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Cryptosporidiosis Surveillance — United States, 2011–2012

Giardiasis Surveillance — United States, 2011–2012

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Cryptosporidiosis Surveillance — United States, 2011–2012

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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: 2011–2012.

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

Results: For 2011, a total of 9,313 cryptosporidiosis cases (confirmed and nonconfirmed) were reported; for 2012, a total of 8,008 cases were reported; 5.8% and 5.3%, respectively, were associated with a detected outbreak. The rates of reported nonconfirmed cases were 1.0 and 0.9 per 100,000 population in 2011 and 2012, respectively, compared with an average of 0.0 during 1995–2004, and 0.3 during 2005–2010. The highest overall reporting rates were observed in the Midwest; 10 states reported >3.5 cases per 100,000 population in 2011 and in 2012. During 2011–2012, reported cases were highest among children aged 1–4 years (6.6 per 100,000 population), followed for the first time by elderly adults aged ≥80 years (3.4), and 75–79 years (3.3). Overall, cryptosporidiosis rates were higher among females than males during both years. For specific age groups, rates were higher among males than females aged <15 years and higher among females than males aged ≥15 years. Cryptosporidiosis symptom onset increased 4.4 fold during late summer.

Interpretation: Cryptosporidiosis incidence rates remain elevated nationally, and rates of nonconfirmed cases have increased. Rates remain highest in young children, although rates among elderly adults are increasing. Transmission of *Cryptosporidium* occurs throughout the United States, with increased reporting occurring in Midwestern states. Seasonal onset peaks coincide with the summer recreational water season and might reflect increased use of communal swimming venues.

Public Health Action: Future research is needed to address the evolving epidemiology of cryptosporidiosis cases, with a specific focus on the increase in nonconfirmed cases and increasing incidence rates among elderly adults. National systematic genotyping and subtyping of *Cryptosporidium* isolates could also help elucidate *Cryptosporidium* transmission and thus cryptosporidiosis epidemiology in the United States.

Introduction

Cryptosporidiosis, a gastrointestinal illness caused by protozoa of the genus *Cryptosporidium*, is a major source of human illness and was the leading cause of all waterborne outbreaks in the United States during 2001–2010 (*1*). An estimated 748,000 cryptosporidiosis cases occur annually (*2*), although less than 2% are reported (*3*). Hospitalizations resulting from cryptosporidiosis cost an estimated $45.8 million per year (*4*).

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Cryptosporidiosis is typically characterized by profuse, watery, nonbloody diarrhea. Other symptoms can include weight loss, abdominal pain, anorexia, fatigue, cramps, headache, fever, and vomiting (*5*). Asymptomatic infection also can occur (*6–9*). Recurrence of symptoms after apparent resolution has been frequently reported; however, illness is self-limiting, and symptoms typically completely resolve within 2–3 weeks in immunocompetent persons (*10*). Cryptosporidiosis can be treated by nitazoxanide, which was approved by the Food and Drug Administration (FDA) in 2005 for all immunocompetent patients aged ≥1 years (*11,12*).

Historically, cryptosporidiosis was considered an opportunistic infection in human immunodeficiency virus (HIV)-infected patients (*13*), with the ability to cause

profuse, watery diarrhea, and life-threatening wasting, and malabsorption (*14*). Extraintestinal cryptosporidiosis (i.e., in the biliary or respiratory tract, or rarely the pancreas) also has been documented in immunocompromised persons (*15–19*). However, the incidence of cryptosporidiosis among HIV-infected persons has decreased since the introduction of highly active antiretroviral therapy for HIV infection (*20,21*).

Health-care providers should consider cryptosporidiosis in their differential diagnosis when a patient experiences diarrhea lasting >3 days. Because routine examination of stool for ova and parasites is unlikely to include testing for *Cryptosporidium* (*22*), health-care providers should specifically request *Cryptosporidium* testing. Oocyst excretion can be intermittent. Because the parasite might not be detected in a given stool specimen, three stool specimens collected on separate days should be examined before considering test results to be negative (*23*). Direct fluorescent antibody (DFA) testing is a highly sensitive and specific diagnostic method and is considered a benchmark for quality in *Cryptosporidium* testing (*24*). Commercially available antigen detection immunoassay kits are available and might be more diagnostically sensitive and specific than routine microscopic examination (*25*).

The majority of *Cryptosporidium* species, all with multiple subtypes, are morphologically indistinguishable by traditional diagnostic tests. Thus, molecular methods must be used to distinguish species and subtypes and are needed to better understand the epidemiology of cryptosporidiosis. Molecular typing tools are increasingly used in outbreak investigations and infection- or contamination-source tracking to differentiate *Cryptosporidium* species and subtypes. However, they are not commercially available. *Cryptosporidium* genotyping and subtyping services are provided free of charge by CDC at http://www.cdc.gov/parasites/crypto/cryptonet.html. If stool is preserved in formalin, *Cryptosporidium* isolates cannot be reliably genotyped or subtyped (*26*).

The majority of cases of cryptosporidiosis in humans are caused by *C. hominis* and *C. parvum* (*27,28*). *C. hominis* is mainly spread through human-to-human transmission, whereas *C. parvum* can be spread through human-to-human or animal-to-human transmission (*27,29*). Human infections caused by *C. meleagridis*, *C. canis*, *C. felis*, *C. ubiquitum, C. cuniculus, C. suis*, *C. muris*, and several other species also have been documented. Species distribution might vary by geographic setting (e.g., urban versus rural) (*29*). Infections caused by the different *Cryptosporidium* species, and subtypes within species, can clinically differ (*30,31*).

Cryptosporidium oocysts are transmitted by the fecal-oral route. *Cryptosporidium* does not reproduce outside of a host, and oocysts are infectious immediately upon being excreted in feces. Infection results from the ingestion of oocysts through fecally contaminated food or water, or through contact with an infected person or animal. The infectious dose is low; feeding studies have demonstrated that the ingestion of ≤10 *C. hominis* or *C. parvum* oocysts can cause infection in healthy persons (*32,33*). Infected persons have been reported to shed 10^7–10^8 oocysts in a single bowel movement (*34*) and can excrete infectious oocysts for up to 60 days after cessation of gastrointestinal symptoms (*35*). *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 (1–3 mg/L) for recreational water venues (e.g., pools and interactive fountains) (*36*). This tolerance makes *Cryptosporidium* ideally suited for transmission via halogenated recreational and drinking water. Transmission is further facilitated by the low infectious dose of *Cryptosporidium*, the substantial number of *Cryptosporidium* oocysts that can be shed by a person in a single bowel movement, and the protracted shedding of oocysts even after symptom resolution (*37*).

Risk factors for cryptosporidiosis include ingestion of recreational water (*38,39*), ingestion of untreated drinking water (*40*), contact with livestock (*38,40,41*), recent international travel (*37,40*), or contact with infected persons (e.g., from young children to caregivers) (*37,38,40*). Risk factors also can vary by geographic setting (e.g., urban versus rural) (*29*). Although cryptosporidiosis cases can occur sporadically, waterborne outbreaks have been documented since the first reported U.S. drinking water-associated outbreak in 1984 (*42*) and the first reported U.S. recreational water-associated outbreak in 1988 (*43,44*). Outbreaks resulting from foodborne, person-to-person, and animal-to-person transmission also have been reported (*45–49*).

Cryptosporidiosis is a nationally notifiable disease; the first full year of reporting was 1995 (*50*). National surveillance data for 1995–2010 have been previously published elsewhere (*3,50–54*). This report summarizes national cryptosporidiosis surveillance data for 2011–2012. Federal, state, and local public health agencies can use these cryptosporidiosis surveillance data to help elucidate the epidemiology of cryptosporidiosis in the United States, establish public health priorities for cryptosporidiosis prevention, and optimize the design of public health interventions to prevent transmission of *Cryptosporidium*.

Methods

Case Definition

The definition of a confirmed case of cryptosporidiosis has changed over time; the first cryptosporidiosis case definition was established in 1995 (*55*), and was subsequently revised

in 1998, 2009, 2011, and 2012 (*56*–*59*). Before 2011, all laboratory-diagnosed cases were considered confirmed cases.

Confirmed cases

2011 Definition: A confirmed case of cryptosporidiosis is defined as having gastrointestinal illness (characterized by diarrhea, abdominal cramping, fever, nausea, vomiting, or anorexia) and having evidence of *Cryptosporidium* organisms or DNA in stool, intestinal fluid, tissue samples, biopsy specimens, or other biological sample by established laboratory methods (e.g., DFA test or polymerase chain reaction [PCR]) (*58*).

2012 Definition: A confirmed case of cryptosporidiosis is defined as having evidence of *Cryptosporidium* organisms or DNA in stool, intestinal fluid, tissue samples, biopsy specimens, or other biological sample by certain laboratory methods with a high positive predictive value (PPV) (e.g., DFA test, PCR, enzyme immunoassay [EIA], or light microscopy of stained specimen) (*59*).

Nonconfirmed cases

For 2011 and 2012, the nonconfirmed cryptosporidiosis cases include probable, suspect, and unknown cases.

2011 Probable: A probable case of cryptosporidiosis is defined as having gastrointestinal illness (characterized by diarrhea, abdominal cramping, fever, nausea vomiting and/or anorexia) and evidence of *Cryptosporidium* antigen by immunodiagnostic methods (e.g., commercially-available immunochromatographic card tests) or epidemiologically linked to a confirmed case (*58*).

2012 Probable: A probable case of cryptosporidiosis is defined as having supportive laboratory test results for *Cryptosporidium* spp. infection using a screening test method (e.g., immunochromatographic card/rapid card test or a laboratory test of unknown method) or is defined as having gastrointestinal illness (characterized by diarrhea and ≥1 of the following: diarrhea with duration of ≥72 hours, abdominal cramping, vomiting, or anorexia) and is epidemiologically linked to a confirmed case (*59*).

2012 Suspect: Suspect cases include persons who have a diarrheal illness and are epidemiologically linked to a probable case diagnosed by an immunocard/rapid card test/or unknown test method (*59*).

Unknown: If a case is not classified as confirmed, probable, or suspect, it is classified as unknown.

Reporting

Public health agencies in the 50 states, the District of Columbia (DC), and New York City voluntarily report cases of cryptosporidiosis to CDC through the National Notifiable Diseases Surveillance System (NNDSS). Reports include the patient's place of residence (e.g., state), age, sex, race, ethnicity (Hispanic or non-Hispanic), date of symptom onset, case status (confirmed, probable, suspect, unknown [i.e., test method is not reported to NNDSS]), and whether the case is associated with an outbreak. Historically, CDC's annual summary of notifiable diseases uses its own criteria to classify case status (*60*). Because data in this report were finalized at a different time, the number of cases differs slightly from the number reported in the annual summary.

Analysis

National cryptosporidiosis surveillance data for 2011–2012 were analyzed using statistical software. Numbers, percentages, and incidence rates (cases per 100,000 population) of cryptosporidiosis were calculated in aggregate for the United States and separately for each reporting jurisdiction. Rates were calculated by dividing the number of reported new cryptosporidiosis cases by each year's mid-year census estimates and multiplying by 100,000 (*61*). In addition to analyzing data nationally and by reporting jurisdiction, data were analyzed by region (Northeast, Midwest, South, and West regions), as defined by the U.S. Census Bureau (*62*). To account for differences in the seasonal use of recreational water, the West region was further subdivided into Northwest and Southwest. To examine reporting over time, cryptosporidiosis rates per 100,000 population were calculated by year (from 1995 to 2012) and case type (confirmed or nonconfirmed). To assess current patterns in reporting, average annual cryptosporidiosis rates per 100,000 population were calculated by demographic variables (e.g., age and sex) and by month of symptom onset across 2011–2012 combined. This was performed by summing all cases occurring in the 2-year period, and then dividing by the sum of the number of persons in reporting jurisdictions in each year, and multiplying by 100,000. Rates could not be calculated for some variables (race and ethnicity) because of a large percentage (>20%) of reports missing data for these variables.

