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

Jonathan Yoder MSW, MPH[1]
Virginia Roberts, MSPH[1,2]
Gunther F. Craun, MPH[3]
Vincent Hill, PhD, PE[1]
Lauri Hicks, DO[4]
Nicole T. Alexander, MPH[4]
Vince Radke MPH[5]
Rebecca L. Calderon, PhD[6]
Michele C. Hlavsa, MPH[1]
Michael J. Beach, PhD[1]
Sharon L. Roy, MD[1]

[1]*Division of Parasitic Diseases, National Center for Zoonotic, Vector-Borne, and Enteric Disease, CDC*
[2]*Atlanta Research and Education Foundation*
[3]*Gunther F. Craun and Associates, Staunton, Virginia*
[4]*Division of Bacterial Diseases, National Center for Immunization and Respiratory Diseases, CDC*
[5]*Division of Emergency and Environmental Health Services, National Center for Environmental Health, CDC*
[6]*U.S. Environmental Protection Agency, Research Triangle Park, North Carolina*

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.

Corresponding author: Jonathan S. Yoder, MSW, MPH, Division of Parasitic Diseases, National Center for Zoonotic, Vector-Borne, and Enteric Diseases, 4770 Buford Hwy., NE, MS F-22, Atlanta, GA 30341. Telephone: 770-488-3602; Fax: 770-488-7761. E-mail: jey9@cdc.gov.

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

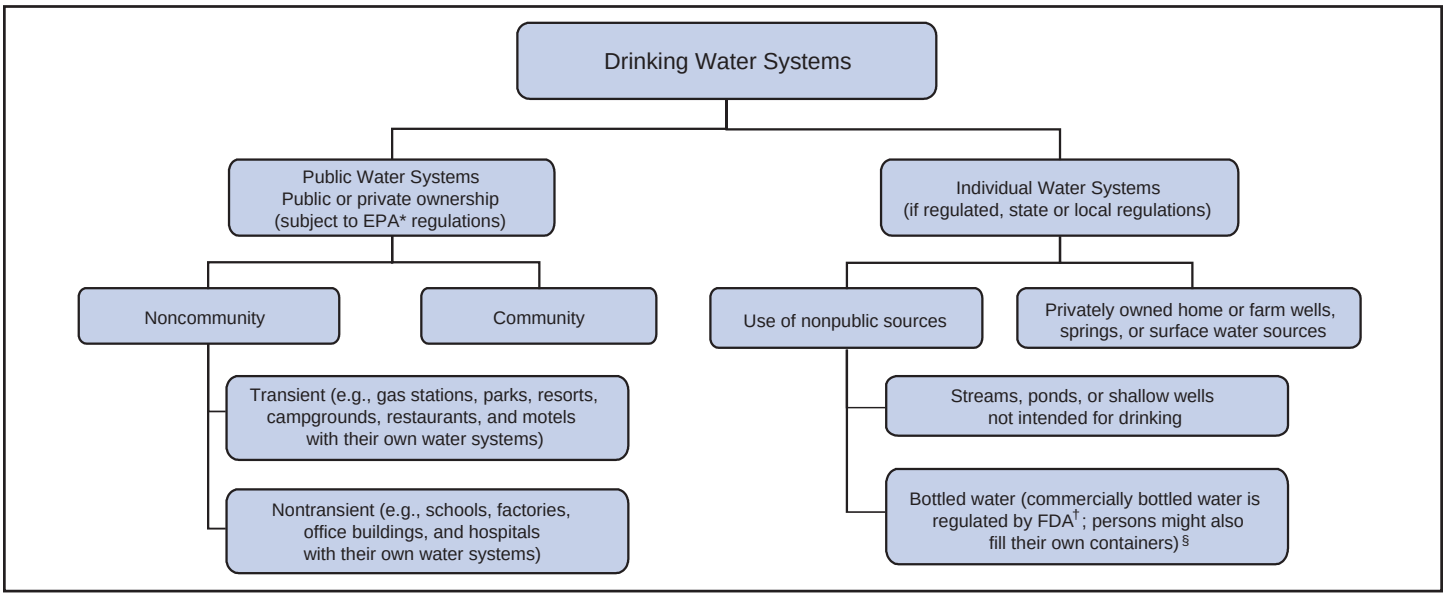
Public health departments in the states, territories, localities, and FAS have primary responsibility for detecting and investigating WBDOs, which they report voluntarily to CDC using a standard form (CDC form 52.12, available at http://www.cdc.gov/healthyswimming/downloads/cdc_5212_waterborne.pdf).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

