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Cryptosporidiosis Surveillance — United States, 2006–2008

and

Giardiasis Surveillance — United States, 2006–2008

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Cryptosporidiosis Surveillance — United States, 2006–2008

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Abstract

Problem/Condition: Cryptosporidiosis is a nationally notifiable gastrointestinal illness caused by chlorine-tolerant protozoa of the genus *Cryptosporidium*.

Reporting Period: 2006–2008.

System Description: State and two metropolitan health departments voluntarily report cases of cryptosporidiosis through CDC's National Notifiable Diseases Surveillance System.

Results: During 2006–2008, the number of reported cases of cryptosporidiosis increased dramatically (79.9%), from 6,479 for 2006 to 11,657 for 2007, and then decreased (9.9%) to 10,500 in 2008. All jurisdictions reported cryptosporidiosis cases during the reporting period, and the number of jurisdictions reporting >2.5 cases per 100,000 population increased from 20 in 2006 to 26 in 2007 and 27 in 2008. A greater number of case reports were received for children aged 1–9 years and for adults aged 25–39 years than were received for persons in other age groups. The number of cases reported among males and females was similar. Racial and ethnic comparisons were difficult because many case-reports did not report race and ethnicity. Peak onset of illness occurred annually during early summer through early fall.

Interpretation: Transmission of cryptosporidiosis occurs throughout the United States, with more frequent diagnosis or reporting occurring in northern states. An increase in cases reported for 2007 and 2008 is attributable partially to multiple large recreational water-associated outbreaks. State incidence figures should be compared with caution because individual state surveillance systems have varying capabilities to detect cases, and reporting might vary. The seasonal peak in age-specific case reports coincides with the summer recreational water season and likely reflects increased use of communal swimming venues (e.g., lakes, rivers, swimming pools, and water parks) by young children.

Public Health Action: Local and state health departments can use cryptosporidiosis surveillance data to better understand the epidemiologic characteristics and the disease burden of cryptosporidiosis in the United States, design efforts to prevent the spread of disease, and establish research priorities.

Introduction

Cryptosporidiosis is a gastrointestinal illness caused by protozoa of the genus *Cryptosporidium* (*1*). In otherwise healthy persons, clinical illness is characterized by watery diarrhea, which can be accompanied by abdominal cramps, loss of appetite, low-grade fever, nausea, vomiting, and weight loss; however, asymptomatic infection occurs frequently (*2*). *Cryptosporidium* also can cause an opportunistic infection in human immunodeficiency virus (HIV)–infected patients, who might experience life-threatening infection with profuse, watery, cholera-like diarrhea. In severely immunocompromised patients, disease can progress to cholangitis or pancreatitis (*3*).

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However, incidence of this parasitic infection among the HIV-infected population has decreased since the introduction of highly active antiretroviral therapy (HAART) for HIV infection (*4*). Nitazoxanide is the only broad-spectrum antiparasitic drug that has been approved in the United States for treatment of cryptosporidiosis. Nitazoxanide can be prescribed for children aged >1 year and adults, but it has not proven effective for immunocompromised persons (*5,6*).

Cryptosporidium is a genus of protozoan parasites within the phylum *Apicomplexa*, and its taxonomy continues to evolve. Cryptosporidiosis is a zoonotic disease that causes clinical disease in both humans and animals; species names are based primarily on the animal species serving as host (*7*). Revised *Cryptosporidium* taxonomy based on recent advances in molecular laboratory testing methods has clarified that multiple species infect humans. *C. hominis* (known previously as *C. parvum* genotype I) primarily infects humans and exists in a human-to-human transmission cycle. *C. parvum* (known previously as *C. parvum* genotype II) can infect both humans and ruminants, each with their own transmission cycles that intersect in zoonotic disease. In addition, molecular studies have demonstrated that humans are susceptible to infection with multiple subtypes of *C. parvum* and *C. hominis* (*7*). To a lesser extent, human infections also have been documented with *C. felis*, from cats; *C. canis*, from dogs; *C. meleagridis*, from birds; *C. suis*, from pigs; *C. muris*, from rodents; and a *C. cervine* genotype from various animals (*7*). Illnesses caused by infection with the different *Cryptosporidium* species might differ clinically (*8*).

Cryptosporidium infection is transmitted by the fecal-oral route and results from the ingestion of *Cryptosporidium* oocysts through the consumption of fecally contaminated food or water or through direct person-to-person or animal-to-person contact. The oocysts are infectious immediately upon being excreted in feces. The infectious dose is low; feeding studies have demonstrated that the ingestion of as few as 10–30 oocysts can cause infection in healthy persons (*9,10*). Infected persons have been reported to shed 10^8–10^9 oocysts in a single bowel movement and to excrete infectious oocysts for up to 50 days after cessation of diarrhea (*11,12*).

Cryptosporidium can exist in a body of water treated with chlorine (i.e., it is chlorine tolerant), which poses challenges for traditional chemical treatment of drinking and recreational water and for environmental surface cleaning. The organism also is not easily inactivated by alcohol-based hand sanitizers. Prevention and control measures include 1) practicing good hygiene (e.g., washing hands and not swimming when ill with diarrhea), 2) treating or avoiding contaminated water (not swallowing pool water, boiling or filtering water, and installing secondary disinfection systems (e.g., ultraviolet irradiation or ozone disinfection systems that inactivate *Cryptosporidium*) in pools, 3) exercising caution when traveling, and 4) avoiding fecal exposure during sexual activity (*13*).

Although cryptosporidiosis cases occur sporadically, outbreaks have been well documented since the first reported U.S. drinking water-associated outbreak in 1984 (*14*) and the first U.S. recreational water-associated outbreak in 1988 (*15*). *Cryptosporidium* has since emerged as the most frequently recognized cause of recreational water-associated outbreaks of gastroenteritis, particularly in treated (disinfected) venues. In addition, foodborne outbreaks of cryptosporidiosis linked to ill food handlers and unpasteurized apple cider have been reported (*16,17*). Outbreaks resulting from person-to-person transmission in child care centers and from animal-to-person transmission in an animal nursery also have been reported (*18,19*).

In 1994, the Council of State and Territorial Epidemiologists called for reporting of cryptosporidiosis as a nationally notifiable disease; the first full year for reporting began in 1995. Surveillance data for 1995–2005 have been published previously (*20–22*). This report summarizes national cryptosporidiosis surveillance data for 2006–2008.

Methods

Case Definition

Confirmed and probable cases of cryptosporidiosis are reported voluntarily to CDC. A confirmed case of cryptosporidiosis (i.e., one that has a positive laboratory finding) is defined as one in which *Cryptosporidium* has been detected in

- organisms in stool, intestinal fluid, or tissue samples or biopsy specimens;
- antigens in stool or intestinal fluid; or
- nucleic acid in stool, intestinal fluid, or tissue samples or biopsy specimens (*23,24*).

A probable case of cryptosporidiosis is a clinically compatible case that is linked epidemiologically to a confirmed case (*23*). This report includes both confirmed and probable cases as reported by jurisdictions.

Testing

Testing for *Cryptosporidium* is not always included in routine examination of stool for ova and parasites (*1*). Commercially available immunoassay kits are available and might be more sensitive and specific than routine microscopic examination (*25*). Direct fluorescent antibody (DFA) testing is an extremely sensitive and specific detection method and is considered the "gold standard" by many laboratorians; other immunodiagnostic kits that do not require microscopy (e.g., enzyme immunoassay [EIA] testing and rapid immunochromatographic cartridge assays) also are available (*25*); they do not take the place of routine ova and parasite examination but might be useful in diagnosing *Cryptosporidium* infections. Only molecular testing (e.g., polymerase chain reaction) can be used to speciate *Cryptosporidium*; however, no species data are reported to CDC.

Reporting

State, District of Columbia (DC), and New York City (NYC) health department jurisdictions report cases of cryptosporidiosis to CDC voluntarily through the National Notifiable Diseases Surveillance System (NNDSS). Reports include the patient's place of residence (i.e., state and county), age, sex, race, ethnicity (i.e., Hispanic or non-Hispanic) and date of illness onset and indicate whether the case is linked to a known outbreak. An outbreak-associated case is a laboratory-confirmed or probable case that is linked epidemiologically to an outbreak. Because this report includes probable cases of cryptosporidiosis, and because some of the data were finalized more recently, the number of cases provided in this report might be slightly higher than the number reported in CDC's annual Summary of Notifiable Diseases.

Analysis

Analysis of national cryptosporidiosis surveillance data for 2006–2008 was conducted using SAS v.9.1 (SAS Institute Inc.; Cary, North Carolina) and the Food Safety Information Link (FSI Link). FSI Link is an intranet-based tool available to CDC staff that provides access to NNDSS data and is used to monitor trends in, and investigate outbreaks of, reportable foodborne and waterborne diseases. Population data from the U.S. Census Bureau were used to calculate incidence rates.

Results

During 2006–2008, the number of reported cases of cryptosporidiosis increased dramatically (79.9%), from 6,479 for 2006 to 11,657 for 2007, and then decreased (9.9%) to 10,500 in 2008 (Table 1). All jurisdictions reported cryptosporidiosis cases during the reporting period, and the number of jurisdictions reporting ≥2.5 cases per 100,000 population increased from 20 in 2006 to 26 in 2007 and 27 in 2008 (Table 1).

During 2006–2008, incidence of cryptosporidiosis per 100,000 population ranged from 0.2 cases (in Hawaii, 2008) to 71.2 cases (in Utah, 2007) (Table 1; Figure 1). The higher incidence of cryptosporidiosis in Utah in 2007 was influenced by a single large outbreak among >1,900 persons (*26*). Increased reporting of cases also occurred in certain Midwestern, Rocky Mountain, and Southwestern states.

Surveillance data displayed a bimodal age distribution, with the greatest number of reported cases occurring among children aged 1–9 years and among adults aged 25–39 years (Figure 2). When reports for which a patient's sex was unknown or missing were excluded, the percentage of cases reported to have occurred among males remained consistent at 51.2% (3,293 of 6,421) for 2006, 49.6% (5,745 of 11,582) for 2007, and 49.7% (5,181 of 10,415) for 2008 (Table 2).

The majority of cases for which data on race were available for 2006–2008 occurred among whites, followed by blacks, Asians/Pacific Islanders, and American Indians/Alaska Natives (Table 2). However, data on race were lacking for 26.7%–32.5% of total annual case reports. Of patients for whom data on ethnicity were reported, 9.4%–15.4% were reported to be Hispanic (Table 2). However, data on ethnicity were lacking for 38%–44% of total annual case reports for 2006–2008.

A tenfold increase in reported cryptosporidiosis cases by illness onset date occurred during June–October compared with January–March (Figure 3). Age-specific analysis indicated that the seasonality in onset of illness was exhibited across all age groups, particularly among children aged 1–4 and 5–9 years (Figure 4).

The increase in cryptosporidiosis cases reported during 2006–2008 is a continuation of the fourfold increase in cryptosporidiosis since 2005 (Figure 5). This coincides with a similar dramatic rise in the number of cryptosporidiosis outbreaks associated with recreational water (Figure 6). During 1988–2006, *Cryptosporidium* was identified as the causal agent of 41.8% (100 of 239) of reported recreational water-associated outbreaks and of 5.7% (13 of 229) of reported drinking water-associated outbreaks of gastroenteritis in the United States (*15,27–39*).

Discussion

National cryptosporidiosis surveillance data are used to assess the epidemiologic characteristics and disease burden of cryptosporidiosis in the United States. The total number of cases reported annually and disease incidence increased during 2006–2008 and has increased dramatically since 2004 (Figures 1 and 5). Whether this increase reflects changes in reporting patterns and diagnostic testing practices or an actual change in infection and disease caused by *Cryptosporidium* is unclear but was clearly influenced by outbreak-related case reporting (Figure 6). However, outbreak-related probable case reporting does not account for the entire increase in reporting (Table 1). This increase also follows the introduction of nitazoxanide, the first licensed treatment for the disease, which was licensed in 2002 for children aged 1–11 years and in 2004 for children aged >11 years and adults (*5*). Because treatment for cryptosporidiosis now is available, health-care providers might be more willing to request *Cryptosporidium* testing, leading to an increase in subsequent case reports. However, no data exist to support this hypothesis. The geographic variation, age distribution, and late-summer through early-fall seasonality were consistent with previous cryptosporidiosis surveillance summaries (*20–22*).

