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Cryptosporidiosis Surveillance — United States, 2009–2010

and

Giardiasis Surveillance — United States, 2009–2010

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Cryptosporidiosis Surveillance — United States, 2009–2010

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Abstract

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

Reporting Period: 2009–2010.

System Description: Fifty state and two metropolitan public health agencies voluntarily report cases of cryptosporidiosis through CDC's National Notifiable Diseases Surveillance System.

Results: For 2009, 7,656 confirmed and probable cases of cryptosporidiosis (2.5 per 100,000 population) were reported; for 2010, 8,951 confirmed and probable cases (2.9 per 100,000 population) were reported. All jurisdictions reported cryptosporidiosis cases for 2009–2010, and the number of jurisdictions reporting >3.5 cases per 100,000 population was 18 for 2009 and 20 for 2010. Cases were most frequently reported in children aged 1–9 years, followed by adults aged 25–29 years. This is the first reporting period in which more cases of cryptosporidiosis were reported in females than in males. Peak onset of illness occurred during early summer through early fall; the sympton onset of cases in children aged 5–9 years peaked earlier than that of cases reported in adults aged 25–34 years.

Interpretation: Transmission of *Cryptosporidium* occurs throughout the United States. Rate data from reporting jurisdictions should be compared with caution because individual jurisdictions have varying capacities to detect, investigate, and report cases. The symptom onset and age-specific peaks coincide with the summer recreational water season and might reflect increased use of communal swimming venues (e.g., swimming pools and interactive fountains) by young children who then transmit the parasite to other users and their caregivers.

Public Health Action: Local, state, and federal public health agencies can use cryptosporidiosis surveillance data to characterize the epidemiology of cryptosporidiosis in the United States, establish public health priorities (e.g., research) to improve cryptosporidiosis prevention and control, and design and evaluate efforts (e.g., health communication and policy) to prevent and control the transmission of *Cryptosporidium*.

Introduction

Cryptosporidiosis is a gastrointestinal illness caused by protozoa of the genus *Cryptosporidium*, whose taxonomy continues to evolve (*1*). Revised *Cryptosporidium* taxonomy based on recent advances in molecular testing methods has revealed that multiple species can infect humans. *C. hominis* (previously known as *C. parvum* genotype I) primarily exists in a human-to-human transmission cycle. *C. parvum* (previously known as *C. parvum* genotype II) can infect both humans and ruminants (e.g., preweaned calves), each with their own transmission cycles that intersect in zoonotic disease. Molecular techniques are needed to distinguish the morphologically indistinguishable oocysts of the two species. In addition, molecular studies have demonstrated that multiple subtypes of *C. parvum* and *C. hominis* can infect humans (*2*). To a lesser extent, human infections caused by *C. felis*, *C. canis*, *C. meleagridis*, *C. suis*, *C. muris*, *C. andersoni*, and *Cryptosporidium* cervine, horse, rabbit, skunk, and chipmunk I genotypes also have been documented. Illnesses caused by infection with the different *Cryptosporidium* species and subtypes within species can differ clinically (*3,4*).

In immunocompetent persons, cryptosporidiosis is characterized by weight loss, abdominal pain, diarrhea, which can be profuse, usually nonbloody, and watery, as well as anorexia, fatigue, joint pain, headache, fever, and vomiting (*5*). However, asymptomatic infection also can occur (*6–9*). Recurrence of symptoms after seeming resolution has been

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frequently reported; illness is self-limiting, and symptoms most frequently completely resolve within 2–3 weeks (*5*). Clinical presentation of cryptosporidiosis in HIV-infected patients varies with level of immunosuppression, ranging from no symptoms or transient disease to relapsing, chronic diarrhea or cholera-like diarrhea, which can lead to life-threatening wasting and malabsorption (*10*). Extraintestinal cryptosporidiosis (i.e., in the biliary or respiratory tract or rarely in the pancreas) has been documented among immunocompromised persons. The incidence of cryptosporidiosis among HIV-infected persons has decreased since the introduction of highly active antiretroviral therapy for HIV infection (*11,12*). The U.S. Food and Drug Administration approved nitazoxanide in 2004 for the treatment of cryptosporidiosis in immunocompetent children aged 1–11 years and in 2005 in immunocompetent persons aged ≥1 years (*13,14*). Nitazoxanide has not been demonstrated to be an efficacious treatment of cryptosporidiosis in immunocompromised persons (*15,16*).

Cryptosporidium oocysts are infectious immediately upon being excreted in feces. *Cryptosporidium* is transmitted by the fecal-oral route and results from the ingestion of oocysts through the consumption of fecally contaminated food or water or through contact with an infected person or animal. The infectious dose is low; studies have demonstrated that the ingestion of ≤10 *C. hominis* or *C. parvum* oocysts can cause infection in healthy persons (*17,18*). Infected persons have been reported to shed 10^7–10^8 oocysts in a single bowel movement (*19*) and can excrete infectious oocysts for up to 60 days after cessation of gastrointestinal symptoms (*20*).

Although cryptosporidiosis cases can occur sporadically, outbreaks have been well documented since the first reported U.S. drinking water-associated outbreak in 1984 (*21*) and the first reported U.S. recreational water–associated outbreak in 1988 (*22,23*). *Cryptosporidium* has since emerged as the most frequently recognized cause of recreational water–associated outbreaks, particularly in treated venues (e.g., pools and interactive fountains) (*24*). *Cryptosporidium* oocysts are extremely chlorine tolerant and can survive for 3.5–10.6 days in water where free chlorine levels are maintained at CDC-recommended levels of 1–3 mg/L (*25*). More recent outbreaks of cryptosporidiosis have been reported between various hosts. Foodborne outbreaks of cryptosporidiosis, most notably associated with food handlers who are ill or with ingestion of unpasteurized apple cider (*26,27*), with outbreaks resulting from person-to-person transmission (particularly in childcare settings (*28*), and from animal-to-person transmission, also have been reported (*29,30*).

In 1994, the Council of State and Territorial Epidemiologists (CSTE) called for the reporting of cryptosporidiosis as a nationally notifiable disease; 1995 marked the first full year of reporting. National surveillance data for 1995–2008 have been published elsewhere (*31–35*). This report summarizes national cryptosporidiosis surveillance data for 2009–2010 and analyzes cryptosporidiosis rates and the annual percentage change in national rates for the years 1995–2010.

Methods

Case Definition

Confirmed and probable cases of cryptosporidiosis are reported voluntarily to CDC. A confirmed case of cryptosporidiosis is defined as detection of *Cryptosporidium*

- organisms in stool, intestinal fluid, tissue samples, or biopsy specimens;
- antigens in stool or intestinal fluid; or
- nucleic acid by polymerase chain reaction (PCR)-based detection in stool, intestinal fluid, tissue samples, or biopsy specimens (*36*).

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

Testing

If a patient experiences diarrhea lasting >3 days, health-care providers should consider cryptosporidiosis in the differential. To ensure appropriate diagnostic testing, health-care providers should specifically request *Cryptosporidium* testing, because routine examination of stool for ova and parasites is unlikely to include testing for *Cryptosporidium*. Oocyst excretion can be intermittent; therefore, the parasite might not be detected in a given stool specimen, so three stool specimens collected on separate days should be examined before considering test results to be negative (*37*). Commercially available immunoassay kits are available and might be more diagnostically sensitive and specific than routine microscopic examination (*38*). Direct fluorescent antibody (DFA) testing is an extremely diagnostically sensitive and specific detection method and is considered a benchmark for quality in testing (*39*). Other immunodiagnostic kits that do not require microscopy (e.g., enzyme immunoassay testing and rapid immunochromatographic cartridge assays) also are available; they do not take the place of routine ova and parasite

examination. False-positive results might occur when using rapid immunochromatographic cartridge assays (*40*); therefore, confirmation by microscopy should be considered.

If PCR-based detection is needed to confirm cryptosporidiosis transmission, health-care providers should contact the state health department or CDC because this specialized testing for *Cryptosporidium* is not commercially available. PCR-based genotyping and subtyping tools are increasingly being used in outbreak investigations and infection- or contamination-source tracking to differentiate *Cryptosporidium* species and subtypes. If stool is preserved in formalin, *Cryptosporidium* isolates cannot be reliably genotyped or subtyped (*41*).

Reporting

Public health agencies in the 50 states, the District of Columbia (DC), and New York City (NYC) voluntarily report cases of cryptosporidiosis to CDC 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 symptom onset, and indicate whether the case is associated with a detected outbreak. Because data on immune status are not collected as part of NNDSS cryptosporidiosis reporting, the number of cryptosporidiosis patients who are immunosuppressed is unknown. Because data in this report were finalized at a different time, the number of cases differs slightly from the number reported in CDC's annual summary of notifiable diseases.

Analysis

National cryptosporidiosis surveillance data for 2009–2010 were analyzed using SAS v.9.3 (SAS Institute Inc.; Cary, North Carolina). Population data from the U.S. Census Bureau using intercensal estimates for April 1, 2000 to July 1, 2010 were used to calculate rates by year, reporting jurisdiction, age, and sex.

Data were analyzed regionally on the basis of the U.S. Census Bureau-defined Northeast, Midwest, South, and West regions (*42*). To account for differences in the seasonal use of recreational water, the West region was further subdivided into Northwest and Southwest.

Results

The total number of reported cases of cryptosporidiosis increased 16.9% from 7,656 for 2009 to 8,951 for 2010 (Table 1). This followed a peak of 11,657 in 2007 (Figure 1). The rate of reported cases was 2.5 and 2.9 per 100,000 population in 2009 and 2010, respectively. The annual rate of reported cryptosporidiosis in the United States was relatively stable during 1995–2004, ranging from 0.4–1.3 per 100,000 population. Rates during 2005–2010 ranged from 2.3–3.9 per 100,000 population, peaking in 2007 (*34*).

Of cases reported for 2009 and 2010, 2.6% and 3.3%, respectively, were reported to be associated with a detected outbreak. All 50 states and two metropolitan jurisdictions reported cryptosporidiosis cases during the reporting period. By region, the rate of reported cryptosporidiosis cases per 100,000 population ranged from 1.5 in the Southwest to 4.3 in the Midwest in 2009 and 1.4 in the Southwest to 6.4 in the Midwest in 2010 (Table 1, Figure 2). By reporting jurisdiction, the rate of reported cryptosporidiosis cases per 100,000 population ranged from 0.1 in Hawaii to 17.1 in South Dakota in 2009 and 0.1 in Hawaii to 17.4 in Wisconsin in 2010. The number of jurisdictions reporting rates of >3.5 cases per 100,000 population was 18 in 2009 and 20 in 2010.