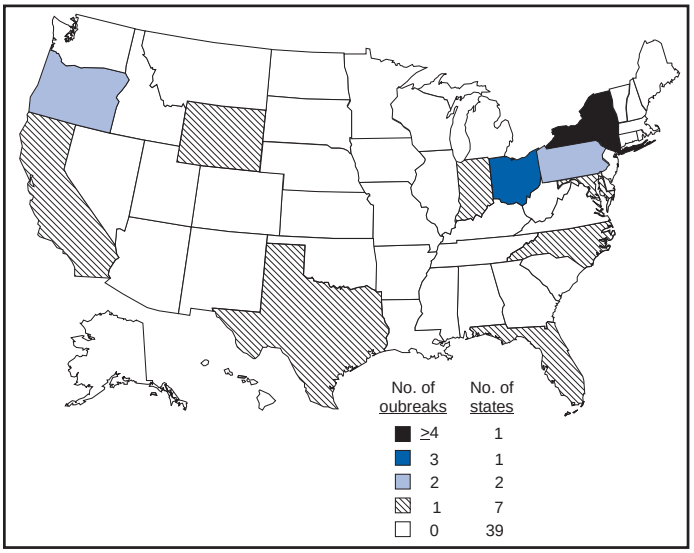
* AGI: acute gastrointestinal illness; and ARI: acute respiratory illness.
† Deaths are indicated in parentheses if they occurred.
§ Deficiency classification for drinking water, water not intended for drinking (excluding recreational water), and water of unknown intent (see Table 2).
¶ **Source:** O'Loughlin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

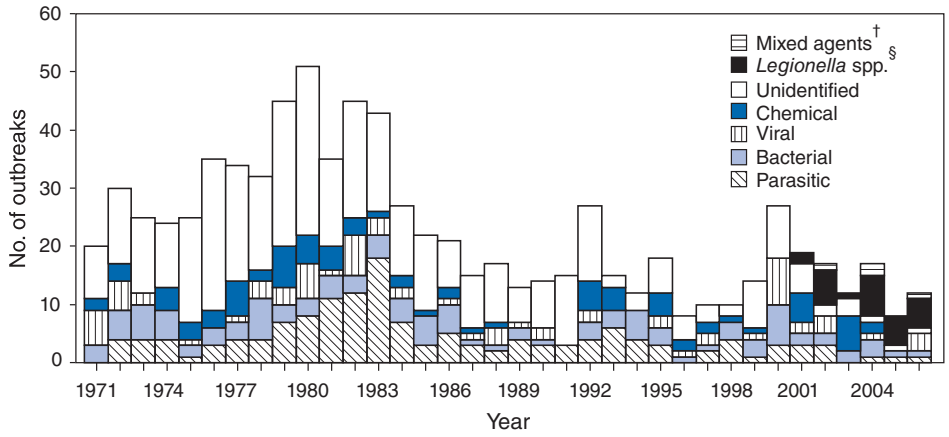
Deficiencies 6–11. Two WBDOs were associated with deficiencies 6–11. In one outbreak (California, July 2005), per-

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

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

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

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



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

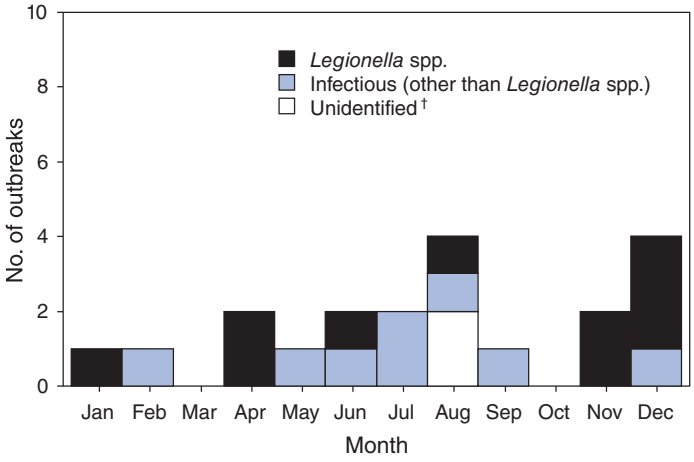
Waterborne Disease and Outbreaks Associated with Water Not Intended for Drinking and Water of Unknown Intent

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).

