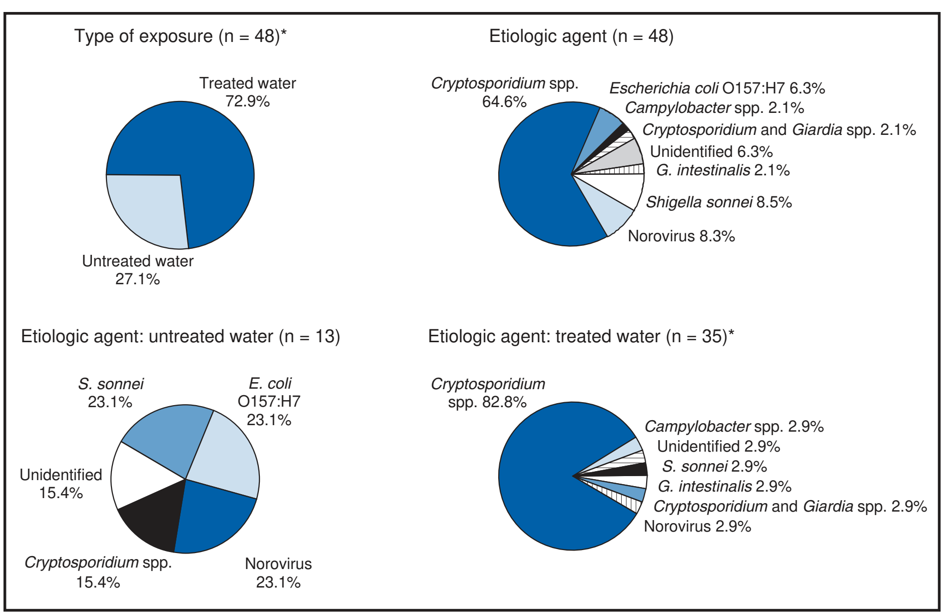
Geographic location. Nearly all *Vibrio* patients reported that they were exposed to recreational water in a coastal state (Figure 6). The most frequently reported location was the Gulf Coast (61.9%); Atlantic Coast states, excluding Florida (19.6%); Pacific Coast states (16.9%); and inland states (1.6%) (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								
	2005			2006			Total		
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.

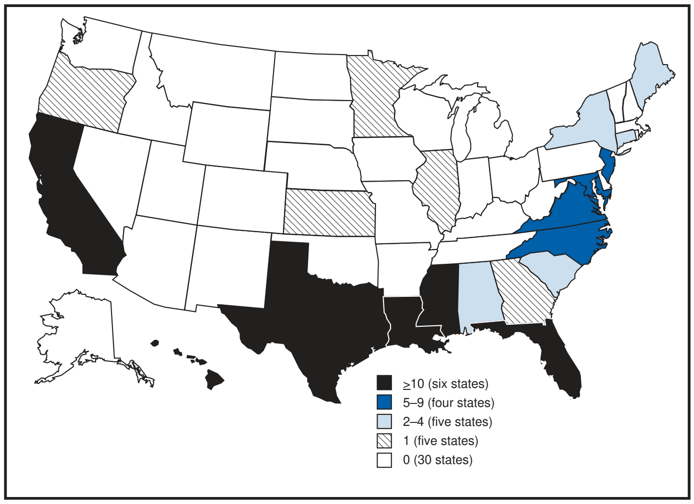
Previously Unreported Outbreaks

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.

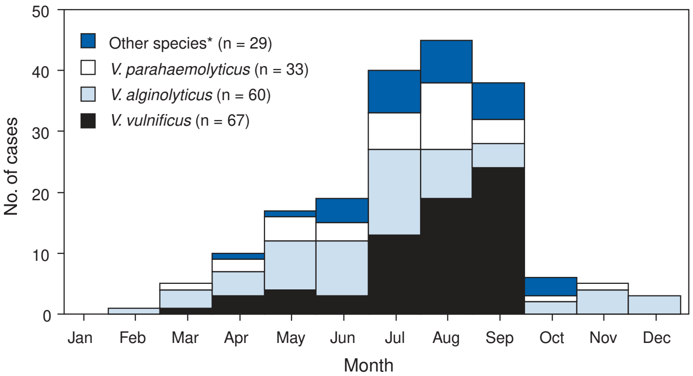
Discussion

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

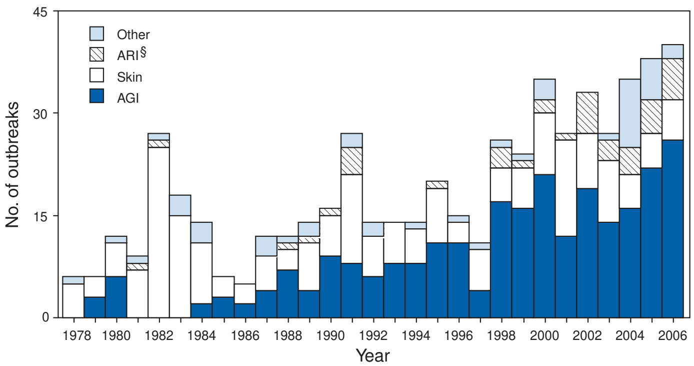
State	Date	Etiologic agent	Predominant illness†	No. of cases (n = 364)	Type	Setting
New York	Mar 1983	Chlorine gas§	ARI	3	Pool	Housing complex
New York	Aug 1983	Chlorine gas§	ARI	1	Pool	Housing complex
New York	May 1984	Chlorine gas¶	ARI	8	Pool	College
New York	Jun 1987	Chlorine gas§	ARI	6	Pool	Community
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.