During 2009–2010, the date of symptom onset was reported nationally for 12,226 (73.6%) of the 16,607 cases reported. The number of cases by symptom onset peaked in mid-August (n = 1,077), which was 4.5 times larger than the lowest number of cases by symptom onset in late December (n = 237) (Figure 3). Increased reporting (>400 cases reported biweekly) was noted during June–September.

National surveillance data displayed a bimodal age distribution; cases were most frequently reported in children aged 1–9 years, followed by adults aged 25–29 years (Figure 4). In 2009, the rate of reported cryptosporidiosis was highest in children aged 1–4 years (5.3 per 100,000 population) and lowest in adults aged 50–54 years (1.5 per 100,000 population). The percentage of cases among males was 46.4% (3,464 of 7,656) and 48.3% (4,295 of 8,951) in 2009 and 2010, respectively (Table 2). The annual incidence rate by sex ranged from 2.3 to 2.9 per 100,000 population for males and females (Table 2, Figure 5). Cryptosporidiosis rates were higher among males aged 1–4 years than among females of the same age group. Conversely, females had a higher rate among persons aged 20–39 years. Symptom onset of cryptosporidiosis in children peaked earlier in the summer than among adults.

TABLE 1. Number, percentage,* and rate† of cryptosporidiosis case reports, by region/state — National Notifiable Diseases Surveillance System, United States, 2009–2010

Region/State	2009				2010			
	No.	(%)	Rate	No. outbreak cases§	No.	(%)	Rate	No. outbreak cases
Northeast	**1,293**	**(16.9)**	**2.3**	**4**	**1,366**	**(15.3)**	**2.5**	**27**
Connecticut	38	(0.5)	1.1		77	(0.9)	2.2	
Maine	67	(0.9)	5.0		93	(1.0)	7.0	5
Massachusetts	181	(2.4)	2.8		173	(1.9)	2.6	2
New Hampshire	84	(1.1)	6.4		59	(0.7)	4.5	1
New Jersey	53	(0.7)	0.6		52	(0.6)	0.6	
New York¶	302	(3.9)	1.6		335	(3.7)	1.7	1
New York City	80	(1.0)	1.0		107	(1.2)	1.3	
Pennsylvania	467	(6.1)	3.7	4	489	(5.5)	3.8	18
Rhode Island	22	(0.3)	2.1		18	(0.2)	1.7	
Vermont	79	(1.0)	12.6		70	(0.8)	11.2	
Midwest	**2,889**	**(37.7)**	**4.3**	**45**	**4,260**	**(47.6)**	**6.4**	**155**
Illinois	154	(2.0)	1.2		334	(3.7)	2.6	64
Indiana	288	(3.8)	4.5		287	(3.2)	4.4	1
Iowa	232	(3.0)	7.6	5	396	(4.4)	13.0	52
Kansas	104	(1.4)	3.7	1	107	(1.2)	3.7	
Michigan	285	(3.7)	2.9		320	(3.6)	3.2	5
Minnesota	347	(4.5)	6.6	29	398	(4.4)	7.5	4
Missouri	193	(2.5)	3.2		548	(6.1)	9.1	
Nebraska	117	(1.5)	6.5		264	(2.9)	14.4	1
North Dakota	31	(0.4)	4.7		35	(0.4)	5.2	
Ohio	388	(5.1)	3.4	10	476	(5.3)	4.1	25
South Dakota	138	(1.8)	17.1		107	(1.2)	13.1	
Wisconsin	612	(8.0)	10.8		988	(11.0)	17.4	3
South	**2,138**	**(27.9)**	**1.9**	**138**	**2,006**	**(22.4)**	**1.7**	**86**
Alabama	68	(0.9)	1.4		184	(2.1)	3.8	19
Arkansas	60	(0.8)	2.1		33	(0.4)	1.1	
Delaware	8	(0.1)	1.4		8	(0.1)	1.3	
District of Columbia	12	(0.2)	1.3		9	(0.1)	1.0	
Florida	497	(6.5)	2.7	52	408	(4.6)	2.2	32
Georgia	336	(4.4)	3.5		266	(3.0)	2.7	
Kentucky	67	(0.9)	1.6		85	(0.9)	2.0	
Louisiana	56	(0.7)	1.2		66	(0.7)	1.5	
Maryland	43	(0.6)	0.8		42	(0.5)	0.7	
Mississippi	19	(0.2)	0.6		24	(0.3)	0.8	
North Carolina	159	(2.1)	1.7	51	94	(1.1)	1.0	5
Oklahoma	142	(1.9)	3.8		120	(1.3)	3.2	
South Carolina	62	(0.8)	1.4	1	123	(1.4)	2.7	30
Tennessee	81	(1.1)	1.3		55	(0.6)	0.9	
Texas	419	(5.5)	1.7	34	359	(4.0)	1.4	
Virginia	86	(1.1)	1.1		109	(1.2)	1.4	
West Virginia	23	(0.3)	1.2		21	(0.2)	1.1	

See table footnotes on page 5.

Of patients for whom race was reported, 85.4% (4,891 of 5,724) and 86.2% (5,977 of 6,933) were white in 2009 and 2010, respectively. Of patients for whom ethnicity was reported, 10.6% (512 of 4,811) and 9.5% (571 of 5,982) were Hispanic in 2009 and 2010, respectively (Table 2). Annually, data on race were missing for approximately one fourth of cases reported; data on ethnicity were missing for approximately one third of cases reported.

Discussion

National surveillance data are used to help characterize the epidemiology of cryptosporidiosis in the United States. In 2009 and 2010, the total number and rate of cases reported annually decreased from that of 2007, but represent a marked increase compared with annual statistics before 2005 (Figure 1). Whether the persistently elevated annual case counts and rates reflect changes in diagnostic testing practices, reporting patterns, or a change in infection and disease caused by *Cryptosporidium* remains unclear. The increased annual number of reported cases and rates during 2005–2010 might be the

TABLE 1. (*Continued*) Number, percentage,* and rate† of cryptosporidiosis, by region/state — National Notifiable Diseases Surveillance System, United States, 2009–2010

Region/State	2009				2010			
	No.	(%)	Rate	No. outbreak cases§	No.	(%)	Rate	No. outbreak cases
Northwest	**491**	**(6.4)**	**3.4**	**14**	**513**	**(5.7)**	**3.6**	**27**
Alaska	8	(0.1)	1.1		6	(0.1)	0.8	
Idaho	98	(1.3)	6.3		110	(1.2)	7.0	
Montana	57	(0.7)	5.8		49	(0.5)	4.9	
Oregon	199	(2.6)	5.2	14	218	(2.4)	5.7	27
Washington	102	(1.3)	1.5		102	(1.1)	1.5	
Wyoming	27	(0.4))	4.8		28	(0.3)	5.0	
Southwest	**845**	**(11.0)**	**1.5**	**0**	**806**	**(9.0)**	**1.4**	**3**
Arizona	34	(0.4)	0.5		40	(0.4)	0.6	
California	459	(6.0)	1.2		384	(4.3)	1.0	
Colorado	138	(1.8)	2.8		134	(1.5)	2.7	
Hawaii	1	(0.0)	0.1		1	(0.0)	0.1	
Nevada	25	(0.3)	0.9		38	(0.4)	1.4	3
New Mexico	149	(1.9)	7.3		137	(1.5)	6.6	
Utah	39	(0.5)	1.4		72	(0.8)	2.6	
Total	**7,656**	**(100.0)**	**2.5**	**201**	**8,951**	**(100.0)**	**2.9**	**298**

Sources: Population estimates are from the U.S. Census Bureau. Intercensal estimates of the resident population for the United States, regions, states, and Puerto Rico: April 1, 2000 to July 1, 2010. Available at http://www.census.gov/popest/data/index.html. Estimates of the New York City population are from Intercensal estimates of the resident population for counties: April 1, 2000 to July 1, 2010 (summing populations of Bronx, Kings, New York, Richmond, and Queens counties). Available at http://www.census.gov/popest/data/intercensal/county/county2010.html.

* Percentages might not total 100% because of rounding.

† Incidence per 100,000 population on the basis of U.S. Census Bureau population estimates.

§ Number of cases linked to a suspected outbreak.

¶ New York State case reports include New York City.

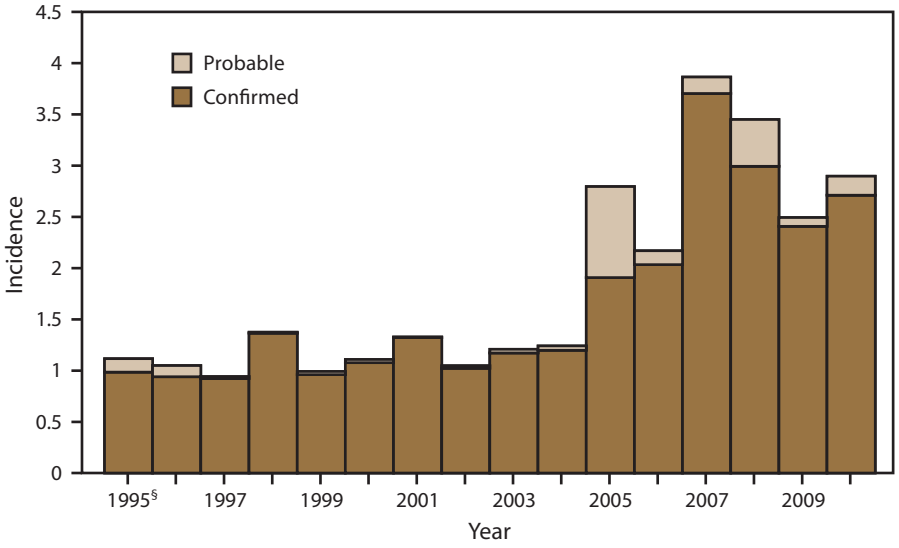
result of an increase in the number of communitywide and large (e.g., >1,000 cases) cryptosporidiosis outbreaks (*24,43–51*). Further, 2009 and 2010 had the lowest annual proportion of cases reported to be associated with detected cryptosporidiosis outbreaks since national reporting began in 1995 (*32–35*). This coincided with a decrease in the number of reported communitywide and large cryptosporidiosis outbreaks during 2009–2010.