Cryptosporidiosis is widespread geographically in the United States. Whereas previous surveillance data indicated that the diagnosis or reporting of cryptosporidiosis might be higher in northern or midwestern states (*20–22*), data from 2006–2008 seem to indicate that cryptosporidiosis incidence has increased in all states in recent years (Figure 1). Interpretation of this observation is difficult, and whether this change reflects an improvement in the diagnostics or detection by reporting systems of those states or represents an actual increase in the number of cases is unclear. Varying cryptosporidiosis surveillance systems and differences in reporting among states might affect the capability to detect and report cases.

Although cryptosporidiosis affects persons in all age groups, the number of reported cases was highest among children aged 1–9 years and adults aged 25–39 years (Figure 2). These

TABLE 1. Number and percentage* of cryptosporidiosis case reports, by state/area — National Notifiable Disease Surveillance System, United States,† 2006–2008

	2006				2007				2008			
State/Area	No.	(%)	Rate§	No. outbreak cases¶	No.	(%)	Rate	No. outbreak cases	No.	(%)	Rate	No. outbreak cases
Alabama	72	(1.1)	1.5		126	(1.1)	2.7	9	74	(0.7)	1.6	
Alaska	4	(0.1)	0.6		4	(0.0)	0.6		3	(0.0)	0.4	
Arizona	29	(0.4)	0.4		53	(0.5)	0.8		89	(0.8)	1.4	
Arkansas	29	(0.4)	1.0		63	(0.5)	2.2		95	(0.9)	3.3	
California	340	(5.2)	0.9		303	(2.6)	0.8		275	(2.6)	0.7	
Colorado	77	(1.2)	1.6	10	216	(1.9)	4.5	10	113	(1.1)	2.3	1
Connecticut	38	(0.6)	1.1		42	(0.4)	1.2		41	(0.4)	1.2	
Delaware	15	(0.2)	1.7		21	(0.2)	2.4		12	(0.1)	1.4	
District of Columbia	17	(0.3)	2.9		3	(0.0)	0.5		15	(0.1)	2.5	
Florida	717	(11.1)	3.9	219	738	(6.3)	4.1	115	549	(5.2)	3.0	72
Georgia	275	(4.2)	2.8		239	(2.1)	2.5		263	(2.5)	2.7	
Hawaii	4	(0.1)	0.3		6	(0.1)	0.5		2	(0.0)	0.2	
Idaho	40	(0.6)	2.6		518**	(4.4)	34.6	365	73	(0.7)	4.8	5
Illinois	257	(4.0)	2.0	66	205	(1.8)	1.6	17	207	(2.0)	1.6	
Indiana	113	(1.7)	1.8		149	(1.3)	2.4		203	(1.9)	3.2	1
Iowa	231	(3.6)	7.7		610	(5.2)	20.4		284	(2.7)	9.5	
Kansas	82	(1.3)	2.9		155	(1.3)	5.6	38	84	(0.8)	3.0	4
Kentucky	44	(0.7)	1.0		249	(2.1)	5.9	179	36	(0.3)	0.8	
Louisiana	86	(1.3)	1.9		64	(0.5)	1.5		67	(0.6)	1.5	
Maine	52	(0.8)	3.9	4	56	(0.5)	4.3	7	46	(0.4)	3.5	7
Maryland	20	(0.3)	0.4		36	(0.3)	0.6		54	(0.5)	1.0	
Massachusetts	175	(2.7)	2.7	5	132	(1.1)	2.0		172	(1.6)	2.6	
Michigan	145	(2.2)	1.4	1	215	(1.8)	2.1		284	(2.7)	2.8	
Minnesota	242	(3.7)	4.6	12	303	(2.6)	5.8	14	236	(2.2)	4.5	6
Mississippi	25	(0.4)	0.9		103	(0.9)	3.5		17	(0.2)	0.6	
Missouri	283	(4.4)	4.8		214	(1.8)	3.6		195	(1.9)	3.3	
Montana	152	(2.3)	15.7	46	77	(0.7)	8.0		45	(0.4)	4.7	
Nebraska	115	(1.8)	6.4	1	196	(1.7)	11.1	2	113	(1.1)	6.3	11
Nevada	14	(0.2)	0.5		37	(0.3)	1.4		17	(0.2)	0.7	4
New Hampshire	47	(0.7)	3.6		47	(0.4)	3.6	1	61	(0.6)	4.6	
New Jersey	42	(0.6)	0.5	1	67	(0.6)	0.8	1	40	(0.4)	0.5	
New Mexico	45	(0.7)	2.3		125	(1.1)	6.4		242	(2.3)	12.2	93
New York††	339	(5.2)	1.7	1	359	(3.1)	1.8	4	376	(3.6)	1.9	
New York City	155	(2.4)	1.9		105	(0.9)	1.3		107	(1.0)	1.3	
North Carolina	101	(1.6)	1.1	7	132	(1.1)	1.5	10	79	(0.8)	0.9	3
North Dakota	20	(0.3)	3.1		78	(0.7)	12.2		16	(0.2)	2.5	
Ohio	369	(5.7)	3.2	8	608	(5.2)	5.3	16	705	(6.7)	6.1	48
Oklahoma	56	(0.9)	1.5		216	(1.9)	6.0	104	238	(2.3)	6.5	44
Oregon	82	(1.3)	2.2	9	163	(1.4)	4.4	38	69	(0.7)	1.8	4
Pennsylvania	287	(4.4)	2.3	17	1,023**	(8.8)	8.2	488	331	(3.2)	2.7	9
Rhode Island	14	(0.2)	1.3		11	(0.1)	1.0		10	(0.1)	1.0	1
South Carolina	131	(2.0)	2.9	44	88	(0.8)	2.0		60	(0.6)	1.3	
South Dakota	86	(1.3)	10.7	5	169	(1.4)	21.2	3	88	(0.8)	10.9	6
Tennessee	48	(0.7)	0.8		141	(1.2)	2.3	5	48	(0.5)	0.8	1
Texas	273	(4.2)	1.1	37	235	(2.0)	1.0	2	3,342**	(31.8)	13.7	1,709
Utah	21	(0.3)	0.8		1,901**	(16.3)	71.2	1,901	49	(0.5)	1.8	
Vermont	54	(0.8)	8.7		47	(0.4)	7.6		64	(0.6)	10.3	
Virginia	71	(1.1)	0.9		90	(0.8)	1.2		81	(0.8)	1.0	
Washington	95	(1.5)	1.5		151	(1.3)	2.3	8	99	(0.9)	1.5	
West Virginia	20	(0.3)	1.1		12	(0.1)	0.7		26	(0.2)	1.4	
Wisconsin	532	(8.2)	9.5	26	790	(6.8)	14.1		786	(7.5)	14.0	
Wyoming	53	(0.8)	9.9		71	(0.6)	13.6	35	26	(0.2)	4.9	2
Total	**6,479**	**(100.0)**	**2.2**	**519**	**11,657**	**(100.0)**	**3.9**	**3,372**	**10,500**	**(100.0)**	**3.5**	**2,031**

Sources: Population estimates are from the Population Division, U.S. Census Bureau. Annual estimates of the resident population for the United States, regions states, and Puerto Rico: July 1, 2000 to July 1, 2008 (NST-EST 2008 01). Available at http://www.census.gov/popest/states. Estimates of the New York City population are from Annual estimates of the population for incorporated places over 100,000, ranked by July 1, 2008 population: April 1, 2000 to July 1, 2008 (SUB-EST 2008-01). Available at http://www.census.gov/popest/cities/tables.

* Percentages might not total 100% because of rounding.

† Cryptosporidiosis is not a reportable condition in U.S. territories or freely associated states.

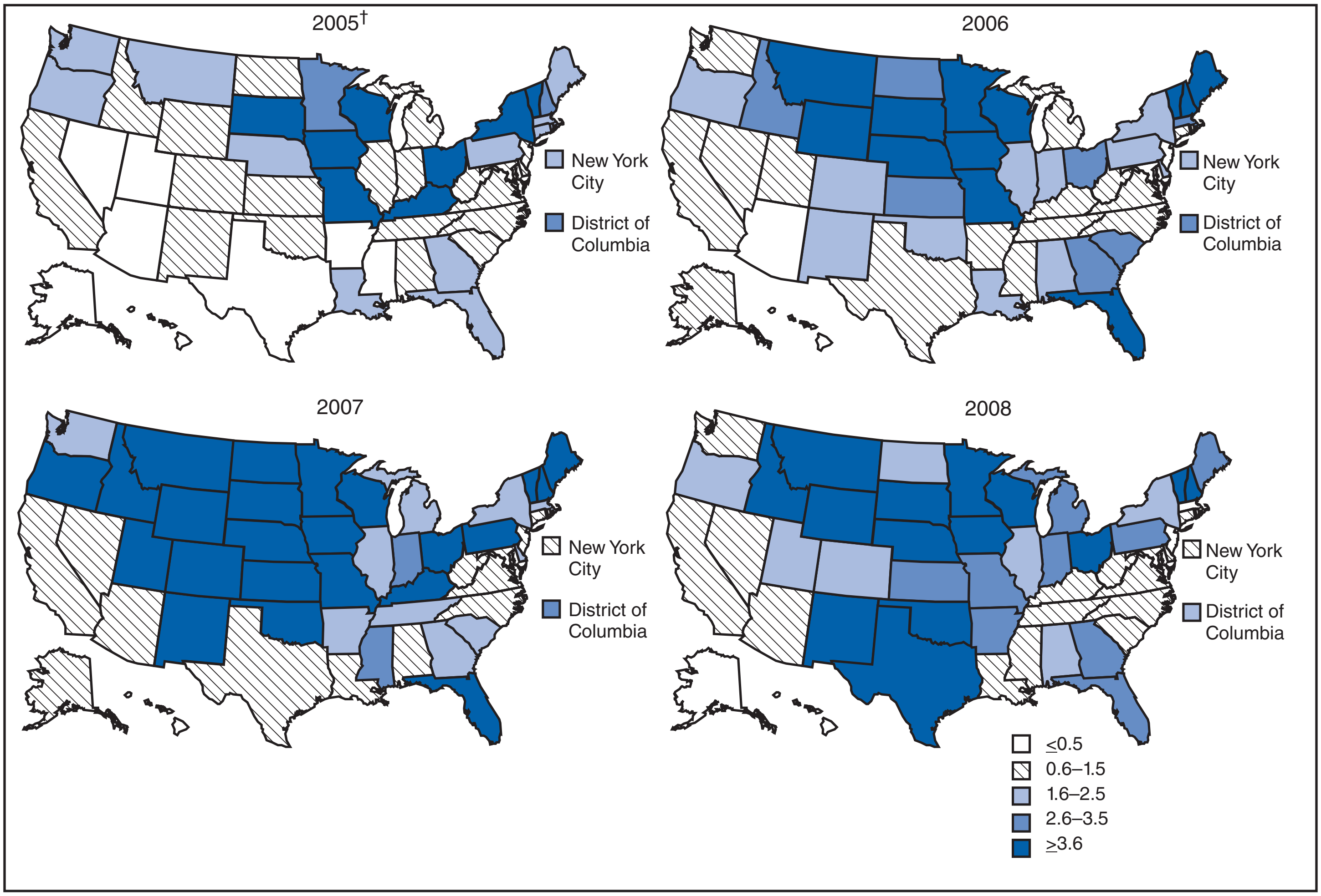
§ Per 100,000 population on the basis of U.S. Census Bureau population estimates.