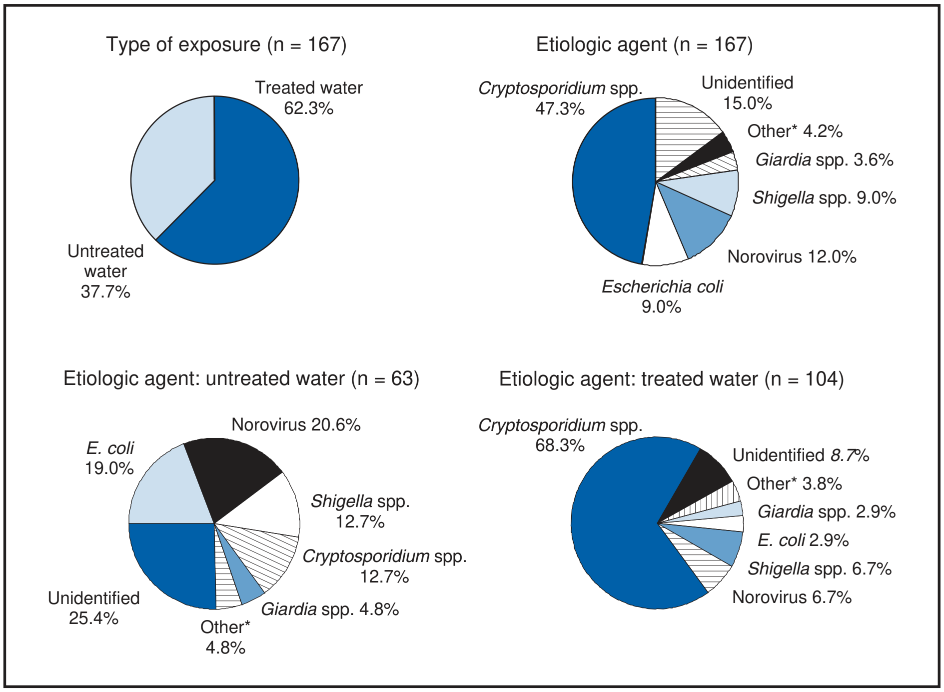
Modification of swimming behavior is a critical component in reducing recreational water-associated outbreaks. Swimming is essentially communal bathing, and continued swimming during diarrheal illness and the common occurrence of swallowing recreational water pose a public health challenge. Multiple 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 particular) 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.

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.

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 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

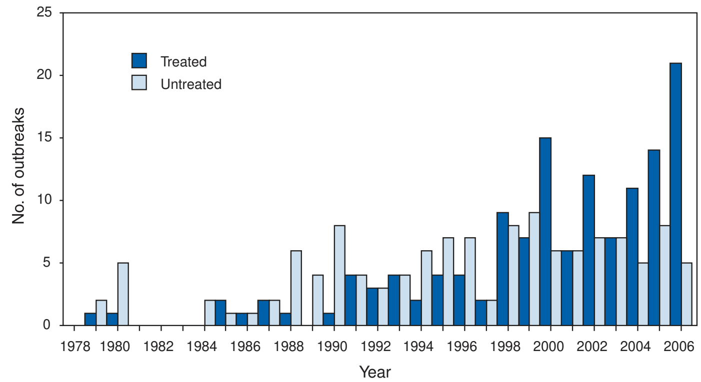
Although the proportion of AGI outbreaks associated with untreated venues (e.g., lakes and rivers) relative to treated venues decreased over the previous decade, the number of outbreaks associated with untreated venues has remained relatively constant (Figure 10). During 2005–2006, a total of 13 outbreaks 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

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



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.

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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References

1. Craun GF, ed. Waterborne diseases in the United States. Boca Raton, FL: CRC Press, Inc.; 1986.
2. Liang JL, Dziuban EJ, Craun GF, et al. Surveillance for waterborne disease and outbreaks associated with drinking water and water not intended for drinking—United States, 2003–2004. In: Surveillance Summaries, December 22, 2006. MMWR 2006;55(No. SS-12):31–65.
3. Blackburn BG, Craun GF, Yoder JS, et al. Surveillance for waterborne-disease outbreaks associated with drinking water—United States, 2001–2002. In: Surveillance Summaries, October 22, 2004. MMWR 2004; 53(No. SS-8):23–45.
4. Lee SH, Levy DA, Craun GF, Beach MJ, Calderon RL. Surveillance for waterborne disease outbreaks—United States, 1999–2000. In: CDC Surveillance Summaries, November 22, 2002. MMWR 2002;51 (No. SS-8):1–47.
5. Barwick RS, Levy DA, Craun GF, Beach MJ, Calderon RL. Surveillance for waterborne disease outbreaks—United States, 1997–1998. In: CDC Surveillance Summaries, May 26, 2000. MMWR 2000;49(No. SS-4):1–35.
6. Levy DA, Bens MS, Craun GF, Calderon RL, Herwaldt BL. Surveillance for waterborne-disease outbreaks—United States, 1995–1996. In: CDC Surveillance Summaries, December 11, 1998. MMWR 1998;47(No. SS-5):1–34.

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

7. Kramer MH, Herwaldt BL, Craun GF, Calderon RL, Juranek DD. Surveillance for waterborne-disease outbreaks—United States, 1993–1994. In: Surveillance Summaries, April 12, 1996. MMWR 1996; 45(No. SS-1).
8. Moore AC, Herwaldt BL, Craun GF, Calderon RL, Highsmith AK, Juranek DD. Surveillance for waterborne disease outbreaks—United States, 1991–1992. In: Surveillance Summaries, November 19, 1993. MMWR 1993;42(No. SS-5):1–22.
9. Herwaldt BL, Craun GF, Stokes SL, Juranek DD. Waterborne-disease outbreaks, 1989–1990. In: Surveillance Summaries, December 1991. MMWR 1991;40(No. SS-3):1–21.
10. Levine WC, Stephenson WT, Craun GF. Waterborne disease outbreaks, 1986–1988. In: Surveillance Summaries, March 1, 1990. MMWR 1990; 39(No. SS-1).
11. St. Louis ME. Water-related disease outbreaks, 1985. In: Surveillance Summaries, June 1, 1988. MMWR 1988;37(No. SS-2):15–24.
12. Yoder JS, Blackburn BG, Craun GF, et al. Surveillance for waterborne-disease outbreaks associated with recreational water—United States, 2001–2002. In: Surveillance Summaries, October 22, 2004. MMWR 2004;53(No. SS-8):1–22.
13. Yoder JS, Roberts V, Craun GF, et al. Surveillance for waterborne disease and outbreaks associated with drinking water and water not intended for drinking — United States, 2005–2006. In: Surveillance Summaries, September 12, 2008. MMWR 2008;57 (No. SS-9):39–69.