The number of reported cases and cost of cryptosporidiosis in the United States continue to be substantial. Approximately 748,000 cryptosporidiosis cases occur annually (*52*). Each year, hospitalizations resulting from cryptosporidiosis cost an estimated $45.8 million; additionally, each ambulatory care visit for cryptosporidiosis costs $267–$757, depending on the patient's type of health-care insurance coverage (*53*). The high incidence and cost of cryptosporidiosis underscores the need for a better understanding of cryptosporidiosis epidemiology in the United States, particularly of risk factors, to optimize prevention and control. Prevention and control measures include 1) practicing good hygiene (e.g., not swimming when ill with diarrhea and washing hands appropriately); 2) avoiding contaminated water (e.g., not swallowing recreational water), using secondary or supplementary treatment systems (e.g., ultraviolet irradiation or ozonation) to inactivate *Cryptosporidium* in treated recreational water venues, and treating and filtering drinking water to inactivate or remove the parasite sufficiently; 3) exercising caution when traveling; and 4) avoiding fecal exposure during sexual activity (Box).

The geographic variation, age distribution, and early-summer through early-fall seasonality described here are consistent with findings of previous reports on U.S. national cryptosporidiosis surveillance data (*32–35*). Cryptosporidiosis is widespread geographically in the United States, with all 50 states and two metropolitan jurisdictions reporting cryptosporidiosis cases during 2009–2010. The cryptosporidiosis rate in the Midwest region was 1.3–2.9 times greater than that of the other regions in 2009 and 1.8–4.6 times greater than that of other regions in 2010. It is difficult to determine whether this disparity is the result of regional differences in the capacity to detect, investigate, or report cases, or if true regional differences exist in the transmission of *Cryptosporidium*. If the latter is correct, the increased cryptosporidiosis rate in the Midwest region might be linked to increased contact with preweaned calves (*54,55*).

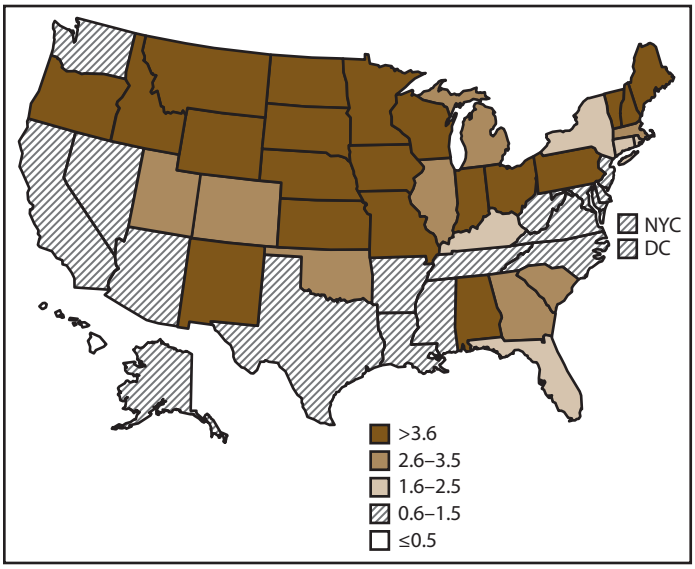
Although cryptosporidiosis affects persons in all age groups, the number of reported cryptosporidiosis cases and rates were highest among children aged 1–4 years, followed by those aged 5–9 years and adults aged 25–29 years (Figure 4). Similar findings also have been noted in U.S. state, Canadian provincial, Australian state, and national Finnish and United Kingdom surveillance data (*56–61*). Among patients aged 1–4

FIGURE 1. Incidence* of cryptosporidiosis, by year — National Notifiable Diseases Surveillance System, United States, 1995–2010†



* Per 100,000 population.
† N = 85,514.
§ First full year of national reporting.

FIGURE 2. Incidence* of cryptosporidiosis, by reporting jurisdiction — National Notifiable Diseases Surveillance System, United States, 2010



Abbreviations: NYC = New York City, DC = District of Columbia.
* Per 100,000 population.

years, the rate was higher in males; among those aged 20–39 years, the rate was higher in females. These data might reflect *Cryptosporidium* transmission from young children to their caregivers (e.g., childcare staff, family members, and other household contacts) (*28*).

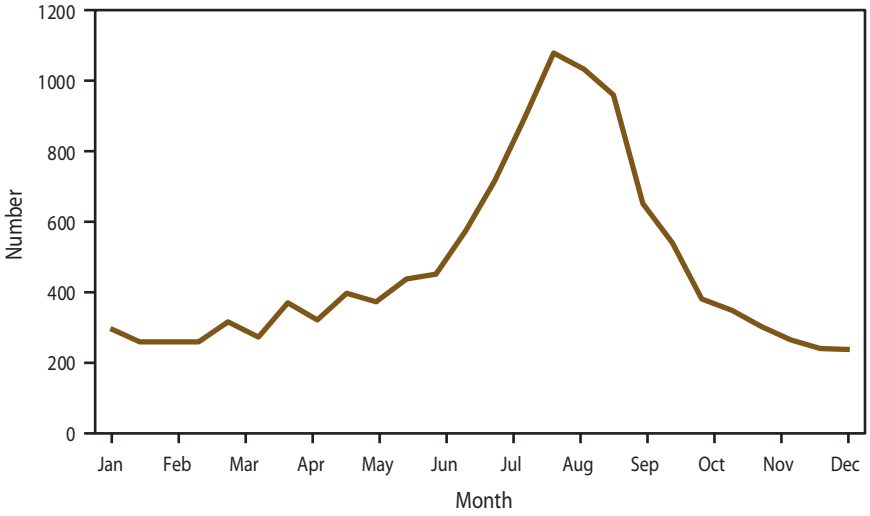
Cryptosporidium can be transmitted by ingesting contaminated food and water or from contact with infected persons or animals. Several studies have characterized risk factors associated with cryptosporidiosis. Persons at increased risk for infection include those who have exposure to recreational water (*73,74*); have contact with livestock, particularly preweaned calves (*73,75,76*); have ingested untreated drinking water (*75*); are close contacts of infected persons (e.g., those in the same family or household or in childcare settings) (*73,74,76*); or who have traveled to areas where the disease is endemic (*73,76*). These risk factors vary by geographic setting (e.g., rural or urban) and by the *Cryptosporidium* species identified in the ill person (*77*).

The five-fold increase in cryptosporidiosis symptom onset during the summer, similarly observed in previous reports from the U.S. and other countries (*56–59,61*), is consistent with increased use of treated recreational water venues during the summer, particularly among younger children (*24,43–51,62–64*). *Cryptosporidium* has become the leading cause of reported treated recreational water–associated outbreaks of gastroenteritis (*24*). 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 (*20,65*), the low infectious dose (*18,66*), and the tolerance of *Cryptosporidium* oocysts to chlorine (*25*).

Recreational water can amplify smaller outbreaks into communitywide transmission when persons who are ill visit multiple recreational water venues or introduce the parasite to other settings (e.g., child care centers or schools) (*67*). To prevent communitywide outbreaks, CDC has collaborated with state health departments to develop guidelines for rapidly implementing communitywide control measures once an increase in case reporting exceeds a preoutbreak disease action threshold (e.g., an outbreak or a twofold to threefold increase in cases over baseline) rather than waiting for an outbreak investigation to implicate a specific source of transmission (*62*).

Reducing the transmission of this highly infectious, extremely chlorine-tolerant pathogen in treated recreational water venues (e.g., pools) requires a multipronged approach. Effective prevention requires that swimmers practice healthy swimming behaviors (e.g., keeping the parasite out of the water by not swimming while ill with diarrhea and, if diagnosed with cryptosporidiosis, at least 2 weeks following recovery). Once the parasite has been introduced into the water, engineering (e.g., secondary or supplemental disinfection systems or enhanced filtration) can minimize contamination and help control *Cryptosporidium* transmission.

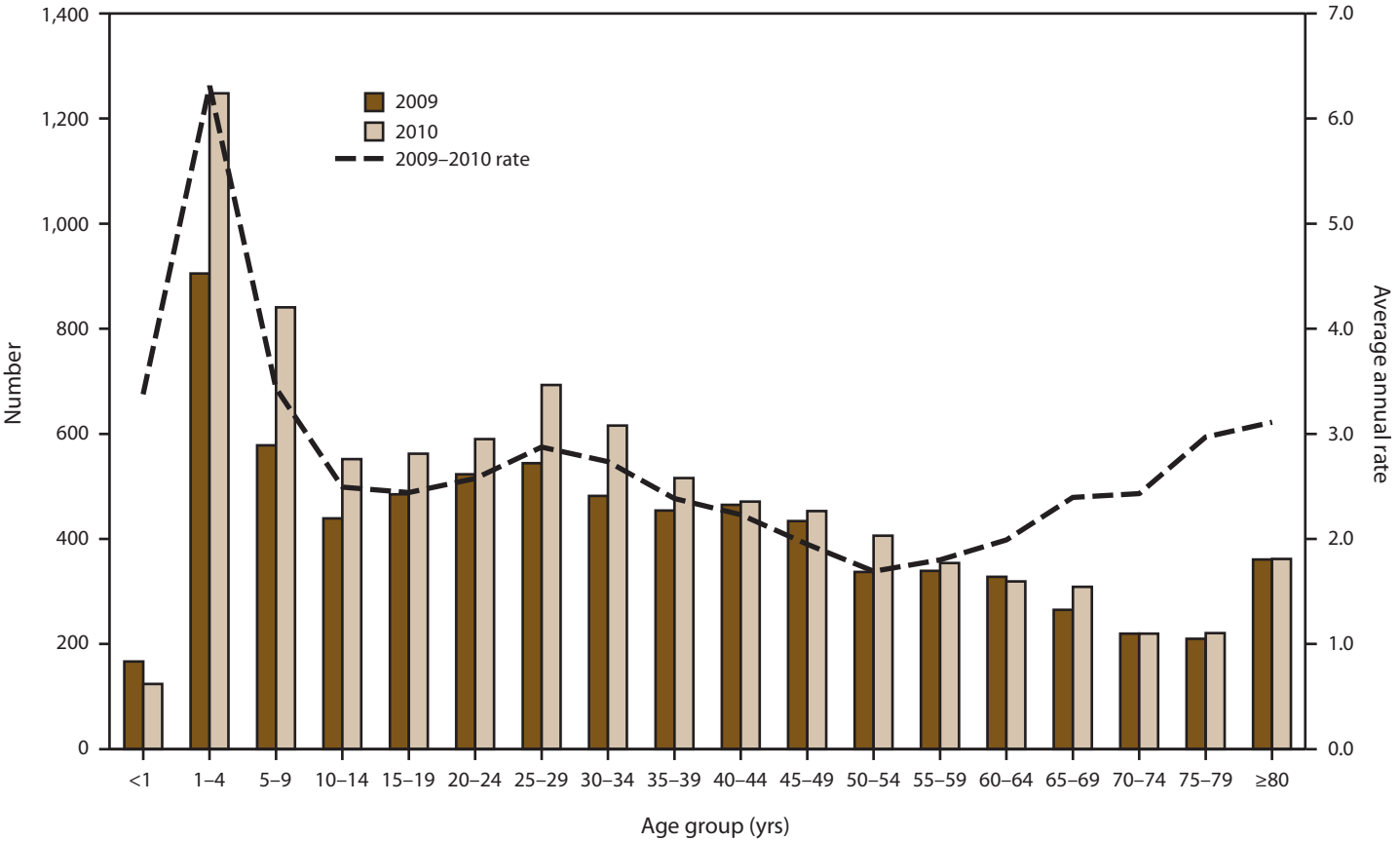
FIGURE 3. Number* of cryptosporidiosis case reports, by date of symptom onset — National Notifiable Diseases Surveillance System, United States, 2009–2010