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

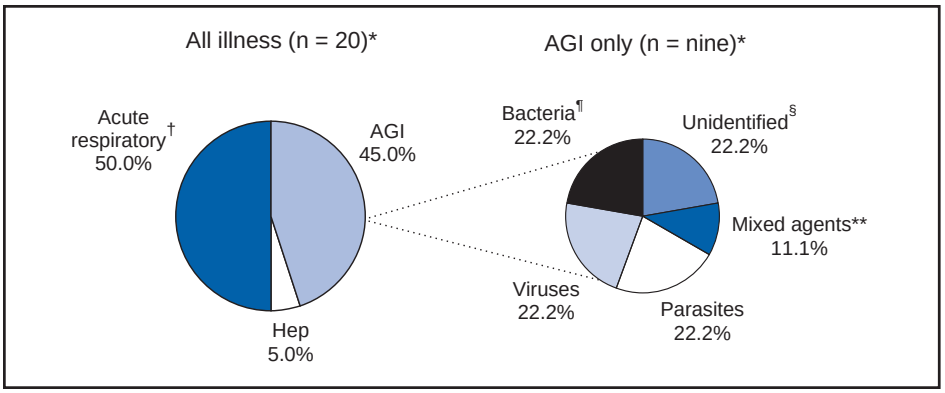


* n = 20.
† Unidentified etiology includes suspected etiologies not confirmed during the outbreak investigation.

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

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

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



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

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

Previously Unreported Outbreaks

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

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

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

* WBDOs with deficiencies 1–4 and 13 (i.e., surface water contamination, ground water contamination, water treatment deficiency, distribution system contamination, and untreated chemical contamination of source water) were used for analysis.
† Community and noncommunity water systems are public water systems that have ≥15 service connections or serve an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for >6 months of the year but not year-round (e.g., factories and schools), whereas transient systems provide water to places in which persons do not remain for long periods of time (e.g., restaurants, highway rest stations, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
§ Excludes commercially bottled water and water not intended for drinking, therefore, not comparable to *Surveillance Summaries* before 2003–2004.
¶ Multiple etiologic agent types (bacteria, parasite, virus, and/or chemical/toxin) identified.
** Norovirus suspected based on incubation period, symptoms, and duration of illness.

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

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

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

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

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

* WBDOs with deficiencies 1–4 and 13 (i.e., surface water contamination, ground water contamination, water treatment deficiency, distribution system contamination, and untreated chemical contamination of source water) were used for analysis.
† Certain WBDOs have multiple deficiencies that are tabulated separately. This table reports 10 deficiencies from eight WBDOs.
§ Community and noncommunity water systems are public water systems that have ≥15 service connections or serve an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for >6 months of the year but not year-round (e.g., factories and schools), whereas transient systems provide water to places in which persons do not remain for long periods (e.g., restaurants, highway rest stations, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
¶ Excludes commercially bottled water and water not intended for drinking, therefore, not comparable to *Surveillance Summaries* before 2003–2004.

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

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

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

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

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

* WBDOs with deficiencies 1–4 and 13 (i.e., surface water contamination, ground water contamination, water-treatment deficiency, distribution system contamination, and untreated chemical contamination of source water) were used for analysis.
† ARI: acute respiratory illness; AGI: acute gastrointestinal illness; and Hep: viral hepatitis.
§ Community and noncommunity water systems are public water systems that have ≥15 service connections or serve an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park. A noncommunity water system serves an institution, industry, camp, park, hotel, or business and can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for >6 months of the year but not year-round (e.g., factories and schools), whereas transient systems provide water to places in which persons do not remain for long periods of time (e.g., restaurants, highway rest stations, and parks). Individual water systems are small systems not owned or operated by a water utility that have <15 connections or serve <25 persons.
¶ Excludes commercially bottled water and water not intended for drinking, therefore, not comparable to *Surveillance Summaries* before 2003–2004.