14. Virginia Graeme Baker Pool and Spa Safety Act. H.R. 6–303 to 309. Title XIV—Pool and Spa Safety.
15. CDC. Surveillance data from swimming pool inspections—selected states and counties, United States, May–September 2002. MMWR 2003;52:513–6.
16. Environmental Protection Agency. Bacterial ambient water quality criteria for marine and fresh recreational waters. Cincinnati, OH: National Service Center for Environmental Publications; 1986. EPA publication no. 440584002.
17. Environmental Protection Agency. 40 CFR Part 131. Water quality standards for coastal and Great Lakes recreation waters. Federal Register 2004;69:67217–43.
18. Wade TJ, Calderon RL, Sams E, et al. Rapidly measured indicators of recreational water quality are predictive of swimming-associated gastrointestinal illness. Environ Health Perspect 2006;114:24–8.
19. Wade TJ, Calderon RL, Brenner KP, et al. A rapid method of measuring recreational water quality demonstrates an enhanced sensitivity of children to swimming associated gastrointestinal illness. Epidemiol 2008;19:375–83.
20. Hery M, Hecht G, Gerber JM, Gendre JC, Hubert G, Rebuffaud J. Exposure to chloramines in the atmosphere of indoor swimming pools. Ann Occup Hyg 1995;39:427–39.
21. Emanuel BP. The relationship between pool water quality and ventilation. Environmental Health 1998;61:17–20.
22. Massin N, Bohadana AB, Wild P, Hery M, Toamain JP, Hubert G. Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming pools. Occup Environ Med 1998;55:258–63.
23. Pruss A. Review of epidemiological studies on health effects from exposure to recreational water. International J Epidemiol 1998;27:1–9.
24. Colford JM Jr, Wade TJ, Schiff KC, et al. Water quality indicators and the risk of illness at beaches with nonpoint sources of fecal contamination. Epidemiology 2007;18:27–35.
25. Podewils LJ, Zanardi BL, Hagenbuch M, et al. Outbreak of norovirus illness associated with a swimming pool. Epidemiol Infect 2007;135: 827–33.
26. CDC. Summary of notifiable diseases—United States, 2006. MMWR 2008.
27. Korich DG, Mead JR, Madore MS, Sinclair NA, Sterling CR. Effects of ozone, chlorine dioxide, chlorine, and monochloramine on *Cryptosporidium parvum* oocyst viability. Appl Environ Microbiol 1990;56:1423–8.
28. CDC. Cryptosporidiosis outbreaks associated with recreational water use—five states, 2006. MMWR 2007;56:729–32.
29. Rochelle PA, Upton SJ, Montelone BA, Woods K. The response of *Cryptosporidium parvum* to UV light. Trends Parasitol 2005;21:81–7.
30. Craik SA, Weldon D, Finch GR, Bolton JR, Belosevic M. Inactivation of *Cryptosporidium parvum* oocysts using medium- and low-pressure ultraviolet radiation. Water Res 2001;35:1387–98.
31. Betancourt WQ, Rose JB. Drinking water treatment processes for removal of *Cryptosporidium* and *Giardia*. Vet Parasitol. 2004;126:219–34.
32. Corona-Vasquez B, Samuelson A, Rennecker JL, Marinas BJ. Inactivation of *Cryptosporidium parvum* oocysts with ozone and free chlorine. Water Res 2002;36:4053–63.
33. CDC. Revised recommendations for responding to fecal accidents in disinfected swimming venues. MMWR 2008;57:151–2.
34. Mohle-Boetani JC, Stapleton M, Finger R, et al. Communitywide shigellosis: control of an outbreak and risk factors in child day-care centers. Am J Public Health 1995;85:812–6.
35. Wheeler C, Vugia D, Thomas G, et al. Outbreak of cryptosporidiosis at a California waterpark: employee and patron roles and the long road towards prevention. Epidemiol Infect. 2007;135:302–10.
36. Gerba CP. Assessment of enteric pathogen shedding by bathers during recreational activity and its impact on water quality. Quant Micrbiol 2000; 2:55–68.
37. Lagerkvist BJ, Bernard A, Blomberg A, et al. Pulmonary epithelial integrity in children: relationship to ambient ozone exposure and swimming pool attendance. Environ Health Perspect 2004;112:1768–71.
38. CDC. Ocular and respiratory illness associated with an indoor swimming pool—Nebraska, 2006. MMWR 2007;56:929–32.
39. Cassan D, Mercier B, Castex F, Rambaud A. Effects of medium-pressure UV lamps radiation on water quality in a chlorinated indoor swimming pool. Chemosphere 2006;62:1507–13.
40. Clancy JL, Marshall MM, Hargy TH, Korich DG. Susceptibility of five strains of *Cryptosporidium parvum* oocysts to UV light. J Am Water Works Assoc 2004;96:84–93.
41. Berger RS, Seifert MR. Whirlpool folliculitis: a review of its cause, treatment, and prevention. Cutis 1990;45:97–8.
42. Price D, Ahearn DG. Incidence and persistence of *Pseudomonas aeruginosa* in whirlpools. J Clin Microbiol 1988;26:1650–4.
43. Gustafson TL, Band JD, Hutcheson RH Jr, Schaffner W. *Pseudomonas folliculitis*: an outbreak and review. Rev Infect Dis 1983;5:1–8.
44. CDC. Surveillance data from public spa inspections—United States, May–September 2002. MMWR 2004;53:553–5.
45. Fields BS, Benson RF, Besser RE. *Legionella* and Legionnaires' disease: 25 years of investigation. Clin Microbiol Rev 2002;15:506–26.
46. CDC. Final recommendations to minimize transmission of Legionnaires' disease from whirlpool spas on cruise ships. Atlanta, GA: US Department of Health and Human Services, CDC; 1997.
47. CDC. Surveillance for travel-associated Legionnaires' disease—United States, 2005–2006. MMWR 2007;56:1261–3
48. CDC. Outbreak of gastroenteritis associated with an interactive water fountain at a beachside park—Florida, 1999. MMWR 2000;49: 565–8.
49. Dziuban EJ, Liang JL, Craun GF, et al. Surveillance for waterborne disease and outbreaks associated with recreational water—United States, 2003–2004. In: Surveillance Summaries, December 22, 2006. MMWR 2006;55:1–30.
50. CDC. Shigellosis outbreak associated with an unchlorinated fill-and-drain wading pool—Iowa, 2001. MMWR 2001;50:797–800.
51. Visvesvara GS, Stehr-Green JK. Epidemiology of free-living ameba infections. J Protozool 1990;37:25S–33S.
52. CDC. Primary amebic meningoencephalitis—Arizona, Florida, and Texas, 2007. MMWR. 2008;57:573–7.
53. Bharti AR, Nally JE, Ricaldi JN, et al. Leptospirosis: a zoonotic disease of global importance. Lancet Infect Dis 2003;3:757–71.
54. Levett PN. Leptospirosis. Clin Microbiol Rev 2001;14:296–326.
55. CDC. Update: leptospirosis and unexplained febrile illness among athletes participating in triathlons—Illinois and Wisconsin, 1998. MMWR 1998;47:673–6.
56. CDC. Update: outbreak of acute febrile illness among athletes participating in Eco-Challenge-Sabah—Borneo, Malaysia, 2000. MMWR 2001;50:21–4.
57. 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.

