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Surveillance for Waterborne-Disease Outbreaks — United States, 1997–1998

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Aging		
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Health-Care Services	NCCDPHP/NIP	1999; Vol. 48, No. SS-8
Health-Related Quality of Life	NCEH/NCCDPHP	1999; Vol. 48, No. SS-8
Injuries and Violence	NCIPC/NCCDPHP	1999; Vol. 48, No. SS-8
Morbidity and Mortality	NCHS/NCCDPHP	1999; Vol. 48, No. SS-8
AIDS/HIV		
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Birth Defects		
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Breast and Cervical Cancer	NCCDPHP	1999; Vol. 48, No. SS-6
Cardiovascular Disease	EPO/NCCDPHP	1998; Vol. 47, No. SS-5
Chancroid	NCPS	1992; Vol. 41, No. SS-3
Chlamydia	NCPS	1993; Vol. 42, No. SS-3
Cholera	NCID	1992; Vol. 41, No. SS-1
Chronic Fatigue Syndrome	NCID	1997; Vol. 46, No. SS-2
Contraception Practices	NCCDPHP	1992; Vol. 41, No. SS-4
Cytomegalovirus Disease, Congenital	NCID	1992; Vol. 41, No. SS-2
Dengue	NCID	1994; Vol. 43, No. SS-2
Developmental Disabilities	NCEH	1996; Vol. 45, No. SS-2
Diabetes Mellitus	NCCDPHP	1993; Vol. 42, No. SS-2
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Family Planning Services at Title X Clinics	NCCDPHP	1995; Vol. 44, No. SS-2
Food Safety	NCID	1998; Vol. 47, No. SS-4
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Hazardous Substances Emergency Events	ATSDR	1994; Vol. 43, No. SS-2
Health Surveillance Systems	IHPO	1992; Vol. 41, No. SS-4

*Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CIO	Centers/Institute/Offices
EPO	Epidemiology Program Office
IHPO	International Health Program Office
NCCDPHP	National Center for Chronic Disease Prevention and Health Promotion
NCEH	National Center for Environmental Health
NCEHIC	National Center for Environmental Health and Injury Control
NCHSTP	National Center for HIV, STD, and TB Prevention
NCID	National Center for Infectious Diseases
NCIPC	National Center for Injury Prevention and Control
NCPS	National Center for Prevention Services
NIOSH	National Institute for Occupational Safety and Health
NIP	National Immunization Program

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Subject	Responsible CIO/Agency*	Most Recent Report
Homicide	NCEHIC	1992; Vol. 41, No. SS-3
Hysterectomy	NCCDPHP	1997; Vol. 46, No. SS-4
Infant Mortality (see also National Infant Mortality; Birth Defects; Postneonatal Mortality)	NCEHIC	1990; Vol. 39, No. SS-3
Influenza	NCID	2000; Vol. 49, No. SS-3
Injury		
Head and Neck	NCIPC	1993; Vol. 42, No. SS-5
In Developing Countries	NCEHIC	1992; Vol. 41, No. SS-1
Lead Poisoning, Childhood	NCEHIC	1990; Vol. 39, No. SS-4
Low Birth Weight	NCCDPHP	1990; Vol. 39, No. SS-3
Lyme Disease	NCID	2000; Vol. 49, No. SS-3
Malaria	NCID	1999; Vol. 48, No. SS-1
Measles	NCPS	1992; Vol. 41, No. SS-6
Meningococcal Disease	NCID	1993; Vol. 42, No. SS-2
Mumps	NIP	1995; Vol. 44, No. SS-3
Neisseria gonorrhoeae, Antimicrobial Resistance in	NCPS	1993; Vol. 42, No. SS-3
Neural Tube Defects	NCEH	1995; Vol. 44, No. SS-4
Occupational Injuries/Disease		
Asthma	NIOSH	1999; Vol. 48, No. SS-3
Silicosis	NIOSH	1997; Vol. 46, No. SS-1
Parasites, Intestinal	NCID	1991; Vol. 40, No. SS-4
Pediatric Nutrition	NCCDPHP	1992; Vol. 41, No. SS-7
Pertussis	NCPS	1992; Vol. 41, No. SS-8
Poliomyelitis	NCPS	1992; Vol. 41, No. SS-1
Postneonatal Mortality	NCCDPHP	1998; Vol. 47, No. SS-2
Pregnancy		
Pregnancy Nutrition	NCCDPHP	1992; Vol. 41, No. SS-7
Pregnancy-Related Mortality	NCCDPHP	1997; Vol. 46, No. SS-4
Pregnancy Risk Assessment Monitoring System (PRAMS)	NCCDPHP	1999; Vol. 48, No. SS-5
Pregnancy, Teenage	NCCDPHP	1993; Vol. 42, No. SS-6
Racial/Ethnic Minority Groups	Various	1990; Vol. 39, No. SS-3
Respiratory Disease	NCEHIC	1992; Vol. 41, No. SS-4
Rotavirus	NCID	1992; Vol. 41, No. SS-3
School Health Education Profiles	NCCDPHP	1998; Vol. 47, No. SS-4
Sexually Transmitted Diseases in Italy	NCPS	1992; Vol. 41, No. SS-1
Smoking	NCCDPHP	1990; Vol. 39, No. SS-3
Smoking-Attributable Mortality	NCCDPHP	1994; Vol. 43, No. SS-1
Tobacco-Control Laws, State	NCCDPHP	1999; Vol. 48, No. SS-3
Tobacco-Use Behaviors	NCCDPHP	1994; Vol. 43, No. SS-3
Spina Bifida	NCEH	1996; Vol. 45, No. SS-2
Streptococcal Disease (Group B)	NCID	1992; Vol. 41, No. SS-6
Syphilis, Congenital	NCPS	1993; Vol. 42, No. SS-6
Syphilis, Primary and Secondary	NCPS	1993; Vol. 42, No. SS-3
Tetanus	NIP	1998; Vol. 47, No. SS-2
Trichinosis	NCID	1991; Vol. 40, No. SS-3
Tuberculosis	NCPS	1991; Vol. 40, No. SS-3
Waterborne-Disease Outbreaks	NCID	2000; Vol. 49, No. SS-4
Years of Potential Life Lost	EPO	1992; Vol. 41, No. SS-6
Youth Risk Behaviors	NCCDPHP	1998; Vol. 47, No. SS-3
College Students	NCCDPHP	1997; Vol. 46, No. SS-6
National Alternative High Schools	NCCDPHP	1999; Vol. 48, No. SS-7

Surveillance for Waterborne-Disease Outbreaks — United States, 1997–1998

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Abstract

Problem/Condition: Since 1971, CDC and the U.S. Environmental Protection Agency (EPA) have maintained a collaborative surveillance system for collecting and periodically reporting data relating to occurrences and causes of waterborne-disease outbreaks (WBDOs).

Reporting Period Covered: This summary includes data from January 1997 through December 1998 and a previously unreported outbreak in 1996.

Description of the System: The surveillance system includes data regarding outbreaks associated with drinking water and recreational water. State, territorial, and local public health departments are primarily responsible for detecting and investigating WBDOs and voluntarily reporting them to CDC on a standard form.

Results: During 1997–1998, a total of 13 states reported 17 outbreaks associated with drinking water. These outbreaks caused an estimated 2,038 persons to become ill. No deaths were reported. The microbe or chemical that caused the outbreak was identified for 12 (70.6%) of the 17 outbreaks; 15 (88.2%) were linked to groundwater sources. Thirty-two outbreaks from 18 states were attributed to recreational water exposure and affected an estimated 2,128 persons. Eighteen (56.3%) of the 32 were outbreaks of gastroenteritis, and 4 (12.5%) were single cases of primary amebic meningoencephalitis caused by *Naegleria fowleri*, all of which were fatal. The etiologic agent was identified for 29 (90.6%) of the 32 outbreaks, with one death associated with an *Escherichia coli* O157:H7 outbreak. Ten (55.6%) of the 18 gastroenteritis outbreaks were associated with treated pools or ornamental fountains. Of the eight outbreaks of dermatitis, seven (87.5%) were associated with hot tubs, pools, or springs.

Interpretation: Drinking water outbreaks associated with surface water decreased from 31.8% during 1995–1996 to 11.8% during 1997–1998. This reduction could be caused by efforts by the drinking water industry (e.g., Partnership for Safe Water), efforts by public health officials to improve drinking water quality, and improved water treatment after the implementation of EPA's Surface Water Treatment Rule. In contrast, the proportion of outbreaks associated with systems supplied by a groundwater source increased from 59.1% (i.e., 13) during 1995–1996 to 88.2% (i.e., 15) during 1997–1998. Outbreaks caused by parasites increased for both drinking and recreational water. All outbreaks of gastroenteritis attributed to parasites in recreational water were caused by *Cryptosporidium*, 90% occurred in treated water venues (e.g., swimming pools and decorative fountains), and fecal accidents were usually suspected. The data in this surveillance summary probably underestimate the true incidence of WBDOs because not all WBDOs are recognized, investigated, and reported to CDC or EPA.

Actions Taken: To estimate the national prevalence of waterborne disease associated with drinking water, CDC and EPA are conducting a series of epidemiologic studies to better quantify the level of waterborne disease associated with drinking water in nonoutbreak conditions. The Information Collection Rule implemented by EPA in collaboration with the drinking water industry helped quantify the level of pathogens in surface water. Efforts by CDC to address recreational water outbreaks have included meetings with the recreational water industry, focus groups to educate parents on prevention of waterborne disease transmission in recreational water settings, and publications with guidelines for parents and pool operators.

INTRODUCTION

Since 1920, national statistics on outbreaks associated with drinking water have been available (*1*). Since 1971, CDC, the U.S. Environmental Protection Agency (EPA), and the Council of State and Territorial Epidemiologists have maintained a collaborative surveillance system of the occurrences and causes of waterborne-disease outbreaks (WBDOs) (*2–5*). This surveillance system includes data regarding outbreaks associated with drinking water and recreational water. This summary includes data for 1997 and 1998 and for one previously unreported outbreak in 1996.

The goals of the waterborne-disease surveillance efforts of CDC and EPA are to a) characterize the epidemiology of WBDOs; b) identify the etiologic agents that caused WBDOs and determine why the outbreaks occurred; c) train public health personnel to detect and investigate WBDOs; and d) collaborate with local, state, federal, and international agencies on initiatives to prevent waterborne diseases. The data gathered through this surveillance system are useful for identifying major deficiencies in providing safe drinking water and recreational water. Surveillance information also influences research priorities and can lead to improved water-quality regulations.

BACKGROUND

EPA Regulations

Drinking Water

Public water systems are regulated under the Safe Drinking Water Act (SDWA) of 1974, which was amended in 1986 and 1996 (*6–8*). The 1996 amendments required EPA to publish every 5 years a list of contaminants known or anticipated to occur in public water systems and possibly needing regulation. The first list, called the drinking water Contaminant Candidate List, was published March 2, 1998, and included 10 microbial contaminants (*9*). Microbial contamination is regulated under the Surface Water Treatment Rule (SWTR) of 1989 and the Total Coliform Rule (TCR) of 1989 (*10–12*). Additional regulations are being developed.