Results

All 50 states, New York City, and DC reported cryptosporidiosis cases to NNDSS for 2011–2012. A total of 17,321 cases of cryptosporidiosis were reported during 2011–2012; 9,313 cases were reported for 2011 (3.0 per 100,000 population) and 8,008 cases for 2012 (2.6). The number of annually reported cases declined 31.3% in 2012 from the 2007 peak of 11,657 (Table 1). The annual rate of reported cryptosporidiosis cases was relatively

TABLE 1. Number, percentage,* and incidence rate† of cryptosporidiosis case reports by region/jurisdiction — National Notifiable Diseases Surveillance System, United States, 2011–2012

Region/State	2011				2012			
	No.	(%)	Rate	No. of outbreak–associated cases	No.	(%)	Rate	No. of outbreak–associated cases
Northeast	**1,330**	**(14.3)**	**2.4**	**33**	**1,202**	**(15.0)**	**2.2**	**20**
Connecticut	71	(0.8)	2.0		41	(0.5)	1.1	
Maine	59	(0.6)	4.4		58	(0.7)	4.4	
Massachusetts	168	(1.8)	2.5		155	(1.9)	2.3	3
New Hampshire	68	(0.7)	5.2		54	(0.7)	4.1	
New Jersey	56	(0.6)	0.6		42	(0.5)	0.5	
New York State§	234	(2.5)	2.1	17	229	(2.9)	2.0	15
New York City§	86	(0.9)	1.0		124	(1.5)	1.5	
Pennsylvania	528	(5.7)	4.1	16	416	(5.2)	3.3	2
Rhode Island	12	(0.1)	1.1		16	(0.2)	1.5	
Vermont	48	(0.5)	7.7		67	(0.8)	10.7	
Midwest	**4,262**	**(45.8)**	**6.3**	**204**	**3,238**	**(40.4)**	**4.8**	**171**
Illinois	213	(2.3)	1.7	29	173	(2.2)	1.3	6
Indiana	275	(3.0)	4.2	2	169	(2.1)	2.6	1
Iowa	364	(3.9)	11.9		328	(4.1)	10.7	7
Kansas	42	(0.5)	1.5	21	122	(1.5)	4.2	
Michigan	358	(3.8)	3.6	11	351	(4.4)	3.6	42
Minnesota	309	(3.3)	5.8	8	347	(4.3)	6.5	51
Missouri	495	(5.3)	8.2		239	(3.0)	4.0	
Nebraska	184	(2.0)	10.0	5	184	(2.3)	9.9	34
North Dakota	32	(0.3)	4.7		35	(0.4)	5.0	
Ohio	1,106	(11.9)	9.6	103	571	(7.1)	4.9	30
South Dakota	146	(1.6)	17.7	18	113	(1.4)	13.6	
Wisconsin	738	(7.9)	12.9	7	606	(7.6)	10.6	
South	**2,425**	**(26.0)**	**2.1**	**267**	**2,041**	**(25.5)**	**1.7**	**79**
Alabama	142	(1.5)	3.0		110	(1.4)	2.3	
Arkansas	32	(0.3)	1.1		42	(0.5)	1.4	
Delaware	7	(0.1)	0.8		15	(0.2)	1.6	
District of Columbia	10	(0.1)	1.6		11	(0.1)	1.7	
Florida	437	(4.7)	2.3	46	470	(5.9)	2.4	74
Georgia	307	(3.3)	3.1		257	(3.2)	2.6	
Kentucky	180	(1.9)	4.1	129	67	(0.8)	1.5	
Louisiana	87	(0.9)	1.9		155	(1.9)	3.4	
Maryland	70	(0.8)	1.2	3	86	(1.1)	1.5	
Mississippi	50	(0.5)	1.7		40	(0.5)	1.3	
North Carolina	115	(1.2)	1.2	8	89	(1.1)	0.9	4
Oklahoma	89	(1.0)	2.4		97	(1.2)	2.5	
South Carolina	132	(1.4)	2.8		72	(0.9)	1.5	
Tennessee	92	(1.0)	1.4		72	(0.9)	1.1	
Texas	504	(5.4)	2.0	81	302	(3.8)	1.2	
Virginia	140	(1.5)	1.7		144	(1.8)	1.8	1
West Virginia	31	(0.3)	1.7		12	(0.1)	0.6	

See table footnotes on next page.

stable during 1995–2004, ranging from 0.9–1.4 per 100,000 population, with few nonconfirmed cases reported (Figure 1).

Of the 9,313 cases for 2011, 65.8% were confirmed. Of the 8,008 cases for 2012, 65.5% were confirmed. During 2005–2012, rates of confirmed cases ranged from 2.2 to 3.9 per 100,000 population, whereas rates of nonconfirmed cases ranged from 0.1 to 1.0 per 100,000 population. Rates of nonconfirmed cases were 1.0 and 0.9 per 100,000 population in 2011 and 2012, respectively, compared with an average of 0.0 during 1995–2004 and 0.3 during 2005–2010. Of all cases reported for 2011 and 2012, 5.8% and 5.3%, respectively, were reported to be associated with a detected outbreak.

By region, the rate of reported cryptosporidiosis cases per 100,000 population ranged from 1.3 in the Southwest to 6.3 in the Midwest in 2011 and 1.4 in the Southwest to 4.8 in Midwest in 2012 (Table 1, Figure 2). The number of jurisdictions reporting rates of >3.5 cases per 100,000 population was 19 and 20 in 2011 and 2012, respectively; 10 Midwest states reported >3.5 cases per 100,000 population in 2011 and 2012. By state, the rate of reported cryptosporidiosis cases per 100,000 population ranged from 0.1 in Hawaii to 17.7 in South Dakota in 2011 and 0.4 in Hawaii to 16.7 in Idaho in 2012.

TABLE 1. (*Continued*) Number, percentage,* and incidence rate† of cryptosporidiosis case reports by region/jurisdiction — National Notifiable Diseases Surveillance System, United States, 2011–2012

Region/State	2011				2012			
	No.	(%)	Rate	No. of outbreak–associated cases	No.	(%)	Rate	No. of outbreak–associated cases
Northwest	**541**	**(5.8)**	**3.7**	**29**	**692**	**(8.6)**	**4.7**	**142**
Alaska	12	(0.1)	1.7		7	(0.1)	1.0	
Idaho	111	(1.2)	7.0	2	267	(3.3)	16.7	141
Montana	77	(0.8)	7.7		69	(0.9)	6.9	
Oregon	207	(2.2)	5.4	10	214	(2.7)	5.5	
Washington	88	(0.9)	1.3		101	(1.3)	1.5	
Wyoming	46	(0.5)	8.1	17	34	(0.4)	5.9	1
Southwest	**755**	**(8.1)**	**1.3**	**11**	**835**	**(10.4)**	**1.4**	**11**
Arizona	46	(0.5)	0.7		47	(0.6)	0.7	
California	347	(3.7)	0.9		370	(4.6)	1.0	
Colorado	147	(1.6)	2.9	8	102	(1.3)	2.0	8
Hawaii	1	(0.0)	0.1		5	(0.1)	0.4	
Nevada	17	(0.2)	0.6		15	(0.2)	0.5	
New Mexico	134	(1.4)	6.4	3	94	(1.2)	4.5	1
Utah	63	(0.7)	2.2		202	(2.5)	7.1	2
Total	**9,313**	**(100.0)**	**3.0**	**544**	**8,008**	**(100.0)**	**2.6**	**423**

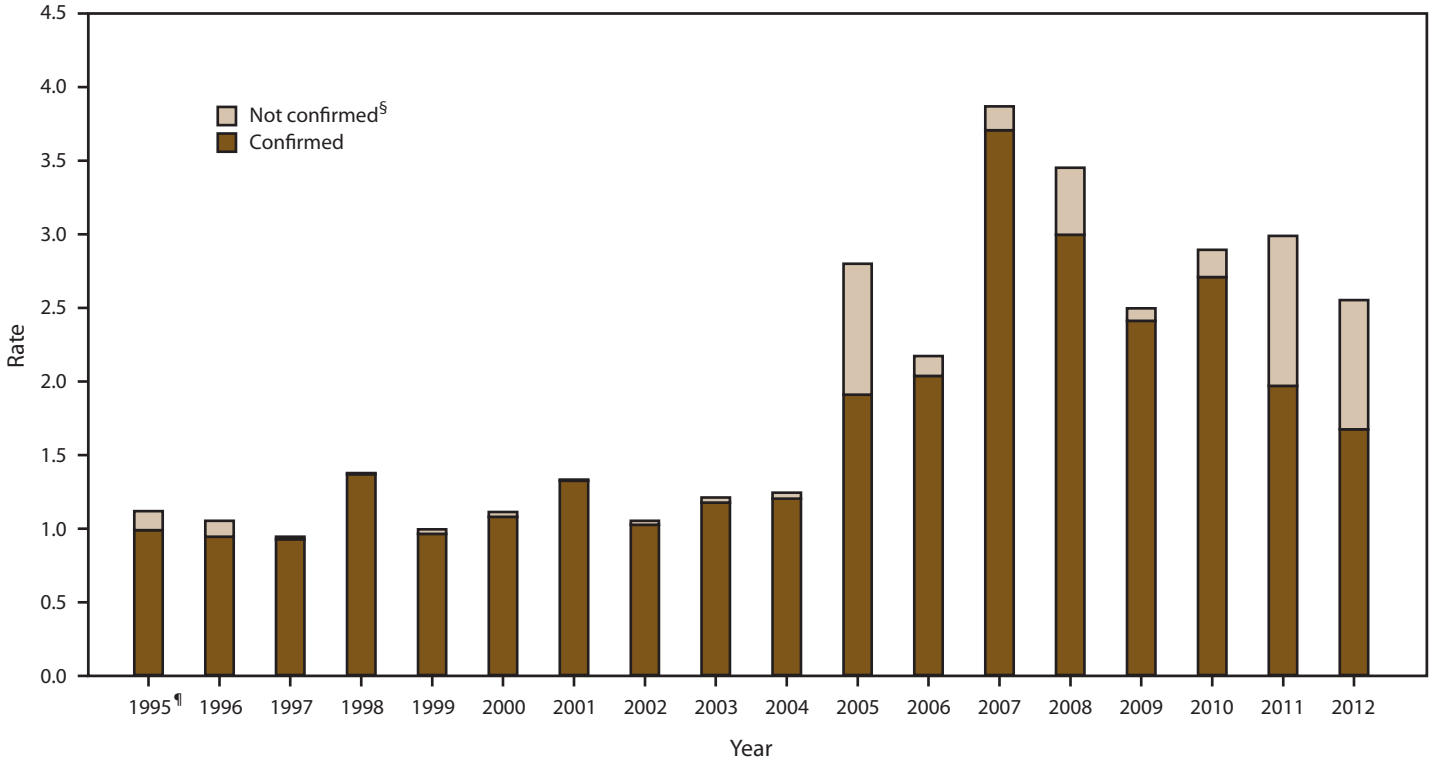
Sources: Population estimates are from the U.S. Census Bureau. Annual estimates of the population for the United States, regions, states, and Puerto Rico: April 1, 2010 to July 1, 2012. Available at http://www.census.gov/popest/data/state/totals/2012. Estimates of the New York City population are from annual estimates of the resident population for incorporated places over 50,000, ranked by July 1, 2012, population: April 1, 2010 to July 1, 2012. Available at http://www.census.gov/popest/data/cities/totals/2012/index.html.

* Regional and overall percentages might not total 100% because of rounding.

† Cases per 100,000 population.

§ New York State and New York City data are mutually exclusive.