58. Verbrugge LM, Rainey JJ, Reimink RL, Blankespoor HD. Swimmer's itch: incidence and risk factors. Am J Public Health 2004;94:738–41.
59. Wade TJ, N Pai, Eisenberg JN, Colford JM. Do U.S. Environmental Protection Agency water quality guidelines for recreational waters prevent gastrointestinal illness? A systematic review and meta-analysis. Environ Health Perspect 2003;111:1102–9.
60. Nobles RE, Brown P, Rose J, Lipp E. The investigation and analysis of swimming-associated illness using the fecal indicator enterococcus in southern Florida's marine water. Florida J Environ Health 2000;169: 13–19.
61. CDC. Cholera and other *Vibrio* surveillance system. March 21, 2008. Available at http://www.cdc.gov/nationalsurveillance/cholera_vibrio_surveillance.html.
62. DC. *Vibrio* illnesses after Hurricane Katrina—multiple states, August–September. MMWR 2005;54:928–31.
63. Klontz KC, Lieb S, Schreiber M, Janowski HT, Baldy LM, Gunn RA. Syndromes of *Vibrio vulnificus* infections. Clinical and epidemiologic features in Florida cases, 1981–1987. Ann Intern Med. 1988;109:318–23.
64. Dechet AM, Yu PA, Koram N, Painter J. Nonfoodborne *Vibrio* infections: an important cause of morbidity and mortality in the United States, 1997–2006. Clin Infect Dis 2008;46:970–6.
65. Oliver JD. Wound infections caused by *Vibrio vulnificus* and other marine bacteria. Epidemiol Infect 2005;133:383–91.
66. Wong DE, Meinking TL, Rosen LB, Taplin D, Hogan DJ, Burnett JW. Seabather's eruption: clinical, histologic, and immunologic features. J Am Acad Dermatol 1994;30:399–406.
67. Kumar S, Hlady WG, Malecki JM. Risk factors for seabather's eruption: a prospective cohort study. Public Health Rep 1997;112:59–62.
68. US Bureau of the Census. Statistical abstract of the United States: 1995. 115th ed. Washington, DC: US Bureau of the Census; 1995.

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 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. 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 112.1°F (44.5°C) 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 $\geq$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