* N = 16,607; date of onset for 4,381 patients was unknown.

Low infectious dose (*18,19*) and extreme chlorine tolerance (*25*) also make *Cryptosporidium* ideally suited for transmission through drinking water. To prevent *Cryptosporidium* transmission through drinking water, the U.S. Environmental Protection Agency (EPA) has implemented regulations designed to enhance the treatment of surface water supplies, including multiple regulatory changes enacted following a massive outbreak of cryptosporidiosis in 1993 in Milwaukee, Wisconsin (*68*). Subsequently, no cryptosporidiosis outbreaks associated with the use of community surface water supplies have been detected in the United States (*44,46,47,49,69–72*), highlighting the potential benefits of these regulations. To address the risk for outbreaks and illness associated with use of groundwater sources,

FIGURE 4. Number* and average annual rate† of cryptosporidiosis case reports, by age group and year—National Notifiable Diseases Surveillance System, United States, 2009–2010



* N = 16,607; age for 214 patients was unknown.
† Incidence per 100,000 population.

TABLE 2. Number, percentage*, and rate† of cryptosporidiosis, by selected patient demographic characteristics — National Notifiable Diseases Surveillance System, United States, 2009–2010

Characteristic	2009			2010		
	No.	(%)	Rate	No.	(%)	Rate
Sex						
Male	3,464	(45.2)	2.3	4,295	(48.0)	2.8
Female	3,998	(52.2)	2.6	4,605	(51.4)	2.9
Missing	194	(2.5)	—	51	(0.6)	—
Race§						
Alaska Native/ American Native	32	(0.4)	—	56	(0.6)	—
Asian Pacific Islander	60	(0.8)	—	67	(0.7)	—
Black	544	(7.1)	—	617	(6.9)	—
White	4,891	(63.9)	—	5,977	(66.8)	—
Other	197	(2.6)	—	216	(2.4)	—
Missing	1,932	(25.2)	—	2,018	(22.5)	—
Ethnicity§						
Hispanic	512	(6.7)	—	571	(6.4)	—
Non-Hispanic	4,299	(56.2)	—	5,411	(60.5)	—
Missing	2,845	(37.2)	—	2,969	(33.2)	—
Total	**7,656**	**(100.0)**	**2.5**	**8,951**	**(100.0)**	**2.9**

Source: Population estimates are from the U.S. Census Bureau. Intercensal estimates of the resident population by sex and age for the United States: April 1, 2000 to July 1, 2010. Available at http://www.census.gov/popest/data/intercensal/national/nat2010.html.
* Percentages might not total 100% because of rounding.
† Incidence per 100,000 population on the basis of U.S. Census Bureau population estimates.
§ Rates by race and ethnicity are not reported because of the high percentage of unreported race and ethnicity.

EPA also is implementing the Groundwater Rule, which requires additional treatment and filtration of certain public ground water (e.g., well) systems (*69*).

In the United States, no federal agency regulates the design, construction, operation, and maintenance of treated recreational water venues. Pool codes are reviewed and approved by state or local public health officials. This lack of uniform national standards has been identified as a barrier to the prevention and control of outbreaks associated with treated recreational water venues. To provide support to state and local health departments, CDC is sponsoring development of the Model Aquatic Health Code (MAHC) (http://www.cdc.gov/healthywater/swimming/pools/mahc). MAHC is a collaborative effort between local, state, and federal public health and the aquatics sector to develop a data-driven, knowledge-based resource for state and local jurisdictions reviewing and updating their existing pool codes to optimally prevent and control recreational water–associated illness.

Limitations

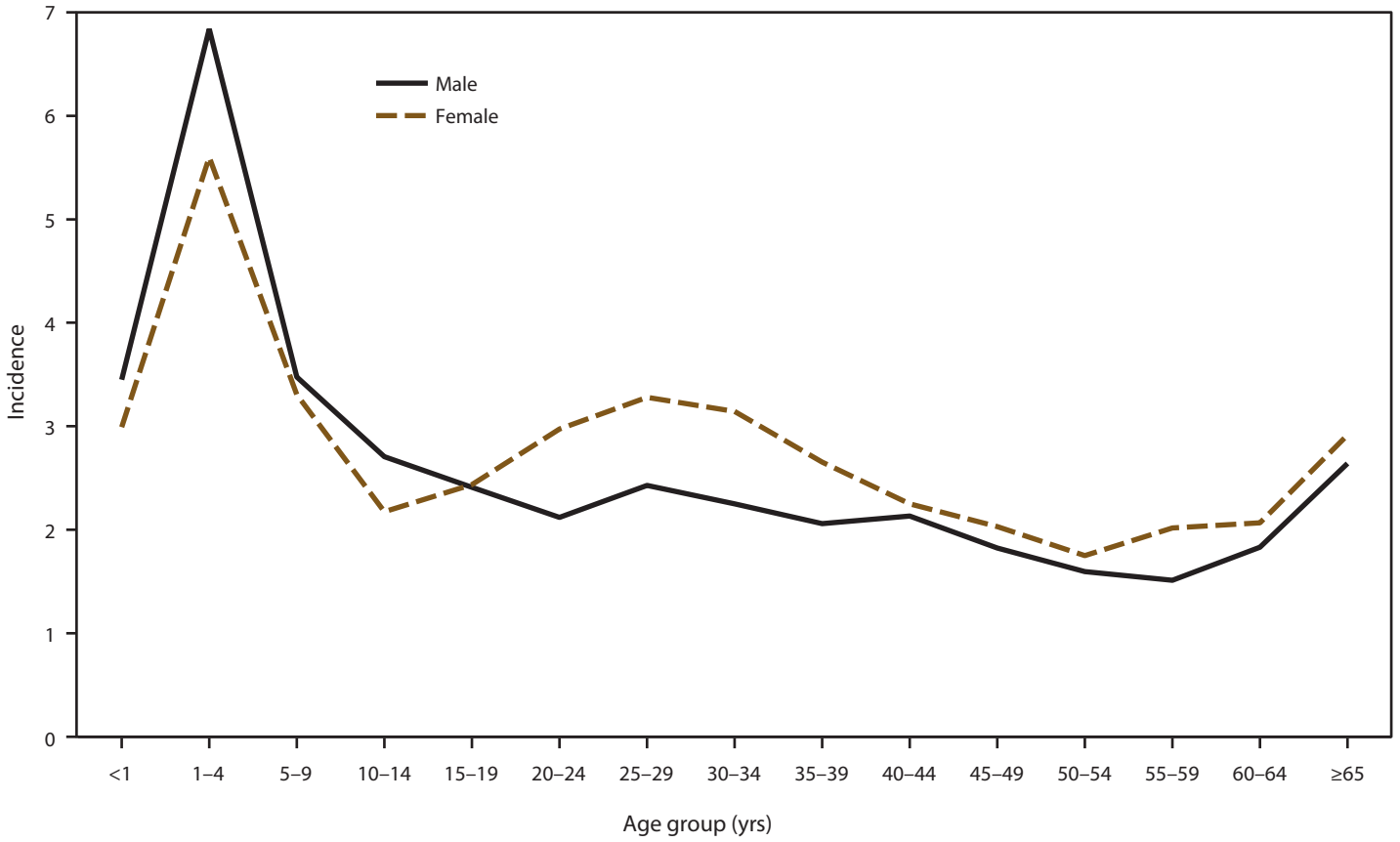
The findings in this report are subject to at least three limitations. First, NNDSS data are incomplete on race, ethnicity, and symptom onset date, and do not include data on exposures and immune status of patients. Second, the cryptosporidiosis rate is likely to be underestimated by these national surveillance data because of underreporting (e.g., not all infected persons are symptomatic, persons who are symptomatic do not always seek medical care, health-care providers do not always include laboratory diagnostics in their evaluation of nonbloody diarrheal diseases, laboratories typically do not include *Cryptosporidium* testing in routine examination of stool for ova and parasites, case reports are not always completed for positive laboratory results or forwarded to public health officials). Third, confirmed cases of cryptosporidiosis based on false-positive results following the use of rapid cartridge assays might have been included.

Conclusion

The quality and completeness of national cryptosporidiosis data can be improved by enhancing the capacity of state and local jurisdictions to detect, investigate, and voluntarily report cases (*78*). Existing state and local public health infrastructure supported through CDC (e.g., FoodNet and Environmental Health Specialists Network [EHS-Net] Water Program) could facilitate enhancement of surveillance efforts. Although many jurisdictions investigate cryptosporidiosis cases, risk-factor data are not available for all jurisdictions via NNDSS. Collaborating with reporting jurisdictions to improve CDC's ability to access jurisdictional risk factor data would enhance national collection efforts while simplifying analysis of these data as well as their comparison with data from other sources (e.g., FoodNet) (*73*). The systematic collection and molecular characterization of *Cryptosporidium* isolates would further the understanding of U.S. cryptosporidiosis epidemiology by revealing transmission patterns and potential risk factors (*79*). Such an effort would require phasing out the practice of preserving stool specimens with formalin, which decreases the ability to perform molecular amplification methods. CDC is preparing to pilot Crypto Net, the first U.S. molecular surveillance system for parasites, to better understand the transmission of cryptosporidiosis in the United States.