FIGURE 1. Incidence rate* of cryptosporidiosis, by year and case classification— National Notifiable Diseases Surveillance System, United States, 1995–2012†



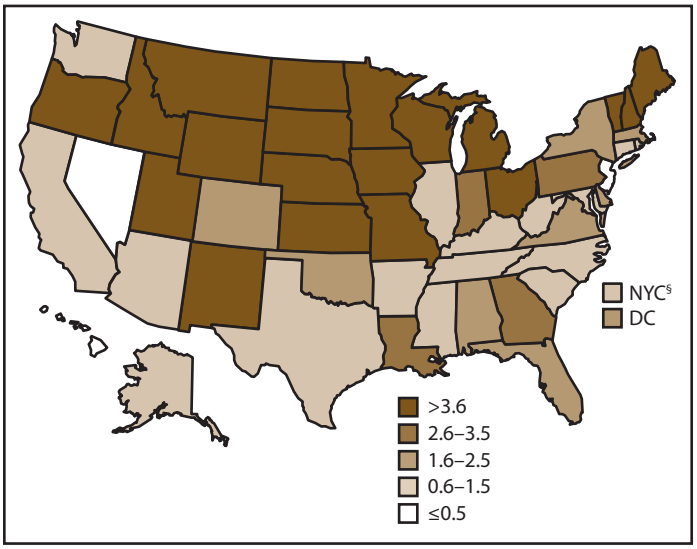
* Cases per 100,000 population.

† N = 102,835.

§ Not confirmed includes probable, suspect, and unknown cases.

¶ First full year of national reporting.

FIGURE 2. Incidence rate* of cryptosporidiosis, by reporting jurisdiction — National Notifiable Diseases Surveillance System, United States, 2012†



* Cases per 100,000 population.
† The categories delineated were used in the previous cryptosporidiosis summaries. The categories have remained the same to allow for comparison over time.
§ New York State and New York City data are mutually exclusive.

In 2011, cases were most frequently reported in children aged 1–4 years followed by those aged 5–9 years and adults aged 25–29 years (Figure 3). In 2012, cases were most frequently reported in children aged 1–4 years, followed by adults aged 20–24 years and 25–29 years. For both 2011–2012, the average annual rate of reported cryptosporidiosis per 100,000 population was highest in those aged 1–4 years (6.6), followed by elderly adults aged ≥80 years (3.4), and 75–79 years (3.3). Rates were lowest among adults aged 50–59 years (1.8).

Of 17,270 cases where sex was reported in 2011–2012, 46.6% were in males (Table 2). Among males, the rate ranged from 1.6 per 100,000 population (aged 50–59 years) to 7.4 (aged 1–4 years) (Figure 4). Among females, the rate ranged from 1.9 per 100,000 population (aged 55–59 years) to 5.7 (aged 1–4 years). Cryptosporidiosis rates were higher among males than females for persons <15 years of age. Conversely, cryptosporidiosis rates were higher among females aged ≥15 years.

Date of symptom onset was reported for 12,581 (72.6%) of 2011–2012 cases. The number of cases by symptom onset peaked in late July and early August (n = 1,128), which was 4.4 times higher than the lowest biweekly number of cases by symptom onset in late December (n = 254) (Figure 5). Increased reporting (i.e., >450 cases biweekly) was noted from the end of May through early October. Symptom onset of cases in those aged 1–4, 5–9, and 25–29 years all peaked at week 32, which led to the overall seasonal peak. Symptom onset in older adults aged ≥75 years did not peak seasonally.

Of 13,752 cases for whom race was reported in 2011–2012, 84.9% were documented in white patients. Of 11,496 patients for whom ethnicity was reported in 2011–2012, 9.2% were Hispanic (Table 2). For 2011–2012, data on race were missing for approximately one fifth of cases, and data on ethnicity were missing for approximately one third of cases.

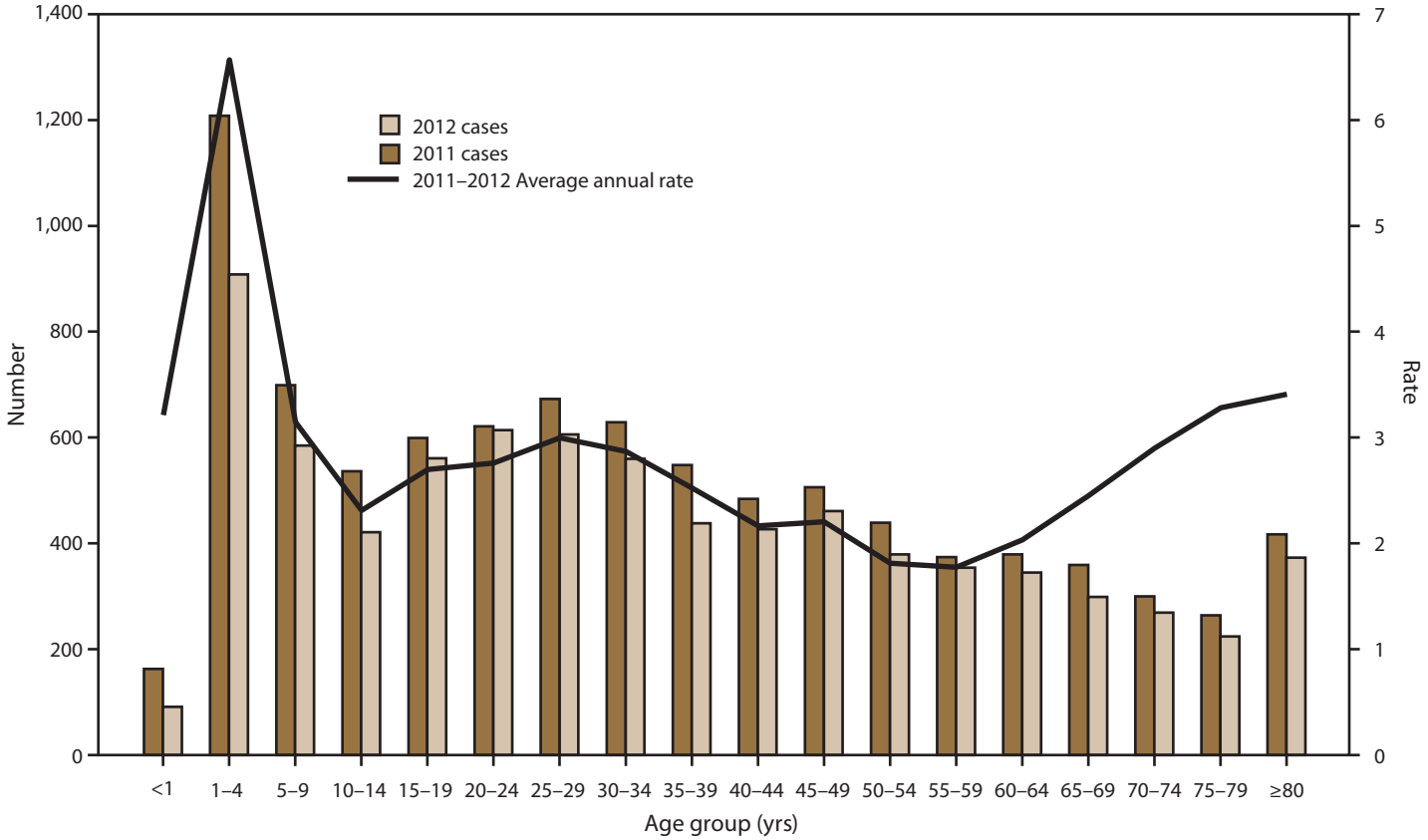
Discussion

National data are critical to characterizing the epidemiology of cryptosporidiosis in the United States. During 1995–2012, communitywide and large (e.g., >1,000 cases) recreational water-associated outbreaks of cryptosporidiosis contributed to the elevated annual case counts and rates (*1,3,50–54,63–73*). For 2007, Utah reported a statewide recreational water-associated outbreak of cryptosporidiosis, which might account for the increased number of cases reported that year (*74*). The 2011 and 2012 annual incidence rates are lower than the peak seen in 2007, but in general appear to be higher than rates during 1995–2004. Other potential contributing factors could include changes in the ordering of diagnostic tests by health-care providers, testing and reporting patterns among laboratories, changes in transmission of and disease caused by *Cryptosporidium*, FDA licensure of nitazoxanide for persons aged ≥1 years in 2005, or a combination of these factors.

During 2011–2012, the geographic variation for cryptosporidiosis was consistent with findings of previous reports on U.S. national cryptosporidiosis surveillance data (*3,50–54*). Cryptosporidiosis was widespread geographically in the United States, with all 50 states and two metropolitan jurisdictions reporting cases. The cryptosporidiosis rate in the Midwest region was 1.7–4.8 times greater than that of other regions in 2011 and 1.0–3.4 times greater in 2012. Although incidence appears to be consistently higher in certain states, differences in reported incidence might reflect differences in risk factors; the magnititude of outbreaks; the capacity to detect, investigate, and report cases; or in the mode of transmission of *Cryptosporidium* in a certain region. If the latter is correct, the increased cryptosporidiosis rate in the Midwest region might be linked to increased contact with livestock, particularly preweaned calves (*75,76*), or increased cattle density (*77*). Systematic national genotyping and subtyping of *Cryptosporidium* isolates could help identify possible geographic differences in the transmission of *Cryptosporidium* in the United States.

Although the overall case counts and rates were consistent with data from recent years, some differences were noted.

FIGURE 3. Number* of cases per year and average annual incidence rate† of cryptosporidiosis, by age group — National Notifiable Diseases Surveillance System, United States, 2011–2012



* N = 17,113; age for 208 patients was unknown.
† Cases per 100,000 population.

The rate of nonconfirmed cryptosporidiosis cases during 2011–2012 increased. This change likely reflects recent revisions to the cryptosporidiosis case definition. In 2011, responding to concern about false positive results, the case definition was revised to include only those cases diagnosed by laboratory methods with a high PPV *(58)*. The 2011 and 2012 revisions of the case definition of cryptosporidiosis, which classify cases diagnosed by immunochromatographic card/rapid card tests or unknown diagnostic method as probable, present challenges to interpreting national trends. However, establishing standards for integrating laboratory methods into the case definition is an important step toward improving the quality of NNDSS data.