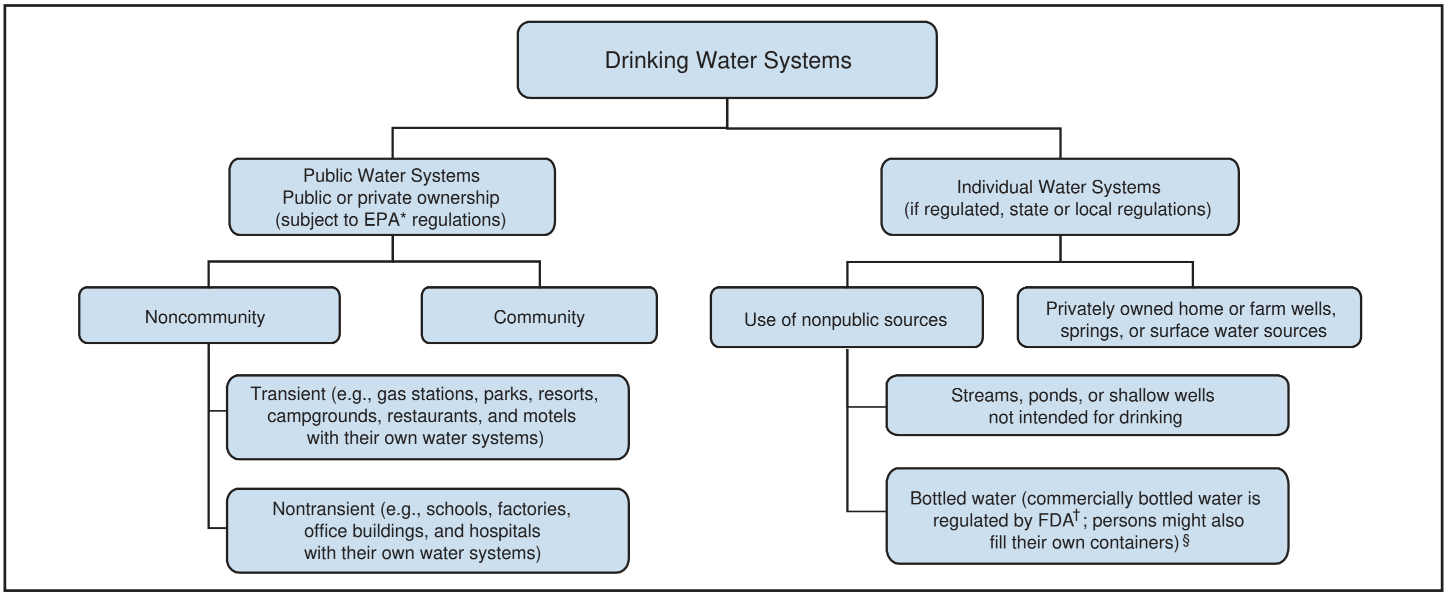
Public health departments in the states, territories, localities, and FAS have primary responsibility for detecting and investigating WBDOs, which they report voluntarily to CDC using a standard form (CDC form 52.12, available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf).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

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

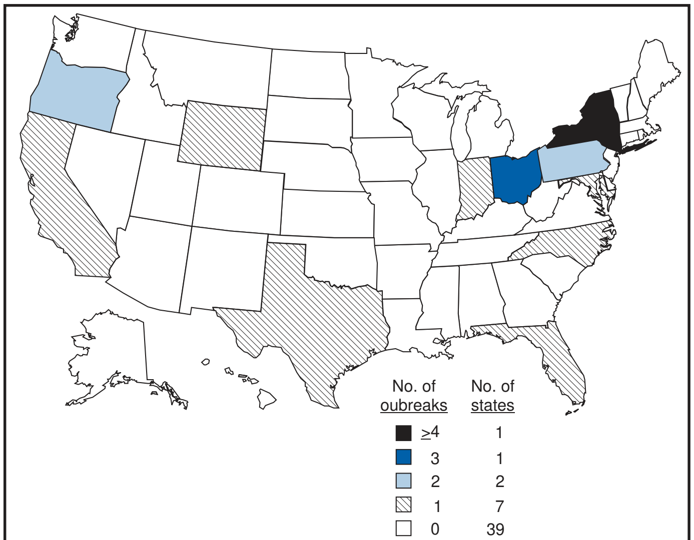
* AGI: acute gastrointestinal illness; and ARI: acute respiratory illness.
† Deaths are indicated in parentheses if they occurred.
§ Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).
¶ **Source:** O'Loughlin 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.

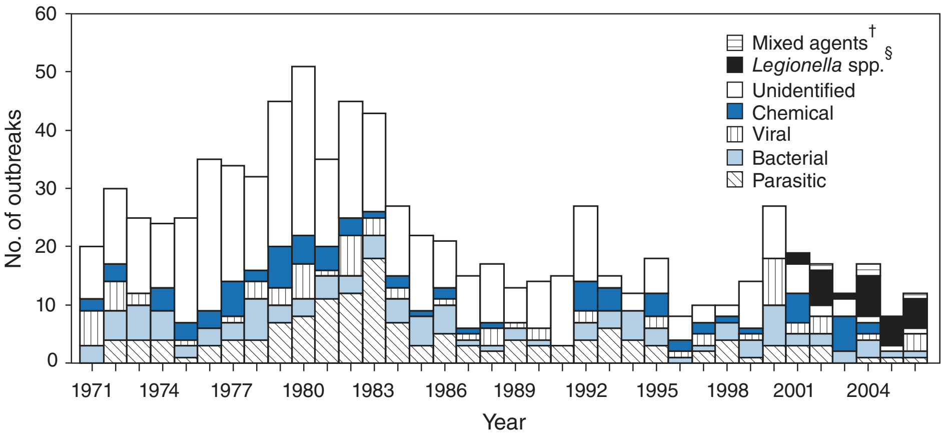
Deficiency 5A: *Legionella* in drinking water. All 10 of the drinking water-associated legionellosis WBDOs occurred in residential buildings, hotels, or in institutional settings and were related to the multiplication of *Legionella* spp. in the building plumbing systems. The majority of cases of legionellosis 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), persons 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

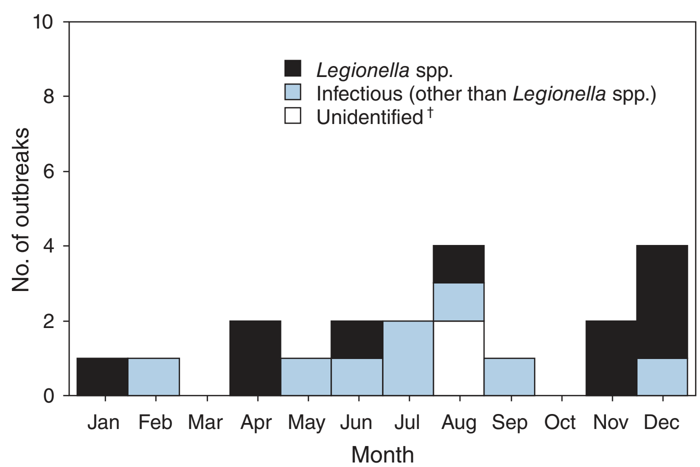


* Single cases of disease related to drinking water (n = 16) have been removed from this figure; therefore, it is not comparable to figures in previous *Surveillance Summaries*.