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

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

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

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

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

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

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

Surveillance Reports Not Classified as Waterborne Disease and Outbreaks

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

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

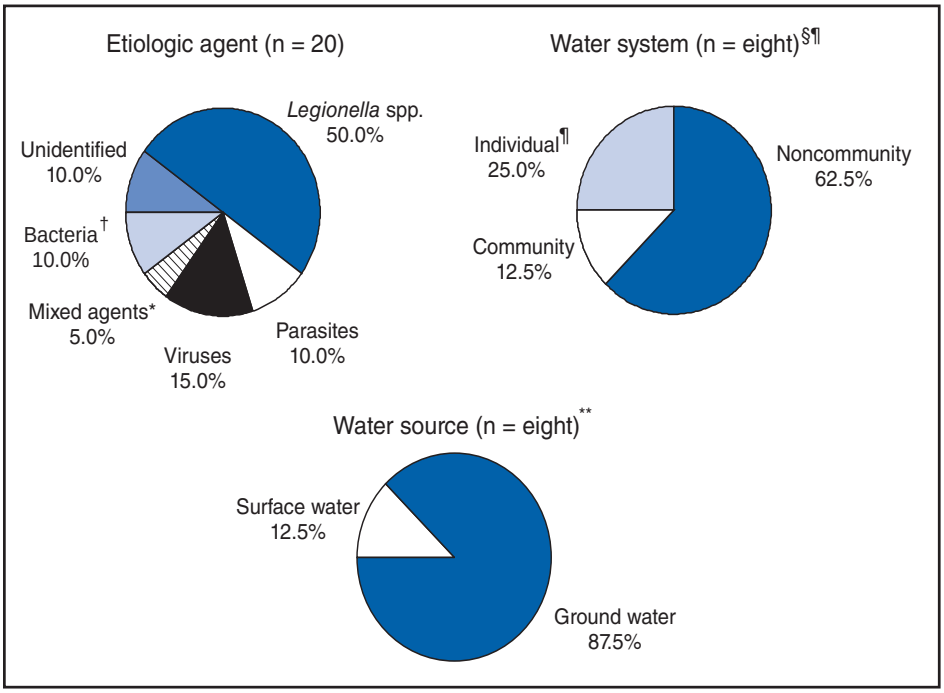
Discussion

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

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

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

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



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

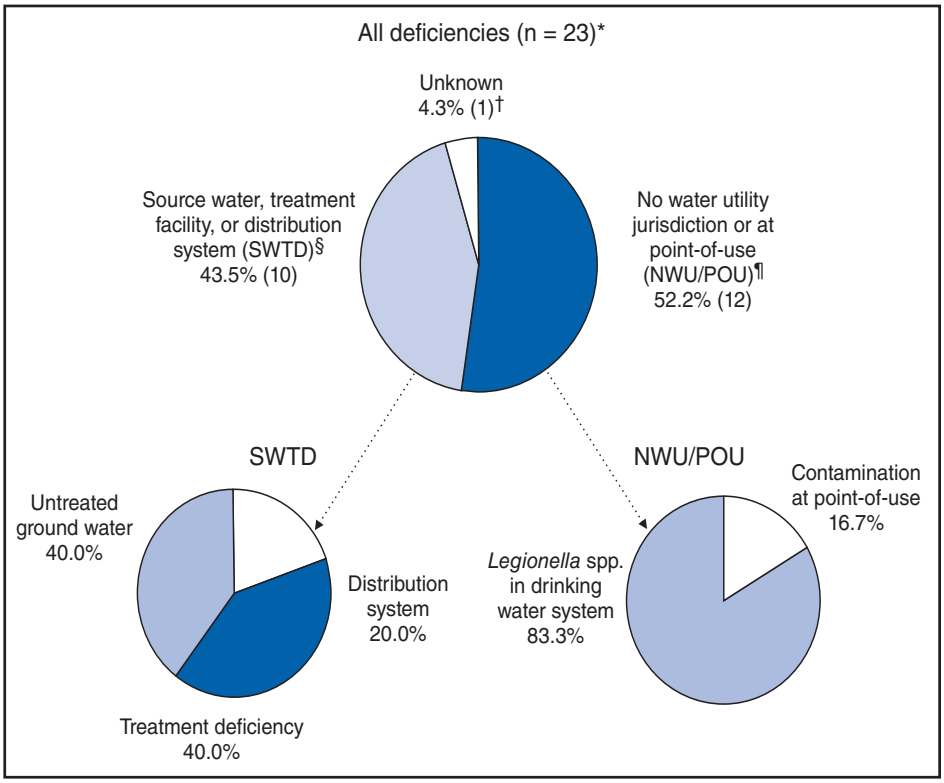
cal and water specimens and refinement in water sampling and testing methods. In previous years, stool specimens were tested routinely for enteric bacterial pathogens and parasites, but testing for viral agents was rarely conducted. Identification of water contamination (by coliform bacteria that might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