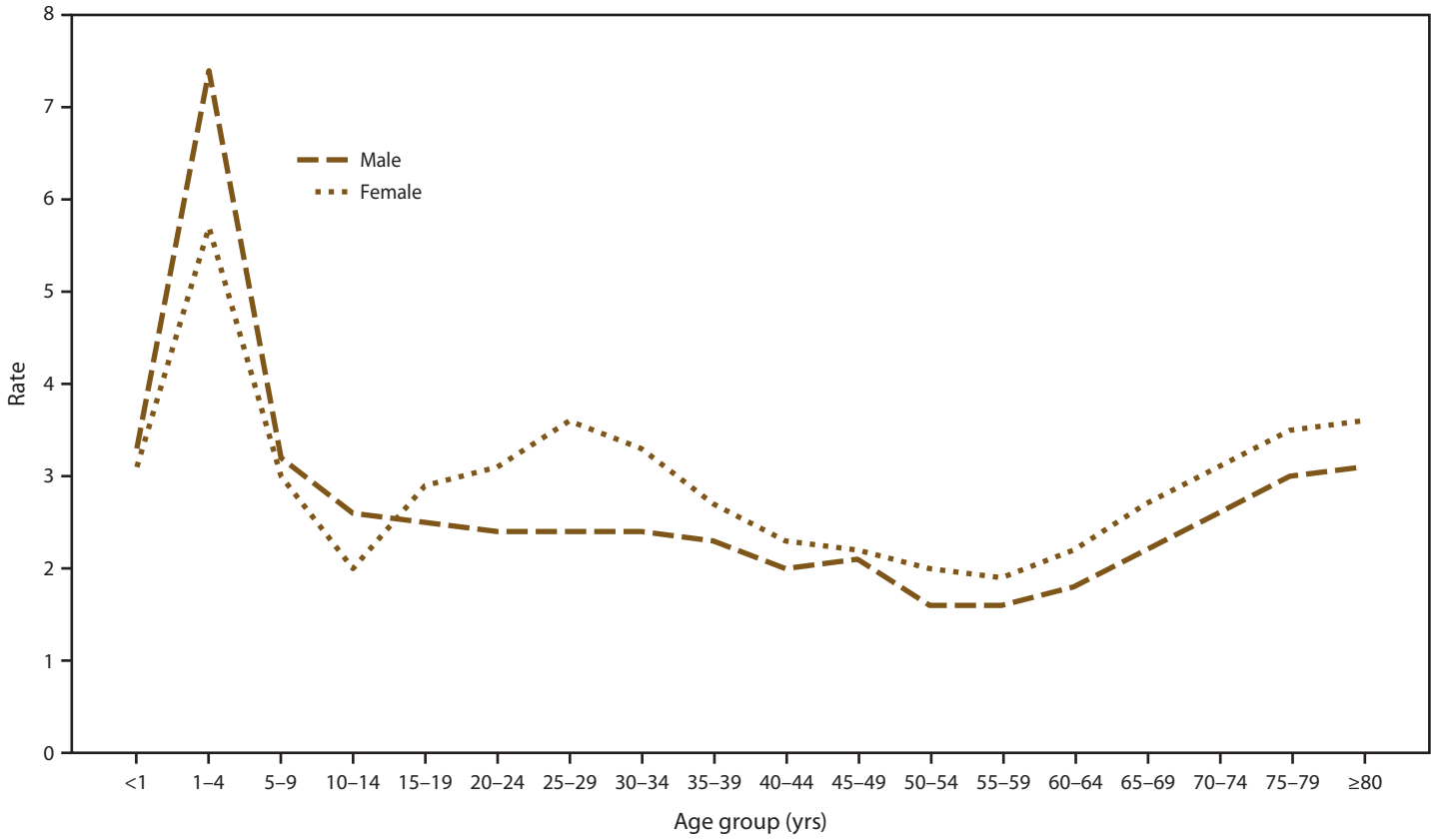
During 2011–2012, the number of reported cryptosporidiosis cases was highest in children aged 1–4 years, followed by children aged 5–9 years and adults aged 25–29 years. Similar findings have been noted in previous reports on U.S. national cryptosporidiosis surveillance data, as well as Canadian provincial, Australian state, and national Finnish and United Kingdom surveillance data (*3,29,50–54,78–82*).

TABLE 2. Number and percentage* of cryptosporidiosis cases, by select patient demographic characteristics — National Notifiable Diseases Surveillance System, United States, 2011–2012

	2011–2012	
Characteristic	**No.**	**(%)**
Sex		
Male	8,068	(46.6)
Female	9,202	(53.1)
Missing	51	(0.3)
Total	**17,321**	**(100.0)**
Race		
Alaska Native/American Native	74	(0.4)
Asian Pacific Islander	184	(1.1)
Black	1,329	(7.7)
White	11,678	(67.4)
Other	487	(2.8)
Missing	3,569	(20.6)
Total	**17,321**	**(100.0)**
Ethnicity		
Hispanic	1,060	(6.1)
Non-Hispanic	10,436	(60.3)
Missing	5,825	(33.6)
Total	**17,321**	**(100.0)**

* Percentages might not total 100% because of rounding.

FIGURE 4. Average annual incidence rate* of cryptosporidiosis, by sex and age group — National Notifiable Diseases Surveillance System, United States, 2011–2012†



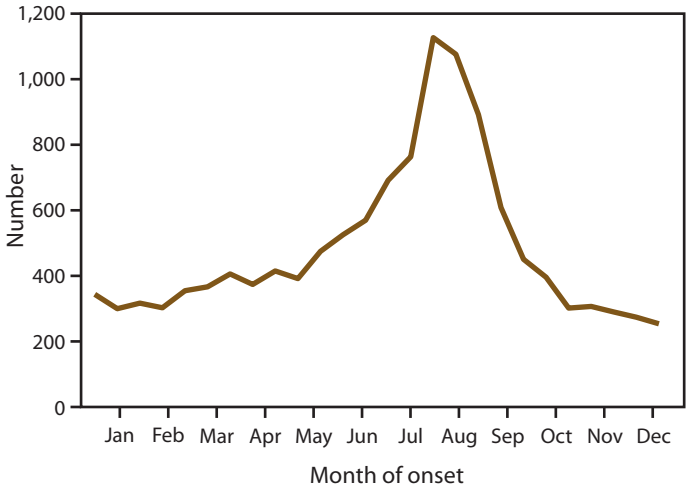
* Cases per 100,000 population.
† N = 17,066; age and sex for 255 patients was unknown.

These findings might reflect *Cryptosporidium* transmission from young children to their caregivers (e.g., child-care staff, family members, and other household contacts) (*47*). Although the number of cases was higher in children and young adults, the rates of cryptosporidiosis infection per 100,000 population were highest in children aged 1–4 years followed by elderly adults aged ≥75 years. Although cryptosporidiosis rates have been increasing in the elderly population in the United States (*3,50–54*), 2011 marks the first year in which cryptosporidiosis rates among elderly persons surpassed rates among children aged 5–9 years and adults in their 20s and 30s. It is unclear whether this finding reflects an actual increase in rates of cryptosporidiosis among elderly adults or changes in diagnostic testing for cryptosporidiosis in elderly populations.

Overall, cryptosporidiosis rates were higher among females than males in 2011 and 2012. These findings are consistent with previous reports of increased rates of cryptosporidiosis in females first noted in 2007 (*3,53,54*). An examination of cryptosporidiosis rates by sex and age revealed that cryptosporidiosis rates were higher among males than females for persons aged <15 years and higher among females aged ≥15 years, which is consistent with 2009–2010 national surveillance data (*3*). It is unclear why rates of cryptosporidiosis have increased and remained elevated in females aged ≥15 years. It is possible that females aged ≥15 years are more likely to fill caregiver roles for young children, which places them at risk for cryptosporidiosis infection (*47*). It is also possible that men are less likely to seek health care when symptoms occur, and therefore less likely to be tested, diagnosed, or reported to have cryptosporidiosis (*83,84*).

During 2011–2012, a 4.4-fold increase occurred in cryptosporidiosis symptom onset during late summer. This finding is consistent with previous reports from the United States and other countries including the United Kingdom, Canada, Finland, and Australia (*3,29,50–54,78–82*). Furthermore, symptom onset of cases in those aged 1–4, 5–9, and 25–29 years all peaked in August, which drove the overall seasonal peak. This finding is consistent with increased use of recreational water venues during the summer, particularly among

FIGURE 5. Number of cryptosporidiosis case reports,* by date of symptom onset† — National Notifiable Diseases Surveillance System, United States, 2011–2012



* Cases per 100,000 population.
† N = 12,581; date of onset for 4,740 patients was unknown.

younger populations (*1,63–74*). Symptom onset in older adults aged ≥75 years did not peak seasonally.

To reduce the transmission of *Cryptosporidium* in treated recreational water, improvements in the design, construction, operation, and maintenance of these aquatic venues are needed. In the United States, no federal agency regulates treated recreational water; pool codes are enacted, implemented, and enforced by state or local officials. The lack of uniform national standards has been identified as a barrier to the prevention and control of illness associated with public treated recreational water venues. To provide support to state and local health departments looking to reduce risk for recreational water-associated illness, CDC has sponsored development and release of the first edition of the Model Aquatic Health Code (MAHC) (http://www. cdc.gov/mahc). Development of the MAHC guidance has been 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 to create or review and update their existing pool codes to optimally prevent and control recreational water-associated illness.

Effective prevention of *Cryptosporidium* transmission through recreational water also requires that swimmers of all ages 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 complete symptom resolution) to prevent contamination. Recreational water can amplify smaller outbreaks into communitywide transmission when persons who are ill introduce the parasite into multiple recreational water venues or other settings (e.g., child-care facilities) (*85*). Once the parasite has been introduced into the water, engineering (e.g., use of ultraviolet or ozone disinfection treatment in addition to standard halogen treatment or enhanced filtration) can help minimize contamination and minimize *Cryptosporidium* transmission in treated recreational water venues. To prevent communitywide outbreaks, CDC has collaborated with state health departments to develop guidelines for rapidly implementing control measures once an increase in case reporting exceeds a predetermined disease–action threshold (e.g., a two- to threefold increase in cases over baseline) rather than waiting for an outbreak investigation to implicate a specific outbreak source (*74*).

To prevent cryptosporidiosis transmission through public drinking water systems, the 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 (*86–89*). Another large outbreak in 1993 occurred in Las Vegas, and lasted for 7 months (*66,90*). During 1994–2012, no cryptosporidiosis outbreaks associated with use of community surface water supplies were detected in the United States (*63–66*). However, in 2013, a cryptosporidiosis outbreak associated with a municipal water system occurred in Baker City, Oregon (*91*). This water system was supplied by surface water and was chlorinated but not filtered. Because of its small population size, the city had not yet been required to provide *Cryptosporidium*-specific treatment, as is required for the majority of surface water systems under the Long Term 2 Enhanced Surface Water Treatment Rule (*87*). This outbreak underscores the importance of source water protection and treatment that removes or inactivates *Cryptosporidium*, as well as enhanced surveillance. To address the risk for outbreaks and illness associated with use of public groundwater supplies, EPA is implementing the Ground Water Rule, which requires sanitary surveys, triggered source water testing, corrective actions when deficiencies or fecal contamination are detected in untreated public groundwater systems, and compliance monitoring for treated groundwater systems (*92*). This rule does not address risk from private wells, which EPA does not have the authority to regulate.

Individual-level prevention and control measures to stop transmission of *Cryptosporidium* include 1) practicing good hygiene (e.g., not swimming when ill with diarrhea and washing hands appropriately), 2) avoiding ingestion of potentially contaminated water (e.g., not swallowing recreational water), 3) exercising food and water precautions when traveling, 4) avoiding ingestion of unpasteurized milk or apple cider, and 5) avoiding fecal exposure during sexual activity (Box).

BOX. CDC recommendations to prevent and control cryptosporidiosis

Practice good hygiene.

- Everywhere
  - Wet hands with clean, running water and apply soap. Lather all surfaces of hands and scrub for at least 20 seconds. Rinse with clean, running water and dry with a clean towel or air
    - 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 caring for someone who is ill with diarrhea,
    - after handling an animal, particularly young livestock, or its waste,
    - after gardening, even if wearing gloves.

Note: alcohol-based hand sanitizers do not effectively kill *Cryptosporidium*.

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

- At child-care facilities
  - Exclude children who are ill with diarrhea from child-care settings until the diarrhea has stopped.

Information about preventing cryptosporidiosis and controlling cryptosporidiosis outbreaks at child-care facilities is available from CDC at http://www.cdc.gov/parasites/crypto/daycare/index.html.

- At the pool
  - Protect others by not swimming if ill with diarrhea.
  - Do not swallow the water.
  - Take young children on bathroom breaks every 60 minutes.

Information about healthy swimming is available from CDC at http://www.cdc.gov/healthywater/swimming/protection/steps-healthy-swimming.html.

Avoid drinking water that might be contaminated.

- Do not drink untreated water from lakes, rivers, springs, ponds, streams, or shallow wells.
- Follow advice given during local drinking water advisories.
- If the safety of drinking water is in doubt (e.g., during an outbreak or if water treatment is unknown), use at least one of the following:
  - bottled water,
  - water that has been previously boiled for 1 minute and left to cool. At elevations above 6,500 feet (1,981 meters), boil for 3 minutes,
  - use a filter designed to remove *Cryptosporidium*.
    - The label might read 'NSF 53' or 'NSF 58'.
    - Filter labels that read "absolute pore size of 1 micron or smaller" are also effective.
- If the safety of drinking water is in doubt (e.g., during an outbreak or if water treatment is unknown), use bottled, boiled, or filtered water to wash fruits and vegetables that will be eaten raw.