† 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.

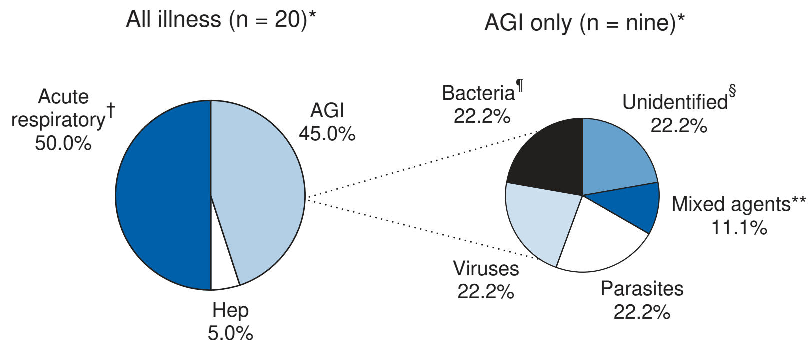
Etiologic Agents

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.

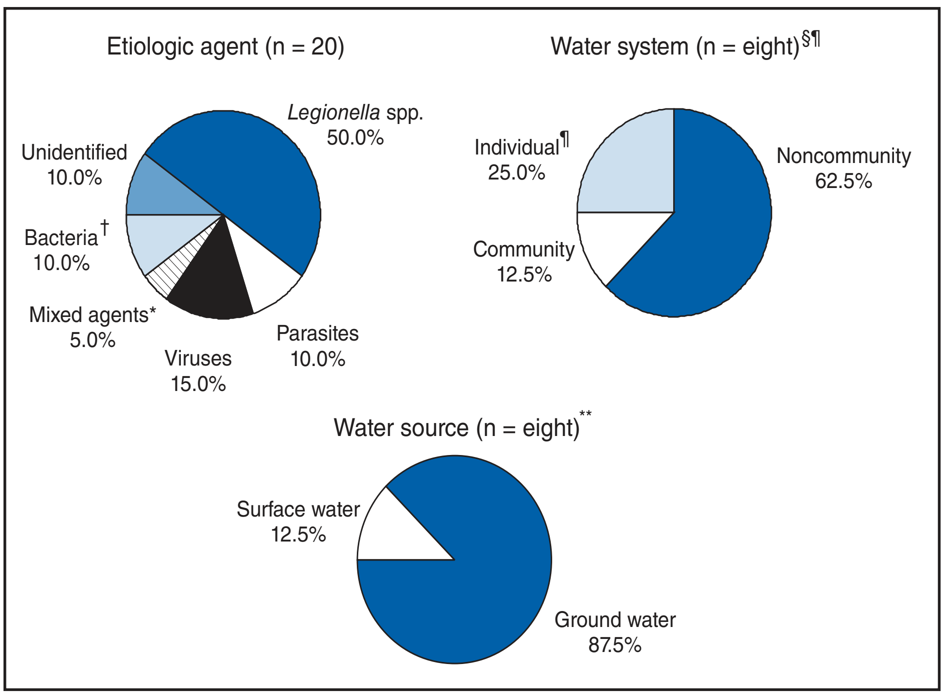
Discussion

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.

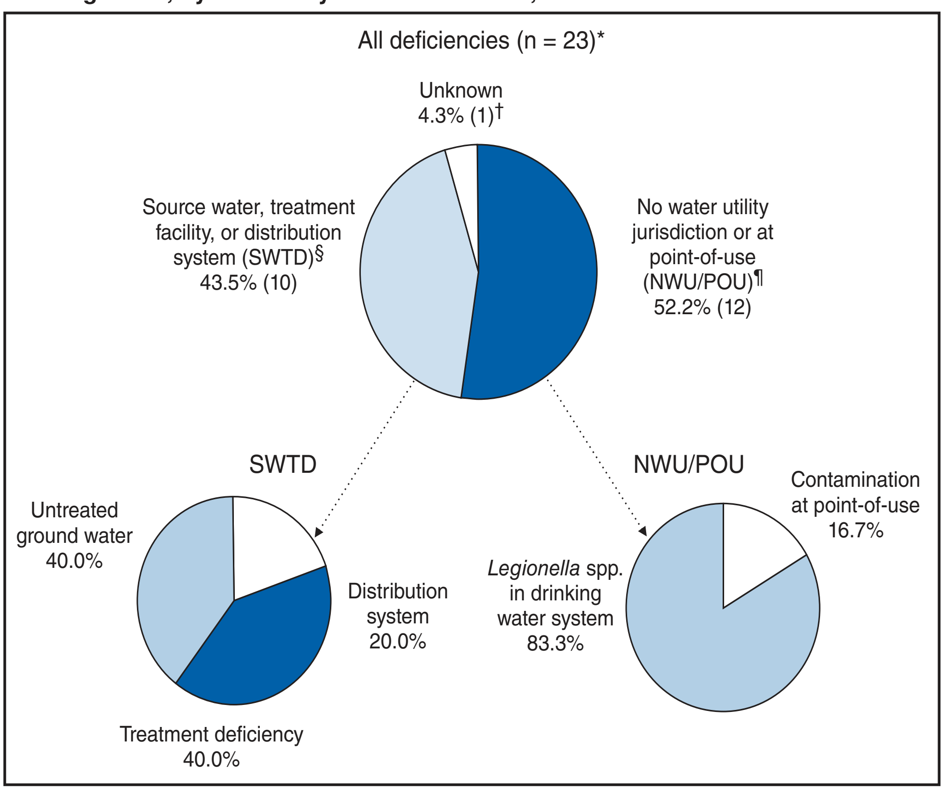
cal and water specimens and refinement in water sampling and testing methods. In previous years, stool specimens were tested routinely for enteric bacterial pathogens and parasites, but testing for viral agents was rarely conducted. Identification of water contamination (by coliform bacteria that might 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 deficiencies 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.

