

## AN OUTBREAK OF FOODBORNE GIARDIASIS

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*GIARDIA LAMBLIA* is recognized as an important cause of acute illness in human beings. Community-wide waterborne outbreaks of giardiasis have been documented with increasing frequency,<sup>1-5</sup> and backpackers have become ill after drinking water from mountain streams.<sup>6,7</sup> Giardiasis has also occurred among travelers to foreign countries, although the methods of transmission in these situations are not clear.<sup>8-10</sup> Person-to-person transmission has been demonstrated in mental institutions,<sup>11-13</sup> in day-care centers,<sup>14,15</sup> and among male homosexuals.<sup>16-18</sup>

To our knowledge, fecally contaminated food has not been documented to be a vehicle for the transmission of giardiasis, even though the fecal-oral route of transmission has been well established.<sup>19</sup> We report here an outbreak of foodborne giardiasis.

On December 13, 1979, a physician notified the Minnesota Department of Health (MDH) that two employees of the Goodhue, Minnesota Public School System were being treated for giardiasis. The physician also reported that the ill employees had estimated that more than half the other employees of the school had a similar diarrheal illness. After a discussion with local school and public-health officials, the MDH initiated an investigation.

Goodhue is a farming community in southeastern Minnesota with a population of 630. The major employer in the community is the consolidated rural school system, which serves 649 students in kindergarten through grade 12 and retains 60 employees. The community is served by a chlorinated but unfiltered public water system. The source of the water is a municipal well; there was no evidence of contamination during the two years before the outbreak.

The school consists of one building built in 1935 and three additions that were built in 1953, 1960, and 1970. The employees have access to either of the two employee lounges, designated for smokers and non-smokers. One is located in the original building, and the other is in the section added in 1960. A central kitchen facility, located in the building, provides approximately 500 daily lunches for employees and students in all grades. The school is connected to the public water system.

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## METHODS

## School-Employee and Family Contact

On December 14, a questionnaire was administered to all employees of the school system. Information obtained included demographic data, personal and family history of diarrhea during the previous three months, history of consumption of untreated water, travel history including trips to surrounding towns, and any social contact with other employees who had diarrhea. All employees without a recent stool examination demonstrating *G. lamblia* were asked to submit stool samples in 3 per cent formalin to the Minnesota Department of Health Division of Medical Laboratories (MDHDMML) for parasitologic examination. Family members of employees who had had diarrhea for five days or longer (persistent diarrhea) during the previous three months were also asked to submit stool samples for parasitologic examination. Stool samples for salmonella, shigella, and campylobacter examination were obtained from seven ill employees who had not been treated previously, and the samples were placed in buffered glycerol transport medium. Samples were immediately refrigerated and processed within 24 hours at the MDHDMML.

## Community and School Survey

Two different surveys were conducted to determine the incidence of persistent diarrhea in residents of Goodhue and rural areas in the Goodhue Public School System for the period from October 1 through December 1. On December 15, a survey was conducted in the community of Goodhue. A questionnaire similar to that used for the school employees was administered by MDH epidemiologists during a door-to-door survey, which covered 114 (50 per cent) of the 224 households in Goodhue. The sample of households represented all geographic regions of the community equally.

On December 18, a questionnaire was sent home to parents with each student in the school system. The parents were asked to complete one questionnaire per family and return it to the school on the next day. The questionnaire, which was self-explanatory, requested information similar to that sought on the employee and community questionnaires. In addition, stool samples were obtained for parasitologic examination from all students with persistent diarrhea from October 1 to December 15 and from 46 healthy controls who were high-school students.

A case of giardiasis was defined in two ways: as persistent (chronic) or recurrent diarrhea of five or more days' duration, with or without a positive stool examination for *G. lamblia* and with two or more additional symptoms (abdominal cramps, unusual fatigue, bloating, fever, malodorous stools, or unintentional weight loss); or as diarrhea of less than five days' duration with two symptoms and a positive stool examination for *G. lamblia*.