¶ Number of cases linked to a known outbreak.

** Includes cases from large recreational water outbreaks.

†† New York State case reports include New York City.

FIGURE 1. Incidence* of cryptosporidiosis, by state — National Notifiable Disease Surveillance System, United States, 2005–2008



* Per 100,000 population.

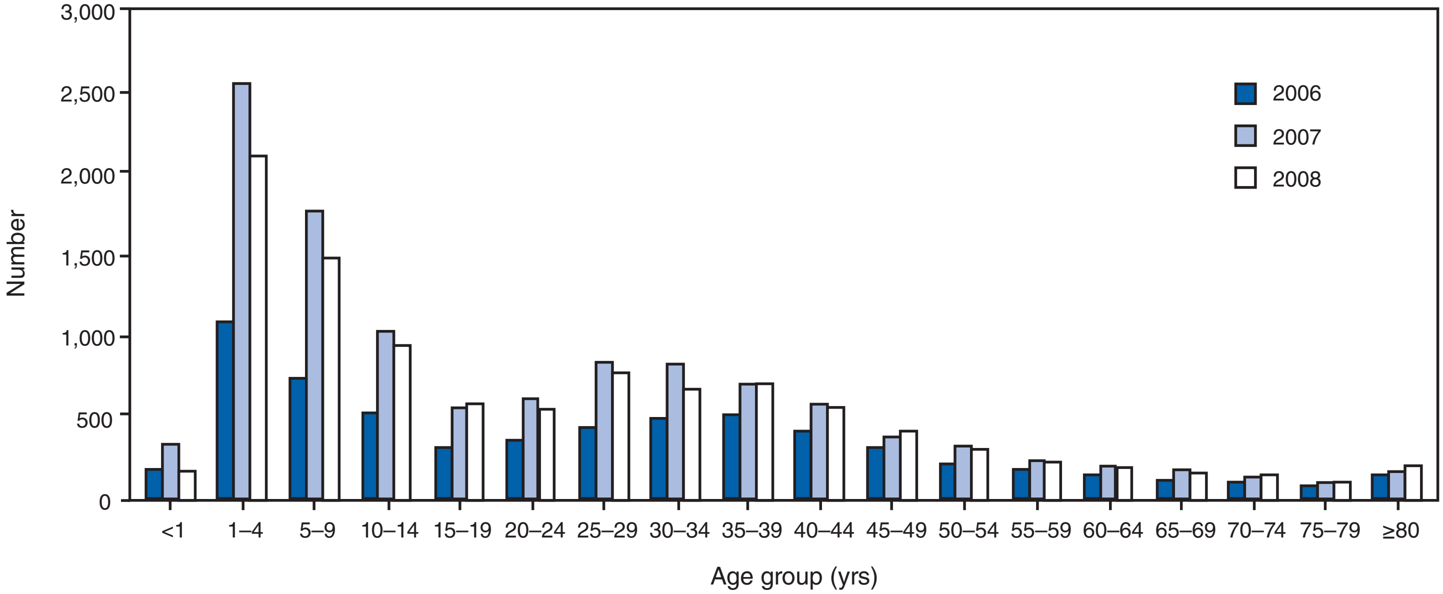
† **Source:** Yoder JS, Beach MJ. Cryptosporidiosis surveillance—United States, 2003–2005. In: Surveillance Summaries, September 7, 2007. MMWR 2007;56(No. SS-7):1–10.

data are consistent with reports of cryptosporidiosis incidence being higher among younger children and of transmission to their caregivers (e.g., child care staff, family members, and other household contacts) (*18,20,21,40,41*). Because information regarding immune system status is not collected as part of NNDSS cryptosporidiosis reporting, the number of immunosuppressed persons aged 25–39 years included in these surveillance data is unknown. However, the introduction of HAART therapy for persons with AIDS has decreased the incidence of cryptosporidiosis and the amount of severe cryptosporidiosis being diagnosed among persons with AIDS in the United States (*4,42*).

The tenfold increase in onset of cryptosporidiosis occurring during summer through early fall (Figure 3) is not unexpected. This increase coincides with increased swimming activities during the summer recreational water season and likely reflects the contribution of recreational water venues in the transmission of *Cryptosporidium*, particularly among younger children (*15,27,29,31–38,43*). *Cryptosporidium* is the leading cause of reported recreational water-associated outbreaks of gastroenteritis (*38*). Transmission through recreational water is facilitated by the substantial number of *Cryptosporidium* oocysts that can be shed by a single person; the extended periods of time that oocysts can be shed (*11,12*); the low infectious dose (*9,10*); the tolerance of *Cryptosporidium* oocysts to chlorine (*44*); and the prevalence of improper pool maintenance (i.e., insufficient disinfection, filtration, and recirculation of water), particularly of children's wading pools (*45*). This seasonal variation also has been noted in state, Canadian provincial, and previous U.S. national surveillance data for cryptosporidiosis and giardiasis (*20–22,40,41,46–48*).

The marked seasonal variation, higher incidence among children, and link to recreational water use for cryptospori-

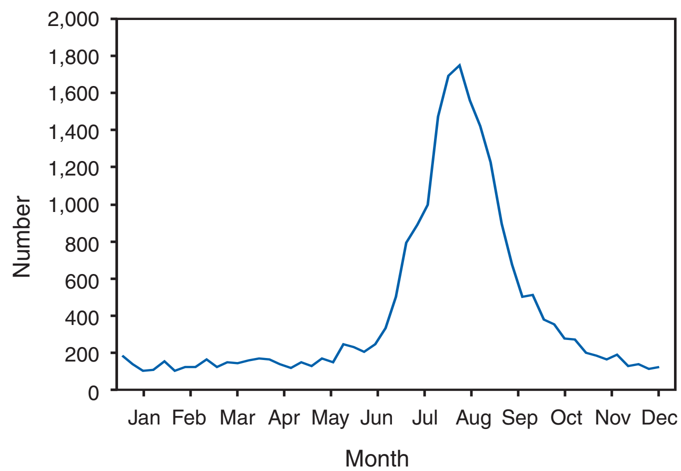
FIGURE 2. Number* of cryptosporidiosis case reports, by age group and year — National Notifiable Disease Surveillance System, United States, 2006–2008



* N = 28,636; age for 332 case-patients was unknown.

diosis is highlighted by the large communitywide outbreak in Utah in 2007 (*26*). The Utah Department of Health reported 1,901 confirmed cryptosporidiosis cases during June–December 2007, compared with the state's normal annual median of 16 confirmed cases. The full magnitude of the outbreak was likely much larger as investigations were limited to laboratory-confirmed cases. Epidemiologic studies implicated multiple recreational water venues as the source of this outbreak, and 80% of patients reported attending recreational water venues within 14 days of illness onset. In addition, 20% of patients reported swimming while ill with diarrhea, which implicated recreational water venues as an ongoing source of *Cryptosporidium* transmission. Children aged <5 years represented 32% of patients (median age: 9 years). After the infection rate peaked in mid-August, with nearly 60 confirmed cases of reported onset of illness on a single day, the Utah Department of Health further intensified control efforts, including hyperchlorination of pools and banning of children aged <5 years from community pools. Disease incidence rates began to decline after the stricter control measures and then continued to decline with the closing of seasonal pools in September. As the outbreak progressed, more patients reported having no recreational water exposure but had contact with persons who were ill with diarrhea. This finding supports a role for secondary person-to-person transmission in communitywide outbreaks. The lack of appropriate stool specimens prevented genotyping, which would have aided in determining chains of transmission. Although the water venues were filtered and chlorinated, the treatment was not sufficient to inactivate *Cryptosporidium*, which is highly chlorine tolerant. After implementation of hyperchlorination and banning of potentially incontinent children from swimming, followed by the closure of community pools at the end of the season, the outbreak began to decline. For 2008, Utah launched an education effort for swimmers and pool operators using multiple media combined with enhanced cryptosporidiosis surveillance

FIGURE 3. Number* of cryptosporidiosis case reports, by date of illness onset — National Notifiable Disease Surveillance System, United States, 2006–2008



* N = 28,636; date of onset for 7,017 case-patients was unknown.

TABLE 2. Number and percentage* of cryptosporidiosis case reports, by selected demographic characteristics — National Notifiable Disease Surveillance System, United States 2006–2008

	2006		2007		2008	
Characteristic	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**
Sex						
Male	3,293	(50.8)	5,745	(49.3)	5,181	(49.3)
Female	3,128	(48.3)	5,837	(50.1)	5,234	(49.9)
Unknown/Missing	58	(0.9)	75	(0.6)	85	(0.8)
Total	**6,479**	**(100.0)**	**11,657**	**(100.0)**	**10,500**	**(100.0)**
Race						
American Indian/Alaska Native	31	(0.5)	73	(0.6)	41	(0.4)
Asian/Pacific Islander	66	(1.0)	84	(0.7)	92	(0.9)
Black	544	(8.4)	618	(5.3)	824	(7.9)
White	3,912	(60.4)	6,858	(58.8)	6,546	(62.3)
Other	170	(2.6)	358	(3.1)	190	(1.8)
Unknown/Missing	1,756	(27.1)	3,666	(32.5)	2,807	(26.7)
Total	**6,479**	**(100.0)**	**11,657**	**(100.0)**	**10,500**	**(100.0)**
Ethnicity						
Hispanic	426	(6.6)	616	(5.3)	1,003	(9.6)
Non-Hispanic	3,472	(53.6)	5,909	(50.7)	5,503	(52.4)
Unknown/Missing	2,581	(39.8)	5,132	(44.0)	3,994	(38.0)
Total	**6,479**	**(100.0)**	**11,657**	**(100.0)**	**10,500**	**(100.0)**

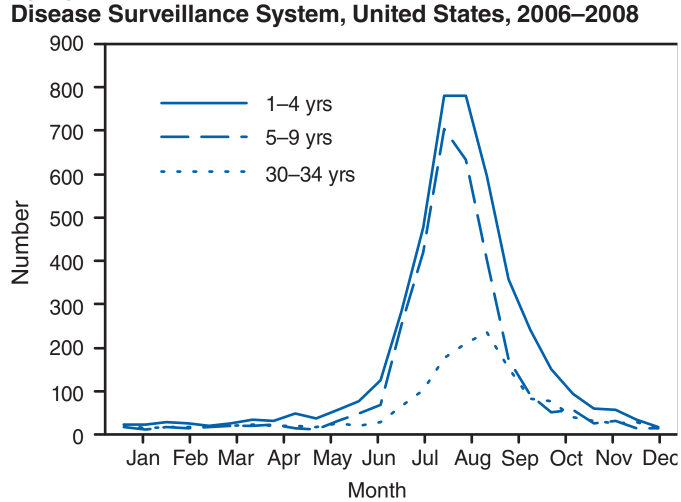
* Percentages might not total 100% because of rounding.

and prevention efforts; only 49 cryptosporidiosis cases were reported in 2008 (Table 1).

Outbreak reports reflecting the multiple routes of transmission for *Cryptosporidium* also were reported during 2006–2008. Twelve cryptosporidiosis outbreaks associated with food, animal contact, or person-to-person transmission were reported to CDC during this period; these outbreaks affected >125 persons (*49,50*). Six outbreaks were associated with animal exposure, three involved unknown exposure in the home, one was associated with a restaurant, and one was associated with a child care facility. The remaining outbreak involved increased reporting of cryptosporidiosis cases in Colorado, which involved multiple risk factors. Investigation determined that ill persons were more likely to have swallowed untreated water from a lake, river, or stream; have had exposure to recreational water; or have had contact with a child in a child care program or in diapers (*51*).