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

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

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

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



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

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

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

* More than one deficiency might have been identified during the investigation of a single waterborne-disease case or outbreak or case.
† Contamination of water and deficiencies occurring in the drinking water system at/in the water source, treatment facility, or distribution system of pipes and storage facilities. For a community water system, the distribution system refers to the pipes and storage infrastructure under the jurisdiction of the water utility before the water meter or property line (if the system is not metered). For noncommunity and nonpublic water systems, the distribution system refers to the pipes and storage infrastructure before entry into a building or house (e.g., in a service line leading to a house or building).
§ Contamination of drinking water and deficiencies occurring in plumbing and pipes that are not part of the distribution system or at other points outside the jurisdiction of a water utility as previously defined. For community systems, this means that after the water meter or property line (if the system is not metered) and for noncommunity and nonpublic systems, this means within the building or house (e.g., in the plumbing inside a house or building) during shipping or hauling, during storage other than in the distribution system, and at the point-of-use).

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

WBDOs Associated with Drinking Water

Etiologic Agents

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Previously Unreported Outbreaks

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

Conclusion

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

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

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

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

Surveillance for waterborne agents and WBDOs occurs primarily at the local and state levels (including territories and FAS). Public health authorities at these levels are responsible for detecting and recognizing drinking water-associated WBDOs and implementing appropriate prevention and control measures (Box). Improved communication among local and state public health departments, regulatory agencies, and water utilities will aid in the detection and control of WBDOs. Routine reporting or sharing of water-quality data within the health and environmental health departments is recommended. Other means of improving surveillance at the local, state, and federal levels include additional review and follow up of information gathered through other mechanisms (e.g., issuances of boil-water advisories or reports of illness associated with agents thought to be waterborne).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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.

The *Morbidity and Mortality Weekly Report (MMWR)* Series is prepared by the Centers for Disease Control and Prevention (CDC) and is available free of charge in electronic format. To receive an electronic copy each week, send an e-mail message to *listserv@listserv.cdc.gov*. The body content should read *SUBscribe mmwr-toc*. Electronic copy also is available from CDC's Internet server at *http://www.cdc.gov/mmwr* or from CDC's file transfer protocol server at *ftp://ftp.cdc.gov/pub/publications/mmwr*. Paper copy subscriptions are available through the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; telephone 202-512-1800.

Data in the weekly *MMWR* are provisional, based on weekly reports to CDC by state health departments. The reporting week concludes at close of business on Friday; compiled data on a national basis are officially released to the public on the following Friday. Data are compiled in the National Center for Public Health Informatics, Division of Integrated Surveillance Systems and Services. Address all inquiries about the *MMWR* Series, including material to be considered for publication, to Editor, *MMWR* Series, Mailstop E-90, CDC, 1600 Clifton Rd., N.E., Atlanta, GA 30333 or to *mmwrq@cdc.gov*.

☆U.S. Government Printing Office: 2008-723-026/41126 Region IV ISSN: 1546-0738