## Laboratory Investigation

Parasitologic study of stools was performed at MDHDMML. Formalin-preserved specimens were examined by direct smear and by the formalin-ether-concentration technique with Dobel's iodine stain.<sup>20</sup> Stool samples for bacteriologic examination were processed within 24 hours at MDHDMML with deoxycholate, SS (salmonella) and shigella) and bismuth sulfite agar plates, and tetrathionate broth with subculture on deoxycholate and brilliant-green agar plates.<sup>21</sup> Campylobacter isolation was performed with specimens of feces swabbed onto the surface of oxoid blood agar base No. 2 containing 7 per cent horse blood, and 10 µg of polymyxin B per milliliter, and 5 µg of trimethoprim per milliliter.<sup>22</sup> The plate was then streaked and incubated at 42°C in an anaerobic jar (with the catalyst removed) containing a disposable GasPak hydrogen and carbon dioxide generator. Plates were examined at 24, 48, and 72 hours of incubation.<sup>23</sup>

Four unopened pint jars of home-canned salmon were examined by the Minneapolis Center for Microbiological Investigations, United States Food and Drug Administration, for jar-opening vacuum with a U.S. Gauge vacuum gauge (range, 0 to 762 mm Hg). Food products from each jar were also examined for aerobic total plate count, total coliform count, and *Escherichia coli* count by standard methods.<sup>24</sup> At present there are no standard methods available

for examination of food products for the presence of parasites. Formalin-ether,<sup>20</sup> zinc sulfate flotation,<sup>20</sup> sucrose-gradient centrifugation,<sup>21</sup> and direct-smear<sup>20</sup> methods for stool examination were modified for use with food samples.

### RESULTS

Twenty-nine of the 60 employees (48 per cent) had diarrhea between November 2 and November 23, 1979 (Fig. 1). The mean and median durations of diarrhea were 16 and 10 days, respectively. Twenty-four cases (83 per cent) had persistent diarrhea accompanied by other symptoms, and five cases (17 per cent) had diarrhea for less than five days with other symptoms and a positive stool examination for *G. lamblia*.

The most frequent symptoms in addition to diarrhea were fatigue, abdominal cramps, bloating, malodorous stools, flatulence, and weight loss (Table 1). Twenty-one of 37 female employees (57 per cent) and eight of 23 male employees (35 per cent) were ill. The cases ranged in age from 22 to 60 years.

Fifteen of the 29 ill employees (52 per cent) and two of the 31 healthy employees (6 per cent) had positive stool examinations for *G. lamblia* ( $P < 0.0001$ ) (Table 2). All 10 employees with diarrhea when a stool sample was obtained for examination, and five of 19 employees (26 per cent) who met the case definition for giardiasis but no longer had diarrhea when the stool sample was obtained, had positive examinations for *G. lamblia*. Salmonella, shigella, and campylobacter were not found in stools from seven ill employees.

In 13 ill employees (45 per cent) diarrhea resolved without treatment. The mean and median durations of diarrhea among these employees were eight and seven days, respectively. However, eight of the 13 employees (62 per cent) had other symptoms (fatigue, abdominal cramps, flatulence, and constipation) for up to 23 days after resolution of the diarrhea. The other 16 ill employees (55 per cent) had persistent or recurrent diarrhea until treatment with metronidazole (Flagyl) or quinacrine hydrochloride (Atabrine). All employees had three negative stool examinations for *G. lamblia* after one treatment, with the excep-

Table 1. Frequency of Symptoms in 29 Cases of Clinical Giardiasis among Employees of the Goodhue, Minnesota, Public Schools, 1979.

SYMPTOM	NO. OF CASES *
Diarrhea	29 (100)
Fatigue	28 (97)
Abdominal cramps	24 (83)
Bloating	23 (79)
Malodorous stool	23 (79)
Flatulence	22 (76)
Weight loss †	17 (59)
Fever	6 (21)
Vomiting	5 (17)

\*Figures in parentheses denote percentages.