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

Practice extra caution when traveling.

- Do not use or drink inadequately treated water or use ice when traveling in countries where the water might be unsafe.
- Avoid eating uncooked foods when traveling in countries where the food supply might be unsafe.

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 barriers (e.g., condoms, natural rubber latex sheets, dental dams, or cut-open non-lubricated condoms) between the mouth and a partner's genitals or rectum.
- Wash hands immediately after handling a condom or other barrier used during anal sex and after touching the anus or rectal area.

Information about cryptosporidiosis prevention in persons with weakened immune systems is available at http://www.cdc.gov/parasites/crypto/ic.

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

Community- and jurisdiction-level prevention encompasses 1) protecting recreational water and drinking water sources from becoming contaminated with *Cryptosporidium* and 2) in the event contamination occurs, treating or filtering water to inactivate or remove the parasite (e.g., using ultraviolet irradiation or ozonation to inactivate *Cryptosporidium* in treated recreational water venues).

Limitations

The findings in this report are subject to at least five limitations. First, incidence rates could not be calculated for race and ethnicity because of missing data. Second, incomplete data on symptom onset date could have led to an inaccurate represention of the seasonal distribution of

cases. Third, lack of data on risk factors or immune status of patients (e.g., HIV status) limits understanding of how these factors might affect national trends. Fourth, the incidence of cryptosporidiosis is likely to be underestimated by these national surveillance data because of underreporting (e.g., not all persons infected with *Cryptosporidium* are symptomatic and, unbeknownst to many health-care providers, laboratories typically do not include *Cryptosporidium* testing in routine examination of stool for ova and parasites). Fifth, it is unclear whether cases of cryptosporidiosis diagnosed on the basis of use of immunochromotographic card tests were reported as confirmed or probable; states might have varied timelines for adapting changes to the NNDSS case definition.

Conclusion

Although cryptosporidiosis rates remain elevated in the United States, the epidemiology of cryptosporidiosis in the United States might be changing, particularly with respect to confirmed case status and patient age. Improved surveillance and epidemiologic studies are needed to clarify if these observed changes reflect actual shifts in *Cryptosporidium* transmission or are artifacts of changes in case definition and diagnostic testing and reporting practices. 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 (*93*). Existing state and local public health infrastructure supported through CDC could facilitate enhancement of surveillance efforts. Examples of CDC support include FoodNet, Environmental Health Specialists Network [EHS-Net], Epidemiology and Laboratory Capacity grants, and CDC-sponsored Council of State and Territorial Epidemiologists Applied Epidemiology Fellows. Although many jurisdictions investigate cryptosporidiosis cases, risk-factor data are not available for all jurisdictions via NNDSS. Collaborating with reporting jurisdictions to collect standardized risk factor data would enhance CDC's understanding of U.S. cryptosporidiosis epidemiology. 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, as exemplified in the United Kingdom (*94*). Such an effort would require phasing out the practice of preserving stool specimens with formalin, which decreases the ability to perform molecular amplification methods.

Ongoing, elevated rates of cryptosporidiosis in the United States underscore the need for improved understanding of cryptosporidiosis epidemiology, particularly of risk factors, to optimize prevention and control. Reducing the transmission of this highly infectious, extremely chlorine-tolerant pathogen requires a multipronged approach, comprising individual-, community-, and jurisdiction-level actions to improve population health.

National surveillance data are critical to understanding the cryptosporidiosis epidemiology in the United States. To enhance cryptosporidiosis surveillance, CDC plans to launch CryptoNet—a DNA sequence-based surveillance system for cryptosporidiosis (http://www.cdc.gov/parasites/crypto/cryptonet.html). CDC has developed a package of molecular characterization methods and a database for this system. These molecular tools are crucial to understanding national transmission patterns and developing targeted prevention guidance. Federal, state, and local public health agencies can use cryptosporidiosis surveillance data to help elucidate the epidemiology of cryptosporidiosis in the United States, establish public health priorities for cryptosporidiosis prevention, target health communication messages, and optimize the design of public health interventions to prevent the transmission of *Cryptosporidium*.

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Giardiasis Surveillance — United States, 2011–2012

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Abstract

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

Reporting Period: 2011–2012.

Description of System: Forty-four states, the District of Columbia, New York City, the Commonwealth of Puerto Rico, and Guam voluntarily reported cases of giardiasis to CDC through the National Notifiable Diseases Surveillance System (NNDSS).

Results: For 2011, a total of 16,868 giardiasis cases (98.8% confirmed and 1.2% nonconfirmed) were reported; for 2012, a total of 15,223 cases (98.8% confirmed and 1.3% nonconfirmed) were reported. In 2011 and 2012, 1.5% and 1.3% of cases, respectively, were associated with a detected outbreak. The incidence rates of all reported cases were 6.4 per 100,000 population in 2011 and 5.8 per 100,000 population in 2012. This represents a slight decline from the relatively steady rates observed during 2005–2010 (range: 7.1–7.9 cases per 100,000 population). In both 2011 and 2012, cases were most frequently reported in children aged 1–4 years, followed by those aged 5–9 years and adults aged 45–49 years. Incidence of giardiasis was highest in Northwest states. Peak onset of illness occurred annually during early summer through early fall.

Interpretation: For the first time since 2002, giardiasis rates appear to be decreasing. Possible reasons for the decrease in rates during 2011–2012 could include changes in transmission patterns, a recent change in surveillance case definition, increased uptake of strategies to reduce waterborne transmission, or a combination of these factors. Transmission of giardiasis occurs throughout the United States, with more frequent diagnosis or reporting occurring in northern states. Geographical differences might suggest actual regional differences in giardiasis transmission or variation in surveillance capacity across states. Six states did not report giardiasis cases in 2011–2012, representing the largest number of nonreporting states since giardiasis became nationally notifiable in 2002. Giardiasis is reported more frequently in young children, which might reflect increased contact with contaminated water or ill persons, or a lack of immunity.

Public Health Action: Educational efforts to decrease exposure to unsafe drinking and recreational water and prevent person-to-person transmission have the potential to reduce giardiasis transmission. The continual decrease in jurisdictions opting to report giardiasis cases could negatively impact the ability to interpret national surveillance data; thus, further investigation is needed to identify barriers to and facilitators of giardiasis case reporting. Existing state and local public health infrastructure supported through CDC (e.g., Epidemiology and Laboratory Capacity grants and CDC-sponsored Council of State and Territorial Epidemiologists Applied Epidemiology Fellows) could provide resources to enhance understanding of giardiasis epidemiology.

Introduction

Giardia intestinalis (also known as *G. lamblia* and *G. duodenalis*), a flagellated protozoan, is the most common intestinal parasite of humans identified in the United States (*1*), and a common cause of outbreaks associated with untreated surface and groundwater (*2,3*). Annually, an estimated 1.2 million cases occur in the United States (*4*); and hospitalizations resulting from giardiasis cost approximately $34 million (*5*).

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Giardiasis is generally a self-limited illness typically characterized by diarrhea, abdominal cramps, bloating, weight loss, and malabsorption; asymptomatic infection also occurs frequently (*6–8*). Case reports and epidemiologic studies have associated giardiasis with the development of chronic enteric disorders, allergies, chronic fatigue, and reactive arthritis (*9–14*).

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 (*15*). The cysts are environmentally hardy, moderately chlorine tolerant, and infectious immediately upon being excreted in feces (*16*). The infectious dose is low; ingestion of 10 cysts has been reported to cause infection (*16*).

Infected persons have been reported to shed 10^8–10^9 cysts in their stool per day and to excrete cysts for months (*16*–*18*). Effective therapies are available for patients with symptomatic giardiasis, including metronidazole, tinidazole, nitazoxanide, paromomycin, furazolidone, albendazole, and quinacrine (*19*).

Giardia is primarily transmitted through ingestion of infected human waste (*20,21*). Drinking untreated water from lakes and rivers, swimming, having contact with some animal species, and sexual practices involving fecal contact might increase risk for giardiasis (*22*). Giardiasis is often detected in international travelers (*23,24*) and among internationally adopted children (*25*). Transmission to close contacts of infected persons can also occur, including to children in child-care settings and their caregivers (*18,26*) or persons with occupational exposure to human waste (*20*, *21*).

CDC recommends that health-care providers consider giardiasis in their differential diagnosis when a patient experiences diarrhea lasting >3 days. Routine examination of stool for ova and parasites does not always include testing for *Giardia* (*27*); thus, health-care providers should specifically request *Giardia* testing. Cyst excretion can be intermittent. Because the parasite might not be detected in a given stool specimen, three stool specimens collected on separate days should be examined before considering test results to be negative (*28*). Direct fluorescent antibody (DFA) testing is an extremely diagnostically sensitive and specific detection method and is considered the standard in *Giardia* testing *(29).*

In the United States, *Giardia* has been reported since 1992 and became a nationally notifiable disease in 2002. Surveillance data for 1992–2010 have been published previously (*30*–*34*). This report summarizes national giardiasis surveillance data for 2011–2012. Federal, state, and local public health agencies can use these giardiasis surveillance data to better understand the epidemiology of giardiasis in the United States, design efforts to prevent the spread of disease, and establish research priorities.

Methods

Case Definition

The first national case definition was published in 1997 (*35*), and a revised case definition was published in 2011 (*36*). The current (2011) case definition differs from the 1997 definition in clarifying that clinical symptoms are necessary for categorizing giardiasis cases as confirmed.

Giardiasis is an illness caused by the protozoan *Giardia intestinalis* (also known as *G. lamblia* or *G. duodenalis*) and characterized by gastrointestinal symptoms (e.g., diarrhea, abdominal cramps, bloating, weight loss, or malabsorption). A confirmed case of giardiasis is defined as a case that meets the clinical description and the criteria for laboratory confirmation. Laboratory-confirmed giardiasis is defined as the detection of *Giardia* organisms, antigen, or DNA in stool, intestinal fluid, tissue samples, biopsy specimens, or other biological samples (*36*).

Nonconfirmed cases of giardiasis include probable, suspected, and unknown cases. A probable case of giardiasis meets the clinical description and is epidemiologically linked to a confirmed case (*36*). A national case definition for suspected cases of giardiasis does not exist; the definition varies by state. If cases are not classified as confirmed, probable, or suspected, then they are considered unknown.

Reporting

Forty-four states, the District of Columbia (DC), New York City (NYC), the Commonwealth of Puerto Rico, and Guam voluntarily reported cases of giardiasis to CDC through the National Notifiable Diseases Surveillance System (NNDSS) in 2011 and 2012. Giardiasis was not reportable in Kentucky, Mississippi, North Carolina, Oklahoma, Tennessee, and Texas. Reports include the patient's place of residence (state), age, sex, race, ethnicity (Hispanic or non-Hispanic), date of symptom onset, and whether the case is outbreak-associated. As has been done historically, the criteria for CDC's annual summary of notifiable diseases were used to classify case status (*37*). 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 2011–2012 were analyzed using statistical software. Numbers, percentages, and incidence rates (cases per 100,000 population) of giardiasis were calculated in aggregate and separately for the United States and territories. Rates were calculated by dividing the number of reported new giardiasis cases by each year's mid-year census estimates for the reporting jurisdictions and multiplying by 100,000 (*38*). In addition to analyzing data nationally and by reporting jurisdiction, data were analyzed by region (Northeast, Midwest, South, and West regions), as defined by the U.S. Census Bureau (*39*). To account for differences in the seasonal use of recreational water, the West region was further subdivided into Northwest and Southwest. To examine reporting over time, giardiasis rates per 100,000 population were calculated by year (from 1993 to 2012) and case type (confirmed or nonconfirmed). To assess current patterns in reporting, average annual giardiasis rates per 100,000 population were calculated by demographic variables (e.g., age and sex) and by month of symptom onset across 2011–2012 combined. This was performed by summing all cases occurring

in the 2-year period, and then dividing by the sum of the number of persons in reporting jurisdictions in each year, and multiplying by 100,000. Rates could not be calculated for some variables (race and ethnicity) because of a large percentage of reports missing data (>20%) for these variables.