Under TCR, all public water systems are required to routinely monitor their tap water for total coliforms. The presence of total coliforms in drinking water indicates that the system is either fecally contaminated or vulnerable to fecal contamination. A system that collects ≥40 samples per month (generally, systems that serve >33,000 persons) violates the Maximum Contaminant Level (MCL) if >5.0% of the samples (routine and repeat samples) collected during each month are total coliform-positive. A system that collects <40 samples per month violates MCL if two samples (routine and repeat samples) during the month are total coliform-positive. If a system has a total coliform-positive sample, then a) that sample must be tested for the presence of fecal coliforms or *Escherichia coli*, and b) three repeat samples must be collected (four, if the system collects ≤1 routine sample per month) within 24 hours and analyzed for total coliforms (then, if positive, analyzed for fecal coliforms or *E. coli*). In addition, approximately five routine samples must be collected during the next month of sampling regardless of system size. For any size system, if two consecutive total coliform-positive samples occur at one site during 1 month, and one of these samples is also fecal coliform-positive or *E. coli*-positive, the system has an acute violation of MCL and must report to the public immediately. TCR also requires a periodic sanitary survey to evaluate and document the capabilities of the water system's sources, treatment, storage, distribution network, operation and maintenance, and overall management to ensure safe drinking water.

SWTR covers all water systems that use surface water or groundwater under the direct influence of surface water. SWTR is intended to protect against exposure to *Giardia intestinalis*, viruses, and *Legionella*, as well as many other pathogens. This rule requires that all such systems reduce the level of *Giardia* by 99.9% (three log reduction) and viruses by 99.99% (four log reduction). All surface water systems must disinfect their water. Most water systems also must filter their water unless they meet EPA-specified filter avoidance criteria that define high-quality source water. Specifically, SWTR requires a) a 0.2 mg/L disinfectant residual entering the distribution system; b) maintenance of a detectable disinfectant residual in all parts of the distribution system; c) a combined filter effluent performance standard for turbidity (i.e., for rapid granular filters, 0.5 nephelometric turbidity unit [NTU] maximum for 95% of measurements [taken every 4 hours] during a month); no single NTU reading >5.0; and d) watershed protection, redundant disinfection capability, and other requirements for unfiltered systems.

On December 16, 1998, EPA promulgated the Interim Enhanced Surface Water Treatment Rule (IESWTR) (*13*), which will provide additional protection against *Cryptosporidium parvum* and other waterborne pathogens. IESWTR covers all public systems that use surface water or groundwater under the direct influence of surface water and serve ≥10,000 persons. Key provisions include:

- A two log *C. parvum* removal requirement for filtered systems.
- Strengthened combined filter effluent turbidity performance standards for systems using conventional filtration treatment or direct filtration (0.3 NTU maximum for 95% of measurements during a month; no single NTU reading >1.0).
- Individual filter turbidity monitoring provisions.

- Disinfection benchmark provisions to ensure continued levels of microbial protection while facilities take the necessary steps to comply with new disinfection byproduct standards.
- Revision of the definition of groundwater under the influence of surface water and the watershed control requirements for unfiltered public water systems to include detection of *C. parvum*.
- Requirements for covers on new, finished water reservoirs.
- Sanitary surveys for all surface water systems regardless of size.
- A MCL goal of zero oocysts for *C. parvum*.

EPA also plans to propose a companion microbial regulation for surface water systems serving <10,000 persons, called the Long Term 1 Enhanced SWTR. This rule will be proposed in Spring 2000.

The Ground Water Rule, which is being developed, will likely stress a multibarrier approach to ensure public health protection for public groundwater systems. EPA has identified five potential areas of importance — groundwater source protection, well and distribution system integrity, distribution system protection, disinfection, and monitoring. The Ground Water Rule is expected to be proposed in Spring 2000. Recent revisions to the Underground Injection Control Regulations published December 7, 1999, could provide additional protection of groundwater from both chemical and microbial contamination from shallow wells, including cesspools (*14*).

To fill gaps in existing data regarding occurrence of microbial pathogens and other indicators of microbial contamination, occurrence of disinfection byproducts, and characterization of treatment processes, EPA promulgated the Information Collection Rule (*15*), which required large water systems serving approximately 100,000 persons to monitor for the presence of *Cryptosporidium* and *Giardia*, total culturable viruses, and total and fecal coliforms or *E. coli* at least once a month for 18 months. The required monitoring ended in December 1998, and data are undergoing analysis. The results could provide information to facilitate development of the Long Term 2 Enhanced SWTR, which is intended to protect against microbial risks and balance the health risks associated with disinfection byproducts.

Recreational Water

State and local governments have jurisdiction over recreational water. The operation, disinfection, and filtration of public swimming and wading pools are regulated by state and local health departments and often vary from place to place. For fresh recreational waters (e.g., lakes, ponds), EPA has established a guideline for microbial water quality that indicates that the monthly geometric mean must be ≤33/100 ml for enterococci or ≤126/100 ml for *E. coli*. However, states can have either more or less stringent guidelines or regulations and can post warning signs to alert potential bathers until water quality improves. When lakes become contaminated, several weeks or months can be required for water quality conditions to improve or return to normal. Prompt identification of potential sources of contamination and remedial action is necessary to return bathing water to an appropriate quality for recreational use (*16*).

METHODS

Sources of Data

State, territorial, and local public health agencies have the primary responsibility for detecting and investigating WBDOs and voluntarily reporting them to CDC on a standard form (CDC form 52.12). CDC annually requests reports from state and territorial epidemiologists or from persons designated as WBDO surveillance coordinators. When needed, additional information regarding water quality and treatment is obtained from the state's drinking water agency.

Definition of Terms*

The unit of analysis for the WBDO surveillance system is an outbreak, not an individual case of a particular disease. Two criteria must be met for an event to be defined as a WBDO. First, at least two persons must have experienced a similar illness after either ingestion of drinking water or exposure to water used for recreational purposes. The stipulation that at least two persons be ill is waived for single cases of laboratory-confirmed primary amebic meningoencephalitis and for single cases of chemical poisoning if water-quality data indicate contamination by the chemical. Second, epidemiologic evidence must implicate water as the probable source of the illness. For drinking water, outbreaks caused by contamination of water or ice at the point of use (e.g., a contaminated water faucet or serving container) are not classified as WBDOs.

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

Public water systems — classified as either community or noncommunity water systems — regularly provide piped water for human consumption to ≥15 service connections or an average of ≥25 persons for ≥60 days/year. Public water systems are regulated under SDWA. A community water system serves year-round residents of a community, subdivision, or mobile home park that has ≥15 service connections or an average of ≥25 residents. There are two categories of noncommunity water systems — nontransient and transient. Nontransient noncommunity water systems are public water systems that serve ≥25 of the same persons for >6 months of the year (e.g., a factory or school). Transient noncommunity water systems do not regularly serve ≥25 of the same persons for >6 months of the year. Typical transient noncommunity water systems are highway rest stations, restaurants, and parks with their own public water systems. The distinction between these two types of systems is important when considering the potential health effects associated with chronic low levels of exposure to certain chemicals (e.g., benzene). However, acute high-level exposure to chemicals or acute exposure to infectious agents are of concern in both types of systems. Of the approximately 170,000 public water systems in the United States, 115,000 (67.6%) are noncommunity systems, serving transients (95,000 systems) and nontransients (20,000); 55,000 (32.4%) are community systems (EPA Safe Drinking Water Information System database, unpublished data,

*Additional terms are defined in the glossary.

1998). Community water systems serve approximately 243 million persons in the United States (91.0% of the U.S. population); approximately 24 million persons (9.0%) rely on private or individual water systems, which are small systems that are not owned or operated by a water utility and that serve <15 connections or <25 persons. In addition, millions of persons use noncommunity systems while traveling or working.

Each drinking water system associated with a WBDO is classified as having one of the deficiencies listed below. If more than one deficiency is noted on the outbreak report form, the deficiency that most likely caused the outbreak is noted. The deficiency classifications are as follows:

1 = Untreated surface water.

2 = Untreated groundwater.

3 = Treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, and inadequate or no filtration).

4 = Distribution system deficiency (e.g., cross-connection, contamination of water mains during construction or repair, and contamination of a storage facility).

5 = Unknown or miscellaneous deficiency (e.g., contaminated bottled water).

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

Classification of Outbreaks

This surveillance system classifies WBDOs according to the strength of the evidence implicating water (Table 1). The classification numbers (i.e., Classes I–IV) are based on the epidemiologic and water-quality data provided on the outbreak report form. Epidemiologic data are weighted more heavily than water-quality data. Thus, although some outbreaks without water-quality data were included in this summary, reports without supporting epidemiologic data were excluded. Outbreaks of *Pseudomonas* dermatitis and single cases of primary amebic meningoencephalitis or single cases of illness resulting from chemical poisoning are not classified according to this scheme.

A classification of I means that adequate epidemiologic and water-quality data were reported but does not necessarily imply that the investigation was optimal. Classifications II–IV do not necessarily imply that the investigations were flawed; the circumstances of each outbreak differ, and not all outbreaks can or should be rigorously investigated.

RESULTS

Outbreaks Associated with Drinking Water

During 1997–1998, a total of 13 states reported 17 outbreaks associated with drinking water. Seven were reported for 1997 and 10 for 1998. Florida reported the most outbreaks (i.e., four). These outbreaks caused an estimated 2,038 persons to become ill. The median outbreak size was 10 persons (range: 2–1,400). No deaths were attributed to these outbreaks. Outbreaks were most common during the summer and fall months (Figure 1). Fifteen (88.2%) of the 17 outbreaks occurred during May–October.

Seven (41.2%) of the 17 outbreaks were assigned to Class I based on epidemiologic and water-quality data; none were Class II or Class IV, and 10 (58.8%) were Class III. Outbreaks are listed by state (Tables 2 and 3) and are tabulated by the etiologic agent and type of water system (Table 4) and by the type of deficiency and type of water system (Table 5).

Etiologic Agents

Ten (58.8%) of the 17 outbreaks were of known infectious etiology, 5 (29.4%) were of unknown etiology, and 2 (11.8%) were attributed to chemical poisoning. Of the 10 outbreaks with known infectious etiology, 6 (60.0%) were caused by parasites and 4 (40.0%) by bacteria (Figure 2).

Parasites. During 1997, two outbreaks were caused by *Giardia*, one in New York and the other in Oregon. The outbreak of giardiasis in New York occurred during June, affected 50 persons, and was associated with a surface water supply that was chlorinated but unfiltered. A beaver was found in a valve box near the reservoir, but no data were provided on the presence of *Giardia* in the beaver. The outbreak at a campground in Oregon also occurred during June, affected 100 persons, and was associated with drinking water from a noncommunity system that combined groundwater from an untreated well and a chlorinated spring. Although rodents were suspected to have contaminated a storage reservoir at a campground, no data were provided regarding *Giardia* in the rodents. Two outbreaks of giardiasis occurred in Florida during 1998. In May, seven persons from two households became ill after drinking water from an untreated groundwater source. In December, two persons became ill in a household with an untreated groundwater system. Recent rainfall and possible flooding were suspected to have contaminated the well.

Two outbreaks were associated with *Cryptosporidium*. The first outbreak occurred at a children's group home in New Mexico where staff, residents, and visitors became ill with cryptosporidiosis after drinking from spigots supplied by chlorinated well water. The home was served by a community water system but also had an irrigation well with several spigots on the grounds. Although the well water was not intended for drinking, the spigots were not marked as nonpotable, and the well did not have a sanitary seal to protect it from surface water drainage. In addition, several persons swam in a pool filled with this well water, which could have contributed to the outbreak. In the second outbreak of cryptosporidiosis, approximately 1,400 persons became ill and 23 were hospitalized in Texas after >160,000 gallons of raw sewage spilled, flowed through underground fissures in a creek bed and into an aquifer located near five municipal utility district wells, and contaminated four of the five wells. The spill was caused by a lightning storm that shorted the controls of a sewage treatment plant. Although no deficiencies were observed in the treatment process of the well water, the treatment provided (chlorine disinfection) would not be expected to kill *Cryptosporidium*.