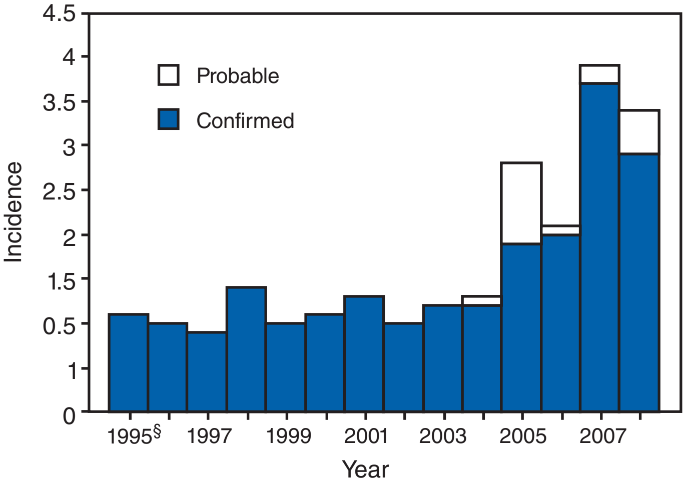
Cryptosporidiosis (as with all diseases caused by enteric pathogens) is likely underreported because 1) not all infected persons are symptomatic, 2) those who are symptomatic do not always seek medical care (*52,53*), 3) health-care providers infrequently include laboratory diagnostics in their evaluation of nonbloody diarrheal diseases (*52*), 4) the majority of physicians do not specifically request testing for *Cryptosporidium* as part of ova and parasite testing (*54*), 5) a majority of laboratories do not test for *Cryptosporidium* unless it is specifically requested (*55*), and 6) case-reports are not always completed for positive laboratory results or forwarded to public health officials (*56*). The licensing of the first treatment for cryptosporidiosis (*5*) might influence health-care providers to request *Cryptosporidium* testing more often when ova and parasite exams are ordered. Its low infectious dose (*9*), protracted communicability (*11,12*), and chlorine tolerance (*44*) make *Cryptosporidium* ideally suited for transmission through drinking and recreational water, food, and both person-to-person and animal-to-person contact. Several studies have characterized risk factors associated with *Cryptosporidium*. Persons at increased risk for infection include 1) those who have contact

FIGURE 4. Number* of cryptosporidiosis case reports, by selected age group† and date of illness onset — National Notifiable Disease Surveillance System, United States, 2006–2008



* N = 9,166.
† The 1–4- and 5–9-year age groups are presented because they have the highest numbers of cryptosporidiosis case reports and have the greatest seasonality. The 30–34-year age group was chosen to illustrate the less pronounced seasonality of the other age groups.

FIGURE 5. Incidence* of cryptosporidiosis, by year — National Notifiable Disease Surveillance System, United States, 1995–2008†



* Per 100,000 population.
† N = 68,907.
§ First full year of national reporting.

with infected animals, 2) those who have ingested contaminated recreational (e.g., lake, river, pool, or hot tub) or drinking water, 3) close contacts of infected persons (e.g., those in the same family or household or in child care settings), and 4) travelers to disease-endemic areas (*1,43,57–59*).

In recent years, three studies conducted in the United States, the United Kingdom, and Australia used multivariate analysis to identify risk factors associated with sporadic cryptosporidiosis. The important risk factors found in these studies included contact with persons with diarrhea, particularly incontinent persons such as young children, and contact with cattle, especially calves (*43,58,59*). The U.S. (*43*) and U.K. (*59*) studies also identified travel abroad as a risk factor whereas the Australian (*58*) study excluded persons who had recently traveled abroad to better characterize endemic disease. In addition, the U.S. study identified swimming in fresh water as a risk factor for becoming ill with cryptosporidiosis, and the U.K. and Australian studies identified drinking unboiled water from rural sources as a risk factor.

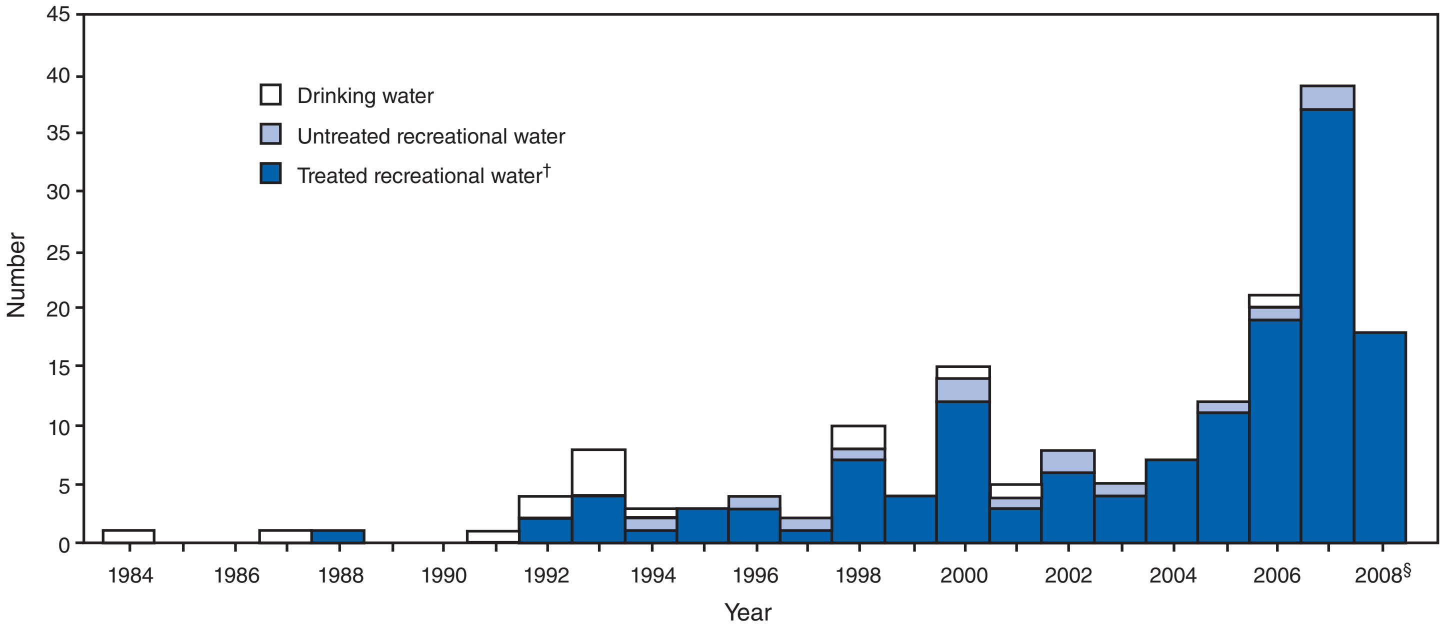
Several additional studies have identified contact with cattle as a significant risk factor for sporadic cryptosporidiosis. During a foot-and-mouth disease outbreak in the United Kingdom in 2001, millions of animals were slaughtered, and access to the countryside was restricted. During this time, the counties with the heaviest restrictions experienced an 82% reduction in the number of cryptosporidiosis cases reported, particularly in the transmission peak temporally corresponding with the spring calving season, suggesting an association between cattle contact and human disease in the United Kingdom (*60*). During 2003–2005, genotyping was performed on samples from 49 sporadic human cases of cryptosporidiosis in Wisconsin. Zoonotic genotypes *C. parvum* and the cervine type were identified in 46 of 49 cases. Nine different subgenotypes of *C. parvum* were identified, all of which had been previously identified in cattle in the surrounding region (*61*). Wisconsin has a high rate of cryptosporidiosis disease, but very few cases are associated with outbreaks (Table 1). Sporadic cryptosporidiosis caused by zoonotic transmission from cattle is the likely main cause of this disease in Wisconsin (*61*).

Non–C. parvum or *C. hominis Cryptosporidium* species are associated less frequently with human infection. The avian pathogen *C. meleagridis* is emerging as an important zoonotic pathogen in immune-competent individuals in some communities. In Peru, where a significant number of infections are attributable to zoonotic transmission, 10%–20% of infections are caused by *C. meleagridis* (*62*). However, *C. meleagridis* is detected rarely in immune-competent patients in industrialized countries (*63, 64*).

Cryptosporidium cannot multiply in food, so transmission of the parasite through food usually occurs through direct contamination of the food by an ill person or fecal contamination caused by improper hygiene practices during food production, processing, or preparation. Limited outbreaks have been associated with nonpasteurized apple cider made from improperly cleaned fruit that was exposed to cattle feces in the orchard (*17,65*). A 1998 outbreak involving 88 persons in the District of Columbia was traced back to contaminated food that had been handled by a cafeteria worker who was sick with cryptosporidiosis (*16*). The food handler had recently spent some time with a young relative who was sick with vomiting and diarrhea and another relative who also had become ill with the same symptoms (*16*). *Cryptosporidium* oocysts have been detected on produce at markets (*66,67*). These vegetables were likely contaminated by *Cryptosporidium*-contaminated water used for irrigation or by the feces of wild animals with access to the fields (*68,69*). Despite the possibility of produce contamination at the farm level, the link between detection of *Cryptosporidium* on fresh produce and human infection is not well understood (*70*). In contrast, case-control studies among persons with sporadic cryptosporidiosis cases have determined that consumption of raw vegetables, particularly carrots, is a protective factor (*43,58,59*). This finding might be explained by repeated exposures to the small amounts of *Cryptosporidium* on the vegetables providing a protective immunity or high fiber in the diet increasing gut motility and thereby preventing the oocysts from invading the intestinal mucosa (*43*).

Water appears to be a more important transmission route for *Cryptosporidium* and frequently is implicated in cryptosporidiosis outbreaks and in studies of sporadic cases (*42,43*) (Figure 6). Risk factors for cryptosporidiosis associated with treated recreational water include fecal accidents in the pool,

FIGURE 6. Number* of outbreaks of cryptosporidiosis associated with water, by water type — Waterborne Disease and Outbreak Surveillance System, United States, 1988–2008



* N = 172.
† Water that has undergone a treatment process (e.g., chlorination and filtration) to make it safe for recreation.
§ Data for 2007 and 2008 are provisional.

diapered toddlers in the pool, swimming while ill with diarrhea, and swallowing pool water (*38,58*). Risk factors for cryptosporidiosis associated with drinking water include drinking large amounts of unboiled rural or well water and failure of treatment protocols for public water supplies (*58*).

Although no formalized national plan exists for preventing cryptosporidiosis in the United States, multiple efforts are focused on reducing the transmission of the parasite through the two major routes of waterborne transmission. For drinking water, the Environmental Protection Agency (EPA) has implemented multiple regulations designed to improve the safety of surface water (e.g., lakes and rivers) supplies, including multiple regulatory changes following an outbreak of cryptosporidiosis in 1993 in Milwaukee, Wisconsin, that sickened >400,000 persons using the city water supply (*34,71*). Since 1993, no *Cryptosporidium* outbreaks associated with use of community surface water supplies have occurred in the United States (*28,30–34,39*). In addition, a study conducted during 1996–2004 in the United Kingdom suggests that improvements in drinking water treatment and source water protection might be responsible for decreasing the number of cryptosporidiosis cases in humans caused by *C. parvum* from ruminants (*72,73*). EPA is implementing the Groundwater Rule in an effort to decrease the risk associated with use of groundwater (well) supplies (*39*). This regulatory change might decrease the occurrence of *Cryptosporidium* outbreaks associated with groundwater use.

For recreational water, *Cryptosporidium* remains the leading cause of diarrheal illness outbreaks, especially in chlorinated venues (*38*). Recently, cryptosporidiosis outbreaks that began in treated recreational water venues have spread to communitywide transmission in multiple venues (e.g., child care centers and schools) (*26*). In addition, limited outbreaks in child care centers or schools can be amplified into communitywide outbreaks by the use of recreational water by ill persons (*74*). To address these challenges, CDC has collaborated with state health departments to develop guidelines for rapidly implementing community control measures when a cryptosporidiosis outbreak is identified (*26*). Efforts to reduce the transmission of this chlorine-tolerant pathogen in pools will require a concerted effort to move beyond existing pool practices to include new secondary disinfection technology (ultraviolet light or ozone inactivation), operational improvements (use of filtration enhancements that improve *Cryptosporidium* removal), and public education to reduce continued swimming by persons who are ill with diarrhea.