†The average weight loss was 4.2 kg.

tion of one employee who initially received metronidazole but had a positive examination two weeks after treatment. After treatment with quinacrine hydrochloride, he had three negative stool examinations.

Three of 161 members of employees' households (1.8 per cent) had persistent diarrhea from October 1 to December 15 (Fig. 1). All three ill contacts and none of 30 healthy family members of employee cases who submitted stools for examination had *G. lamblia* in the stool ( $P < 0.0003$ ). Two of the ill family contacts had diarrhea 18 and 26 days after the onset of diarrhea in their family members employed by the school; this rate of development is consistent with secondary transmission. The third family-member case had onset of diarrhea on November 16, when the employees became ill. Her husband, an employee at the school, had not had any diarrheal illness during the preceding six months, and his stool was negative for *G. lamblia* on four different occasions.

Data from employee, community, and school questionnaires were combined for summary analysis, with no person counted more than once. Fifteen of 1262 adults (excluding school employees) and children in the school district (1.2 per cent) had persistent diarrhea during the period from October 1 through December 1. Seven of 391 persons in the community of

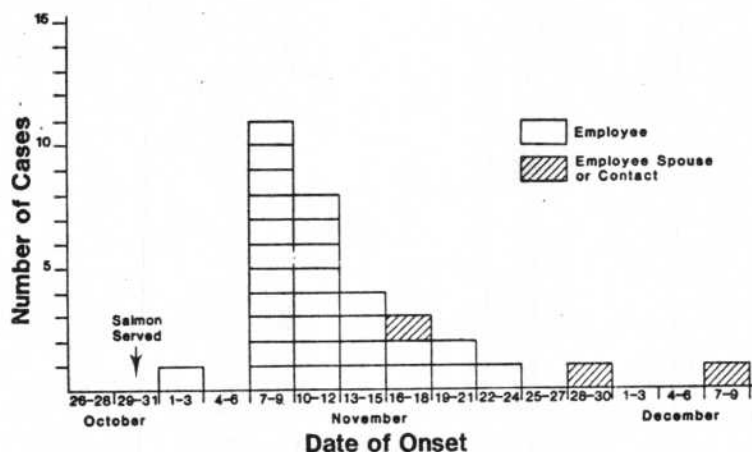


Figure 1. Giardiasis in Employees of the Goodhue, Minnesota, Public Schools and Employee Contacts by Date of Onset, 1979.

Table 2. Results of Stool Examination among 60 Employees and 33 Family Contacts of Employees with Giardiasis.

RESULT	EMPLOYEES	FAMILY CONTACTS
Positive case, positive stool	15 *	3 †
Positive case, negative stool	14 *	0
Negative case, positive stool	2	0
Negative case, negative stool	29	30
P value	<0.0001 ‡	<0.0003 §

\*All 10 employees with diarrhea when stool samples were obtained, and five of 19 employees who met the case definition for giardiasis but who no longer had diarrhea when stool samples were obtained, had *Giardia lamblia* identified in the stool.

†All three cases had diarrhea when stool samples were obtained.

‡Chi-square = 13.0.

§Fisher's two-tailed exact test.

Goodhue (1.8 per cent) and eight of 871 rural residents (0.9 per cent) were ill. The age group with the highest percentage (3.1 per cent) of persons who were ill was that of children nine years old and younger. Seven students (1 per cent) had persistent diarrhea. None of these students and none of the 46 healthy student controls had *G. lamblia* identified by stool examination.

An inspector from the MDH Division of Environmental Health conducted an extensive inspection of the school's plumbing and kitchen facilities on December 18. No code violations or unsafe environmental conditions were found.

#### Transmission Investigation

After analysis of the questionnaire administered to employees, no single community social event or history of water consumption could be associated with the employees' illness. A second questionnaire was administered to employees and to 164 high-school students on December 20. It included a history of food and drink items consumed at the school from October 1 to November 16. Employees and students use the same cafeteria and have access to the same food.

