

Waterborne Giardiasis in the United States: A Review

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Introduction

Giardia lamblia is a flagellated protozoan of the small intestine. Its pathogenicity has been questioned in the past, but there is now clinical and epidemiologic evidence that this organism is a cause of acute illness in man. Clinical manifestations range from asymptomatic cyst passage to severe malabsorption. Recently *G. lamblia* has been identified as the etiologic agent in common-source outbreaks.¹⁻⁴

Waterborne transmission of *G. lamblia* was suggested as early as 1946 by an epidemiologic investigation of an outbreak of amebiasis attributed to sewage contamination of a water supply in a Tokyo apartment building.⁵ *Entamoeba histolytica* and *G. lamblia* were recovered from 64 per cent and 77 per cent of the occupants respectively; *G. lamblia* was found in the stools of 80 per cent of the occupants who had experienced diarrhea with abdominal discomfort but were negative for *E. histolytica*.

Reports of epidemic giardiasis in travelers to the Soviet Union may have been responsible for increased recognition, investigation, and reporting of the disease in the United States. The first reports involving American travelers appeared in 1970 and implicated Leningrad as the site of acquisition of the infection and tap water as the probable mode of transmission.⁶⁻⁸ Numerous retrospective and prospective epidemiologic studies⁹⁻¹⁹ of outbreaks among American and other tourists to Leningrad since then have confirmed the relationship between giardiasis in tourists and tap water consumption in Leningrad. It has not been possible to obtain data directly on water supplies in Leningrad, but a limited report by Ryan and Grainge²⁰ does provide some basis for questioning the adequacy of water treatment for part of this city. Chloramines are used for disinfection, and it is likely that sufficient contact time and/or concentration of combined available chlorine are not provided to inactivate *Giardia* cysts, especially in the cold water temperatures of winter and early spring. Upward filtration is also provided, but reported turbidity values indicate poor filtration (possibly caused by high filtration rates or inadequate control of chemical pretreatment) and suggest that this filtration is not always effective in removal of *Giardia* cysts.

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Waterborne Outbreaks of Giardiasis

The most commonly identified pathogen in waterborne outbreaks in the United States during the past five years (1972-77) has been *G. lamblia*.²¹⁻²³ Twenty-three waterborne outbreaks* of giardiasis affecting 7,009 persons have been reported to the Center for Disease Control and the Environmental Protection Agency since the first documented waterborne outbreak²⁴ in the United States at Aspen, Colorado, in 1965 (Table 1).

TABLE 1—Waterborne Outbreaks of Giardiasis in United States

Year	Outbreaks	Cases
1965	1	123
1966	—	—
1967	—	—
1968	—	—
1969	1	19
1970	1	34
1971	—	—
1972	4	124
1973	4	73
1974	4	4,930*
1975	1	9
1976	3	639
1977	4	1,058

*4,800 cases used for Rome, New York as reported in Reference 18.

In a few outbreaks, heavy bacterial contamination of the water or an obvious human source of contamination was found. However, in most outbreaks, little or no bacterial contamination of the water was reported. *Giardia* cysts were isolated from drinking water or water sources in four outbreaks; ^{18, 25-30} trophozoites³¹ were reportedly isolated from drinking water in one outbreak, but this finding is questionable ^{32, 33} (Table 2). At least two large outbreaks of giardiasis have occurred in the United States where failure to isolate *G. lamblia* from the suspect water has strongly influenced investigators to reject drinking water as the possible vehicle of infection. One outbreak occurred in 1954 in Portland, Oregon,³⁴⁻³⁶ and affected an estimated 50,000 persons; the second occurred in Boulder, Colorado,³⁷ from June-August 1972.

*These are outbreaks in which drinking water has been implicated epidemiologically as the vehicle of transmission. Single cases of giardiasis reported in backpackers, which may have been related to drinking untreated water, have not been included.

TABLE 2—Waterborne Outbreaks of Giardiasis in the United States where *Giardia* have been Isolated from Water

Year	Location	Description
1973	Tennessee ^{31, 32, 33}	Numerous trophozoites of <i>G. lamblia</i> were found in water samples collected from an underground cistern
1974	Rome, New York ^{18, 25}	A single <i>Giardia</i> cyst was found after filtering 1,059,800 liters of raw water from the plant intake
1976	Camas, Washington ^{26, 27}	<i>Giardia</i> cysts were found in the raw water and distribution system
1976	Camp, Estes Park, Colorado ^{29, 30}	<i>Giardia</i> cysts were found in a water filtrate sample taken from a beaver pond located upstream from the water supply reservoir
1977	Berlin, New Hampshire ^{26, 28}	<i>Giardia</i> cysts were recovered from both raw water resources and several sites within the distribution system