Bacteria. Four outbreaks were caused by bacteria; three were attributed to *E. coli* O157:H7 and one to *Shigella sonnei*. The first outbreak of *E. coli* O157:H7 occurred in Wyoming, affected 157 persons, and was associated with a community water system supplied by a spring and two wells. The water in this system was not treated, and the outbreak could have resulted from fecal contamination by wildlife near the spring. A second outbreak of *E. coli* O157:H7 in Illinois involved three persons who drank from an untreated well located near a cattle pasture. *E. coli* O157:H7 was isolated from the well water. The third outbreak of *E. coli* O157:H7 occurred in Washington at a trailer park and was associated with a chlorinated groundwater supply. Approximately four persons became ill, and one was hospitalized. The method of contamination could not be determined, but the water system was not in compliance with state and county regulations.

A cross-connection was blamed for an outbreak of *S. sonnei* that occurred in Minnesota at a local fair supplied by a community water system. The outbreak affected 83 persons, four of whom were hospitalized. Pulse-field gel electrophoresis (PFGE) subtyping was used to identify the outbreak strain. Two foodborne outbreaks of *S. sonnei* occurred earlier in 1998 in Minnesota at two restaurants, and the waterborne outbreak strain from the fair matched the strain associated with the restaurant outbreaks. One person exposed to *S. sonnei* at one of the restaurant outbreaks reported attending the fair while ill.

Chemicals. Two outbreaks of copper poisoning were reported in Florida. In the first outbreak, two persons became ill after consuming fruit drink made with tap water. Improper wiring and plumbing procedures caused leaching of copper from restaurant piping. After the outbreak, the owners of the restaurant replaced the copper tubing with polyvinyl chloride (PVC) and replaced the check valve. In the second outbreak, elevated levels of copper in tap water were associated with gastrointestinal illness among 35 persons in one community. A defective check valve and a power outage led to a malfunction at a water treatment facility, releasing high levels of sulfuric acid, which corroded the pipes and allowed leaching of copper into the system.

Unidentified Etiologic Agent

The etiologic agent was not identified for five (29.4%) of the 17 WBDOs associated with drinking water. The illnesses associated with at least four of the outbreaks had incubation periods, durations, and symptom complexes consistent with viral syndromes. Three outbreaks occurred during 1997 — one in Colorado, one in New Mexico, and one in South Dakota. In Colorado, nine persons became ill after an extended family leased recreational cabins for the summer. The cabins' water system was supplied by a spring, but the system's chlorinator was not functioning at the time of the outbreak. No stool specimens were available for laboratory diagnosis. In New Mexico, 123 persons became ill with gastroenteritis after visiting a country club. The country club was supplied by a groundwater source that was not chlorinated routinely. Before the outbreak, the club had a history of problems, including sewage leaks and high coliform levels in the tap water. Stool specimens were submitted for diagnostics, and 11 specimens were positive for *E. coli* O86:H11. However, because *E. coli* O86:H11 is not a recognized pathogen and lacks virulence markers, its role in the illness was not established. Although one specimen was positive for *Giardia*, the median incubation period (20 hours) and duration of illness (2 days) were not consistent with giardiasis. In South Dakota, 16 persons at a camp became ill with gastroenteritis associated with drinking tap water. In 1998, one outbreak of unknown etiology was reported in Montana when five persons became ill after drinking tap water from an individual household supplied by well water treated with chlorine. One person was hospitalized. In Ohio, 10 persons became ill after a temporary cross-connection in the water treatment plant and its offices occurred. Stool specimens were submitted for diagnostics, and 1 of 15 was positive for *Blastocystis hominis* and *Endolimax nana,* suggesting exposure to feces.

Water-Quality Data

Information regarding the presence of coliform bacteria, pathogens, or chemical contaminants was available for 16 (94.1%) of the 17 reported outbreaks. Water samples were tested for coliform bacteria during the investigation of 12 (70.6%) of the 17 outbreaks and were positive for total or fecal coliforms for 10 (83.3%) of the 12 outbreaks. No information regarding the presence of coliforms was available for one outbreak of undetermined etiology and two of four outbreaks caused by *Giardia*. However, in two outbreaks of giardiasis, water samples were tested for *Giardia* cysts. One of the giardiasis outbreaks was associated with chlorinated, unfiltered surface water; 200 cysts/100 L were found in a tap water sample. The second outbreak was associated with a chlorinated groundwater source, and 1.1 cysts/100 L were found in a sample of water collected at a campsite. In two other outbreaks of giardiasis in Florida, water was not tested for *Giardia* cysts, but coliforms were detected in one of the outbreaks. Both of these outbreaks were associated with untreated well water.

In one outbreak of cryptosporidiosis associated with chlorinated well water, tap water samples were negative for coliforms, but fecal coliforms, total coliforms, and oocysts were detected in the well water. In a second outbreak, samples from a chlorinated well were positive for total and fecal coliforms, but oocysts were not detected.

Total coliforms were detected in tap water samples for all four of the bacterial outbreaks and four (80.0%) of the five outbreaks of unknown etiology. In the outbreak of unknown etiology in New Mexico, which was caused by contamination within the water distribution system, EPA used tissue culture techniques to detect the presence of an enteric virus in a 150-gallon water sample from the well. Fecal coliforms were also detected in two of the bacterial outbreaks and one of the outbreaks of unknown etiology. In the outbreak of *E. coli* O157:H7 in Illinois, the organism was cultured from a water sample from the untreated well.

Tap water was tested for copper levels in both copper poisoning outbreaks. In the restaurant outbreak, 3.6 mg/L of copper was found in the tap water after leaching from copper plumbing. In the second outbreak, copper levels of 33 mg/L and 138 mg/L and a pH <6 were found in two water samples collected on the day that excess sulfuric acid was inadvertantly added to the water system.

Water System and Water Source

Eight (47.1%) of the 17 WBDOs were associated with community systems, 5 (29.4%) with noncommunity systems, and 4 (23.5%) with individual water systems (Tables 4 and 5). Only two (11.8%) of the outbreaks were associated with surface water systems.

Three (37.5%) of the eight outbreaks associated with community water systems were caused by problems at water treatment plants, three (37.5%) were the result of problems in the water distribution systems and plumbing of individual facilities (e.g., offices, schools, and restaurants), and two (25.0%) were associated with contaminated, untreated groundwater.

All five of the outbreaks in noncommunity systems were associated with groundwater systems. Two (40.0%) of the five outbreaks were caused by contamination in the distribution system. Interruption of chlorination was responsible for two outbreaks of unknown etiology. Inadequate chlorination of a well water source (i.e., coliforms were present in tap water) caused an outbreak of *E. coli* O157:H7.

All four outbreaks in individual water systems were associated with groundwater systems. Outbreaks caused by *Giardia*, *Cryptosporidium*, and *E. coli* O157:H7 were reported in untreated well water systems; an outbreak of unknown etiology was associated with inadequate chlorination of well water (i.e., coliforms were present in tap water).

Of the six protozoan outbreaks, five (83.3%) occurred in groundwater systems (four used well water sources and one used both well and spring water sources). All four of the outbreaks of bacterial etiology occurred in groundwater systems (three used well water and one used both well and spring water). Four (75.0%) of the five outbreaks of unknown etiology occurred in groundwater systems (three used well water and one spring water).

Outbreaks Associated with Recreational Water

During 1997–1998, a total of 18 states reported 32 outbreaks associated with recreational water (Tables 6–9). Seven outbreaks were reported for 1997 and 25 for 1998. The states that reported the most outbreaks were Wisconsin (seven outbreaks) and Minnesota (four outbreaks). These 32 outbreaks caused illness in an estimated 2,128 persons. The median outbreak size was 11 persons (range: 1–650).

All but 1 of the 18 outbreaks of gastroenteritis occurred during the summer (Figure 3). The four cases of primary amebic meningoencephalitis also occurred during summer months. Six (75%) of the eight outbreaks of dermatitis (i.e., rash) occurred during January or February.

Etiologic Agents

Twenty-nine (90.6%) of the 32 recreational water outbreaks were of known infectious etiology (Tables 6–9). Nine (50.0%) of the 18 outbreaks of gastroenteritis were caused by parasites, 4 (22.2%) by bacteria, 2 (11.1%) by viruses, and 3 (16.7%) were of unknown etiology (Tables 6–9). There was one outbreak of Pontiac fever and one of leptospirosis. Of the 32 recreational water outbreaks, 15 (46.9%) were associated with fresh water and 17 (53.1%) with treated water (Figure 4).

Parasites. All of the outbreaks of gastroenteritis caused by parasites were caused by *Cryptosporidium*. One was associated with fresh water and eight with treated recreational water, either in pools or fountains (Figure 4).

One outbreak occurred in Pennsylvania, where eight persons became ill with cryptosporidiosis after swimming in a lake at a state park; two persons were hospitalized. The other eight outbreaks of cryptosporidiosis were associated with treated recreational water. In Minnesota, 369 persons became ill after playing in a sprinkler fountain at a local zoo (*17*). The fountain was originally designed as a decorative fountain. The water was not intended for drinking but had become a popular interactive play area for children. Water was sprayed through the air, drained through grates, collected, passed through a sand filter, and chlorinated and recirculated. The original source of contamination was unknown, but the fountain was a popular place for children to soak themselves during the heat of the summer. Two other outbreaks of cryptosporidiosis occurred in Minnesota during 1998, one at a swim club and the other at a community pool. The source of the outbreak at the community pool was unknown, but the suspected source at the swim club was a child with cryptosporidiosis who swam in the pool 7–10 days before the outbreak. An outbreak occurred in Florida in a day care pool when seven persons became ill with cryptosporidiosis. Although the source of the outbreak was unknown, there were reports of babies in diapers swimming in the pool. In Oregon, 69 persons became ill with cryptosporidiosis after swimming in a community pool. The source of the outbreak was unknown although fecal contamination was suspected. Three outbreaks of *Cryptosporidium* occurred in Wisconsin, all associated with public pools, and in all, the suspected source was fecal accidents. One outbreak in Wisconsin involved three separate swimming pools with a total of 12 persons acquiring cryptosporidiosis. The source of the outbreak was suspected to be a child, later diagnosed with *Cryptosporidium*, who had a fecal accident in three community swimming pools on three successive days. Pool operators were unaware of the accidents until the mother of the child reported them 2 weeks later.

In 1998, four cases of primary amebic meningoencephalitis were attributed to *Naegleria*. All four of the infected children, who ranged in age from 3–14 years, died. Infection was acquired when the children swam in a lake (two children), river (one child), or canal (one child). Two of the cases were associated with exposure in Texas, one in Florida, and one in Oklahoma.

Bacteria. Four (22.2%) of the 18 outbreaks of gastroenteritis were attributed to bacteria. Three of these outbreaks were caused by *E. coli* O157:H7, two in fresh water and one in treated water (Figure 4). Eight persons attending a family reunion became ill in Missouri after swimming at a lake resort. In an outbreak at a water park in Georgia, 26 persons became infected with *E. coli* O157:H7 (*18*). Seven of these case-patients developed hemolytic uremic syndrome and one died. A fecal accident in a children's pool in the water park was suspected to be the source of the outbreak. Low chlorine levels documented during that period could have been inadequate to inactivate the bacteria. In Minnesota, five persons developed gastroenteritis caused by *E. coli* O157:H7 after swimming in a lake. One person was hospitalized. Nine persons became ill from *S. sonnei* in Massachusetts. This outbreak was associated with a wading pool that included a sprinkler fountain. The system recirculated chlorine-treated water, and many diaper-aged children were observed sitting in the wading pool.