Results

During 2011–2012, all jurisdictions in the United States where giardiasis is reportable (including 44 states, DC, and NYC) voluntarily reported giardiasis cases to CDC through the National Notifiable Diseases Surveillance System (NNDSS). Among United States territories, Puerto Rico reported cases in 2011–2012, and Guam reported cases in 2012. A total of 16,868 giardiasis cases were reported in 2011 (98.8% confirmed), and 15,223 cases were reported in 2012 (98.8% confirmed) (Table 1). The rates of reported cases were 6.4 per 100,000 population in 2011 and 5.8 in 2012. This represents a slight decline from the relatively steady rates observed during 2005–2010 (range: 7.1–7.9 cases per 100,000 population), and a further decline from the peak of 13.84 cases per 100,000 population reported in 1995 (Figure 1). Approximately 99% of cases were confirmed for both 2011 and 2012, which is consistent with previous years. Of all cases reported for 2011 and 2012, 1.5% (251 of 16,868) and 1.3% (200 of 15,223) were reported to be associated with a detected outbreak (Table 1).

By region, the rates of reported giardiasis cases per 100,000 population ranged from 4.8 in the Southwest to 9.4 in the Northwest in 2011 and 4.6 in the Southwest and South to 8.5 in the Northwest in 2012 (Table 1). By state, giardiasis rates were lowest in Arizona (2.1 in 2011 and 1.7 in 2012) and highest in Vermont (35.6 in 2011 and 29.2 in 2012); 10 jurisdictions had rates higher than 10 per 100,000 population in 2012 (Figure 2, Table 1). The categories delineated in Figure 2 were initially used in the 1998–2002 giardiasis surveillance summary *(31)*. In this and previous surveillance summaries they have remained the same to allow for comparison over time.

Surveillance data displayed a bimodal age distribution, with the largest number and rate of reported cases occurring among young children aged 1–9 years, with a smaller, flatter peak among middle-aged adults aged 40–49 years (Figure 3). In both 2011 and 2012, the largest number of cases was reported in children aged 1–4 years followed by those aged 5–9 years and adults aged 45–49 years. During 2011–2012, the rate of reported giardiasis per 100,000 population was highest in children aged 1–4 years (16.4) and 5–9 years (8.4) followed by adults aged 40–44 years (6.3) and 45–49 years (6.2). Rates were lowest among adults aged ≥80 years (2.7 per 100,000 population).

During 2011–2012, a total of 18,437 (57.7%) patients were male and 13,354 (41.8%) were female; 190 (0.6%) were missing data on sex (Table 2). The majority of cases for which data on race were available occurred among whites, followed by blacks, and Asians/Pacific Islanders (Table 2). However, data on race were not included for 41.2% of total annual case reports. Although 6.5% (2,074 of 16,590) of patients were identified as Hispanic, data on ethnicity were lacking for 48.1% of total annual case reports.

Analysis of rates by age and sex showed that giardiasis rates were higher among males in almost every age group (Figure 4). This difference was most pronounced among males aged 45–49 years. However, in persons aged 65–69 years, rates were slightly higher among females than males (5.1 versus 4.9 per 100,000 population).

Date of symptom onset was reported for 17,105 (53.5%) of the 31,981 cases during 2011–2012. The number of cases by symptom onset peaked in late July to early August (n = 1,075), which was 2.2 times higher than the lowest number of cases by symptom onset in February (n = 480) (Figure 5).

Discussion

National giardiasis surveillance data are critical in assessing the disease prevalence and epidemiologic characteristics of giardiasis in the United States. Following a gradual decline in case reports during 1996–2001, the number of case reports and disease rates stabilized during 2002–2010, coinciding with the disease becoming nationally notifiable in 2002 (Figure 1) (*30–34*). For the first time in 10 years, giardiasis rates appear to be decreasing. Possible reasons for the decreased rates during 2011–2012 might include changes in transmission of disease caused by *Giardia*, a decreased emphasis on giardiasis surveillance in public health agencies, the 2011 change in case definition clarifying that clinical symptoms are necessary for categorizing giardiasis cases as confirmed, increased uptake of strategies to reduce waterborne transmission (e.g., implementation of EPA's Ground Water Rule to address contamination of public ground water systems (*40*), or a combination of these factors.

The last national surveillance data were published in 2009–2010 (*34*). Since publication of that data, rates have declined across all regions. Giardiasis rate reductions were most pronounced in the Midwest, where rates declined from 10.3 and 11.4 per 100,000 population in 2009 and 2010 to 6.6 and 5.8 in 2011 and 2012. As in previous years, rates were highest in northern states, and Vermont reported the highest rate for the last 7 years. The geographic differences might suggest actual regional differences in giardiasis transmission,

TABLE 1. Number, percentage,* and incidence rate† of giardiasis case reports, by region, state, and territory — National Notifiable Diseases Surveillance System, United States, 2011–2012

	2011				2012			
United States	**No.**	**%**	**Rate**	**No. of outbreak cases**	**No.**	**%**	**Rate**	**No. of outbreak cases**
Northeast	**4,888**	**29.0**	**8.8**	**28**	**4,365**	**28.7**	**7.8**	**40**
Connecticut	233	1.4	6.5		223	1.5	6.2	
Maine	171	1.0	12.9		169	1.1	12.7	4
Massachusetts	758	4.5	11.5		698	4.6	10.5	
New Hampshire	131	0.8	9.9		106	0.7	8.0	
New Jersey	437	2.6	4.9		423	2.8	4.8	
New York State§	1,144	6.8	10.2	6	975	6.4	8.7	20
New York City§	917	5.4	11.1		872	5.7	10.5	
Pennsylvania	795	4.7	6.2	22	658	4.3	5.2	16
Rhode Island	79	0.5	7.5		58	0.4	5.5	
Vermont	223	1.3	35.6		183	1.2	29.2	
Midwest	**4,434**	**26.3**	**6.6**	**45**	**3,934**	**25.8**	**5.8**	**15**
Illinois	407	2.4	3.2	8	347	2.3	2.7	
Indiana	331	2.0	5.1	2	227	1.5	3.5	6
Iowa	271	1.6	8.8		251	1.7	8.2	
Kansas	139	0.8	4.8		133	0.9	4.6	
Michigan	550	3.3	5.6		547	3.6	5.5	5
Minnesota	672	4.0	12.6		610	4.0	11.3	
Missouri	344	2.0	5.7		330	2.2	5.5	
Nebraska	180	1.1	9.8		195	1.3	10.5	
North Dakota	54	0.3	7.9		64	0.4	9.1	3
Ohio	799	4.7	6.9	18	582	3.8	5.0	1
South Dakota	110	0.7	13.4	11	144	1.0	17.3	
Wisconsin	577	3.4	10.1	6	504	3.3	8.8	
South	**3,281**	**19.5**	**5.2**	**158**	**2,950**	**19.4**	**4.6**	**108**
Alabama	171	1.0	3.6		178	1.2	3.7	
Arkansas	123	0.7	4.2		108	0.7	3.7	
Delaware	34	0.2	3.7		24	0.2	2.6	
District of Columbia	56	0.3	9.0		77	0.5	12.2	
Florida	1,255	7.4	6.6	129	1,095	7.2	5.7	108
Georgia	651	3.9	6.6		544	3.6	5.5	
Kentucky	NR				NR			
Louisiana	226	1.3	4.9		224	1.5	4.9	
Maryland	291	1.7	5.0	24	239	1.6	4.1	
Mississippi	NR				NR			
North Carolina	NR				NR			
Oklahoma	NR				NR			
South Carolina	117	0.7	2.5	5	128	0.8	2.7	
Tennessee	NR				NR			
Texas	NR				NR			
Virginia	295	1.8	3.6		274	1.8	3.3	
West Virginia	62	0.4	3.3		59	0.4	3.2	
Northwest	**1,372**	**8.1**	**9.4**	**13**	**1,247**	**8.2**	**8.5**	**22**
Alaska	101	0.6	14.0		96	0.6	13.1	
Idaho	178	1.1	11.2	6	153	1.0	9.6	19
Montana	87	0.5	8.7		68	1.5	6.8	
Oregon	436	2.6	11.3	6	381	2.5	9.8	1
Washington	529	3.1	7.8		512	3.4	7.4	
Wyoming	41	0.2	7.2	1	37	0.2	6.4	2
Southwest	**2,809**	**16.7**	**4.8**	**7**	**2,701**	**17.7**	**4.6**	**15**
Arizona	133	0.8	2.1		113	0.7	1.7	
California	1,750	10.4	4.6		1,725	11.3	4.5	6
Colorado	445	2.6	8.7	7	356	2.3	6.9	1
Hawaii	38	0.2	2.8		34	0.2	2.4	
Nevada	79	0.5	2.9		91	0.6	3.3	
New Mexico	108	0.6	5.2		95	0.6	4.6	1
Utah	256	1.5	9.1		287	1.9	10.1	7
Total United States	**16,784**	**99.5**	**6.5**	**251**	**15,197**	**99.8**	**5.8**	**200**

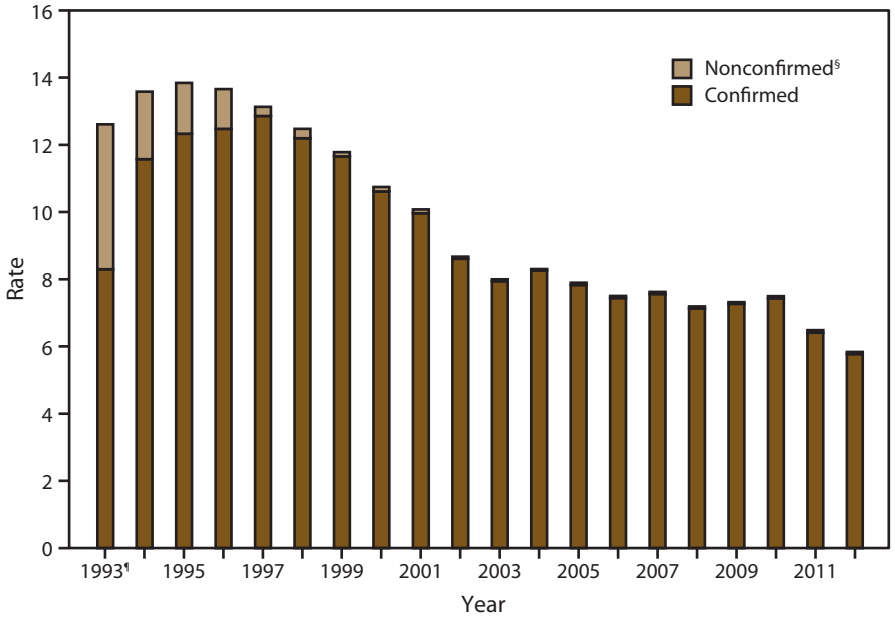
See table footnotes on next page.

TABLE 1. (*Continued*) Number, percentage,* and incidence rate† of giardiasis case reports, by region, state, and territory — National Notifiable Diseases Surveillance System, United States, 2011–2012

	2011				2012			
United States	**No.**	**%**	**Rate**	**No. of outbreak cases**	**No.**	**%**	**Rate**	**No. of outbreak cases**
Territory								
Guam	—	—	—-		2	<0.1	1.1	
Puerto Rico	84	0.5	2.3		24	0.2	0.7	
Total territories	**84**	**0.5**	**2.2**	**0**	**26**	**0.2**	**0.7**	**0**
Total	**16,868**	**100.0**	**6.4**	**251**	**15,223**	**100.0**	**5.8**	**200**

Abbreviation: NR = not reportable.
Sources: Population estimates are from the U.S. Census Bureau. Table 1. Annual estimates of the population for the United States, regions, states, and Puerto Rico: April 1, 2010 to July 1, 2012. Data in this table were accessed on November 9, 2013 at http://www.census.gov/popest/data/state/totals/2012/. Estimates of the New York City population: annual estimates of the resident population for incorporated places over 50,000, ranked by July 1, 2012, population: April 1, 2010 to July 1, 2012. Data in this table were accessed on November 9, 2013 at http://www.census.gov/popest/data/cities/totals/2012/index.html. Estimates for the population of Guam are from the International Data Base (IDB) Data Access. Data in this table were accessed on January 9, 2014 at http://sasweb.ssd.census.gov/cgi-bin/broker.
* Percentages might not total 100% because of rounding.
† Cases per 100,000 population.
§ New York State and New York City data are mutually exclusive.