References

1. Gorman AE, Wolman A. Water-borne outbreaks in the United States and Canada and their significance. J Amer Water Works Assoc 1939; 31:225–75.
2. Eliassen R, Cummings RH. Analysis of waterborne outbreaks, 1938-45. J Amer Water Works Assoc 1948;40:509–28.
3. Weibel SR, Dixon FR, Weidner RB, McCabe LJ. Waterborne disease outbreaks 1946–60. J Amer Water Works Assoc 1964;56:947–58.
4. Craun GF, McCabe, LJ. Review of the causes of waterborne-disease outbreaks, J Amer Water Works Assoc 1973;65:74–84.
5. Liang JL, Dziuban EJ, Craun GF, et al. Surveillance for waterborne disease and outbreaks associated with drinking water and water not intended for drinking—United States, 2003–2004. In: Surveillance Summaries, December 22, 2006. MMWR 2006;55(No. SS-12):31–65.
6. Environmental Protection Agency. Water programs: national interim primary drinking water regulations. 40 CFR Part 141. Federal Register 1975;40:59566–74.
7. Pontius FW, Roberson JA. The current regulatory agenda: an update. Major changes to USEPA's current regulatory agenda are anticipated when the SDWA is reauthorized. J Amer Water Works Association 1994;86:54ve:–63.
8. Pontius FW. Implementing the 1996 SDWA amendments. J Amer Water Works Association 1997;89:18–36.
9. Environmental Protection Agency. Drinking water; national primary drinking water regulations; total coliforms (including fecal coliforms and *E. coli*); final rule. 40 CFR Parts 141 and 142. Federal Register 1989;54:27544–68.
10. Environmental Protection Agency. Drinking water; national primary drinking water regulations; total coliforms; corrections and technical amendments; final rule. 40 CFR Parts 141 and 142. Federal Register 1990;55:25064–5.
11. Environmental Protection Agency. National primary drinking water regulations: ground water rule; proposed rules. 40 CFR Parts 141 and 141. Federal Register 2000;65:30194–274.
12. Environmental Protection Agency. National primary drinking water regulations: ground water rule. 40 CFR Parts 141 and 141. Federal Register 2006;71:65573–660.
13. Environmental Protection Agency. Drinking water; national primary drinking water regulations; filtration, disinfection; turbidity, *Giardia lamblia*, viruses, *Legionella*, and heterotrophic bacteria; final rule. 40 CFR Parts 141 and 142. Federal Register 1989;54:27486–541.
14. Environmental Protection Agency. National primary drinking water regulations: interim enhanced surface water treatment; final rule. 40 CFR Parts 9, 141, and 142. Federal Register 1998;63:69478–521.
15. Environmental Protection Agency. National primary drinking water regulations: long term 1 enhanced surface water treatment rule; final rule. 40 CFR Parts 9, 141, and 142. Federal Register 2002;67:1812–44.
16. Environmental Protection Agency. National primary drinking water regulations: monitoring requirements for public drinking water supplies: *Cryptosporidium*, *Giardia*, viruses, disinfection byproducts, water treatment plant data and other information requirements; final rule. 40 CFR Part 141. Federal Register 1996;61:24353–88.
17. Environmental Protection Agency. National primary drinking water regulations: stage 2 disinfectants and disinfection byproducts rule. 40 CFR Parts 9, 141, and 142. Federal Register 2006;71:387–493.
18. Environmental Protection Agency. National primary drinking water regulations: long term 2 enhanced surface water treatment rule. 40 CFR Parts 9, 141 and 142. Federal Register 2006;71:653–702.
19. Environmental Protection Agency. National primary drinking water regulations: filter backwash recycling rule; final rule. 40 CFR Parts 9, 141, and 142. Federal Register 2001;66:31086–105.
20. Environmental Protection Agency. National primary drinking water regulations; arsenic and clarifications to compliance and new source contaminants monitoring. 40 CFR Parts 9, 141, and 142. Federal Register 2001;66:6976–7066.
21. Environmental Protection Agency. National primary drinking water regulations for lead and copper; final rule. 40 CFR Parts 9, 141, and 142. Federal Register 2000;65:1949–2015.
22. Environmental Protection Agency. Announcement of the drinking water contaminant candidate list; notice. Federal Register 1998;63: 10274–87.
23. Environmental Protection Agency. Drinking water contaminant candidate list 2; final notice. Federal Register 2005;70:9071–7.