An outbreak of leptospirosis occurred among competitors in a triathlon in Illinois during 1998 (*19*). Three hundred seventy-five persons became ill after swimming in a lake, 28 of whom were hospitalized, making this the largest outbreak of leptospirosis ever reported in the United States. Wisconsin reported one outbreak of Pontiac fever among 45 guests at a hotel. The source of exposure was linked to use of the hotel whirlpool. The whirlpool log indicated adequate amounts of disinfectant in the whirlpool during the time of exposure.

Other. After swimming at a public lake beach, 30 persons in Ohio and an estimated 18 persons in Wisconsin became ill with Norwalk-like virus (NLV). In both outbreaks, lake water tested positive for fecal coliforms, but the source of the virus was not identified. In the Ohio outbreak, latrines were located close to a stream that fed into the lake and were considered a potential source of contamination. No agent could be identified for three (16.7%) of the 18 outbreaks of gastroenteritis; all three were associated with lakes.

An estimated 127 persons were affected in eight outbreaks of dermatitis associated with pools, hot tubs, springs, or lakes. All eight outbreaks had known or suspected infectious etiologies (Table 9). *P. aeruginosa* was confirmed as the etiologic agent for three (42.9%) of the seven *Pseudomonas* outbreaks and was suspected in the other five, based on the clinical syndromes. A *Schistosoma* species was the presumptive etiologic agent of the one outbreak of swimmer's itch because the clinical signs were consistent with cercarial dermatitis.

Previously Unreported Outbreak

A previously unpublished NLV outbreak during 1996 was reported (Table 10). This outbreak was associated with drinking tap water at an elementary school in Florida. An estimated 594 persons, including students and staff, became ill with gastrointestinal symptoms; no one was hospitalized. Investigation of the water supply system failed to identify evidence of contamination or any event that could have resulted in contamination.

Outbreaks Not Classified as Waterborne-Disease Outbreaks

Outbreaks attributed to drinking water contaminated at the point of use, rather than at the source or in the distribution system, are not classified as WBDOs. Although several point-of-use outbreaks were reported to the WBDO surveillance system during 1997–1998, these outbreaks are not included in this surveillance summary.

In 1997, a total of 11 residents and employees of a group home in Missouri became ill with fever and upper respiratory symptoms associated with vaporizer and whirlpool use; five persons were hospitalized. The following agents were isolated from patients: *P. aeruginosa, Serratia marcesens*, *Klebsiella pneumoniae*, *Citrobacter* species, *Enterobacter aerogenes*, *E. cloacae*, and *P. alcaligenes*. Evidence of *P. aeruginosa* and *E. cloacae* also were found in the vaporizers and whirlpools. During 1998, an outbreak in Missouri possibly was associated with contaminated ice. Four persons who consumed ice from a restaurant storage bin became ill with gastroenteritis attributed to *S. aureus*.

In 1997, an outbreak of *Campylobacter jejuni* was reported among 106 guardsmen of the Minnesota Army National Guard following a training exercise in Greece. The source of the outbreak was bottled water consumed during international field exercises. The water was bottled in Greece. Five additional outbreaks that occurred during 1997–1998 were not included in this surveillance summary because of insufficient epidemiologic data to classify them as WBDOs (i.e., the outbreaks did not meet the criteria for Classes I–IV).

DISCUSSION

General Considerations Regarding Surveillance Data

Waterborne-disease surveillance data are useful for evaluating the adequacy of approaches for providing safe drinking and recreational water. However, the data in this surveillance summary probably underestimate the true incidence of WBDOs or the relative incidence of outbreaks caused by various etiologic agents. Not all WBDOs are recognized, investigated, and reported to CDC or EPA, and the extent to which WBDOs are unrecognized and underreported is unknown. A national quick-response notification system through which public health officials and health-care providers could share provisional data on WBDOs would be useful.

The likelihood that individual cases of illness will be detected, epidemiologically linked, and associated with water varies considerably among locales and is dependent on many factors. These factors include a) public awareness, b) the likelihood that persons who are ill will consult the same rather than different health-care providers, c) availability and extent of laboratory testing, d) local requirements for reporting cases of particular diseases, and e) the surveillance and investigative activities of state and local health and environmental agencies. Therefore, the states that report the most outbreaks might not be those where the most outbreaks occur. Recognition of WBDOs also is dependent on certain outbreak characteristics; outbreaks involving serious illness are most likely to receive the attention of health authorities. Outbreaks of acute diseases, particularly those characterized by a short incubation period, are more readily identified than those associated with disease from chronic, low-level exposure to an agent (e.g., some chemicals). Recreational water outbreaks that result from persons congregating in one venue, then dispersing into a wide area could be difficult to document. Outbreaks associated with community water systems are more likely to be recognized than those associated with noncommunity systems because the latter serve mostly nonresidential areas and transient populations. Outbreaks associated with individual systems are the most likely to be underreported because they generally involve few persons.

The identification of the etiologic agent of a WBDO depends on the timely recognition of the outbreak so that appropriate clinical and environmental samples can be obtained. The practices of investigators' laboratories can also influence whether the etiologic agent is identified. For example, diarrheal stool specimens generally are examined for bacterial pathogens, but not for viruses. In many laboratories, testing for the parasite *Cryptosporidium* is conducted only if requested and is not included in routine stool examinations for ova and parasites (*20*). The water-quality data collected vary widely among outbreak investigations, depending on such factors as available fiscal, investigative, and laboratory resources. Furthermore, a few large outbreaks can substantially alter the relative proportion of cases of waterborne disease attributed to a particular agent. Finally, the number of reported cases is generally an approximate figure, and the method and accuracy of the approximation vary among outbreaks.

Outbreaks Associated with Drinking Water

The number of outbreaks reported during 1997 (i.e., 7) and 1998 (i.e., 10) is comparable with those reported during 1996 (i.e., 6). However, the number of outbreaks reported for these 3 years is lower than those reported for any 2-year period since 1971. WBDO reports peaked during 1979–1983 (Figures 5–6). The increase and subsequent decrease in the number of reports might reflect, at least in part, changes in surveillance activities or be a reporting artifact (*21*). The recent decrease in the number of outbreaks reported since 1996 could also be caused by improved implementation of water treatment regulations (e.g., SWTR), increased efforts by many water utilities to produce drinking water substantially better than EPA standards require, and efforts by public health officials to improve drinking water quality.

Drinking water outbreaks associated with surface water decreased from 31.8% (i.e., 7) during 1995–1996 to 11.8% during 1997–1998, when only two outbreaks were attributed to surface water supplies. One was an outbreak of giardiasis and the other was of unknown etiology. The outbreak of giardiasis that occurred in New York during 1997 was associated with a surface water supply that was chlorinated but not filtered. Outbreaks associated with surface water demonstrate the importance of requiring water systems to provide an adequate chlorine concentration and contact time (as specified by SWTR) to inactivate *Giardia* and other organisms that are relatively chlorine-resistant, especially if the surface water is unfiltered (*22*). *Giardia* can be inactivated by disinfection without filtration, but only if stringent conditions are consistently maintained. Providing both filtration and chlorination is an example of using multiple barriers to protect water supplies.

The number of outbreaks associated with systems supplied by a groundwater source (i.e., 15) increased from the 1995–1996 reporting period (i.e., 13), representing the largest proportion (88.2%) of such outbreaks since 1978, when outbreak source water was first recorded (i.e., surface water versus groundwater). Of the 15 outbreaks associated with groundwater during 1997–1998, a total of 10 (66.7%) were associated with a system that had a treatment problem or distribution deficiency; 4 (26.7%) were associated with systems that had untreated water; and 1 (6.67%) had an unknown problem. Groundwater is often not routinely disinfected and almost never filtered at the treatment plant. Therefore, wells and springs must be protected from sources of contamination (e.g., surface runoff, septic tank drainage, and sewage discharges). EPA is developing a groundwater rule. Adequate and continuous disinfection of groundwater used for drinking water should be considered to reduce the occurrence of WBDOs caused by chlorine-sensitive organisms, particularly for systems in which intermittent contamination of wells and springs is difficult to detect or prevent.

Three of the four outbreaks of *Giardia* were attributed to groundwater. Two involved water from groundwater systems that were untreated except for ion exchange softening, whereas the third outbreak involved water disinfected with chlorine. Three of the four outbreaks of unknown etiology associated with drinking water occurred in systems using groundwater that experienced treatment deficiencies.

The outbreak in Texas during 1998 that was attributed to *Cryptosporidium* was associated with chlorinated wells located in limestone. *Cryptosporidium* is a smaller (4–6 µm) protozoan parasite than *Giardia* and is >50-fold more resistant to chlorine. Because *Cryptosporidium* is highly resistant to the chemicals typically used to treat drinking water, the parasite must be physically removed by filtration. However, karst (limestone) and fractured bedrock do not provide adequate natural filtration (*23*). Groundwater in these types of geologic formations can be under the direct influence of surface water and is more likely to be contaminated. Groundwater sources under the direct influence of surface water are included in SWTR, and the water might need to be filtered as well as disinfected.

All four drinking water outbreaks attributed to bacteria during this reporting period were associated with groundwater. This has been the case for all reported bacterial outbreaks since 1989. Three of the four outbreaks reported during this period were associated with untreated or inadequately chlorinated well water. In two of the three outbreaks, groundwater contamination was attributed to migration of fecal bacteria carried by surface water through the soil.

Although major advances have been made in detecting viruses in stool and environmental samples, and many outbreaks of acute gastrointestinal illness of unknown etiology (AGI) have epidemiologic and clinical characteristics consistent with viral etiology, only two outbreaks caused by a viral agent have been reported to CDC since 1991. Investigators are encouraged to submit clinical specimens for viral testing, either to CDC or state laboratories that conduct these tests.

Two outbreaks of chemical poisoning were reported to CDC during 1997–1998, a decrease from the number of outbreaks during 1995–1996 (i.e., 7). Both outbreaks were caused by copper poisoning, but the outbreak in 1998 underscores that corrosive water can cause leaching of metals from the plumbing and water distribution system. EPA requires monitoring for copper (and lead) at the tap rather than at the treatment plant, and EPA's action level for copper is 1.3 mg/mL (*24*). The results of this monitoring are used to determine whether treatment to control corrosion is needed or is being applied properly.

Waterborne chemical poisonings are probably underreported to CDC. Several reasons could explain the low reporting rate, including the following:

- Most poisonings of this nature (e.g., those associated with the leaching of copper from plumbing systems) probably occur in private residences, affect relatively few persons, and might not come to the attention of public health officials.
- Exposure to chemicals via drinking water can a) cause illness that is difficult to attribute to chemical intoxication or b) cause nonspecific symptoms that are difficult to link to a specific chemical.
- The mechanisms for detecting waterborne chemical poisonings and reporting them to the WBDO surveillance system are not as well-established as those for WBDOs caused by infectious agents.
- Physicians might have difficulties recognizing and diagnosing chemical poisonings.

Future efforts should be tailored to improving the sensitivity of surveillance activities, the detection of associations between environmental releases or exposure incidents and individual health events, and the assessment of the public health burden associated with water-related chemical exposures. Physicians should also be educated to recognize and diagnose poisonings caused by waterborne chemicals.

The relative proportion of outbreaks associated with various types of water systems has remained fairly constant (Figure 6). However, the proportion of reported outbreaks associated with community water systems that were attributed to problems at water treatment plants, and thus affected entire communities, declined during 1989–1996 and remained below the proportions for the 1989–1994 reporting periods (i.e., 72.7% for 1989–1990, 62.5% for 1991–1992, 57.1% for 1993–1994, 30.0% for 1995–1996, and 37.5% for 1997–1998). This decrease could reflect improvements in water-treatment practices and plant operations. During 1997–1998, three (37.5%) of the eight outbreaks in community water systems were caused by improper plumbing or cross-connections in the distribution system at individual facilities (e.g., a restaurant). This is a decrease from the previous reporting period (i.e., 70.0%). These types of problems could be remedied by effective cross-connection control regulations that require inspection and testing. However, monitoring, regulating, and standardizing the practices of the multitudinous individual facilities (e.g., offices, schools, and restaurants) in this country is a daunting task.