CDC can further optimize the quality of national surveillance data by investigating reports of and factors associated with false-positive cryptosporidiosis results (e.g.,

FIGURE 5. Incidence* of cryptosporidiosis, by sex and age group — National Notifiable Diseases Surveillance System, United States, 2009–2010



* Per 100,000 population.

testing for *Cryptosporidium* when the testing method is not indicated, user error, or problems with test validity) when using rapid cartridge assays (*40*) (e.g., conducting a head-to-head comparison of rapid cartridge assays to DFA), and responding accordingly. Establishing standards for how diagnostic methods are integrated into the case definition will improve the stability of NNDSS data and allow for the interpretation of national reporting trends.* Additionally, advocating for the incorporation of *Cryptosporidium* testing in standard ova and parasite testing, and educating health-care providers to specifically name request testing for *Cryptosporidium*, might also improve data quality.

Improving the completeness and quality of national surveillance data will better direct the design and evaluation of health communication and policy efforts to prevent and control cryptosporidiosis. In response to the increased case counts and rates of cryptosporidiosis and treated recreational water–associated outbreaks of cryptosporidiosis, CDC has developed two websites: Cryptosporidiosis (available at http://www.cdc.gov/parasites/crypto) and Healthy Swimming (available at http://www.cdc.gov/healthywater/swimming/index.html). The websites target multiple audiences (e.g., state and local public health partners, the aquatics sector, and the public) and provide resources (e.g., for responding to cryptosporidiosis outbreaks) and recommendations (e.g., on inactivation of *Cryptosporidium* in treated recreational water or preventing and controlling *Cryptosporidium* transmission in child care settings). National surveillance data can be used to guide the revision, updating, and expansion of health communication efforts and other public health interventions (e.g., MAHC) to prevent and control cryptosporidiosis.

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* In 2011, the CDC/CSTE national cryptosporidiosis case definition changed, reflecting that cases diagnosed by rapid cartridge assays are classified as probable cases.

BOX. 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 stool.

Information about hand hygiene is available from CDC at http://www.cdc.gov/healthywater/hygiene/hand/handwashing.html.

Note: *Cryptosporidium* oocysts are not effectively inactivated by alcohol-based hand sanitizers.

- At child care facilities
  - Exclude children with diarrhea from child care settings until the diarrhea has stopped.
- At the pool
  - Protect others by not swimming if you are experiencing diarrhea (this is essential for children in diapers). 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.

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

- Around animals
  - Minimize contact with the stool of all animals, particularly young animals.
  - Wear disposable gloves when cleaning up after a pet, 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. Cryptosporidiosis can become a life-threatening disease for immunocompromised persons.
  - Do not handle animal feces because infection can be life-threatening for immunocompromised persons.

Avoid water (drinking and recreational) 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 or supplemental disinfection systems (e.g., ultraviolet light and ozone) to inactivate 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, and lack of water treatment systems),
  - drink bottled water, or
  - disinfect by heating the water to a rolling boil for 1 minute, or
  - use a filter that has been tested and rated by National Sanitation 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 from CDC at http://www.cdc.gov/parasites/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.
- Avoid eating uncooked foods when traveling in countries with poor water treatment and food sanitation.

Practice extra caution when traveling.

Information about how to prevent illnesses while traveling is available from CDC 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.

Information about cryptosporidiosis prevention and control is available from CDC at http://www.cdc.gov/parasites/crypto/prevention.html.

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Giardiasis Surveillance — United States, 2009–2010

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Abstract

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

Reporting Period: 2009–2010.

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

Results: During 2009–2010, the total number of reported cases of giardiasis increased slightly from 19,403 for 2009 to 19,888 for 2010. During this period, 50 jurisdictions reported giardiasis cases. A larger number of case reports were received for children aged 1–9 years than with other age groups. The number of cases peaked 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 surveillance capacity differs between states. Giardiasis is reported more frequently in young children, which might reflect increased contact with contaminated water or ill persons.

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 and epidemiologic studies have associated giardiasis with the development of chronic enteric disorders, allergies, chronic fatigue, and reactive arthritis (*5–10*).

Giardia infection is transmitted through 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 (*11*). The cysts are infectious immediately upon being excreted in feces (*12*). The infectious dose is low; ingestion of 10 cysts has been reported to cause infection (*12*).

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Infected persons have been reported to shed 10^8–10^9 cysts in their stool per day and to excrete cysts for months (*12–14*). Effective therapies are available for patients with symptomatic giardiasis, including metronidazole, tinidazole, nitazoxanide, paromomycin, furazolidone, and quinacrine (*15*).

Giardiasis is often detected in travelers to areas where disease is endemic (*16,17*) and among internationally adopted children (*18*). Transmission can occur to close contacts of infected persons, including to children in childcare settings and their caregivers (*14,19*). Participation in backpacking, camping, and swimming, having contact with some animal species, and certain sexual practices might increase the risk for giardiasis (*20*).

Because *Giardia* cysts can be excreted intermittently, multiple stool collections (i.e., three stool specimens collected on separate days) increase test sensitivity (*21*). Use of concentration methods and trichrome staining might not be sufficient to identify *Giardia* because variability in the concentration of organisms in stool can make this infection difficult to diagnose. For this reason, fecal immunoassays that are more sensitive and specific should be used (*22*). Direct fluorescent antibody (DFA) testing is an extremely sensitive and specific detection method, and is considered the benchmark for accuracy 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 (*22*); they do not take the place of routine ova and parasite examination and DFA.

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 1992–2008 have been published previously (*23–26*). Reporting of giardiasis as a nationally notifiable disease began in 2002. This report summarizes national giardiasis surveillance data for 2009–2010 and the annual percentage change in national rates for the years 1995–2010.

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* organisms, antigen, or DNA in stool, intestinal fluid, tissue samples, biopsy specimens, or other biological sample (*27*).

A probable case of giardiasis is a clinically compatible case that is linked epidemiologically to a confirmed case (*27*).

Reporting

States, the District of Columbia (DC), New York City (NYC), the Commonwealth of Puerto Rico, and Guam voluntarily report cases of giardiasis to CDC through the National Notifiable Diseases Surveillance System (NNDSS). Giardiasis is not reportable in Kentucky, Mississippi, North Carolina, or Texas. It became nonreportable in Tennessee starting in January 2010 and in Oklahoma starting in July 2010. 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 symptom onset, and indicate whether the reporting jurisdiction classified the case as outbreak-associated. Because data in this report were finalized at a different time, the number of cases differs slightly from the number reported in CDC's annual summary of notifiable diseases.

Analysis

National giardiasis surveillance data for 2009–2010 were analyzed using SAS v.9.3 (SAS Institute Inc.; Cary, North Carolina). Population data from the U.S. Census Bureau using intercensal estimates for April 1, 2000 to July 1, 2010, were used to calculate rates by year, age, and sex. Data were analyzed regionally on the basis of U.S. Census Bureau-defined regions (Northeast, Midwest, South, and West). To account for differences in the seasonal use of recreational water, the West region was further subdivided into Northwest and Southwest.

Results

During 2009–2010, the total number of reported cases of giardiasis increased 1.9%, from 19,562 for 2009 to 19,927 for 2010 (Table 1). During this period, 50 jurisdictions (46 states, two cities (DC and NYC), Puerto Rico, and Guam) reported giardiasis cases. Giardiasis rates in the United States remained relatively stable at 7.3–7.6 cases per 100,000 population.

For 2010, among reported cases, the rate of giardiasis per 100,000 population ranged from 2.6 in Arizona to 29.6 in Vermont (Table 1, Figure 1). Vermont reported the highest rate for both years of the reporting period, at 35.4 in 2009 and 29.6 in 2010. The Midwest region reported the highest rate of giardiasis in 2010 at 11.4 per 100,000 population, followed by the Northwest at 10.3 (Table 1, Figure 1).

Surveillance data displayed a bimodal age distribution, with the greatest number and rate of reported cases occurring among children aged 1–9 years, with a smaller, flatter peak among adults aged 35–49 years (Figure 2). When reports for which a patient's sex was missing or unknown were excluded (1%–2.5%), the percentage of cases reported to have occurred among males remained consistent at 56.2% (10,635 of 18,911) for 2009 and 56.7% (11,138 of 19,638) for 2010 (Table 2). Analysis of rates by age and sex revealed that giardiasis was more often reported among males in each age group (Figure 3). This difference was most pronounced among men aged 35–54 years.

Most cases for which data on race were available for 2009–2010 occurred among whites, followed by blacks, Asians/Pacific Islanders, and American Indians/Alaska Natives (Table 2). However, data on race were not included for 41.9%–43.7% of total cases reported annually. Although 6.9%–9.6% of patients were identified as Hispanic, data on ethnicity were lacking for 48.9% of total annual case reports.

A twofold increase in reported giardiasis cases occurred during the peak month of reporting in August compared with the lowest month, December (Figure 4). The increased number of cases began in mid-May, peaked in August, and declined through September.

Among all jurisdictions that reported cases of giardiasis, the rate has declined from 13.8 to 7.6 (45%) since the peak in case reporting in 1995. Since 2002, when giardiasis became nationally notifiable, the incidence rates have remained relatively stable, ranging from 8.7–7.2 (Figure 5).