In the United States, no federal oversight of chlorinated swimming venues occurs. All pool codes are reviewed and approved by state or local public health officials. As a result, the United States has no uniform national standards governing the design, construction, operation, and maintenance of swimming pools and other treated recreational water venues. To provide guidance and improve nationwide pool code uniformity, CDC is sponsoring an effort to develop a data-driven, knowledge-based National Model Aquatic Health Code (available at http://www.cdc.gov/healthywater/swimming/pools/mahc/). This effort involves state, local, and federal public health officials and the aquatics industry in creating a voluntary model regulatory structure for state and local health departments to use in developing pool codes. Health communication efforts also should continue to educate swimmers about the hazards of swallowing pool water and swimming while ill with diarrhea.

Limitations

The data provided in this report are subject to certain limitations, including likely underreporting of cases, lack of information on race and ethnicity on most case reports, unknown HIV status, and lack of information on risk factors or attributable fractions by exposure types. Despite these limitations, these data provide the only national estimate of the number of cases of cryptosporidiosis that is available.

Conclusion

Continued efforts to reduce risk and improve diagnosis and reporting of cryptosporidiosis are needed to decrease the transmission of cryptosporidiosis in the United States. Prevention measures (Box 1) and measures to improve surveillance and prevention for cryptosporidiosis and increase understanding of its epidemiology and the associated disease burden (Box 2) have been recommended. Additional information about cryptosporidiosis epidemiology, diagnosis, treatment, prevention, and control is available at http://www.cdc.gov/crypto.

BOX 1. CDC recommendations to prevent and control cryptosporidiosis

Practice good hygiene.

- Everywhere
  - Wash hands with soap and water for at least 20 seconds, rub hands together vigorously, and scrub all surfaces
    - before preparing or eating food,
    - after using the toilet,
    - after changing diapers or cleaning up a child who has used the toilet,
    - before and after tending to someone who is ill with diarrhea, and
    - after handling an animal or its feces.

Additional information about hygiene is available at http://www.cdc.gov/healthywater/hygiene.

- At child care facilities
  - To reduce risk for disease transmission, exclude children with diarrhea from child care settings until the diarrhea has stopped.
- At recreational water venues
  - Protect others by not swimming while experiencing diarrhea (this is essential for children in diapers and aquatics staff). If cryptosporidiosis is diagnosed, do not swim for at least 2 weeks after diarrhea stops.
  - Shower before entering the water.
  - Wash children thoroughly (especially their bottoms) with soap and water after they use the toilet or their diapers are changed and before they enter the water.
  - Take children on frequent bathroom breaks and check their diapers often.
  - Change diapers in the bathroom, not at the poolside.

Additional information about recreational water illnesses and how to stop them from spreading is available at http://www.cdc.gov/healthywater/swimming.

- Around animals
  - Minimize contact with the feces of all animals, particularly young animals.
  - When cleaning up animal feces, wear disposable gloves, and always wash hands when finished.
  - Wash hands after any contact with animals or their living areas.
- Outside
  - Wash hands after gardening, even if wearing gloves.
- Immunocompromised persons
  - Avoid close contact with anyone who has cryptosporidiosis.
  - Do not handle animal feces because infection can be life threatening for immunocompromised persons.

Additional information about cryptosporidiosis prevention and control is available at http://www.cdc.gov/crypto/gen_info/prevent.html.

Avoid water that might be contaminated.

- Do not swallow water while swimming in swimming pools, spas, interactive fountains, lakes, rivers, springs, ponds, streams, or the ocean.
- Reduce contamination of treated recreational water venues by having pool operators install in-line secondary disinfection systems (e.g., ultraviolet light, ozone) to inactive this chlorine-tolerant parasite.
- Do not drink untreated water from lakes, rivers, springs, ponds, streams, or shallow wells.
- Do not drink inadequately treated water or ice made from water during communitywide outbreaks caused by contaminated drinking water.
- Do not use or drink inadequately treated water or use ice when traveling in countries where the water supply might be unsafe.
- If the safety of drinking water is in doubt (e.g., outbreak, poor sanitation, or lack of water treatment systems),
  - drink bottled water
  - disinfect water by heating it to a rolling boil for 1 minute, or
  - use a filter that has been tested and rated by National Safety Foundation (NSF) Standard 53 or NSF Standard 58 for cyst and oocyst reduction; filtered water will need additional treatment to kill or inactivate bacteria and viruses.

Additional information about water filters is available at http://www.cdc.gov/crypto/gen_info/filters.html.

Avoid eating food that might be contaminated.

- Use safe, uncontaminated water to wash all food that is to be eaten raw.
- After washing vegetables and fruit in safe, uncontaminated water, peel them before eating them raw.
- Avoid eating uncooked foods when traveling in countries with poor water treatment and food sanitation.

Information about how to prevent illnesses while traveling is available at http://wwwnc.cdc.gov/travel/content/safe-food-water.aspx.

Prevent contact and contamination with feces during sex.

- Use a barrier during oral-anal sex.
- Wash hands immediately after handling a condom used during anal sex and after touching the anus or rectal area.

BOX 2. CDC recommendations to improve surveillance for cryptosporidiosis and increase understanding of its epidemiology and associated disease burden

- Encourage health-care providers to consider and specifically request testing for *Cryptosporidium* in the evaluation of gastrointestinal illness.
- Encourage laboratories to test routinely for *Cryptosporidium* when examining stool for ova and parasites.
- Expand the use of molecular testing and the application of molecular epidemiology to *Cryptosporidium*-positive samples.
- Continue to educate health-care providers as well as public and private laboratories to improve reporting of cases of cryptosporidiosis to jurisdictional health departments.
- Encourage jurisdictional health departments to report cryptosporidiosis data to CDC through the National Notifiable Diseases Surveillance System (NNDSS).
- Publish and distribute cryptosporidiosis surveillance data regularly for public health education purposes.
- Conduct further epidemiologic studies of the geographic variability, incidence, and risk factors for cryptosporidiosis.

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Giardiasis Surveillance — United States, 2006–2008

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Abstract

Problem/Condition: Giardiasis is a nationally notifiable gastrointestinal illness caused by the protozoan parasite *Giardia intestinalis*.

Reporting Period: 2006–2008.

System Description: State, commonwealth, territorial, and two metropolitan health departments voluntarily report cases of giardiasis through CDC's National Notifiable Disease Surveillance System.

Results: During 2006–2008, the total number of reported cases of giardiasis increased slightly from 19,239 for 2006 to 19,794 for 2007 and decreased slightly to 19,140 for 2008. During this period, 49 jurisdictions reported giardiasis cases; giardiasis is a reportable condition in 45 states (not reportable in Indiana, Kentucky, Mississippi, North Carolina, and Texas). A greater number of case reports were received for children aged 1–9 years and for adults aged 35–44 years compared with other age groups. Incidence of giardiasis was highest in northern states. Peak onset of illness occurred annually during early summer through early fall.

Interpretation: Transmission of giardiasis occurs throughout the United States, with more frequent diagnosis or reporting occurring in northern states. However, state incidence figures should be compared with caution because individual state surveillance systems have varying capabilities to detect cases. The seasonal peak in age-specific case reports coincides with the summer recreational water season and likely reflects increased outdoor activities and exposures such as camping and use of communal swimming venues (e.g., lakes, rivers, swimming pools, and water parks) by young children.

Public Health Action: Local and state health departments can use giardiasis surveillance data to better understand the epidemiologic characteristics and the disease burden of giardiasis in the United States, design efforts to prevent the spread of disease, and establish research priorities.

Introduction

Giardia intestinalis (also known as *G. lamblia* and *G. duodenalis*) is the most common intestinal parasite of humans identified in the United States (*1*). This flagellated protozoan causes a generally self-limited clinical illness (i.e., giardiasis) typically characterized by diarrhea, abdominal cramps, bloating, weight loss, and malabsorption; asymptomatic infection also occurs frequently (*2–4*). Case reports have associated giardiasis with the development of chronic enteric disorders, allergies, and reactive arthritis (*5–7*).

Giardia infection is transmitted by the fecal-oral route and results from the ingestion of *Giardia* cysts through the consumption of fecally contaminated food or water or through person-to-person (or, to a lesser extent, animal-to-person) transmission. The cysts are infectious immediately upon being excreted in feces. The infectious dose is low; ingestion of 10 cysts has been reported to cause infection (*8*). Infected persons have been reported to shed 10^8–10^9 cysts in their stool per day and to excrete cysts for months (*8–10*). Effective therapies are available for patients with symptomatic giardiasis, including metronidazole, nitazoxanide, tinidazole, paromomycin, furazolidone, and quinacrine (*11*).

Giardia is distributed globally and has been detected in nearly all classes of vertebrates, including domestic animals and wildlife (*12*). Although *G. intestinalis* infects both humans and animals, the role of zoonotic transmission to humans and the importance of animal contamination of food and water are being re-examined. Recent advances in molecular epidemiology have permitted identification of specialized genetic groups (i.e., assemblages) that are relatively species-specific. Assemblages A and B of *G. intestinalis* infect primarily humans and primates; assemblages C and D infect dogs, assemblage F infects cats, assemblage E infects hoofstock, and assemblage G

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infects rodents (*13*). These findings suggest that *G. intestinalis* does not have as high a level of zoonotic disease transmission potential as thought previously (*13*).

Persons at increased risk for infection include 1) travelers to disease-endemic areas, 2) children in child care settings, 3) close contacts of infected persons (e.g., those in the same family or household or in a child care setting), 4) persons who ingest contaminated drinking water, 5) persons who swallow contaminated recreational water (e.g., water in lakes, rivers, and pools), 6) persons taking part in outdoor activities (e.g., backpacking or camping) who consume unfiltered, untreated water or who fail to practice good hygienic behaviors (e.g., hand washing), 7) persons who have contact with infected animals, and 8) men who have sex with men (*2,14–18*). Giardiasis does not appear to be opportunistic in persons infected with human immunodeficiency virus. The relative contribution of person-to-person, animal-to-person, foodborne, and waterborne transmission to sporadic human giardiasis in the United States is not well understood.

Although giardiasis cases occur sporadically, outbreaks from multiple transmission routes are well documented. During 1997–2006, *Giardia* was identified as a causal agent of six (3.7%) of 162 reported recreational water-associated gastroenteritis outbreaks and of 15 (10.6%) of 141 reported drinking water-associated gastroenteritis outbreaks in the United States (*19–24*). Worldwide, it is one of the most frequently identified parasites associated with waterborne disease outbreaks (*25*). Foodborne outbreaks of giardiasis are reported rarely. During 1998–2007, of 7,650 foodborne outbreaks with an identified etiology, 15 (0.2%) were attributed to *Giardia*. (*26*). Improper hygiene practices have contributed to outbreaks of giardiasis associated with food (*27*), person-to-person transmission in child care centers (*28*), and communitywide outbreaks with waterborne and person-to-person transmission routes (*29*). Outbreaks associated with drinking water might be associated with animal contamination of water systems (*30,31*). However, the zoonotic transmission of giardiasis is not believed to play a major role in human disease (*32*).

In 1992, the Council of State and Territorial Epidemiologists assigned a reporting number for giardiasis (code 11570) to facilitate transmission of reported giardiasis data to CDC. Surveillance data for 1992–2005 have been published previously (*33–35*). Reporting of giardiasis as a nationally notifiable disease began in 2002. This report summarizes national giardiasis surveillance data for 2006–2008.

Methods

Case Definition

Confirmed and probable cases of giardiasis are reported voluntarily to CDC. A confirmed case of giardiasis (i.e., one that has a positive laboratory finding) is defined as the detection of *Giardia intestinalis*

- cysts in stool specimens or trophozoites in stool specimens, duodenal fluid, or small-bowel tissue by microscopic examination using staining methods (e.g., trichrome) or direct fluorescent antibody assays (DFA); or
- antigens in stool specimens by immunodiagnostic testing (e.g., enzyme-linked immunosorbent assay) (*36*).