Outbreaks Associated with Recreational Water

The most frequently reported WBDOs caused by exposure to recreational water were outbreaks of gastroenteritis. Although fewer outbreaks of gastroenteritis were reported during 1997–1998 (i.e., 18) than during 1995–1996 (i.e., 22), this number was higher than previous years (Figure 7). There has been a gradual increase in the number of gastroenteritis outbreaks reported since 1989. This increase is not statistically significant (p value ≥0.18), and there is not enough evidence to determine if the increase represents the beginning of a trend or a reporting artifact. The 15 recreational water outbreaks reported in 1998 represent the largest number of outbreaks since 1989. Recreational water outbreaks of gastroenteritis reported during 1997–1998 accounted for illness in >1,570 persons, compared with 2,038 persons affected by drinking water outbreaks reported during this same period.

Because swimming is essentially communal bathing, rinsing of soiled bodies and overt fecal accidents cause fecal contamination of the water. Unintentional ingestion of recreational water contaminated with pathogens can then lead to gastrointestinal illness, even in nonoutbreak settings (*25,26*). Fresh and marine waters are also subject to other modes of contamination from point sources (i.e., sewage releases), watersheds (runoff from agricultural and residential areas), and floods.

The number of outbreaks of gastroenteritis caused by parasites in recreational water has been consistently ≤10 since 1989–1990 (i.e., zero for 1989–1990, 6 for 1991–1992, 10 for 1993–1994, 7 for 1995–1996, and 10 for 1997–1998). No outbreaks of gastroenteritis caused by parasites were reported during 1989–1990, but that could be because little routine diagnostic testing for *Cryptosporidium* occurred at that time. Of the gastrointestinal outbreaks attributed to parasites during 1997–1998, all were caused by *Cryptosporidium*; 90% were associated with recreational use of treated water in venues such as swimming pools and fountains, and human fecal accidents were suspected in most of these outbreaks (Figure 4).

Because infection with *Cryptosporidium* can occur after swallowing as few as 10–100 oocysts (*27,28*), swallowing a single mouthful of contaminated water could cause illness. *Cryptosporidium*, and to a lesser extent *Giardia*, are resistant to disinfection by chlorine at levels generally used in swimming pools. Although some pools might have filters and disinfection practices capable of removing or killing parasites, several hours could be required to completely recirculate and cleanse the pool water. In the meantime, pool water can become recontaminated. Either way, swimmers remain at risk until all of the water is recirculated through an effective water treatment process. The risk for transmission of cryptosporidiosis can increase because of the protracted periods of time necessary for moving all water through filtration equipment (i.e., turnover rates), problems in the design of pools that result in areas with poor water circulation (dead spots) (*29*), mixing of water from different pools during filtration, and the depletion of disinfectants by organic matter, which leaves insufficient residual disinfectant (*30*). Because *Cryptosporidium* oocysts measure only 4–6 µm in diameter, pool filtration systems that use sand or other large granular materials (without the special chemical pretreatment coagulants commonly used by the drinking water industry) might not be effective in removing oocysts.

The number of reported outbreaks of gastroenteritis in recreational water caused by bacteria decreased from 10 during 1995–1996 to 4 during 1997–1998. One outbreak was in a large water park where residual disinfectant would be expected to prevent these types of outbreaks. Chlorine levels during the period of the outbreak were low when measured by county public health officials. This underscores the difficulty of maintaining adequate chlorination levels in large shallow pools used by many young children. Because fecal contaminants and other organic material can rapidly consume the available chlorine, pool operators need to maintain their disinfectant at regulated levels and test those levels on a regular and frequent basis.

In contrast with the outbreaks caused by parasites, most of which were associated with chlorinated water, 50% (i.e., 2) of the outbreaks attributed to bacteria were associated with unchlorinated water (i.e., lakes) (Figure 4). Freshwater venues, which lack filtration and disinfection safeguards, present more of a challenge for prevention. Contamination of these venues can require protracted periods of closure or other ways to limit use, to ensure appropriate water quality. EPA has published criteria for evaluating the quality of both marine and fresh water used for recreation (*16,31*). Microbial monitoring has been recommended for recreational areas potentially contaminated by sewage or human use. However, epidemiologic studies have not clearly defined what health risks might be associated with specific levels of total or fecal coliforms detected in bathing waters.

Prevention efforts have focused on providing adequate bathroom facilities (e.g., including diaper-changing areas at recreational areas) and on limiting the number of swimmers per unit area. Other prevention measures can include patron and operator education, as well as efforts to a) improve filtration methods, disinfection methods, and pool design and b) change recreational water industry practices (e.g., provide specific pools with dedicated filtration systems for children so the water is not mixed with adults pools, limit access of young children to adult pools and operate filtration systems at higher turnover rates [in keeping with existing state and local regulatory requirements for suction injuries]). However, such changes can be costly, and the degree to which they reduce risk is unknown. Development and enforcement of clear and effective policies regarding fecal accidents in recreational water facilities is needed. However, questions that still need to be addressed include:

- What is the prevalence of pathogens in formed fecal accidents that are usually observed by pool operators?
- How long should a pool be vacated after a fecal accident?
- Is it beneficial to drain a pool after a fecal accident?
- Is hyperchlorination a strategy that should be used, especially for *Cryptosporidium*?
- What role do swim diapers/pants have in reducing fecal accidents?

Strategies to change behaviors of recreational water guests might also be important. Public education should stress that swimming is communal bathing and therefore requires good hygiene practices, and that chlorine does not kill all pathogens. Outbreaks of gastroenteritis associated with recreational water use could be reduced if a) those experiencing diarrhea refrain from swimming and continue to do so for 2 weeks after the resolution of their diarrhea and b) swimmers avoid swallowing recreational water.

During 1997–1998, most of the reported outbreaks of dermatitis were associated with hot tubs and pools. The outbreak of Pontiac fever in Wisconsin was also associated with whirlpool use. Outbreaks of *Pseudomonas* dermatitis and Pontiac fever associated with hot tubs are preventable if water is maintained at a pH of 7.2–7.8 with free, residual chlorine levels in the range of 2.0–5.0 mg/L (*32*). A person's susceptibility and immersion time, along with the number of bathers per unit area, also could influence the risk for infection (*33*). Close operator attention to pool and hot tub bather load, as well as frequent disinfectant level checks and additions could help prevent these outbreaks.

During 1997–1998, four deaths were caused by primary amebic meningoencephalitis, which is fewer than the six deaths reported during 1995–1996. *Naegleria* infections are generally acquired during the summer months when the temperature of fresh water is favorable for multiplication of the organism (*34,35*). The ameba could enter a person's body through the nasal passages when water is forced up the nose during swimming. Limiting the amount of fresh water forced into the nasal passages during jumping or diving (e.g., holding the nose or wearing nose plugs) could reduce the risk for these infections.

CONCLUSION

Information from the nationwide surveillance for WBDOs is used to characterize the epidemiology of waterborne diseases in the United States. Data regarding the types of water systems and deficiencies associated with outbreaks are used to evaluate the adequacy of current regulations for water treatment and monitoring of water quality. The identification of the etiologic agents of outbreaks is critical because agents newly associated with WBDOs could require new methods of control. Trends in the incidence of WBDOs caused by various etiologic agents can lead to changes in policies or resource allotment.

For agents that are recognized as important waterborne pathogens, surveillance at the local and state levels facilitates rapid recognition and control of WBDOs. Close communication among state and local health departments and water utilities is crucial. For example, if epidemiologic evidence suggests the possibility of waterborne transmission, water utilities should be contacted promptly and asked about such factors as recent treatment events and changes in source water quality. Similarly, local policies should be developed that specify the thresholds for reporting various water-quality data to health departments. Timely water testing and environmental investigations can help identify an outbreak's etiologic agent and the correctable source(s) of water contamination, as well as establish whether control measures (e.g., boil-water advisories) are indicated.

Ways to improve the WBDO surveillance system should be explored. Reviewing information gathered through other mechanisms (e.g., issuances of boil-water advisories and computerized data regarding water quality) could help detect WBDOs. Special epidemiologic studies are needed to supplement the findings of the existing surveillance system by addressing such issues as the public health importance of newly identified agents of waterborne disease, the effectiveness of prevention strategies in nonoutbreak settings, and the timeliness with which state and local health departments act in response to these pathogens.

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

Additional information is available from the following sources:

- EPA's Safe Drinking Water Hotline, (800) 426-4791 (telephone) or <sdwa@epamail.epa.gov> (E-mail).
- CDC's Cryptosporidiosis Information Line of the Parasitic Diseases Information Line, (888) 232-3228 (voice telephone system) or (888) 232-3299 (fax).
- CDC's NCID Internet site at <http://www.cdc.gov/ncidod/index.htm>.

Information regarding cryptosporidiosis is available at the Internet site of CDC's Division of Parasitic Diseases, NCID, which is located at the following address: <http://www.cdc.gov/ncidod/dpd/parasites/cryptosporidiosis/default.htm>. WBDOs should be reported to this division by telephone at (770) 488-7760 or by fax at (770) 488-7761.

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

Class[†]	Epidemiologic data	Water-quality data
I	Adequate[§] a) Data were provided regarding exposed and unexposed persons; and b) relative risk or odds ratio was ≥ 2, or the p-value was <0.05.	Provided and adequate (Historical information or laboratory data [e.g., chlorinator malfunction or 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., stating that a lake was crowded)
III	Provided, but limited a) Epidemiologic data provided did not meet the criteria for Class I; or b) the claim was made that ill persons had no exposures in common besides water, but no data were provided.	Provided and adequate
IV	Provided, but limited	Not provided or inadequate

*Outbreaks of *Pseudomonas* dermatitis and single cases of primary amebic meningoencephalitis or illness resulting from chemical poisoning are not classified according to this scheme.

[†]Based on the epidemiologic and water-quality data provided on CDC form 52.12.

[§]Adequate data were provided to implicate water as the source of the outbreak.

TABLE 2. Waterborne-disease outbreaks associated with drinking water — United States, 1997 (n = 7)*

State	Month	Class†	Etiologic agent	No. of cases	Type of system§	Deficiency¶	Source	Setting
Colorado	Jul	III	AGI**	9	NCom	3	Spring	Cabins
Florida	Mar	III	Copper poisoning	2	Com	4	Well	Restaurant
New Mexico	Jul	I	AGI††	123	NCom	4	Well	Country club
New York	Jun	I	*Giardia intestinalis*	50	Com	3	Lake	Community
Oregon	Jun	III	*G. intestinalis*	100	NCom	4	Well/spring	Campground
South Dakota	May	I	AGI	16	NCom	3	Well	Campground
Washington	Sep	III	*Escherichia coli* O157:H7	4	NCom	3	Well	Trailer park

* An outbreak is defined as a) at least two persons experiencing a similar illness after ingestion of drinking water and b) epidemiologic evidence that implicates water as the probable source of the illness.

† Based on the epidemiologic and water-quality data provided on CDC form 52.12.

§ Com=community; NCom=noncommunity. Community and noncommunity water systems are public water systems that serve ≥15 service connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for >6 months of the year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks).

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

** Acute gastrointestinal illness of unknown etiology.

†† Eleven persons had stool specimens that tested positive for *E. coli* O86:H11; one stool specimen was also positive for *Giardia*.