TABLE 1. Number, percentage,* and rate† of giardiasis case reports, by region/state/territory — National Notifiable Diseases Surveillance System, United States, 2009–2010

Region/State/Territory	2009				2010			
	No.	(%)	Rate	No. outbreak cases§	No.	(%)	Rate	No. outbreak cases§
Northeast	**5,278**	**(27.0)**	**9.6**	**43**	**5,086**	**(25.5)**	**9.2**	**19**
Connecticut	290	(1.5)	8.1		291	(1.5)	8.1	
Maine	223	(1.1)	16.8		223	(1.1)	16.8	
Massachusetts	751	(3.8)	11.5	8	725	(3.6)	11.1	
New Hampshire	198	(1.0)	15.0		156	(0.8)	11.8	
New Jersey	430	(2.2)	4.9		484	(2.4)	5.5	
New York¶	2251	(11.5)	11.7	19	2152	(10.8)	11.1	3
New York City	832	(4.3)	10.2		922	(4.6)	11.3	
Pennsylvania	839	(4.3)	6.6	16	787	(3.9)	6.2	16
Rhode Island	75	(0.4)	7.1		83	(0.4)	7.9	
Vermont	221	(1.1)	35.4		185	(0.9)	29.6	
Midwest	**4,890**	**(25.0)**	**10.3**	**5**	**5,417**	**(27.2)**	**11.4**	**11**
Illinois	613	(3.1)	4.8		691	(3.5)	5.4	
Indiana	312	(1.6)	4.8	4	398	(2.0)	6.1	4
Iowa	291	(1.5)	9.6		284	(1.4)	9.3	
Kansas	161	(0.8)	5.7		208	(1.0)	7.3	
Michigan	672	(3.4)	6.8	1	697	(3.5)	7.1	3
Minnesota	675	(3.5)	12.8		850	(4.3)	16.0	
Missouri	524	(2.7)	8.8		426	(2.1)	7.1	
Nebraska	178	(0.9)	9.8		223	(1.1)	12.2	
North Dakota	32	(0.2)	4.8		37	(0.2)	5.5	
Ohio	806	(4.1)	7.0		872	(4.4)	7.6	2
South Dakota	112	(0.6)	13.9		103	(0.5)	12.6	
Wisconsin	514	(2.6)	9.1		628	(3.2)	11.0	2
South	**4,738**	**(24.2)**	**6.6**	**89**	**4,621**	**(23.2)**	**7.2**	**122**
Alabama	204	(1.0)	4.3		220	(1.1)	4.6	1
Arkansas	155	(0.8)	5.4		138	(0.7)	4.7	
Delaware	29	(0.1)	3.3		35	(0.2)	3.9	1
District of Columbia	73	(0.4)	12.3	2	56	(0.3)	9.3	
Florida	1981	(10.1)	10.6	87	2139	(10.7)	11.4	106
Georgia	747	(3.8)	7.8		796	(4.0)	8.2	
Kentucky	NR				NR			
Louisiana	203	(1.0)	4.5		197	(1.0)	4.3	
Maryland	277	(1.4)	4.8		262	(1.3)	4.5	2
Mississippi	NR				NR			
North Carolina	NR				NR			
Oklahoma	171	(0.9)	4.6		62**	(0.3)	3.3	
South Carolina	106	(0.5)	2.3		147	(0.7)	3.2	
Tennessee	230	(1.2)	3.6		NR			
Texas	NR				NR			
Virginia	504	(2.6)	6.4		512	(2.6)	6.4	12
West Virginia	58	(0.3)	3.1		57	(0.3)	3.1	

See table footnotes on page 16.

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 (*23,24*), the number of cases reported and rates appears to have stabilized, coinciding with the disease becoming nationally notifiable in 2002 (Figure 1). Although giardiasis is reported throughout the United States, the rates are highest in northern states (Figure 1), and Vermont has reported the highest rate for each of the last 5 years. It is difficult to determine whether this finding is of biologic significance or if it reflects different surveillance capacities among states.

Giardia is primarily transmitted through ingestion of infected human waste, either through exposure to fecally contaminated water or food, through contact with an infected person (e.g., exposure during diaper changing), or occupational exposure to human waste (*28,29*). Drinking water is an important vehicle for *Giardia* transmission. *G. intestinalis* was the single most frequently identified pathogen in all drinking water outbreaks reported in the United States during 1971–2006, responsible for 121 (28%) of 432 outbreaks with an identified etiology (*30*). Untreated drinking water was identified as a risk factor

TABLE 1. (*Continued*) Number, percentage,* and rate† of giardiasis case reports, by region/state/territory — National Notifiable Diseases Surveillance System, United States, 2009–2010

Region/State/Territory	2009				2010			
	No.	(%)	Rate	No. of outbreak cases§	No.	(%)	Rate	No. of outbreak cases§
Northwest	**1,413**	**(7.2)**	**9.9**	**4**	**1,479**	**(7.4)**	**10.3**	**5**
Alaska	111	(0.6)	15.9		98	(0.5)	13.7	
Idaho	208	(1.1)	13.4	1	215	(1.1)	13.7	3
Montana	133	(0.7)	13.5		110	(0.6)	11.1	
Oregon	421	(2.2)	11.1	3	481	(2.4)	12.5	
Washington	467	(2.4)	7.0		521	(2.6)	7.7	
Wyoming	73	(0.4)	13.0		54	(0.3)	9.6	2
Southwest	**3,084**	**(15.8)**	**5.4**	**11**	**3,228**	**(16.2)**	**5.6**	**26**
Arizona	198	(1.0)	3.1	4	167	(0.8)	2.6	7
California	1832	(9.4)	5.0		1783	(8.9)	4.8	
Colorado	499	(2.6)	10.0		691	(3.5)	13.7	
Hawaii	21	(0.1)	1.6		59	(0.3)	4.3	
Nevada	109	(0.6)	4.1	5	107	(0.5)	4.0	18
New Mexico	113	(0.6)	5.5		108	(0.5)	5.2	
Utah	312	(1.6)	11.5	2	313	(1.6)	11.3	1
Total region/state	**19,403**	**(99.2)**	**7.3**	**152**	**19,831**	**(99.5)**	**7.6**	**183**
Territory	**159**		**5.8**	**152**	**96**		**4.2**	**183**
Guam	3	(<0.1)	1.7		3	(<0.1)	1.7	
Puerto Rico	156	(0.8)	4.1		93	(0.5)	2.5	
Total	**19,562**	**(100.0)**	—	**152**	**19,927**	**(100.0)**	—	**183**

Abbreviation: NR = not reportable.
Sources: Population estimates are from the U.S. Census Bureau. Intercensal estimates of the resident population for the United States, regions, states, and Puerto Rico: April 1, 2000 to July 1, 2010. Available at http://www.census.gov/popest/data/index.html. Estimates of the New York City population are from Intercensal estimates of the resident population for counties: April 1, 2000 to July 1, 2010 (summing populations of Bronx, Kings, New York, Richmond, and Queens counties). Available at www.census.gov/popest/data/intercensal/county/county2010.html. Estimates of the population of Guam are from the 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.
† Incidence per 100,000 population on the basis of U.S. Census Bureau population estimates.
§ Number of cases linked to a detected outbreak.
¶ New York State case reports include New York City.
** Oklahoma reported through June 2010; rate reflects the reduced person-time of observation.

for sporadic giardiasis in studies in the United States (*31,32*) and New Zealand (*17*). Untreated groundwater appeared to be particularly risky if it was acquired from poorly constructed or maintained wells that might have been subject to surface water contamination (*17*).

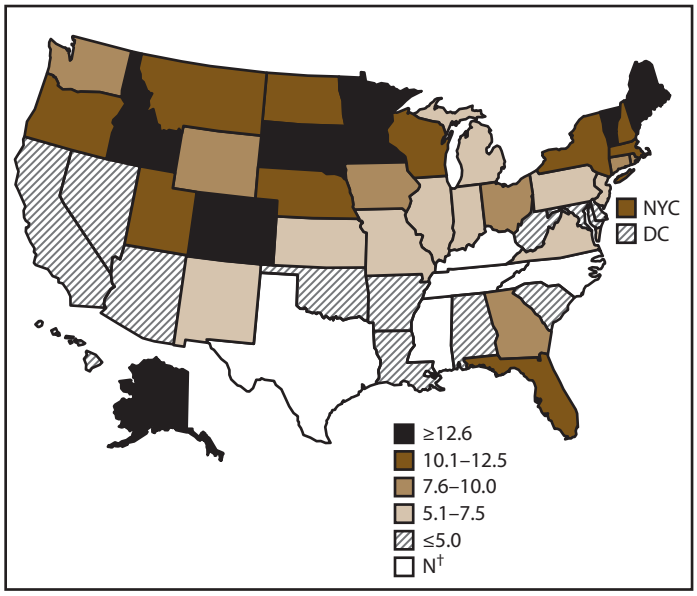
Treated or untreated recreational water also has been implicated as a vehicle of giardiasis transmission. During 1999–2008, *Giardia* was identified as a causal agent of eight (3.5%) of 228 reported recreational water-associated gastroenteritis outbreaks (*33*). In studies of sporadic giardiasis, swallowing water while swimming and during other recreational contact with fresh water were both risk factors for contracting *Giardia* (*17,20*). *Giardia* can be frequently detected in fecal material in pools (*34*) and transmission has been documented among diapered children (*35–37*) who use swimming venues regularly.

Reported foodborne outbreaks of giardiasis have generally been caused by direct contamination by an infected food handler (*38,39*) or by animal contamination of food (*40*). However, foodborne outbreaks of giardiasis are infrequently reported in the United States; during 2000–2010, <1% of foodborne outbreaks with an identified etiology were attributed to *Giardia* (*41*). Infections from contamination of widely distributed foods (e.g., fresh produce) might be more difficult to detect. In a study of sporadic giardiasis in England, eating lettuce was associated with increased risk for giardiasis (*20*). Use of reclaimed wastewater for irrigation is associated with finding *Giardia* cysts on fresh produce (*42*), highlighting the necessity of using noncontaminated irrigation water to prevent foodborne disease.

Person-to-person transmission of *Giardia* also occurs. Persons attending or working in childcare settings or those who have close contact with persons with giardiasis are at increased risk for being infected (*31,32,43*). Exposure to feces through handling diapers (*28*) and poor hygiene, particularly after toileting, in childcare settings (*35*) might contribute to increased risk.