A probable case of giardiasis is a clinically compatible case that is linked epidemiologically to a confirmed case (*36*).

Testing

Because *Giardia* cysts can be excreted intermittently, multiple stool collections (i.e., three stool specimens collected every other day) increase test sensitivity (*37*). The use of concentration methods and trichrome staining might not be sufficient to identify *Giardia* because variability in the concentration of organisms in the stool can make this infection difficult to diagnose. For this reason, fecal immunoassays that are more sensitive and specific should be used (*38*). Direct fluorescent antibody (DFA) testing is an extremely sensitive and specific detection method and is considered the "gold standard" by many laboratorians; other immunodiagnostic kits that do not require microscopy (e.g., enzyme immunoassay [EIA] testing and rapid immunochromatographic cartridge assays) also are available (*38*); they do not take the place of routine ova and parasite examination but might be useful in diagnosing *Giardia* infections. Only molecular testing (e.g., polymerase chain reaction [PRC]) can be used to subtype *Giardia*; however, no subtyping data are reported to CDC.

Reporting

Health departments in 45 states (all except Indiana, Kentucky, Mississippi, North Carolina, and Texas), the District of Columbia (DC), New York City (NYC), the Commonwealth of Puerto Rico, and Guam voluntarily report laboratory-confirmed and probable cases of giardiasis to CDC through the National Notifiable Disease Surveillance System (NNDSS). Reports include the patient's place of residence (i.e., state and county), age, sex, race, ethnicity (i.e., Hispanic or non-Hispanic), and date of illness onset and indicate whether the case is linked epidemiologically to a known outbreak. Because this report includes probable cases of giardiasis, and because certain data were finalized recently, the number of cases might differ slightly from the number reported in CDC's annual Summary of Notifiable Diseases.

Analysis

Analysis of national giardiasis surveillance data for 2006–2008 was conducted using SAS v.9.1 (SAS Institute, Inc.; Cary, North Carolina) and the Food Safety Information Link (FSI Link). FSI Link is an intranet-based tool available to CDC staff that provides access to NNDSS data and is used to monitor trends in and investigate outbreaks of reportable foodborne and waterborne diseases. Population data from the U.S. Census Bureau were used to calculate incidence rates.

Results

During 2006–2008, the total number of reported cases of giardiasis increased 2.9%, from 19,239 for 2006 to 19,794 for 2007 and then decreased 3.3% to 19,140 for 2008 (Table 1). During this period, 49 jurisdictions (45 states, two cities, Puerto Rico, and Guam) reported giardiasis cases. No reports were received from the five states (Indiana, Kentucky, Mississippi, North Carolina, and Texas) in which giardiasis is not a reportable disease.

For 2008, among jurisdictions reporting cases, incidence of giardiasis per 100,000 population ranged from 2.2 cases in Arizona to 33.8 cases in Vermont (Table 1; Figure 1). Vermont reported the greatest number of cases per 100,000 population for each of the 3 years of the reporting period. Northern states reported more cases annually per 100,000 population than southern states (Table 1; Figure 1).

Surveillance data displayed a bimodal age distribution, with the greatest number of reported cases occurring among children aged 1–4 and 5–9 years and adults aged 35–44 years (Figure 2). When reports for which a patient's sex was missing or unknown were excluded, the percentage of cases reported to have occurred among males remained consistent at 56.2% (10,671 of 18,994) for 2006, 56.5% (11,069 of 19,585) for 2007, and 56.7% (10,786 of 19,019) for 2008 (Table 2).

The majority of cases for which data on race were available for 2006–2008 occurred among whites, followed by blacks, Asians/Pacific Islanders, and American Indians/Alaska Natives (Table 2). However, data on race were not included for 41.2%–43.7% of total annual case reports. Although 7.2%–8.2% of patients for whom data on ethnicity were reported were identified as Hispanic, data on ethnicity were lacking for 49.3%–52.2% of total annual case reports.

A twofold increase in reported giardiasis cases by onset of illness occurred during June–October compared with January–March (Figure 3). Age-specific analysis indicated a twofold increase in onset of illness during June–October among all age groups. This seasonality is particularly evident among children (Figure 4). The highest numbers of giardiasis cases were reported among children aged 1–4 and 5–9 years and adults aged 40–44 years (Figure 4). The incidence of giardiasis has remained relatively stable since it became nationally notifiable in 2002 (Figure 5).

Discussion

National giardiasis surveillance data are used to assess the epidemiologic characteristics and disease burden of giardiasis in the United States. Following a gradual decline in case reports during 1996–2001 (*33,34*), the number of case reports and disease incidence appears to have stabilized, coinciding with the disease becoming nationally notifiable in 2002 (Figure 5).

Giardiasis is widespread geographically in the United States. The number of cases reported is higher in the northern states (Figure 1). However, because differences in giardiasis surveillance systems among states can affect the capability to detect cases, whether this finding is of biologic significance or only reflects differences in case detection or reporting is difficult to determine.

Although giardiasis affects persons in all age groups, the number of reported cases was highest among children aged 1–9 years and adults aged 35–44 years. These data for younger age groups are consistent with reports published previously of giardiasis incidence being higher among younger children as well as contributing to transmission to their caregivers (e.g., child care facility staff, family members, and other household contacts) (*2,33–35,39,40*). *Giardia* was identified frequently as the cause of diarrhea among children examined in outpatient clinics (*41*), and transmission from ill children to household contacts has been documented in outbreak investigations (*29,42*).

The marked seasonality in the onset of illness occurring in early summer through early fall is not unexpected. A twofold increase in transmission of giardiasis occurred during the summer, coinciding with increased outdoor activities (e.g., camping and swimming). This increase likely reflects increased use of untreated water for drinking (e.g., lakes and rivers) while outdoors as well as increased use of community swimming (essentially communal bathing) venues by younger children during the summer months. In addition to animal contamination of surface water, transmission through use of surface water (e.g., lakes and rivers) and disinfected venues (e.g., swimming pools and water parks) is facilitated by the substantial number of *Giardia* cysts that can be shed by a single person (*9*); the extended periods of time that cysts can be shed (*10*); the low infectious dose (*8*); the moderate chlorine tolerance of *Giardia* (*43*); the prevalence of improper pool maintenance (i.e., insuf-

TABLE 1. Number and percentage* of giardiasis case reports, by state/area — National Notifiable Disease Surveillance System, United States, 2006–2008

State/Area	2006				2007				2008			
	No.	(%)	Rate†	No. outbreak cases§	No.	(%)	Rate	No. outbreak cases	No.	(%)	Rate	No. outbreak cases
Alabama	224	(1.2)	4.8		273	(1.4)	5.9		281	(1.5)	6.0	
Alaska	113	(0.6)	16.5	5	79	(0.4)	11.6		108	(0.6)	15.7	
Arizona	163	(0.8)	2.5		192	(1.0)	3.0		142	(0.7)	2.2	
Arkansas	148	(0.8)	5.2		158	(0.8)	5.6		143	(0.7)	5.0	
California	2,303	(12.0)	6.3		2,336	(11.8)	6.4		2,017	(10.5)	5.5	
Colorado	554	(2.9)	11.2	6	580	(2.9)	12.0	4	564	(2.9)	11.4	1
Connecticut	307	(1.6)	8.8		370	(1.9)	10.6		334	(1.7)	9.5	
Delaware	43	(0.2)	4.9		41	(0.2)	4.8		42	(0.2)	4.8	
District of Columbia	69	(0.4)	11.7		74	(0.4)	12.6		72	(0.4)	12.2	
Florida	1,165	(6.1)	6.4	156	1,268	(6.4)	7.0	83	1,391	(7.3)	7.6	82
Georgia	642	(3.3)	6.6		681	(3.4)	7.2		691	(3.6)	7.1	
Hawaii	58	(0.3)	4.5		77	(0.4)	6.0		42	(0.2)	3.3	
Idaho	191	(1.0)	12.5	1	224	(1.1)	15.0	9	211	(1.1)	13.8	1
Illinois	695	(3.6)	5.4	3	866	(4.4)	6.8		705	(3.7)	5.5	
Indiana	N¶				N				N			
Iowa	303	(1.6)	10.1		301	(1.5)	10.1		326	(1.7)	10.9	
Kansas	198	(1.0)	7.1		184	(0.9)	6.6	2	162	(0.8)	5.8	
Kentucky	N				N				N			
Louisiana	87	(0.5)	2.0		139	(0.7)	3.2		150	(0.8)	3.4	
Maine	192	(1.0)	14.6		197	(1.0)	15.0		188	(1.0)	14.3	1
Maryland	256	(1.3)	4.5	2	269	(1.4)	4.8	6	284	(1.5)	5.0	2
Massachusetts	621	(3.2)	9.6		605	(3.1)	9.4	12	678	(3.5)	10.4	3
Michigan	715	(3.7)	7.1		620	(3.1)	6.2	10	611	(3.2)	6.1	2
Minnesota	1,001	(5.2)	19.2		913	(4.6)	17.6		769	(4.0)	14.7	
Mississippi	N				N				N			
Missouri	548	(2.8)	9.3		515	(2.6)	8.8		468	(2.4)	7.9	
Montana	104	(0.5)	10.8		113	(0.6)	11.8		93	(0.5)	9.6	
Nebraska	122	(0.6)	6.8		161	(0.8)	9.1		210	(1.1)	11.8	1
Nevada	110	(0.6)	4.2		146	(0.7)	5.7	2	121	(0.6)	4.7	
New Hampshire	26	(0.1)	2.0		33	(0.2)	2.5		164	(0.9)	12.5	
New Jersey	476	(2.5)	5.5	96	403	(2.0)	4.7	115	520	(2.7)	6.0	
New Mexico	80	(0.4)	4.0		119	(0.6)	6.1	5	107	(0.6)	5.4	
New York**	2,311	(12.0)	11.9	32	2,122	(10.7)	10.9	24	2,133	(11.1)	10.9	33
New York City	936	(4.9)	11.3		847	(4.3)	10.2		851	(4.4)	10.2	
North Carolina	N				N				N			
North Dakota	38	(0.2)	5.9		60	(0.3)	9.4		36	(0.2)	5.6	1
Ohio	809	(4.2)	7.0	5	826	(4.2)	7.2	7	904	(4.7)	7.9	5
Oklahoma	166	(0.9)	4.6		172	(0.9)	4.8		180	(0.9)	4.9	
Oregon	417	(2.2)	11.0	9	462	(2.3)	12.4		455	(2.4)	12.0	4
Pennsylvania	825	(4.3)	6.6	47	758	(3.8)	6.1	58	879	(4.6)	7.1	31
Rhode Island	117	(0.6)	11.1		85	(0.4)	8.1		90	(0.5)	8.6	
South Carolina	112	(0.6)	2.5		121	(0.6)	2.7		136	(0.7)	3.0	3
South Dakota	97	(0.5)	12.1		104	(0.5)	13.1	5	136	(0.7)	16.9	11
Tennessee	241	(1.3)	3.9		304	(1.5)	4.9		225	(1.2)	3.6	
Texas	N				N				N			
Utah	471	(2.4)	17.2	21	466	(2.4)	17.5		374	(2.0)	13.7	
Vermont	193	(1.0)	31.1	1	171	(0.9)	27.5		210	(1.1)	33.8	
Virginia	514	(2.7)	6.6		582	(2.9)	7.6	3	432	(2.3)	5.6	
Washington	451	(2.3)	6.9		595	(3.0)	9.2		486	(2.5)	7.4	
West Virginia	57	(0.3)	3.1		52	(0.3)	2.9		71	(0.4)	3.9	2
Wisconsin	587	(3.1)	10.4	9	555	(2.8)	9.9		523	(2.7)	9.3	
Wyoming	38	(0.2)	7.1		49	(0.2)	9.4		49	(0.3)	9.2	5
Total 50 states	**18,958**	**(98.5)**	**7.5**	**392**	**19,421**	**(98.1)**	**7.6**	**345**	**18,913**	**(98.8)**	**7.4**	**188**

TABLE 1. (*Continued*) Number and percentage* of giardiasis case reports, by state/area — National Notifiable Disease Surveillance System, United States, 2006–2008

	2006				2007				2008			
State/Area	No.	(%)	Rate†	No. outbreak cases§	No.	(%)	Rate	No. outbreak cases	No.	(%)	Rate	No. outbreak cases
Guam	5	(<0.1)	2.9		2	(<0.1)	1.2		0			
Puerto Rico	276	(1.4)	7.0	1	371	(1.9)	9.4	1	227	(1.2)	5.7	1
Total	**19,239**	**(100.0)**	**—**	**393**	**19,794**	**(100.0)**	**—**	**346**	**19,140**	**(100.0)**	**—**	**189**

Sources: Population estimates are from the Population Division, U.S. Census Bureau. Annual estimates of the resident population for the United States, regions, states, and Puerto Rico: April 1, 2001–July 1, 2008 (NST-EST 2008-01) available at http://www.census.gov/popest/states. Estimates of the New York City population are from annual estimates of the population for incorporated places over 100,000, ranked by July 1, 2005 Population: April 1, 2001–July 1, 2008 (SUB-EST 2008-01) available at http://www.census.gov/popest/cities. Estimates of the population of Guam are from International Data Base (IDB) data access–spreadsheet available at http://www.census.gov/ipc/www/idbsprd.html.