TABLE 3. Waterborne-disease outbreaks associated with drinking water — United States, 1998 (n = 10)*

State	Month	Class†	Etiologic agent	No. of cases	Type of system§	Deficiency¶	Source	Setting
Florida	May	III	*Giardia intestinalis*	7	Com	2	Well	Community
Florida	Sep	III	Copper poisoning	35	Com	3	Well	Community
Florida	Dec	III	*G. intestinalis*	2	Ind	2	Well	House
Illinois	May	III	*Escherichia coli* O157:H7	3	Ind	2	Well	House
Minnesota	Aug	I	*Shigella sonnei*	83	Com	4	Well	Fairgrounds
Montana	Jul	III	AGI**	5	Ind	3	Well	Home
New Mexico	Jul	I	*Cryptosporidium parvum*††	32	Ind	5	Well	Group home
Ohio	Oct	III	AGI§§	10	Com	4	Surface¶¶	Treatment plant
Texas	Jul	I	*C. parvum****	1400	Com	3	Well	Subdivision
Wyoming	Jun	I	*E. coli* O157:H7	157	Com	2	Well/spring	Community

* An outbreak is defined as a) at least two persons experiencing a similar illness after ingestion of drinking water and b) epidemiologic evidence that implicates water as the probable source of the illness.

† Based on the epidemiologic and water-quality data provided on CDC form 52.12.

§ Com=community; Ind=Individual. A community water system is a public water system that serves year-round residents of a community, subdivision, or mobile-home park with ≥15 service connections or an average of ≥25 residents for ≥60 days/year. Individual water systems are small systems that are not owned or operated by a water utility and that serve <15 connections or <25 persons.

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

** Acute gastrointestinal illness of unknown etiology.

†† Nine persons had stool specimens that tested positive only for *Cryptosporidium*, and one person had a specimen that was also positive for *Blastocystis hominis*.

§§ One person had a stool specimen that was positive for *B. hominis*.

¶¶ Surface water from an unknown source.

*** Eighty-nine persons had stool specimens that tested positive only for *Cryptosporidium*, and one person had a specimen that tested positive only for *Giardia*. None of the specimens were positive for both organisms.

TABLE 4. Waterborne-disease outbreaks associated with drinking water, by etiologic agent and type of water system — United States, 1997–1998 (n = 17)

	Type of water system*							
	Community		Noncommunity		Individual		Total	
Etiologic agent	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases
AGI[†]	1	10	3	148	1	5	5	163
Copper	2	37	0	0	0	0	2	37
Cryptosporidium parvum	1	1,400	0	0	1	32	2	1,432
Escherichia coli O157:H7	1	157	1	4	1	3	3	164
Giardia intestinalis	2	57	1	100	1	2	4	159
Shigella sonnei	1	83	0	0	0	0	1	83
Total (%)	**8**	**1,744**	**5**	**252**	**4**	**42**	**17**	**2,038**
	(47.1%)	**(85.6%)**	**(29.4%)**	**(12.4%)**	**(23.5%)**	**(2.1%)**	**(100.0%)**	**(100.0%)**

*Community and noncommunity water systems are public water systems that serve ≥15 service connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for >6 months of the year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks). Individual water systems are small systems not owned or operated by a water utility that serve <15 connections or <25 persons.

[†]Acute gastrointestinal illness of unknown etiology.

TABLE 5. Waterborne-disease outbreaks associated with drinking water, by type of deficiency and type of water system — United States, 1997–1998 (n = 17)

	Type of water system*							
	Community		Noncommunity		Individual		Total	
Type of deficiency†	Outbreaks	(%)	Outbreaks	(%)	Outbreaks	(%)	Outbreaks	(%)
Untreated surface water	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
Untreated groundwater	2	(25.0)	0	(0.0)	2	(50.0)	4	(23.5)
Inadequate treatment	3	(37.5)	3	(60.0)	1	(25.0)	7	(41.2)
Distribution system	3	(37.5)	2	(40.0)	0	(0.0)	5	(29.4)
Miscellaneous or unknown	0	(0.0)	0	(0.0)	1	(25.0)	1	(5.9)
Total	**8**	**(100.0)**	**5**	**(100.0)**	**4**	**(100.0)**	**17**	**(100.0)**

*Community and noncommunity water systems are public water systems that serve ≥15 service connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for >6 months of the year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks). Individual water systems are small systems not owned or operated by a water utility that serve <15 connections or <25 persons.

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

TABLE 6. Waterborne-disease outbreaks of gastroenteritis associated with recreational water — United States, 1997 (n = 3)

State	Month	Class*	Etiologic agent	Illness	No. of cases	Source	Setting
Massachusetts	Jul	III	*Shigella sonnei*	Gastroenteritis	9	Pool/fountain	Public park
Minnesota	Jul	II	*Cryptosporidium parvum*	Gastroenteritis	369	Fountain	Zoo
Missouri	Jul	I	*Escherichia coli* O157:H7	Gastroenteritis	8	Lake	Resort

*Based on the epidemiologic and water-quality data provided on CDC form 52.12.

TABLE 7. Waterborne-disease outbreaks of gastroenteritis associated with recreational water — United States, 1998 (n = 15)

State	Month	Class*	Etiologic agent	Illness	No. of cases	Source	Setting
Florida	Jul	IV	*Cryptosporidium parvum*	Gastroenteritis	7	Pool	Day care center
Georgia	Jun	I	*Escherichia coli* O157:H7	Gastroenteritis	26	Pool	Water park
Maine	Aug	I	AGI†	Gastroenteritis	650	Lake	Campground
Minnesota	Apr	IV	*C. parvum*	Gastroenteritis	45	Pool	Swim club
Minnesota	Jul	IV	*E. coli* O157:H7	Gastroenteritis	5	Lake	Beach
Minnesota	Jul	IV	*C. parvum*	Gastroenteritis	7	Pool	Community pool
Ohio	Jul	III	NLV§	Gastroenteritis	30	Lake	Campground
Oregon	Aug	II	*C. parvum*	Gastroenteritis	69	Pool	Community pool
Pennsylvania	Jul	III	*C. parvum*	Gastroenteritis	8	Lake	State park
Washington	Jul	II	AGI	Gastroenteritis	41	Lake	Children's camp
Washington	Jul	III	AGI	Gastroenteritis	248	Lake	Park
Wisconsin	Jun	I	NLV	Gastroenteritis	18	Lake	Public beach
Wisconsin	Jun	III	*C. parvum*	Gastroenteritis	12	Pool	Community pool
Wisconsin	Jul	III	*C. parvum*	Gastroenteritis	9	Pool	Community pool
Wisconsin	Jul	IV	*C. parvum*	Gastroenteritis	12	Pool	Community pool

*Based on the epidemiologic and water-quality data provided on CDC form 52.12.
†Acute gastrointestinal illness of unknown etiology.
§Norwalk-like virus.

TABLE 8. Waterborne-disease outbreaks of meningoencephalitis, leptospirosis, and Pontiac fever associated with recreational water — United States, 1998 (n = 6)

State	Month	Class*	Etiologic agent	Illness	No. of cases	Source	Setting
Florida	Aug	NA†	*Naegleria*	Meningoencephalitis	1	Stream	Drainage canal
Illinois	Jun	I	*Leptospira*	Leptospirosis	375	Lake	Triathalon
Oklahoma	Aug	NA	*Naegleria*	Meningoencephalitis	1	Lake	Lake
Texas	Jul	NA	*Naegleria*	Meningoencephalitis	1	Lake	Lake
Texas	Aug	NA	*Naegleria*	Meningoencephalitis	1	River	River
Wisconsin	Jan	I	*Legionellae*	Pontiac fever	45	Whirlpool	Hotel

*Based on the epidemiologic and water-quality data provided on CDC form 52.12.
† Not applicable.

TABLE 9. Waterborne-disease outbreaks of dermatitis associated with recreational water — United States, 1997–1998 (n = 8)

State	Year	Month	Class*	Etiologic agent	No. of cases	Source	Setting
Alaska	1998	Jun	NA[†]	*Pseudomonas aeruginosa*[§]	50	Spring	Resort
Arkansas	1997	Jan	NA	*P. aeruginosa*[¶]	12	Pool and hot tub	Hotel
Indiana	1997	Feb	NA	*P. aeruginosa*[§]	42	Pool	Hotel
Maine	1997	Jan	NA	*P. aeruginosa*[¶]	3	Hot tub	Hotel
Maryland	1998	Feb	NA	*P. aeruginosa*[¶]	7	Hot tub	Hotel
Oregon	1997	Jul	IV	*Schistosoma spindale*[¶]	2	Lake	Campground
Wisconsin	1998	Feb	NA	*P. aeruginosa*[§]	8	Pool	Hotel
Wisconsin	1998	Feb	NA	*P. aeruginos*[¶]	3	Hot tub	Hotel

*Based on the epidemiologic and water-quality data provided on CDC form 52.12.

[†] Not applicable.

[§] Laboratory-confirmed case.

[¶] Suspected case based on clinical syndrome.

TABLE 10. Waterborne-disease outbreak of gastroenteritis associated with drinking water that was not included in the previous surveillance summary — United States, 1996 (n = 1)*

State	Month	Class[†]	Etiologic agent	No. of cases	Type of system[§]	Deficiency[¶]	Source	Setting
Florida	Oct	II	Norwalk-like virus	594	Com	5	Well	School

*An outbreak is defined as a) at least two persons experiencing a similar illness after ingestion of drinking water and b) epidemiologic evidence that implicates water as the probable source of the illness.

[†]Based on the epidemiologic and water-quality data provided on CDC form 52.12.

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

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

FIGURE 1. Number of waterborne-disease outbreaks associated with drinking water, by etiologic agent and month — United States, 1997–1998 (n = 17)

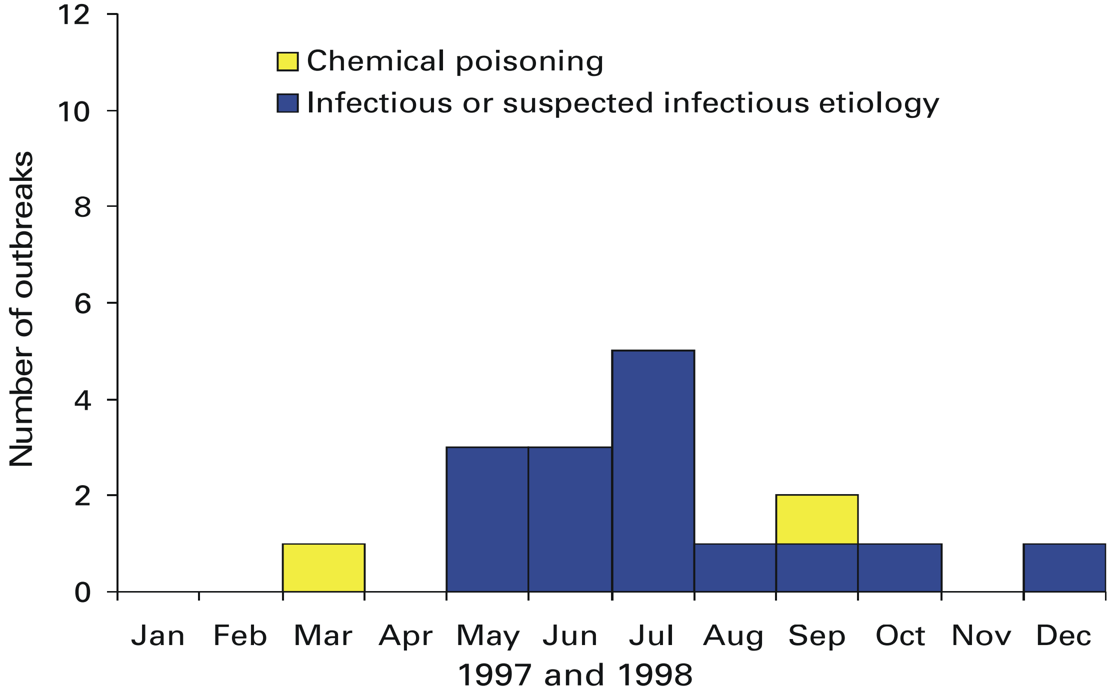


FIGURE 2. Waterborne-disease outbreaks associated with drinking water, by etiologic agent, water system, water source, and deficiency — United States, 1997–1998 (n = 17)