Although *G. intestinalis* infects both humans and animals, the importance of zoonotic transmission to humans and the role of animal contamination of food and water are being reexamined as a result of advances in molecular epidemiology. *Giardia* has been detected in nearly all classes of vertebrates,

FIGURE 1. Incidence* of giardiasis, by state/area — National Notifiable Diseases Surveillance System, United States, 2010



Abbreviations: NYC = New York City; DC = District of Columbia.
* Per 100,000 population.
† Not a reportable disease in these states

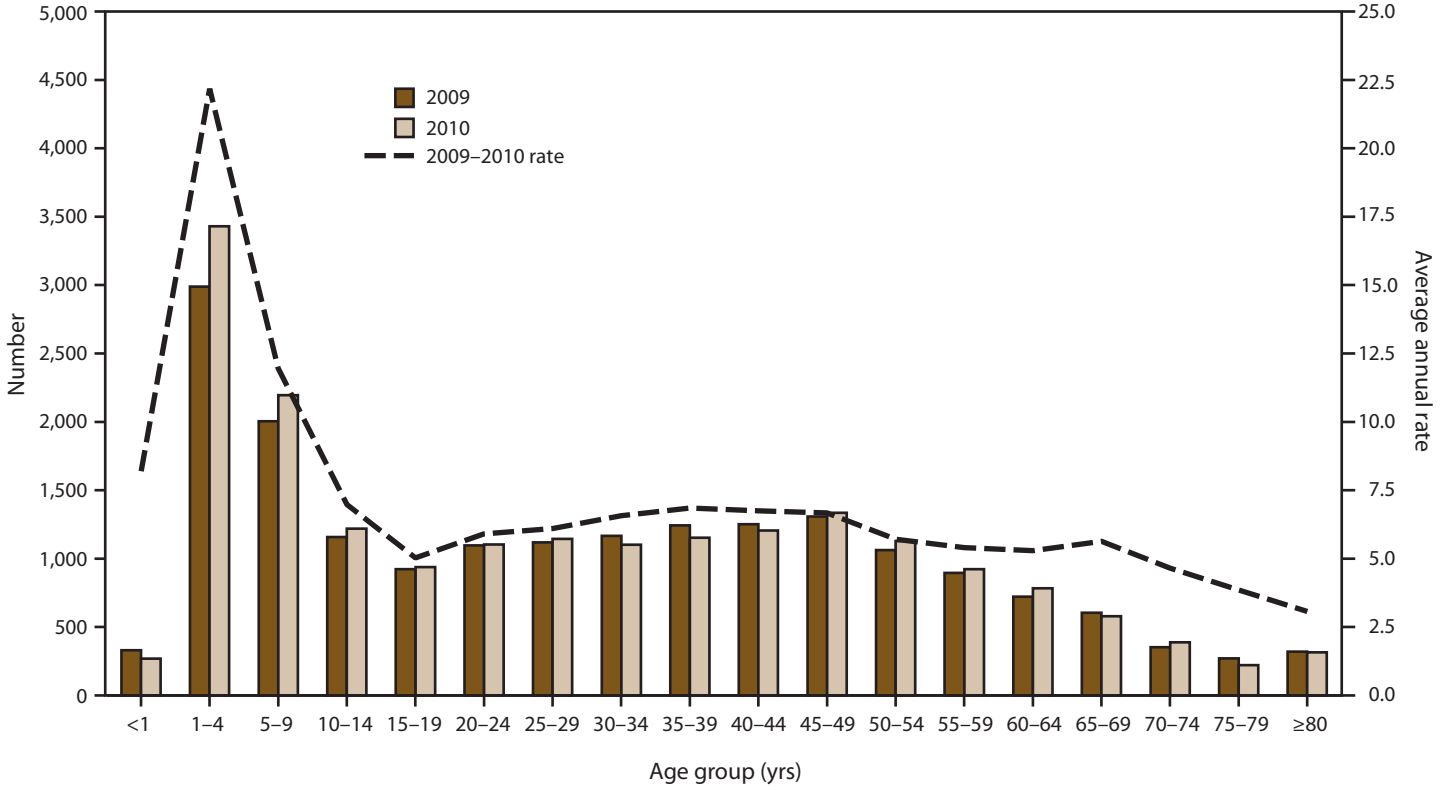
including domestic animals and wildlife (*44*). However, molecular characterization of *Giardia* has identified relatively species-specific genetic assemblages. Humans are primarily infected with assemblages A and B, although these assemblages are also found in other species (*44*). Animal contamination has been suspected of causing outbreaks associated with drinking water (*45,46*). In the United States and Australia, livestock are infected predominately with the bovine-specific genetic assemblage E (*11*). Although human-pathogenic assemblage A can be found in a small proportion of cattle, investigations of contaminated water supplies typically incriminate effluent from human waste as the source (*11*,*44*). Thus farm run-off and land application of animal waste might not be major contributors to human giardiasis as was previously thought. Household pets represent a potential source of zoonotic transmission; however, findings from molecular studies of human and animal *Giardia* species and assemblages suggest that the risk for *G. intestinalis* zoonotic transmission is not as high as previously thought (*11*). *Giardia* was identified in 9.4% of otherwise healthy pet dogs in Australia; however, assemblages C and D (rarely infectious to humans) were identified most frequently (*47*). Data implicating pets as a risk factor for giardiasis are limited, and additional molecular epidemiology studies are needed to clarify this question (*48*). No molecular data are reported to CDC surveillance systems, limiting the ability to understand the role of zoonotic transmission.

The rate of giardiasis varies by age and sex. The rate of reported giardiasis is higher in males than in females in most age groups, particularly among adults aged 35–54 years (Table 2, Figure 3). Although giardiasis affects persons in all age groups, the number of reported cases was highest among children aged 1–9 years. Data for younger age groups are consistent with reports published previously documenting higher rates of giardiasis among younger children (*23–26*). Higher rates of giardiasis in children might be related to increased recreational water exposures, poor sanitation and hygiene skills, and close contact with other potentially infected children in childcare settings (*4,49,50*). *Giardia* was identified as the cause of nondysenteric diarrhea in 15% of children examined in outpatient clinics (*51*), and transmission from children who are ill to household contacts has been documented in outbreak investigations (*37,52*).

A marked increase in the number of giardiasis cases occurred during the summer, similar to the profile observed for other bacterial and parasitic enteric diseases. This seasonal variation also has been noted in state, Canadian provincial, and previous U.S. national surveillance data for giardiasis and cryptosporidiosis (*23–26,49,50*). This might be attributable to increased outdoor activities during the summer. Transmission associated with outdoor activities is facilitated by the substantial number of *Giardia* cysts that can be shed by a single person (*13*), the environmental hardiness of the organism (*53*), the extended periods of time that cysts can be shed (*14*), and the low infectious dose (*12*).

Its low infectious dose, protracted communicability, and moderate chlorine tolerance make *Giardia* ideally suited for transmission through drinking and recreational water, and person-to-person contact. Strategies to reduce the incidence of giardiasis have focused on reducing waterborne and person-to-person transmission. The U.S. Environmental Protection Agency (EPA) enacted the Surface Water Treatment Rule (SWTR) in 1989 and the Interim Enhanced SWTR in 1998. These regulations have decreased the number of giardiasis outbreaks associated with community drinking water systems (*30*). In 2006, EPA finalized the Ground Water Rule to address contamination of public ground water (well) systems, which might reduce the number of groundwater-associated outbreaks of giardiasis. For treated recreational water venues, conducting proper pool maintenance (i.e., sufficient disinfection, filtration, and recirculation of water) and implementing exclusion criteria (i.e., prohibiting persons with diarrhea from swimming) should decrease transmission of *Giardia* through treated recreational water. Person-to-person transmission of *Giardia* is difficult to interrupt in a systematic fashion, particularly in childcare

FIGURE 2. Number* and average annual rate† of giardiasis case reports, by age group and year — National Notifiable Diseases Surveillance System, 2009–2010



* N = 39,234; age is unknown for 1,041 cases.
† Incidence per 100,000 population.

TABLE 2. Number and percentage* of giardiasis case reports, by selected demographic characteristics — National Notifiable Diseases Surveillance System, United States 2009–2010

Characteristic	2009		2010	
	No.	(%)	No.	(%)
Sex				
Male	10,635	(54.8)	11,138	(56.2)
Female	8,276	(42.7)	8,500	(42.9)
Unknown/Missing	492	(2.5)	193	(1.0)
Total	**19,403**	**(100.0)**	**19,831**	**(100.0)**
Race				
Native American	88	(0.5)	82	(0.4)
Asian/Pacific Islander	1,042	(5.4)	1,204	(6.1)
Black	1,408	(7.3)	1,620	(8.2)
White	7,925	(40.8)	7,522	(37.9)
Other	810	(4.2)	739	(3.7)
Unknown/Missing	8,130	(41.9)	8,684	(43.7)
Total	**19,403**	**(100.0)**	**19,831**	**(100.0)**
Ethnicity				
Hispanic	1,867	(9.6)	1,376	(6.9)
Non-Hispanic	8,043	(41.5)	8,607	(43.4)
Unknown/Missing	9,493	(48.9)	9,848	(49.7)
Total	**19,403**	**(100.0)**	**19,831**	**(100.0)**