Outbreaks have occurred primarily in mountainous areas particularly in the Rocky Mountains, New England, and the Pacific Northwest. These areas have traditionally depended upon surface water sources free of gross human sewage contamination, and water treatment has been minimal consisting primarily of disinfection only. Colorado has reported nine outbreaks, more than any other state; this may reflect increased surveillance and investigation.** Waterborne outbreaks of giardiasis have generally affected small municipal water systems or semipublic water systems in recreational areas.***

Most outbreaks occurred as the result of consuming untreated surface water or surface water with disinfection as the only treatment (Table 3). The largest waterborne outbreak of giardiasis occurred in Rome, New York, November

TABLE 3—Water System Deficiencies Responsible for Waterborne Outbreaks of Giardiasis in United States

Deficiency	Outbreaks	Cases
Surface Water With Chlorination Only*	10	5,307
Untreated Surface Water	6	186
Ineffective Filtration	2	1,350
Untreated Ground Water	2	19
Ground Water with Chlorination Only	1	123
Contaminated Cistern	1	5
Unknown	1	19

*Includes one outbreak where filtration facilities were available but used intermittently.

1974-June 1975, and affected an estimated 4,800¹⁸ to 5,300²⁵ individuals. Rome used a surface water source of relatively good bacterial quality with disinfection by chloramines as the only treatment.

The first outbreak involving a filtered water supply occurred in Camas, Washington,^{26, 27} in the spring of 1976. The

**New Colorado drinking water regulations require filtration of surface water supplies in addition to chlorination.³⁸

***Ten outbreaks (6,695 cases) occurred in municipal water systems; 10 (266 cases) in semipublic water systems; and 3 (48 cases) in individual water systems.

watersheds for the surface water sources used by Camas were well isolated, had no human habitation, and had extremely limited human activity, but three *Giardia*-positive beavers were found within foraging distance of the water intakes. The chlorination equipment had failed prior to the outbreak, and a number of deficiencies were found in the condition and operation of the pressure filters, including ineffective chemical pretreatment. The treated water reportedly met both turbidity and coliform standards prior to and during the outbreak.

A second waterborne outbreak of giardiasis involving a filtered water supply occurred in Berlin, New Hampshire,^{26, 28} in the spring of 1977. Numerous deficiencies which would allow cysts to pass through the pressure filters were found. An engineering evaluation of a second surface source revealed that a common wall separating filtered and unfiltered water was improperly constructed and allowed unfiltered water to bypass this modern, conventional treatment plant. Again, routine bacterial samples from the distribution system prior to the outbreak showed that the coliform standards had not been exceeded.

Waterborne giardiasis outbreaks have affected both visitors or campers and the usual residents of an area (Table 4). Outbreaks in visitors occur primarily during the summer

TABLE 4—Seasonal Distribution of Waterborne Outbreaks of Giardiasis in United States

Month	Outbreaks	Population Affected	
		Visitors or Campers	Usual Residents
January	0	—	—
February	1	—	1
March	3	2	1
April	1	—	1
May	1	1	—
June	4	3	1
July	3	1	2
August	2	2	—
September	3	3	—
October	0	—	—
November	2	—	2
December	3	1	2
TOTAL	23	13	10

months, implying increased contamination of water supplies during this period or, if it is assumed that the water supplies are always contaminated, use by larger numbers of susceptible individuals. Most outbreaks affecting usual residents occurred in later fall through early spring.

Endemic Waterborne Giardiasis

Studies in Colorado³⁹ and Minnesota⁴⁰ have suggested consumption of untreated drinking water to be an important cause of endemic infection in the United States. A survey of 256 Colorado residents having *Giardia*-positive stools and 256 controls matched by age, sex, race, and place of residence showed a higher proportion of cases than controls who visited Colorado mountains (69 per cent vs 47 per cent), camped overnight (38 per cent vs 18 per cent), and drank untreated mountain water (50 per cent vs 17 per cent). Person-to-person transmission was found to be relatively infrequent and swimming in unchlorinated pools, domestic animal exposure, or out-of-state foreign travel were not associated with *G. lamblia* infections. A survey of 78 Minnesota residents having *Giardia*-positive stools and no history of recent foreign travel showed that 63 per cent had consumed untreated water during the period of study and 46 per cent had not been out of the state in the two months before onset of symptoms. Unfortunately, an appropriate control group was not included for comparison.

Summary

Twenty-three waterborne outbreaks of giardiasis have been reported in the US, 1972-77. Data indicate that disinfection as the only treatment for surface water sources is ineffective in preventing waterborne transmission of this organism. To protect against transmission, all surface water should receive chemical pretreatment, preferably with sedimentation, and filtration in addition to disinfection. Outbreak data indicate that negative coliform tests do not provide assurance that water is free of *Giardia* cysts.

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