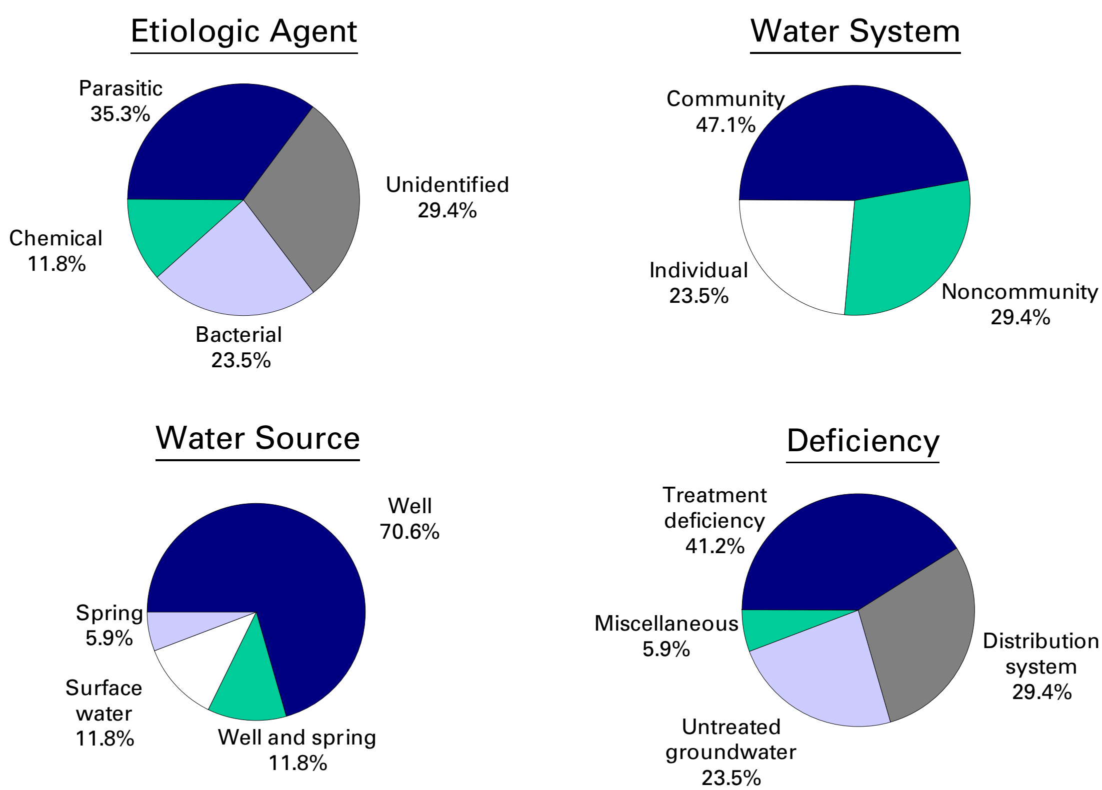


FIGURE 3. Number of waterborne-disease outbreaks associated with recreational water, by illness and month — United States, 1997–1998 (n = 32)

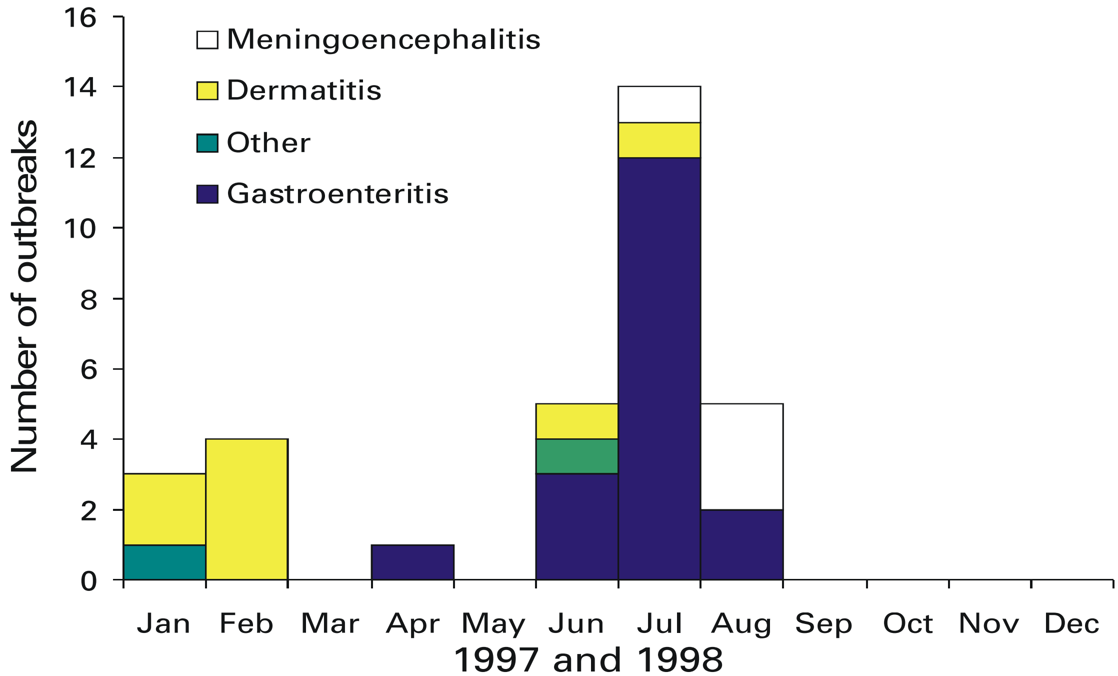
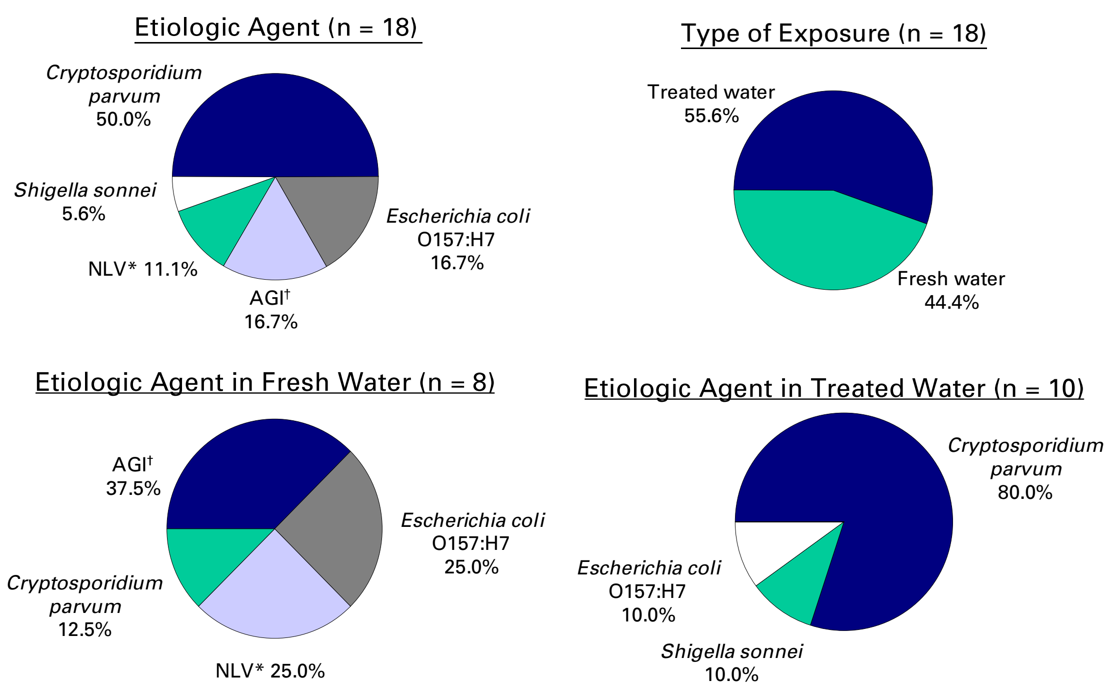


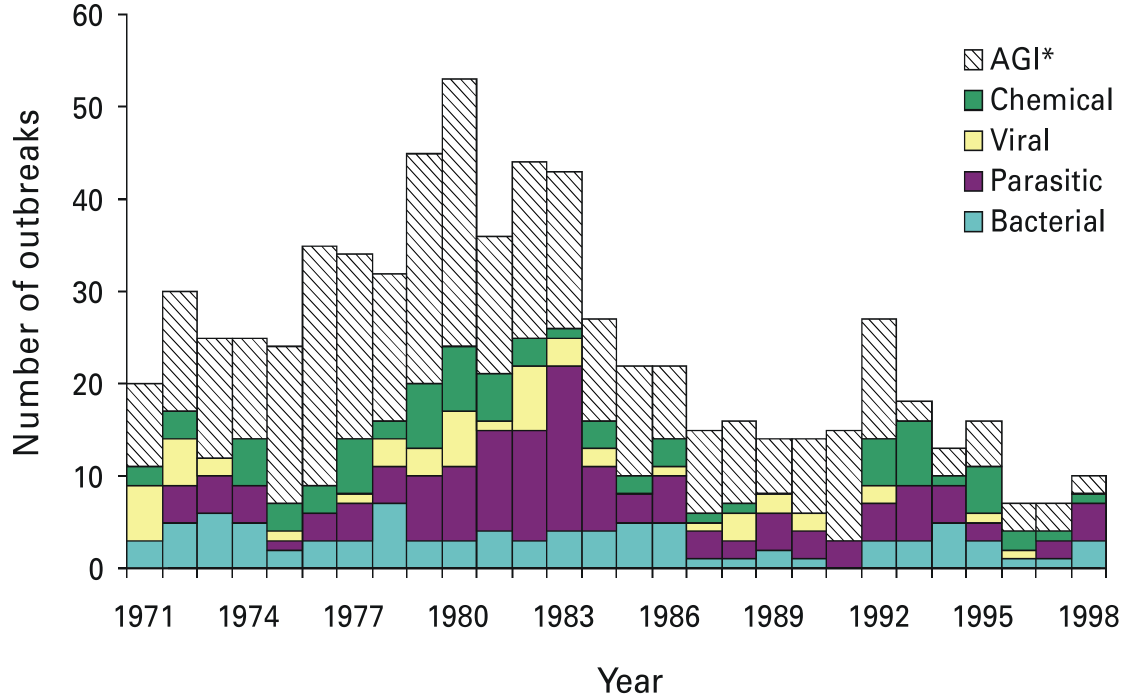
FIGURE 4. Waterborne-disease outbreaks of gastroenteritis associated with recreational water, by etiologic agent and type of exposure — United States, 1997–1998



*Norwalk-like virus.

†Acute gastrointestinal illness of unknown etiology.

FIGURE 5. Number of waterborne-disease outbreaks associated with drinking water, by year and etiologic agent — United States, 1971–1998 (n = 691)



*Acute gastrointestinal illness of unknown etiology.