* Percentages might not total 100% because of rounding.

† Per 100,000 population.

§ Number of cases linked to a known outbreak.

¶ *Giardia* is not a reputable condition in five states.

** New York State case reports include New York City.

ficient disinfection, filtration, and recirculation of water), particularly of children's wading pools (*44*); the prevalence of *Giardia* in fecal material in pools (*45*); and documented transmission of *Giardia* infection among diapered children (*28,42,46*) who use swimming venues regularly. This seasonal variation also has been noted in state, Canadian provincial, and previous U.S. national surveillance data for giardiasis and cryptosporidiosis (*33–35,39,40*).

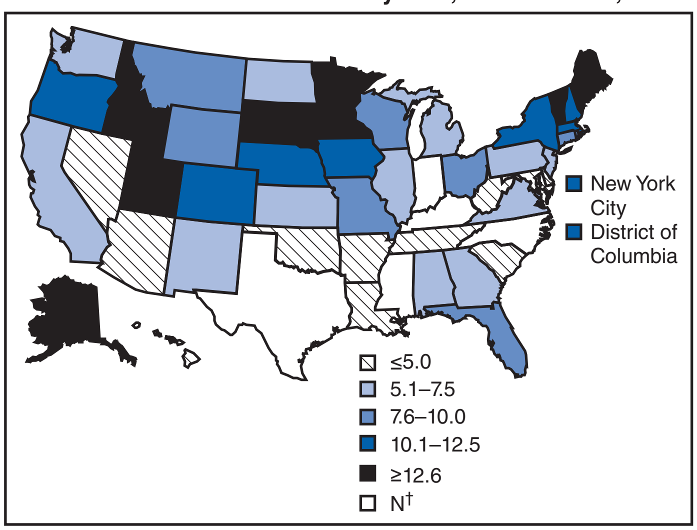
Among patients for whom data on sex were reported, a majority of cases occurred among males (Table 2). This might be attributable in part to sexual contact among men who have sex with men (*16*). However, the majority of cases occurred in males in nearly every age group (except those aged ≥65 years), which suggests the influence of other factors.

Outbreaks have been linked to drinking water sources contaminated with *Giardia*. In 2007, a neighborhood outbreak of giardiasis in New Hampshire was linked to contamination of a ground water well used for drinking water by the community (*30*). Thirty-one confirmed or probable cases were identified and determined to be associated with drinking tap water. One of the groundwater wells supplying the community was dug in close proximity to surface water, a small stream, where evidence of beaver inhabitation was discovered. The well tested positive for fecal coliforms and was disconnected from the water supply, after which the outbreak declined. PCR testing was used to genotype the cases as assemblage B, a subtype that has not been reported previously in humans but has been found in beavers in nearby Massachusetts. Two beavers from the area tested negative for *Giardia*, but beavers could not be ruled out as the source because shedding of cysts is sporadic.

Although untreated or unfiltered drinking water is a risk factor for giardiasis, contaminated recreational water has also been implicated as a source of illnesses and outbreaks. In a study of sporadic giardiasis in England, swallowing water while swimming and recreational contact with fresh water were both risk factors for contracting *Giardia* (*18*). An outbreak in Florida in 2006 at an interactive fountain was caused by *Giardia* and *Cryptosporidium* and resulted in illness among 57 persons over a 2-month period (*47*). Investigation of this outbreak revealed deficiencies in the design, maintenance, and operation of the interactive fountain as well as bather behavior (i.e., swimming while ill with diarrhea) that led to ongoing contamination of the interactive fountain.

Foodborne transmission of *Giardia* generally occurs by direct contamination by an infected food handler (*27*), the use of contaminated water in the preparation of food (*48*), or animal contamination of food (*49*). In a study of sporadic giardiasis in England, eating lettuce was associated with increased risk for giardiasis (*18*). The use of reclaimed wastewater for irrigation

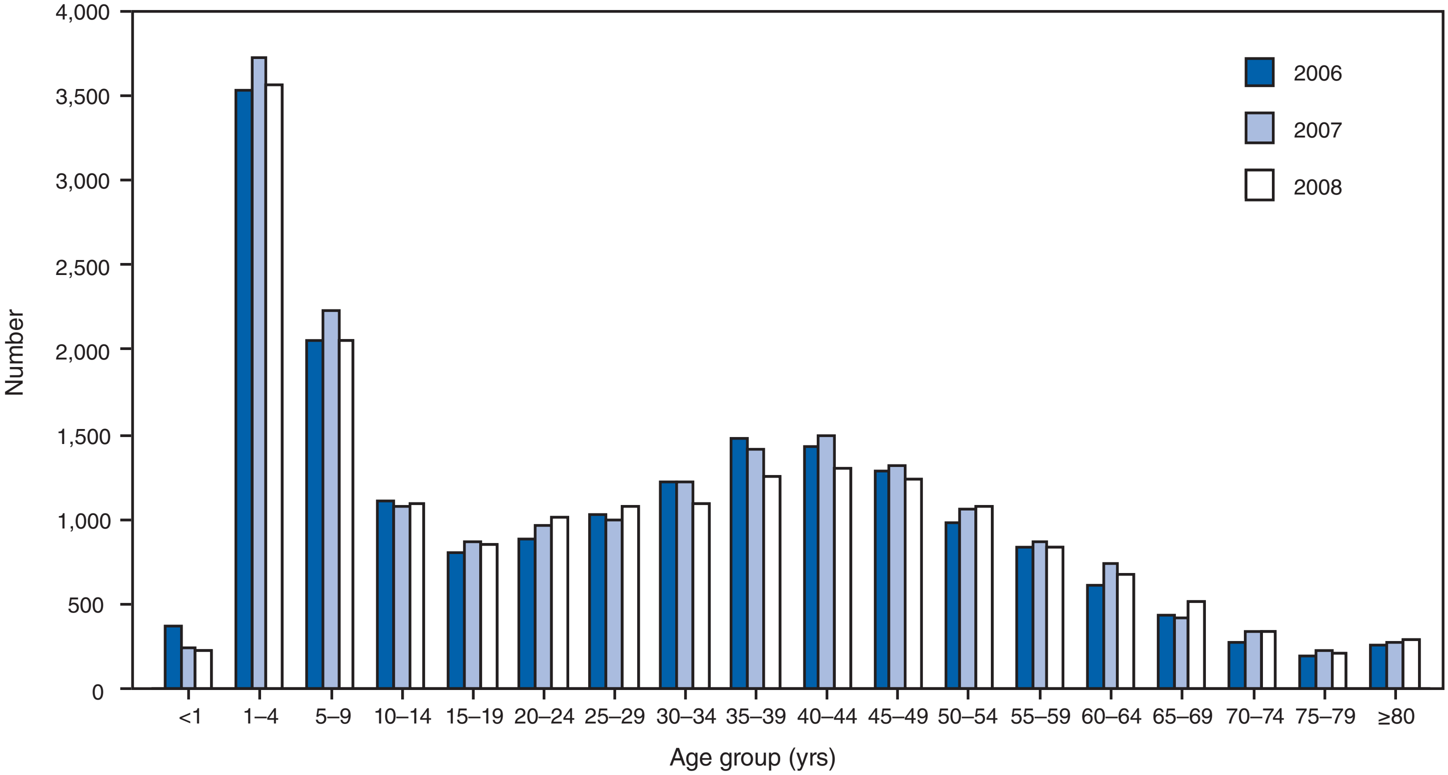
FIGURE 1. Incidence* of giardiasis, by state/area — National Notifiable Disease Surveillance System, United States, 2008



* Per 100,000 population.

† Not a reportable disease in these states.

FIGURE 2. Number* of giardiasis case reports, by age group and year — National Notifiable Disease Surveillance System, United States, 2006–2008



* N = 58,186; age group unknown for 1,083 cases.

is associated with the finding of *Giardia* cysts on fresh produce (*50*). The importance of food in the transmission of *Giardia* is highlighted by five giardiasis outbreaks during 2006–2007.

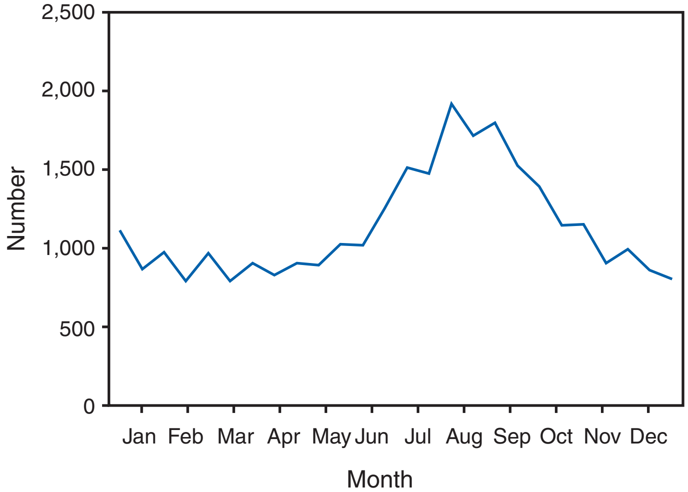
In 2006, two confirmed foodborne outbreaks occurred in California and New York (*26*). In California, 48 ill persons had attended the same church event, and in New York, eight patients

TABLE 2. Number and percentage* of giardiasis case reports, by selected demographic characteristics — National Notifiable Disease Surveillance System, United States 2006–2008

Characteristic	2006 No.	2006 (%)	2007 No.	2007 (%)	2008 No.	2008 (%)
Sex						
Male	10,671	(55.5)	11,069	(55.9)	10,786	(56.4)
Female	8,323	(43.3)	8,516	(43.0)	8,233	(43.0)
Unknown/Missing	245	(1.3)	209	(1.1)	121	(0.6)
Total	**19,239**	**(100.0)**	**19,794**	**(100.0)**	**19,140**	**(100.0)**
Race						
American Indian/Alaska Native	86	(0.4)	79	(0.4)	70	(0.4)
Asian/Pacific Islander	726	(3.8)	878	(4.4)	1,203	(6.3)
Black	1,231	(6.4)	1,517	(7.7)	1,333	(7.0)
White	8,063	(41.9)	8,089	(40.9)	7,895	(41.2)
Other	720	(3.7)	684	(3.5)	752	(3.9)
Unknown/Missing	8,413	(43.7)	8,547	(43.2)	7,887	(41.2)
Total	**19,239**	**(100.0)**	**19,794**	**(100.0)**	**19,140**	**(100.0)**
Ethnicity						
Hispanic	1,584	(8.2)	1,430	(7.2)	1,436	(7.5)
Non-Hispanic	7,784	(40.5)	8,033	(40.6)	8,277	(43.2)
Unknown/Missing	9,871	(51.3)	10,331	(52.2)	9,427	(49.3)
Total	**19,239**	**(100.0)**	**19,794**	**(100.0)**	**19,140**	**(100.0)**

* Totals might not add up to 100% because of rounding.