The food-history questionnaire listed all food and drink items served through the school's lunch program by day. Persons were asked to indicate which food or drink items were consumed or not consumed. If they could not recall the consumption history, they were asked to indicate the items that were likely to have been consumed. Employees were also asked to identify which of 26 food items and four drink items brought to the employees' lounges by other employees were consumed between October 1 and November 16. The students did not have access to these items.

For purposes of analysis, responses indicating definite consumption and probable consumption were combined. A chi-square value was calculated for each food and liquid item for both employees and students for each day on which it was served.

Only two food items had chi-square values greater than 3.8. Home-canned salmon (chi-square, 28.6) and homemade cream-cheese dip (chi-square, 12.3), both

prepared by employees and served in the employees' lounges on October 29, were statistically associated with the illness (Table 3). The salmon was served in both the smokers' and nonsmokers' lounges; the dip was served only in the nonsmokers' lounge. The typical amount of salmon consumed was approximately one tablespoon (15 ml).

Since both food items were served on the same day, the Mantel-Haenszel chi-square method was used to determine the association of a food item with the illness on the basis of its being grouped with another food item or items strongly associated with the illness.<sup>26</sup> Both items retained significance, but the difference between the Mantel-Haenszel chi-square statistics for salmon (22.4) and cream cheese (4.9) increased.

The salmon (*Salvelinus namaycush*) were caught in Lake Michigan by one of the employees on October 24. The employee and his wife canned approximately 70 pint jars of the salmon at that time. The salmon meat was placed in the jars with seasoning and vinegar and then pressure-cooked at 10 psi (703 g per square centimeter) for 90 minutes. The jars were cooled for 30 to 45 minutes, and the screw lids were then tightened by hand. Before the salmon was eaten by school employees on October 31, at least five jars of salmon were eaten by neighbors and relatives. None of these persons became ill.

Four unopened jars of the salmon were obtained from the employee and examined for proper seals. The opening vacuum pressures for the jars were 673, 673, 655, and 660 mm Hg; the normal pressure used in the commercial canning process is 305 to 381 mm Hg. Bacteriologic analysis of the salmon from these jars showed no growth on aerobic total plate count, total coliform count, and *Esch. coli* count. Results of examinations of the salmon for *G. lamblia* cysts with the formalin-ether, zinc sulfate flotation, sucrose-gradient centrifugation, and direct-smear methods were negative. These results indicated that the product was properly processed and correctly sealed.

The wife of the employee who brought the salmon to the school had opened two pint jars of salmon approximately 30 minutes before taking them to the school. She drained off the excess juice (approximately 25 ml) and placed the contents of each jar into one of two plastic containers. One container was placed in each of the employee lounges. She could not remember the exact mechanism by which she had handled the salmon in transferring it from the jars to the plas-

Table 3. Association of Selected Food Consumption and Giardiasis among Employees.

FOOD ITEM	CHI-SQUARE TEST		MANTEL-HAENSZEL CHI-SQUARE TEST	
	CHI-SQUARE	P VALUE	CHI-SQUARE	P VALUE
Home-canned salmon	28.6	<0.00001	22.4 *	<0.00001
Cream-cheese dip	12.3	<0.00045	4.9 †	<0.02685

\*Adjusted for consumption of cream-cheese dip.

†Adjusted for consumption of home-canned salmon.

tic containers; however, it was most likely that she had handled it as she was draining off the excess juices.

The employee's wife was also the family contact described above in whom clinical giardiasis developed on November 16, 19 days after the salmon was served to the employees. She had not had diarrhea during the six months preceding the outbreak, and she had not eaten any of the canned salmon on the day it was served at school.

Before transferring the salmon, she had diapered her 12-month-old grandson. She reported having washed her hands after the diapering procedure. During the investigation, her hygiene was noted by two of us (M.T.O., J.C.F.) to be good.