FIGURE 6. Number of waterborne-disease outbreaks associated with drinking water, by year and type of water system — United States, 1971–1998 (n = 691)

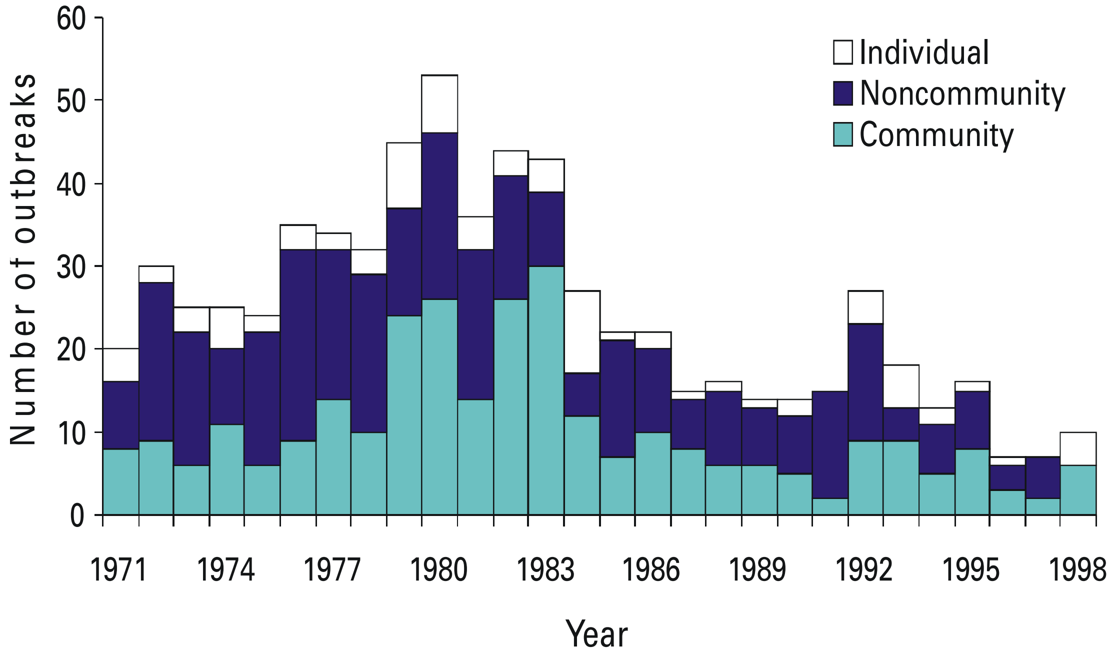
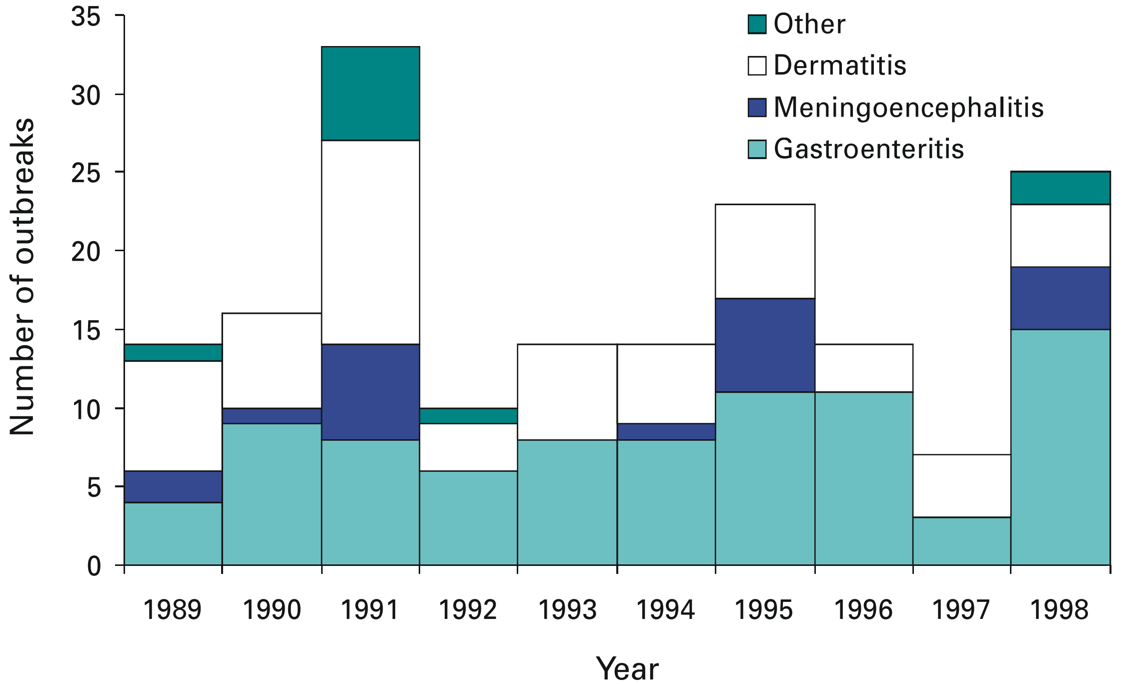


FIGURE 7. Number of waterborne-disease outbreaks associated with recreational water, by year and illness — United States, 1989–1998 (n = 171)



Glossary

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

Boil-water advisory: A statement to the public advising persons to boil tap water before drinking it.

Class: WBDOs are classified according to the strength of the epidemiologic and water-quality data implicating water as the source of the outbreak (Table 1).

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

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

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

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

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

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

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

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

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

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

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

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

Finished water: The water (i.e., drinking water) delivered to the distribution system after treatment, if any.

Flocculation: The water-treatment process after coagulation that uses gentle stirring to cause suspended particles to form larger, aggregated masses (floc). The aggregates are removed from the water by a separation process (e.g., sedimentation, flotation, or filtration).

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

Groundwater system: A system that uses water extracted from the ground (i.e., a well or spring).

Heterotrophic microflora: Microorganisms that utilize organic material for energy and growth.

Individual water system: A small water system not owned or operated by a water utility that serves <15 residences or farms that do not have access to a public water system.

Maximum-contaminant level: The maximum permissible concentration (level) of a contaminant in water supplied to any user of a public water system.

Nephelometric turbidity units: The units in which the turbidity of a sample of water is measured when the degree to which light is scattered is assessed with a nephelometric turbidimeter.

Noncommunity water system: A public water system that a) serves an institution, industry, camp, park, hotel, or business that is used by the public for ≥60 days per year, b) has ≥15 service connections or serves an average of ≥25 persons, and c) is not a community water system.

Oocyst: The infectious stage of *Cryptosporidium parvum* and some other coccidian parasites with a protective wall, which facilitates survival in water and other environments.

Public water system: A system, classified as either a community water system or a noncommunity water system, that provides piped water to the public for human consumption and is regulated under the Safe Drinking Water Act.

Raw water: Surface water or groundwater that has not been treated in any way.

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

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

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

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

Total coliforms: Nonfecal and fecal coliforms that are detected with a standard test.

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

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

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

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

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

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

State and Territorial Epidemiologists and Laboratory Directors

State and Territorial Epidemiologists and Laboratory Directors are acknowledged for their contributions to *CDC Surveillance Summaries*. The epidemiologists and the laboratory directors listed below were in the positions shown as of May 2000.

State/Territory	Epidemiologist	Laboratory Director
Alabama	John P. Lofgren, MD	William J. Callan, PhD
Alaska	John P. Middaugh, MD	Bernard Jilly, PhD
Arizona	Norman Peterson, MD, MPH	Wes Press, MS
Arkansas	Thomas C. McChesney, DVM	Michael G. Foreman
California	Duc J. Vugia, MD, MPH	Paul Kimsey, PhD
Colorado	Richard E. Hoffman, MD, MPH	Ronald L. Cada, DrPH
Connecticut	James L. Hadler, MD, MPH	Katherine Kelley, DrPH
Delaware	A. LeRoy Hathcock, PhD	Jane Getchall, DrPH
District of Columbia	Martin E. Levy, MD, MPH	—
Florida	Richard S. Hopkins, MD, MSPH	Ming Chan, PhD
Georgia	Paul Blake, MD, MPH	Elizabeth A. Franko, DrPH
Hawaii	Paul V. Effler, MD, MPH	Vernon K. Miyamoto, PhD
Idaho	Christine G. Hahn, MD	Richard H. Hudson, PhD
Illinois	Shari L. Bornstein, MD, MPH	Bernard T. Johnson, MS
Indiana	Robert Teclaw, DVM, PhD, MPH	David E. Nauth
Iowa	M. Patricia Quinlisk, MD, MPH	Mary J. R. Gilchrist, PhD
Kansas	Gianfranco Pezzino, MD, MPH	Roger H. Carlson, PhD
Kentucky	Glyn G. Caldwell, MD	Samuel Gregorio, DrPH
Louisiana	Louise McFarland, DrPH	Henry B. Bradford, Jr, PhD
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Maryland	Jeffrey C. Roche, MD, MPH (Acting)	J. Mehsen Joseph, PhD
Massachusetts	Alfred DeMaria, Jr, MD	Ralph J. Timperi, MPH
Michigan	Matthew L. Boulton, MD, MPH	Frances Pouch Downes, DrPH
Minnesota	Richard Danila, PhD, MPH	Norman Crouch, PhD
Mississippi	Mary Currier, MD, MPH	Joe O. Graves, PhD
Missouri	H. Denny Donnell, Jr, MD, MPH	Eric C. Blank, DrPH
Montana	Todd A. Damrow, PhD, MPH	Mike Spence, MD
Nebraska	Thomas J. Safranek, MD	Steve Hinrichs, MD
Nevada	Randall L. Todd, DrPH	L. Dee Brown, MD, MPH
New Hampshire	Jesse Greenblatt, MD, MPH	Veronica C. Malmberg, MSN
New Jersey	Eddy A. Bresnitz, MD, MS	S. I. Shahied, PhD
New Mexico	C. Mack Sewell, DrPH, MS	David E. Mills, PhD
New York City	Benjamin A. Mojica, MD, MPH	Alex Ramon, MD, MPH
New York State	Perry F. Smith, MD	Lawrence S. Sturman, MD, PhD
North Carolina	Newton J. MacCormack, MD, MPH	Lou F. Turner, DrPH
North Dakota	Larry A. Shireley, MPH, MS	Bonna Cunningham
Ohio	Forrest W. Smith, MD	William Becker, DO
Oklahoma	J. Michael Crutcher, MD, MPH	John Hitz, DrPH
Oregon	David W. Fleming, MD	Michael R. Skeels, PhD, MPH
Pennsylvania	James T. Rankin, Jr, DVM, PhD, MPH	Bruce Kleger, DrPH
Rhode Island	Utpala Bandyopadhyay, MD, MPH	Gregory Hayes, DrPH
South Carolina	James J. Gibson, MD, MPH	Harold Dowda, PhD
South Dakota	Sarah L. Patrick, PhD, MPH	Michael Smith
Tennessee	William L. Moore, Jr, MD	Michael W. Kimberly, DrPH
Texas	Dennis M. Perrotta, PhD	David L. Maserang, PhD
Utah	Craig R. Nichols, MPA	Charles D. Brokopp, DrPH
Vermont	Peter D. Galbraith, DMD, MPH	Burton W. Wilcke, Jr, PhD
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Wyoming	Karl Musgrave, DVM, MPH	Richard Harris, PhD
American Samoa	Joseph Tufa, DSM, MPH	Joseph Tufa, DSM, MPH
Federated States of Micronesia	Jean-Paul Chaine	—
Guam	Robert L. Haddock, DVM, MPH	Aurelto S. Espinola, MD
Marshall Islands	Tom D. Kijiner	—
Northern Mariana Islands	Jose L. Chong, MD	Joseph K.P. Villagomez
Palau	Jill McCready, MS, MPH	—
Puerto Rico	Carmen C. Deseda, MD, MPH	José Luis Miranda Arroyo, MD
Virgin Islands	Jose Poblete, MD (Acting)	Norbert Mantor, PhD

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