FIGURE 1. Incidence rate* of giardiasis, by year and case classification — National Notifiable Diseases Surveillance System, United States, 1993–2012†

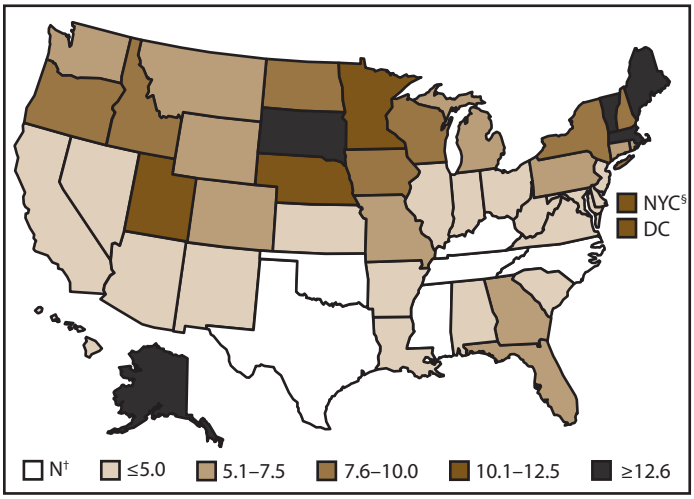


* Cases per 100,000 population.
† N = 423,450.
§ Nonconfirmed includes probable, suspect, and unknown cases.
¶ First full year of reporting.

or they might reflect variation in surveillance capacity across states. Although giardiasis is a nationally notifiable disease, six states did not report giardiasis during 2011–2012. The number of states that do not report giardiasis cases has increased from four to six states over the past 2 years (*34*). This represents the largest number of nonreporting states since giardiasis became nationally notifiable in 2002 *(31–34)*, which is a concerning trend, given that giardiasis is the most frequently identified enteric parasite in the United States (*1*). However, the nonreporting states do not explain the declines in national rates because rates declined in most states that consistently reported cases.

Giardiasis rates varied by age and sex. The rate of reported giardiasis was higher in males than females in almost all age groups, particularly among adults aged 45–49 years. Compared with previous years, giardiasis rates declined across most age groups and both sexes in 2011–2012. Among males and females, rates were highest among children aged 1–9 years, which is consistent with previously published reports (*30–34*). Higher rates in children might be related to increased recreational water exposures, poor hygiene skills, close contact with other potentially infected children in child-care settings, and lack of previous exposure to *Giardia,* which could render them more susceptible to infection and illness (*41,42*). *Giardia* has been identified frequently as the cause of diarrhea among children examined in outpatient clinics (*43*), and transmission from ill children to household contacts has been documented in outbreak investigations (*44,45*). The sharpest declines were seen in this age group as well. The rate among children aged 1–4 years declined from 23.5 per 100,000 population in 2009–2010 to 16.4 in 2011–2012, and the rate among children aged 5–9 years dropped from 12.5 per 100,000 population in 2009–2010 to 8.4 in 2011–2012 (*34*). No national efforts to prevent person-to-person transmission in child-care settings have occurred that would explain the rate reductions in young children. Interventions to reduce drinking water-associated transmission of *Giardia* (e.g., EPA's Ground Water Rule) might have a larger impact on the young, because

FIGURE 2. Incidence rate* of giardiasis, by reporting jurisdiction — National Notifiable Diseases Surveillance System, United States, 2012



* Cases per 100,000 population.
† Not a reportable disease in these states.
§ New York State and New York City data are mutually exclusive.

TABLE 2. Number and percentage* of giardiasis cases, by selected patient demographic characteristics — National Notifiable Diseases Surveillance System, United States, 2011–2012

Characteristic	No.	%
Sex		
Male	18,437	57.7
Female	13,354	41.8
Missing	190	0.6
Total	**31,981**	**100.0**
Race		
Alaska Native/American Native	119	0.4
Asian Pacific Islander	1,690	5.3
Black	2,179	6.8
White	13,737	43.0
Other	1,076	3.4
Missing	13,180	41.2
Total	**31,981**	**100.0**
Ethnicity		
Hispanic	2,074	6.5
Non-Hispanic	14,516	45.4
Missing	15,391	48.1
Total	**31,981**	**100.0**

* Percentages might not total 100% because of rounding.

older persons have had more opportunities to be previously infected with *Giardia*, which could confer partial protection from reinfection or symptomatic infection (*46,47*). Reducing the presence of this parasite in the water might, in turn, prevent person-to-person transmission in settings that foster increased risk for infection, such as child-care centers (*18,26*).

During 2011–2012, a twofold increase in giardiasis reporting occurred during summer compared with winter months, with a peak in late July and early August. This finding is consistent with temporal patterns observed previously in the United States (*30–34*) and Canada (*41*), and similar to the seasonal profile of other parasitic and bacterial enteric diseases (e.g., cryptosporidiosis and vibriosis) (*48,49*). The summer peak coincides with increased outdoor activities (e.g., camping and swimming) that likely increase exposure to contaminated water. Transmission associated with outdoor activities is facilitated by the substantial number of *Giardia* cysts that can be shed by a single person (*17*), the environmental hardiness of the organism (*50*), the extended periods of time that cysts can be shed *(18),* and the low infectious dose for infection *(16).*

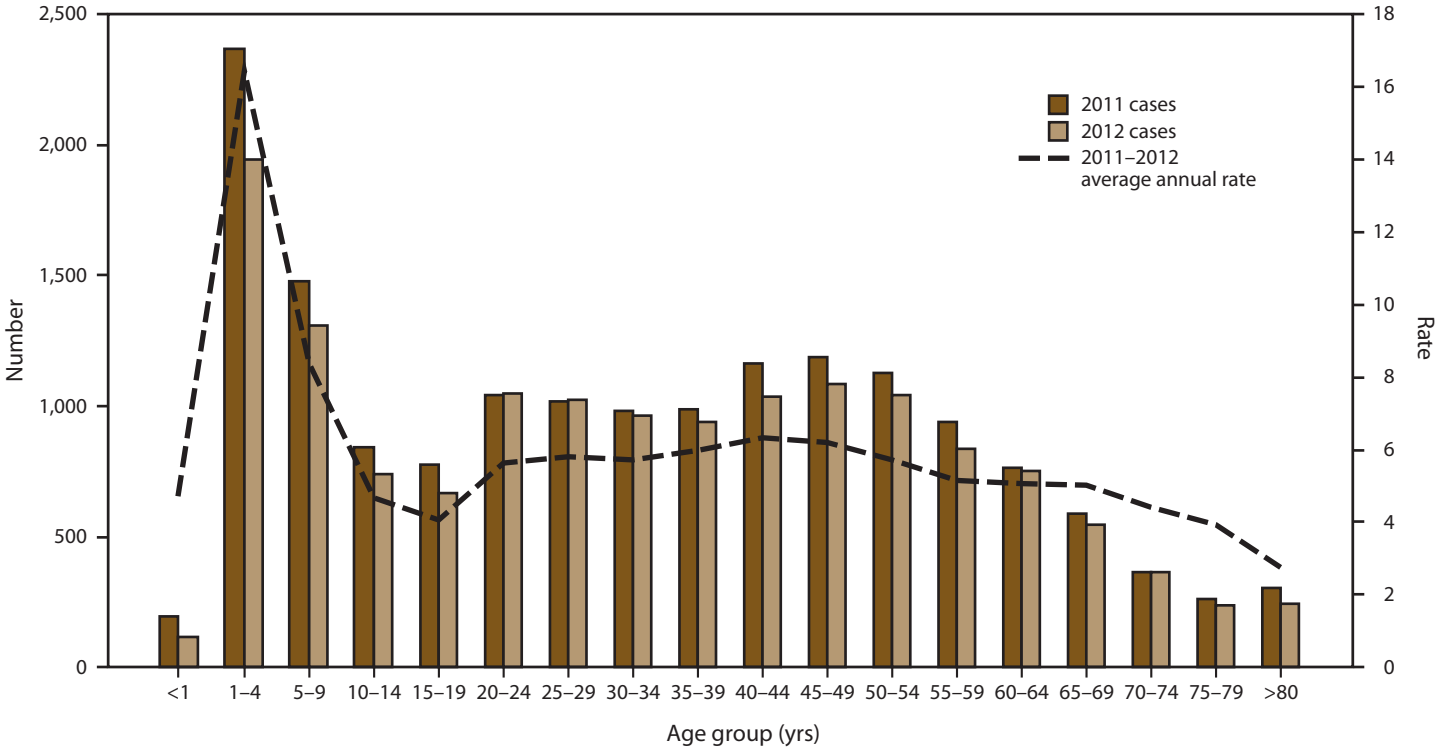
Drinking water is a well-documented vehicle for *Giardia* transmission. *G. intestinalis* was the single most frequently identified pathogen in all drinking water outbreaks reported in the United States during 1971–2006, responsible for 28% of all outbreaks with an identified etiology (*3*). Untreated drinking water has been identified as a risk factor for sporadic giardiasis in the United States (*51,52*) and New Zealand *(24)*. Groundwater can be particularly risky if acquired from poorly constructed or maintained wells that might have been subject to surface water contamination.

Both treated and untreated recreational water also have been implicated as vehicles 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 (53). In studies of sporadic giardiasis, swallowing water while swimming and recreational contact with fresh water were both risk factors for contracting *Giardia* (*22,24*). *Giardia* can be frequently detected in fecal material in pools (*54*), and transmission has been documented among diapered children who use swimming venues regularly (*45,55,56*).

Reported foodborne outbreaks of giardiasis have generally been caused by direct contamination by an infected food handler (*57,58*) or animal contamination of food (*59*). However, foodborne outbreaks of giardiasis are infrequently reported in the United States. During 2000–2010, <1% of foodborne outbreaks with an identified etiology was attributed to *Giardia* (*59*). Infections from contamination of widely distributed foods (e.g., fresh produce) might be difficult to detect. A recent study of Canadian produce showed that 1.8% of precut salad and leafy green samples were contaminated with *Giardia* (*60*), and a study of sporadic giardiasis in England identified eating lettuce as a risk factor for giardiasis (*22*). The use of reclaimed wastewater for irrigation is associated with the finding of *Giardia* cysts on fresh produce (*61*), highlighting the importance of using noncontaminated irrigation water to prevent foodborne disease.