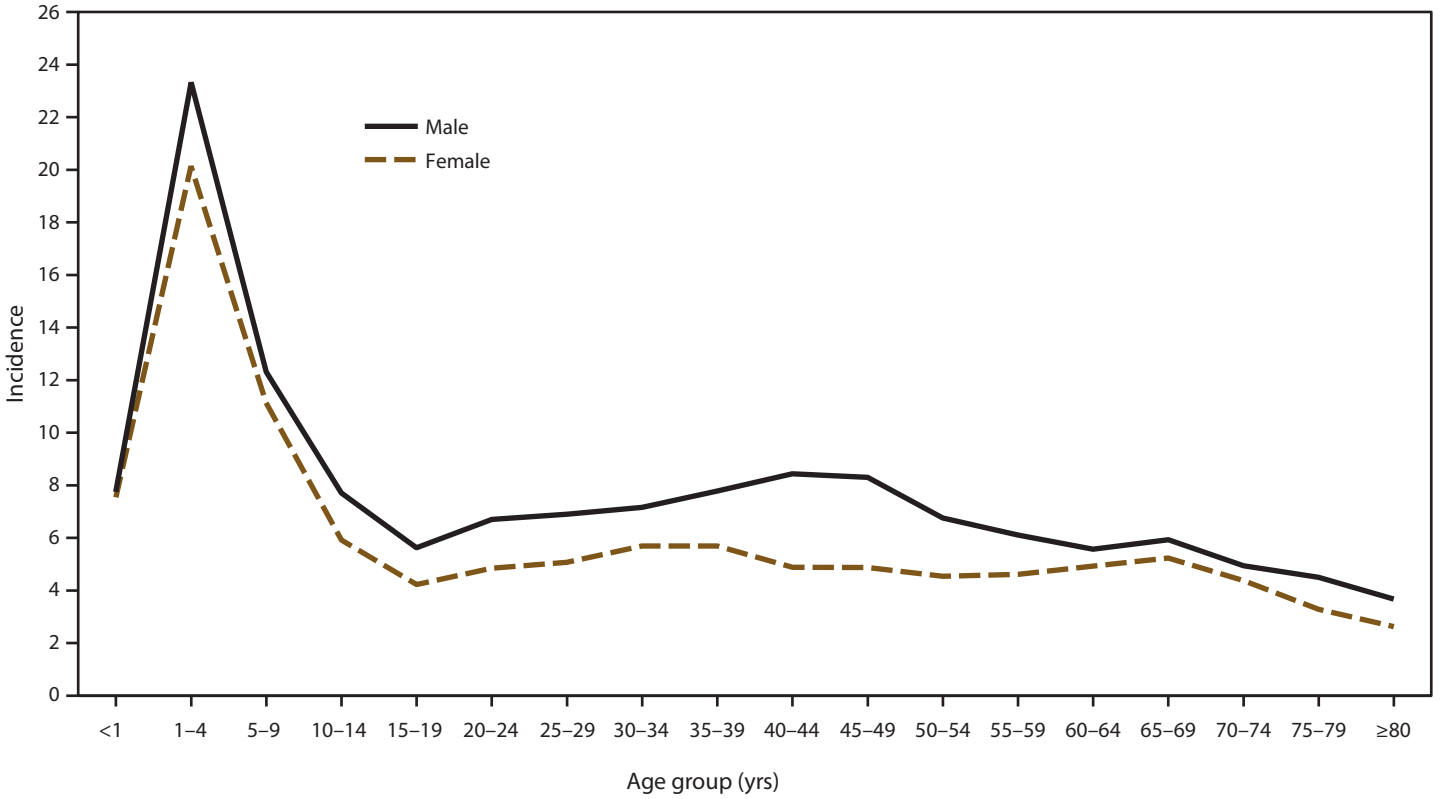
* Percentages might not total 100% because of rounding.

settings (*54*). Adherence to appropriate infection control (e.g., exclusion or separation of children ill with diarrhea, hand washing, and diaper changing) policies is recommended for controlling giardiasis and other enteric pathogens in these group settings (*55*).

Limitations

The data provided in this report are subject to at least three limitations. First, NNDSS data are incomplete on race, ethnicity, and symptom onset date, and do not include data on exposures. Second, incidence of giardiasis is likely to be underestimated by these national surveillance data because of underreporting (e.g., not all infected persons are symptomatic, persons who are symptomatic do not always seek medical care, health-care providers do not always include laboratory diagnostics in their evaluation of nonbloody diarrheal diseases, and case reports are not always completed for positive laboratory results or forwarded to public health officials). Finally, giardiasis is not a reportable disease in all states.

FIGURE 3. Incidence* of giardiasis case reports, by age group and sex — National Notifiable Diseases Surveillance System, United States, 2009–2010



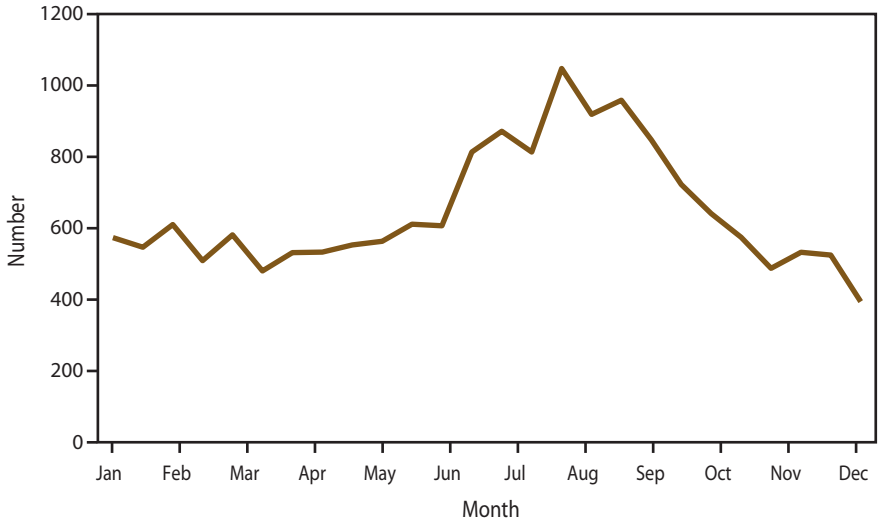
* Per 100,000 population.

Conclusion

Although giardiasis is the most common enteric parasitic infection in the United States, knowledge of its epidemiology is still lacking in public health research. The majority of data on giardiasis transmission comes from outbreak investigations; however, the overwhelming majority of reported giardiasis cases occur sporadically. During 2009–2010, <1% of reported giardiasis cases were associated with outbreaks (Table 1). Relative contributions of person-to-person, animal-to-person, foodborne, and waterborne transmission to sporadic human giardiasis in the United States are not well understood. It is unclear whether the geographic variability noted in this report reflects true differences in transmission patterns and disease burden. Ecological studies could characterize the potential contributions of private wells, septic systems, land application of biosolids, and agricultural operations in giardiasis transmission. Infected persons can shed *Giardia* for several weeks, and symptomatology is variable; however, until recently, no reliable serologic assays for *Giardia* have been available, and no population studies of *Giardia* seroprevalence have been conducted. With recent laboratory advances (*56*), such studies might now be feasible and would contribute substantially to our understanding of the prevalence of giardiasis in the United States. Enhanced genotyping methods would increase our knowledge of the molecular epidemiology of *Giardia*, including elucidating species-specific subassemblages. These tools, combined with traditional epidemiology and surveillance, would improve understanding of giardiasis risk factors, identify outbreaks by linking cases currently classified as sporadic infections, and provide risk factor information needed to inform prevention strategies. Although recent studies indicate a potential for chronic sequelae from giardiasis (*5–10*), additional research is needed to further improve understanding of the burden and scope of these conditions.

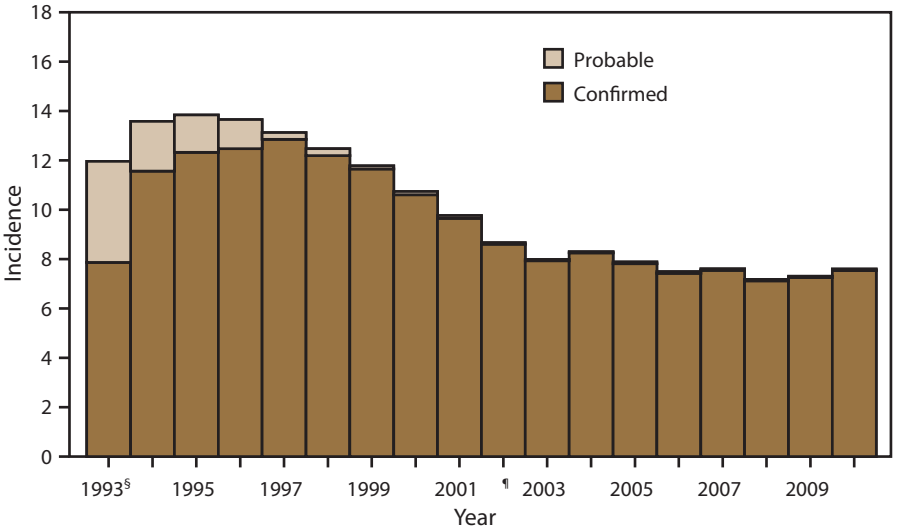
The burden and cost of acute giardiasis in the United States continue to be substantial. An estimated 1.2 million cases occur annually (*57*). Each year, hospitalizations resulting from giardiasis cost approximately $34 million; additionally, each ambulatory care visit for giardiasis costs $121–$273, depending on the patient's type of health-care insurance coverage (*58*). Because giardiasis is the most commonly reported intestinal

FIGURE 4. Number* of giardiasis case reports, by date of illness onset — National Notifiable Diseases Surveillance System, United States, 2009–2010



* N = 39,234; onset date was unknown for 19,636 cases.

FIGURE 5. Incidence* of giardiasis, by year — National Notifiable Diseases Surveillance System, United States, 1993–2010†



* Per 100,000 population. Population estimates are from the Population Division, US Census Bureau. Available at http://www.census.gov/popest/. Accessed August 15, 2011.
† N = 391,492.
§ First year that giardiasis case reports were assigned a reporting number.
¶ Giardiasis became nationally notifiable in 2002.

parasitic infection in the United States and no declines in incidence have occurred in recent years, new epidemiologic studies are needed to identify effective public health measures.

Measures to prevent (Box 1) and 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/parasites/giardia/.

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This report is based, in part, on contributions by jurisdiction surveillance coordinators Ruth Ann Jajosky, DMD, and Willie Anderson, Office of Surveillance, Epidemiology, and Laboratory Services, CDC.

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BOX 1. CDC recommendations to prevent and control giardiasis

Practice good hygiene.

- Everywhere
  - Wash hands with soap and water for at least 20 seconds, rubbing hands together vigorously and scrubbing 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 animal waste.

Information about hand hygiene is available from CDC at http://www.cdc.gov/healthywater/hygiene/hand/handwashing.html.

- At child care facilities
  - Exclude children with diarrhea from child care settings until the diarrhea has stopped.
- At the pool
  - Protect others by not swimming if you are experiencing diarrhea (this is essential for children in diapers).
  - If diagnosed with giardiasis, do not swim for at least 1 week 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.

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

- Around animals
  - Minimize contact with the stool of all animals, particularly young animals.
- Wear disposable gloves when cleaning up after a pet 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 (drinking and recreational) 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, and lack of water treatment systems),
  - drink bottled water, or
  - disinfect it by heating the water to a rolling boil for 1 minute, or
  - use a filter that has been tested and rated by National Sanitation 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 from CDC at http://www.cdc.gov/parasites/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.
- Avoid eating uncooked foods when traveling in countries with poor water treatment and food sanitation.

Practice extra caution when traveling.

Information about how to prevent illnesses while traveling is available from CDC 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.

Information about giardiasis prevention and control is available from CDC at http://www.cdc.gov/parasites/giardia/prevent.html.

BOX 2. 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.
- Expand the use of serologic testing during outbreaks and other investigations.
- Encourage jurisdictional health departments to transmit 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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