FIGURE 3. Number* of giardiasis case reports, by date of illness onset — National Notifiable Disease Surveillance System, United States, 2006–2008



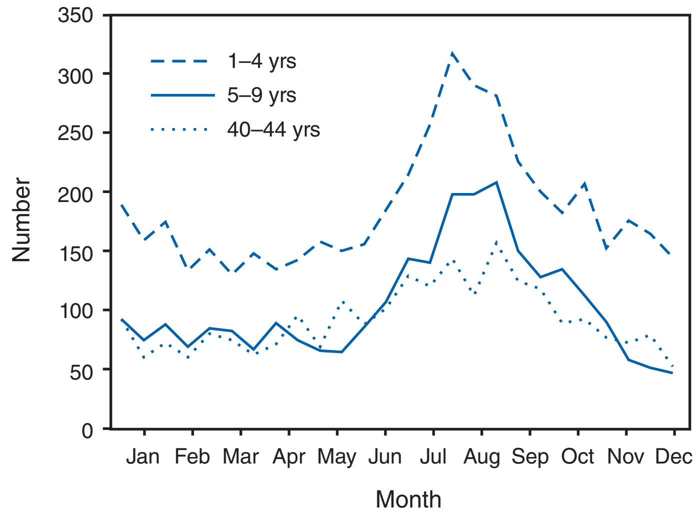
* N = 58,186; onset date was unknown for 28,650 cases.

became ill after a restaurant-catered lunch at a school. A third suspected outbreak occurred in Florida, where four patients had eaten at the same restaurant. In 2007, two confirmed foodborne outbreaks occurred in Missouri and Vermont (*26*). In Missouri, 15 attendees at a catered event became ill after eating chicken parmesan and lettuce salads. The caterer was not licensed and worked out of her home (*26*). In Vermont, 36 boys became ill at a summer camp with no running water or electricity. The source of the outbreak was not identified (*26*).

The relative importance of zoonotic transmission of *Giardia*, either directly or indirectly (e.g., through water or food contamination) is unknown. Cattle have been suspected to contribute to the contamination of drinking water with *Giardia* as a result of farm run-off and the land application of animal waste. In the United States and Australia, livestock are infected predominately with the bovine-specific genetic assemblage E (which is not infective to humans). Assemblage A (which is a human pathogen) can be found in a small proportion of cattle, but investigations of contaminated water supplies typically incriminate effluent from human waste as the source of contamination (*12*). However, as the New Hampshire outbreak demonstrates, other potential zoonotic sources exist in wildlife. In a molecular study, the same genetic assemblage B was identified in samples from humans, muskrats, beavers, and rabbits, suggesting the potential for zoonotic transmission or water contamination from these species (*51*).

Household pets also represent a potential source of zoonotic transmission. *Giardia* is the most prevalent intestinal parasite in otherwise healthy pet dogs in Australia; 9.4% of dogs in a study tested positive on fecal specimens; assemblages C and D were identified most frequently (*52*). A study in India identified

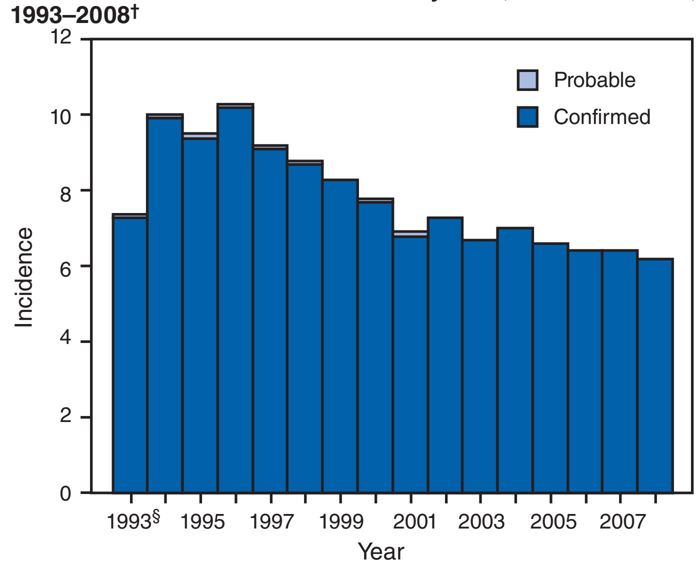
FIGURE 4. Number* of giardiasis case reports, by selected age group† and date of illness onset — National Notifiable Disease Surveillance System, United States, 2006–2008



* N = 9,921.
† The three age groups (1–4, 5–9, and 40–44 years) with the highest numbers of giardiasis case reports are presented. All age groups exhibited a twofold or greater increase during summer months.

identical assemblages (A and B) in humans and their pet dogs (*53*). Because of poor hygiene in the village, including the dogs' access to human feces, whether the infection was of zoonotic or anthroponotic transmission was unclear. Ongoing advances in molecular epidemiology will increase understanding of the importance of animals as a risk factor for giardiasis (*54*).

FIGURE 5. Incidence* of giardiasis, by year — National Notifiable Disease Surveillance System, United States, 1993–2008†



* Per 100,000 population.
† N = 354,385.
§ First year with use of assigned reporting number.

Despite the zoonotic potential, infected human waste is the greatest known risk factor for infection with *Giardia*, whether transmission is through direct fecal-oral contact or indirectly through ingestion of fecally contaminated water. In a study of sporadic giardiasis in New Zealand, exposure to human waste was a significant risk factor, specifically exposure to diaper changing and occupational exposure to human waste (*55*). The study also determined that housewives and nursing mothers were at increased risk for giardiasis compared with other social groups, which is consistent with increased risk for exposure to diapers (*55*). Children attending child care facilities are at increased risk for giardiasis (*15*), and outbreaks have occurred in child care facilities, leading to infections among caregivers and household members (*28,56,57*).

Giardiasis (as with all diseases caused by enteric pathogens) is likely underreported because 1) not all infected persons are symptomatic, 2) those who are symptomatic do not always seek medical care (*58,59*), 3) health-care providers do not always include laboratory diagnostics in their evaluation of non-bloody diarrheal diseases (*58*), 4) case reports are not always completed for positive laboratory results or forwarded to public health officials (*60*), and 5) giardiasis is not a reportable disease in five states.

Its low infectious dose, protracted communicability, and moderate chlorine tolerance make *Giardia* ideally suited for transmission through drinking and recreational water, food, and person-to-person contact. Strategies to reduce the incidence of giardiasis have focused on reducing waterborne and person-to-person transmission. The Environmental Protection Agency (EPA) enacted the Surface Water Treatment Rule (SWTR) in 1989 and the Interim Enhanced SWTR in 1998 (*21*). These regulations have decreased the number of giardiasis outbreaks associated with community drinking water systems (*20–24*). In 2006, EPA finalized the Ground Water Rule to address contamination of public ground water (well) systems, which is likely to reduce the number of groundwater-associated outbreaks of giardiasis. Person-to-person transmission of *Giardia* is difficult to interrupt in a systematic fashion, particularly in childcare settings (*56*). Adherence to appropriate infection control (e.g., exclusion of children ill with diarrhea, hand washing, diaper changing, and separation of ill children) policies is recommended for controlling giardiasis, and other enteric pathogens, in these group settings (*57*).

Limitations

The data provided in this report are subject to several limitations, including likely underreporting of cases, lack of information on race and ethnicity on the majority of case-reports, and absence of information on risk factors or attributable fractions by exposure types. Despite these limitations, the data in this report provide the only national overview of giardiasis available.

Conclusion

Continued efforts to reduce risk and improve diagnosis and reporting of giardiasis are needed to decrease the transmission of giardiasis in the United States. Prevention measures (Box 1) and measures to improve surveillance for giardiasis and increase understanding of its epidemiology and the associated disease burden (Box 2) have been recommended. Additional information about giardiasis is available at http://www.cdc.gov/ncidod/dpd/parasites/giardiasis/factsht_giardia.htm.

BOX 1. CDC recommendations to prevent and control giardiasis

Practice good hygiene.

- Everywhere
  - Wash hands with soap and water for at least 20 seconds, rub hands together vigorously, and scrub all surfaces
    - before preparing or eating food,
    - after using the toilet,
    - after changing diapers or cleaning up a child who has used the toilet,
    - before and after tending to someone who is ill with diarrhea, and
    - after handling an animal or its waste.

Additional information about hygiene is available at http://www.cdc.gov/healthywater/hygiene.

- At child care facilities
  - To reduce risk for disease transmission, exclude children with diarrhea from child care settings until the diarrhea has stopped.
- At recreational water venues
  - Protect others by not swimming if while experiencing diarrhea (this is essential for children in diapers and aquatics staff).
  - Shower before entering the water.
  - Wash children thoroughly (especially their bottoms) with soap and water after they use the toilet or their diapers are changed and before they enter the water.
  - Take children on frequent bathroom breaks and check their diapers often.
  - Change diapers in the bathroom, not at the poolside.

Additional information about recreational water illnesses and how to stop them from spreading is available at http://www.cdc.gov/healthywater/swimming.

- Around animals
  - Minimize contact with the stool of all animals, particularly young animals.
  - When cleaning up animal feces, wear disposable gloves, and always wash hands when finished.
  - Wash hands after any contact with animals or their living areas.
- Outside
  - Wash hands after gardening, even if wearing gloves.

Avoid water that might be contaminated.

- Do not swallow water while swimming in swimming pools, spas, interactive fountains, lakes, rivers, springs, ponds, streams, or the ocean.
- Do not drink untreated water from lakes, rivers, springs, ponds, streams, or shallow wells.
- Do not drink inadequately treated water or ice made from water during communitywide outbreaks caused by contaminated drinking water.
- Do not use or drink inadequately treated water or use ice when traveling in countries where the water supply might be unsafe.
- If the safety of drinking water is in doubt (e.g., outbreak, poor sanitation, or lack of water treatment systems),
  - drink bottled water
  - disinfect water by heating it to a rolling boil for 1 minute, or
  - use a filter that has been tested and rated by National Safety Foundation (NSF) Standard 53 or NSF Standard 58 for cyst and oocyst reduction; filtered water will need additional treatment to kill or inactivate bacteria and viruses.

Information about water filters is available at http://www.cdc.gov/crypto/gen_info/filters.html.

Avoid eating food that might be contaminated.

- Use safe, uncontaminated water to wash all food that is to be eaten raw.
- After washing vegetables and fruit in safe, uncontaminated water, peel them before eating them raw.
- Avoid eating uncooked foods when traveling in countries with poor water treatment and food sanitation.

Information about how to prevent illnesses while traveling is available at http://wwwnc.cdc.gov/travel/content/safe-food-water.aspx.

Prevent contact and contamination with feces during sex.

- Use a barrier during oral-anal sex.
- Wash hands immediately after handling a condom used during anal sex and after touching the anus or rectal area.

BOX 2. CDC Recommendations to improve surveillance for giardiasis and increase understanding of its epidemiology and associated disease burden

- Encourage health-care providers to consider and specifically request testing for *Giardia* in the workup of gastrointestinal illness (i.e., order testing of stool for ova and parasites).
- Continue to educate and encourage health-care providers as well as public and private laboratories to improve reporting of cases of giardiasis to jurisdictional health departments.
- Expand the use of molecular testing and the application of molecular epidemiology to *Giardia*-positive samples.
- Encourage jurisdictional health departments to report giardiasis data to CDC through the National Notifiable Diseases Surveillance System (NNDSS).
- Publish and distribute giardiasis surveillance data regularly for public health education purposes.
- Conduct further epidemiologic studies of the geographic variability, incidence, and risk factors for giardiasis.

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