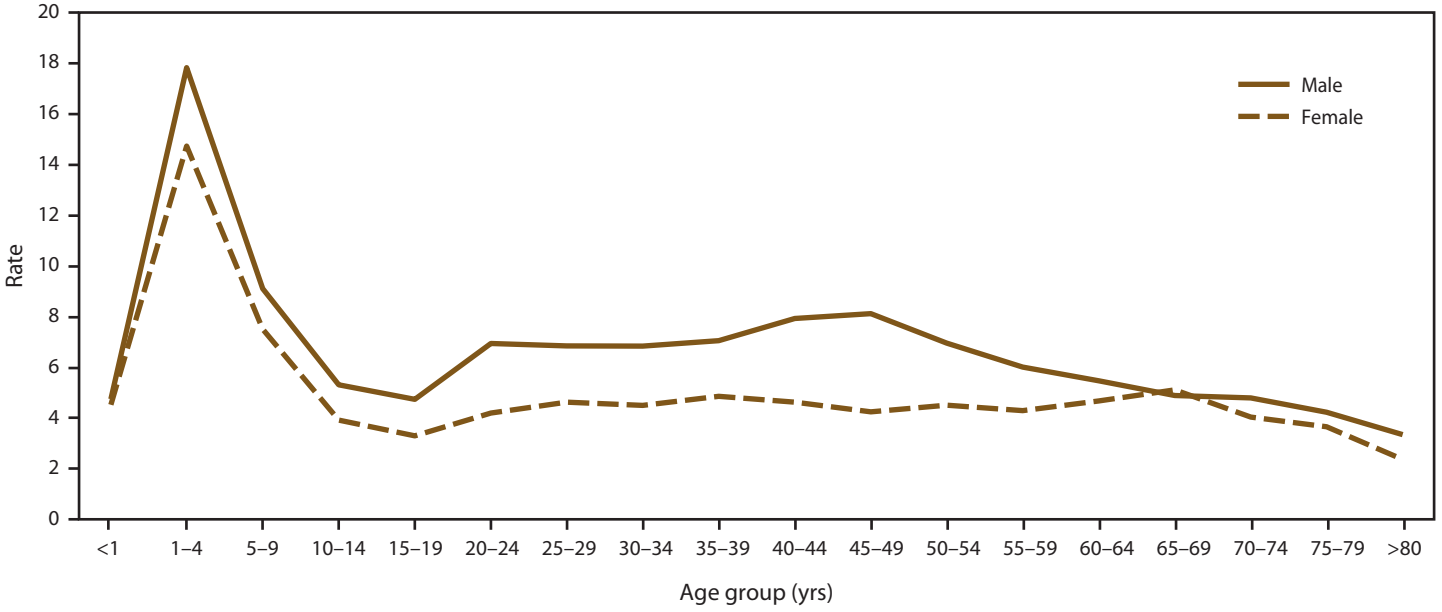
Person-to-person transmission of *Giardia* also occurs. Persons attending or working in child-care settings or those who have close contact with persons with giardiasis are at increased risk for being infected (*51,52,62,63*). Exposure to

FIGURE 3. Number* of cases per year and average annual incidence rate† of giardiasis, by age group — National Notifiable Diseases Surveillance System, United States, 2011–2012



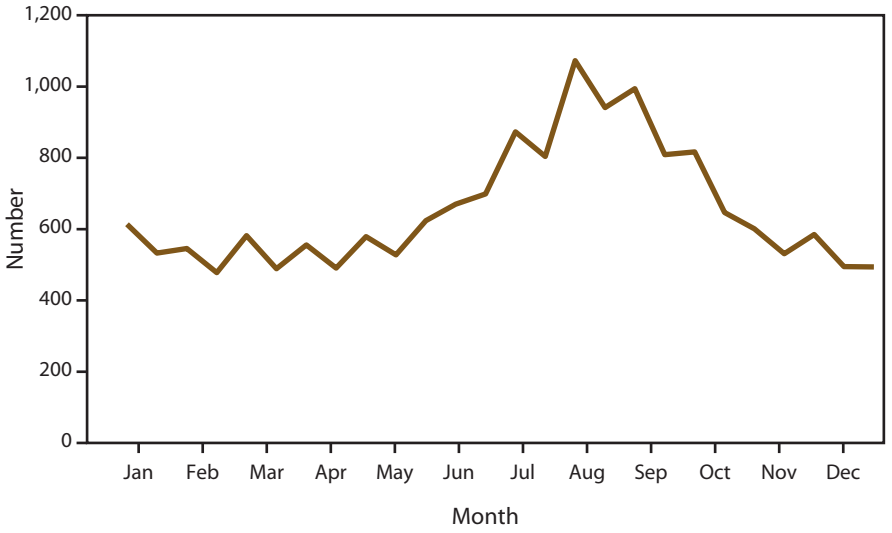
* N = 31,167; age for 814 patients was unknown.
† Cases per 100,000 population.

FIGURE 4. Average annual incidence rate* of giardiasis, by sex and age group — National Notifiable Diseases Surveillance System, United States, 2011–2012†



* Cases per 100,000 population.
† N = 30,997; age and sex for 1,094 patients was unknown.

FIGURE 5. Number* of giardiasis case reports, by date of symptom onset — National Notifiable Diseases Surveillance System, United States, 2011–2012



* Of total number of cases (N = 31,981), date of onset for 14,876 patients was unknown.

feces through handling diapers and poor hygiene, particularly after toileting, in child-care settings might contribute to increased risk (*20,55*).

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 reexamined in light of advances in molecular epidemiology. *Giardia* has been detected in nearly all classes of vertebrates, including domestic animals and wildlife (*64*), but molecular characterization of *G. intestinalis* has identified relatively species-specific genetic assemblages. Humans are only infected with assemblages A and B, which can sometimes be found in other animals. However, animals are usually infected with other species-specific assemblages (*64*). Epidemiologic data implicating wildlife, cattle, and pets as sources of human-pathogenic *Giardia* assemblages are limited, and findings from molecular studies of *G. intestinalis* assemblages and subtypes suggest that the risk of zoonotic transmission is not as high as previously thought (*15*). No molecular data are reported to CDC surveillance systems, limiting the ability to understand the role of zoonotic transmission.

Strategies to reduce the incidence of giardiasis have focused on reducing waterborne and person-to-person transmission (Box). The low infectious dose of *Giardia*, protracted shedding of cysts, and moderate chlorine tolerance make it ideally suited for transmission through these pathways. The Environmental Protection Agency (EPA) enacted a series of rules designed to prevent pathogens in surface water sources from contaminating drinking water systems (*65,66,67,68*). These regulations might have contributed to a decrease in the number of giardiasis outbreaks associated with community drinking water systems (*3*). 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 (*40*). For recreational water, proper pool maintenance (i.e., sufficient disinfection, filtration, and recirculation of water) and excluding children with diarrhea from pools should decrease transmission through treated recreational water. Person-to-person transmission of *Giardia* is difficult to interrupt in a systematic fashion, particularly in child-care settings (*63*). Adherence to appropriate infection control policies (e.g., exclusion of children ill with diarrhea, hand washing, diaper changing, and separation of ill children from well children) is recommended for controlling giardiasis and other enteric pathogens in these group settings (*69*).

Limitations

The findings in this report are subject to at least five limitations. First, case reports lack data on exposure history and often have incomplete data on race and ethnicity; thus, it was not possible to evaluate the contributions of exposures or identify racial or ethnic groups at increased risk for giardiasis. Second, incomplete data on symptom onset date could have led to an inaccurate representation of the seasonal distribution of cases. Third, incidence of giardiasis is likely to be underestimated by these national surveillance data because of underreporting (e.g., not all persons infected with *Giardia* 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). Fourth, the 2011 case definition clarification that symptoms should be present for a case to be confirmed might limit direct rate comparisons with previous years. Finally, giardiasis is not a reportable disease in all states, which can lead to an incomplete picture of its geographic distribution and an underestimation or overestimation of national incidence rates.

Future Directions

Although giardiasis is the most common enteric parasitic infection in the United States, gaps in understanding of its epidemiology still exist. Methods to improve reporting include encouraging health-care providers to consider and specifically request testing for *Giardia* in the workup of gastrointestinal

BOX. CDC recommendations to prevent and control giardiasis

Practice good hygiene.

- Everywhere
  - Wet hands with clean, running water and apply soap. Lather all surfaces of hands and scrub for at least 20 seconds. Rinse with clean, running water and dry with a clean towel or air
    - 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 caring for someone who is sick with diarrhea,
    - after touching an animal or animal waste,
    - after gardening, even if wearing gloves.

Note: It is unknown whether alcohol-based hand sanitizers effectively kill *Giardia*.

Information about handwashing is available from CDC at http://www.cdc.gov/handwashing/when-how-handwashing.html.

- At child-care facilities
  - Exclude children who are ill with diarrhea from child-care settings until the diarrhea has stopped.
  - Wash hands before water-based activities like water tables.
- At the pool
  - Protect others by not swimming if ill with diarrhea.
  - Do not swallow the water.
  - Take young children on bathroom breaks every 60 minutes.

Information about healthy swimming is available from CDC at http://www.cdc.gov/healthywater/swimming/protection/steps-healthy-swimming.html.

Avoid drinking water that might be contaminated.

- Do not drink untreated water from lakes, rivers, springs, ponds, streams, or shallow wells.
- Follow advice given during local drinking water advisories.
- If the safety of drinking water is in doubt (e.g., during an outbreak or if water treatment is unknown), use at least one of the following:
  - bottled water.
  - water that has been previously boiled for 1 minute and left to cool. At elevations above 6,500 feet (1,981 meters), boil for 3 minutes.
  - a filter designed to remove Giardia
    - The label might read certified to "NSF 53" or "NSF 58".
    - Filter labels that read “absolute pore size of 1 micron or smaller” are also effective.

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

- If the safety of drinking water is in doubt (e.g., during an outbreak or if water treatment is unknown), use bottled, boiled, or filtered water to wash fruits and vegetables that will be eaten raw.

Practice extra caution when traveling.

- Do not use or drink inadequately treated water or use ice when traveling in countries where the water might be unsafe.
- Avoid eating uncooked foods when traveling in countries where the food supply might be unsafe.

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 with feces during sex.

- Use barriers (e.g., condoms, natural rubber latex sheets, dental dams, or cut-open non-lubricated condoms) between the mouth and a partner’s genitals or rectum.
- Wash hands immediately after handling a condom or other barrier used during anal sex and after touching the anus or rectal area.

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

illness, and encouraging health-care providers and laboratories to improve reporting of cases to jurisdictional health departments. Improved case investigations, geospatial studies, serosurveys, and the use of molecular tools would enhance understanding of the epidemiology of giardiasis. The majority of data on giardiasis transmission comes from outbreak investigations; however, the overwhelming majority of reported giardiasis cases occur sporadically. During 2011–2012, <2% of reported giardiasis cases was associated with outbreaks. Many giardiasis outbreaks associated with drinking water occur *(3)*, but the relative contributions of waterborne, foodborne, person-to-person, and animal-to-person transmission are not well understood, especially for sporadic cases. Whether the geographic variability noted in this report reflects actual differences in transmission patterns and disease burden versus diagnosis and reporting artifacts is unclear; however, the sharp decline in rates in the Midwest is likely because of a regional decrease in transmission.

Future research is needed to help elucidate the sources of nonoutbreak associated giardiasis infections. Ecologic studies could characterize the potential contributions of private wells, septic systems, land application of biosolids (organic matter recycled from sewage), and agricultural operations in giardiasis transmission. Infected persons can shed *Giardia* for several weeks, and symptoms are 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 (*70*), such studies might now be feasible and would contribute substantially to understanding of the prevalence of giardiasis in the United States. Enhanced genotyping methods would increase knowledge of the molecular epidemiology of *Giardia*, including elucidating the importance of zoonotic transmission. Molecular methods also could be used to assist public health officials in linking cases sharing common transmission routes, which could lead to increased outbreak detection. These tools, combined with traditional epidemiology and surveillance, would improve understanding of giardiasis risk factors and inform future prevention strategies. Although recent studies indicate a potential for chronic sequelae from giardiasis (*9–14*), additional research is needed to further improve understanding of the prevalence and scope of these conditions.

Conclusion

For the first time since 2002, giardiasis rates appear to be decreasing. Despite this decrease, giardiasis remains the most commonly reported intestinal parasitic infection in the United States. National surveillance data can be used to guide the revision, updating, and expansion of health communication efforts and other public health interventions to prevent and control giardiasis. Federal, state, and local health agencies can use giardiasis surveillance data to help elucidate the epidemiology of giardiasis in the United States, establish public health priorities for giardiasis prevention, target health communication messages, and design public health interventions to prevent the transmission of *Giardia*. Additional information about giardiasis is available at http://www.cdc.gov/parasites/giardia/.

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