24. Environmental Protection Agency. Unregulated contaminant monitoring regulation for public water systems; analytical method for list 2 contaminants; clarifications to the unregulated contaminant monitoring regulation. 40 CFR Part 141. Federal Register 2001;66:2273–308.
25. Environmental Protection Agency. Unregulated contaminant monitoring regulation for public water systems; amendment to the list 2 rule and partial delay of reporting of monitoring results. 40 CFR Part 141. Federal Register 2001;66:46221–4.
26. Environmental Protection Agency. Unregulated contaminant monitoring regulation for public water systems; establishment of reporting date. 40 CFR Part 141. Federal Register 2002;67:11043–6.
27. Environmental Protection Agency. Unregulated contaminant monitoring regulation: approval of analytical method for *Aeromonas*; national primary and secondary drinking water regulations: approval of analytical methods for chemical and microbiological contaminants. 40 CFR Part 141. Federal Register 2002;67:65888–902.
28. Lee SH, Levy DA, Craun GF, Beach MJ, Calderon RL. Surveillance for waterborne-disease outbreaks—United States, 1999–2000. In: Surveillance Summaries, November 22, 2002. MMWR 2002;51 (No. SS-8):1–47.
29. Environmental Protection Agency. Establishment of the total coliform rule distribution system advisory committee. 40 CFR Part 141. Federal Register 2007;72:35869–70.
30. Yoder JS, Hlavsa M, Craun GF, et. al. Surveillance for waterborne disease and outbreaks associated with recreational water use and other aquatic facility-associated health events — United States, 2005–2006. In: Surveillance Summaries, September 12, 2008. MMWR 2008;57 (No. SS-9):39–70.
31. CDC. Summary of notifiable diseases—United States, 2006. MMWR 2008;55.
32. Environmental Protection Agency. Factoids: drinking water and ground water statistics for 2007. March 2008, April 2008. Available at http://www.epa.gov/safewater/data/getdata.html.
33. Environmental Protection Agency. Private drinking water wells. February 21, 2006. Available at http://www.epa.gov/safewater/privatewells/index2.html.
34. CDC. Gastroenteritis among attendees at a summer camp—Wyoming, June–July 2006. MMWR 2007;56:368-370.
35. Benin AL, Benson RF, Besser RE. Trends in Legionnaires' disease, 1980–1998: declining mortality and new patterns of diagnosis. Clin Infect Dis 2002;35:1039–46.
36. 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.
37. Hewitt DJ, Weeks DA, Millner GC, Huss RG. Industrial *Pseudomonas folliculitis*. Amer J Ind Med 2006;49:895–9.
38. Frost FJ, Calderon RL, Craun GF. Waterborne disease surveillance: findings of a survey of state and territorial epidemiology programs. J Environ Health 1995;58:6–11.
39. Frost FJ, Craun GF, Calderon RL. Waterborne disease surveillance. J Amer Water Works Association 1996;88:66–75.
40. Hopkins RS, Shillam P, Gaspard B, Eisnach L, Karlin RJ. Waterborne disease in Colorado: three years' surveillance and 18 outbreaks. Am J Public Health 1985;75:254–7.
41. Craun GF, Frost FJ, Calderon RL, et al. Improving waterborne disease outbreak investigations. Int J Environ Health Res 2001;11:229–43.
42. Frost FJ, Calderon RL, Craun GF. Improving waterborne disease surveillance. In: Pontius FW, ed. Drinking water regulation and health. New York, NY: John Wiley & Sons; 2s003:25–44.
43. Hunter PR, Waite M, Ronchi E, eds. Drinking water and infectious disease: establishing the links. Boca Raton, FL: CRC Press; 2003:221.
44. Hill VR, Kahler AM, Jothikumar N, Johnson TB, Hahn D, Cromeans TL. Multistate evaluation of an ultrafiltration-based procedure for simultaneous recovery of enteric microbes in 100-liter tap water samples. App Environ Microbiol 2007;73:4218–25.
45. Colford JM, Roy SL, Beach MJ, Hightower A, Shaw SE, Wade TJ. A review of household drinking water intervention trials and an approach to the estimation of endemic waterborne gastroenteritis in the United States. J Water and Health 2006;4(Suppl 2):71–88.
46. Messner M, Shaw S, Regli S, Rotert K, Blank V, Soller J. An approach for developing a national estimate of waterborne disease due to drinking water and a national estimate model application. J Water Health 2006;4(Suppl 2):201–40.
47. Environmental Protection Agency, Office of Water. The history of drinking water treatment. Available at http://www.epa.gov/safewater/consumer/pdf/hist.pdf.
48. US General Accounting Office. Drinking water: information on the quality of water found at community water systems and private wells. Washington, DC: US General Accounting Office; 1997. GAO publication no. GAO/RCED-97–123.
49. Marston BJ, Plouffe JF, File TM, et al. Incidence of community-acquired pneumonia requiring hospitalization. Results of a population-based active surveillance study in Ohio. The community-based pneumonia incidence study group. Arch Intern Med 1997;157:1709-18.
50. Bartlett JG. Decline in microbial studies for patients with pulmonary infections. Clin Infect Dis 2004;39:170–2.
51. Fields BS, Benson RF, Besser RE. *Legionella* and Legionnaires' disease: 25 years of investigation. Clin Microbiol Rev 2002;15:506–26.
52. SHRAE Standard Project Committee. Minimizing the risk of legionellosis associated with building water systems. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2000.
53. Heffelfinger JD, Kool JL, Fridkin S, et al. Risk of hospital-acquired Legionnaires' disease in cities using monochloramine versus other water disinfectants. Infect Control Hosp Epidemiol 2003;24:569–4.
54. Phares CR, Russell E, Thigpen MC, et al. Legionnaires' disease among residents of a long-term care facility: The sentinel event in a community outbreak. Am J Infect Control 2007;35:319–3
55. Cordell K, Green G, Betz C, Fly M, Stephens B. Recreation statistics update. Update Report No. 1, August 2004—participation rates for outdoor activities in 2004. Available at: http://www.srs.fs.usda.gov/trends/RECUPDATES/recupdate0804.pdf.
56. Boulware DR, Forgey WW, Martin WJ. Medical risks of wilderness hiking. Am J Med 2003;114:288–3.
57. Boulware DR. Influence of hygiene on gastrointestinal illness among wilderness backpackers. J Travel Med 2004;11:27–33.
58. Boulware DR. Gender differences among long-distance backpackers: a prospective study of women Appalachian Trail backpackers. Wilderness Environ Med 2004;15:175–80.
59. Twombly SE, Schussman LC. Gender differences in illness and injury rates on wilderness backpacking trips. Wilderness Environ Med 1995;4:363–76.
60. Gardner TB, Hill DR. Illness and injury among long-distance hikers on the Long Trail, Vermont. Wilderness Environ Med 2002;13:131–4.
61. Crouse BJ, Josephs D. Health care needs of Appalachian trail hikers. J Fam Pract 1993;36:521–5.
62. Welch TR. Evidence-based medicine in the wilderness: The safety of backcountry water. Wilderness Environ Med 2004;15:235–7.

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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