The grandson lived with his parents in Hawaii; he had been visiting the states of Washington and Montana for the two-week period before his stay in Goodhue, from October 16 through October 30. Because of the acute nature of the onset of giardiasis in the employee's wife and her negative history of diarrhea in the preceding six months, we suspected that she had been infected only recently. For this reason, and because of the well-documented presence of asymptomatic *G. lamblia* carriers among young children, we requested stool specimens from the grandson and his parents for parasitologic examination. The grandson had no siblings. He occasionally attended a day-care center in Hawaii. Except for two days of diarrhea while visiting in Montana, he had a negative history of diarrhea in the preceding six months. Neither he nor his parents had had any diarrhea before collection of their stool samples.

Three stool specimens from the father, mother, and child were placed in 3 per cent formalin and sent to the MDHDMML for parasitologic examination two months after the outbreak. All the grandson's stools were positive for *G. lamblia*. The laboratory microbiologists who were responsible for the parasitologic examinations at MDHDMML observed the densities of cysts to be numerous to heavy (one to 10 cysts per microscopic field at  $\times 44$  magnification) on direct smear. Neither parent had *G. lamblia* in the stool.

#### DISCUSSION

The evidence that food was a vehicle for the transmission of giardiasis was the most important finding of this investigation. Previous studies suggested that giardiasis was not foodborne,<sup>27</sup> although the fecal-oral route of giardiasis transmission<sup>19</sup> has been established and the disease can be waterborne.<sup>28</sup> *G. lamblia* cysts have recently been found on strawberries, without evidence of transmission of the disease to human beings (Jackson JG. Personal communication).

The lack of previous reports of foodborne giardiasis seems curious to us, since the mechanisms of transmission in this outbreak did not appear to be remarkably different from those in other outbreaks involving foodborne enteric pathogens. The fact that *G. lamblia* does not reproduce in food seems only partly responsible for the lack of outbreaks, since viral hepatitis A

can be transmitted through contaminated food although it does not replicate outside the host. Rendtorff<sup>19</sup> has estimated that ingestion of fewer than 10 viable cysts can produce infection. Since there appears to be little difference between the mechanisms of transmission by food and water, it seems likely that some agent-specific attribute is important in transmission. It is possible that incubation in the presence of salmon or an acid environment in this outbreak enhanced the infectivity of the cysts in some way. Amebiasis, another enteric disease caused by an encysting parasite, has a fecal-oral mode of transmission and has not been shown to be foodborne.<sup>29</sup> We strongly encourage public-health officials to consider the possibility of foodborne transmission in any apparent outbreak of giardiasis.

Previous investigations of waterborne outbreaks have used various minimum durations of diarrhea (five to 10 days) to define a clinical case of giardiasis.<sup>30</sup> Juranek recently suggested that diarrhea lasting for at least seven days should be considered indicative of a clinical case of giardiasis.<sup>30</sup> We agree that the definition of clinical giardiasis in most outbreaks should be based on that criterion. The outbreak in Goodhue was unique, however, since transmission occurred from a point source over a short and definable period, the group exposed was easily identified, and the background occurrence of diarrhea of at least five days' duration in the community was only 1.2 per cent for the two-month period before and during the outbreak. For this reason we used a clinical case definition based on diarrhea with a minimum duration of five days instead of seven. Our definition was more sensitive, since 24 cases had diarrhea for at least five days and only 20 cases had diarrhea for at least seven days. The five-day definition was equally specific, with all four cases with diarrhea of five or six days' duration having positive stool examinations for *G. lamblia*.

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## DRUG THERAPY

### Spasticity (First of Two Parts)

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SPASTICITY has been defined in strictly physiologic terms as "a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes ('muscle tone') with exaggerated tendon jerks, result-

ing from hyperexcitability of the stretch reflex, as one component of the upper motor neuron syndrome."<sup>1</sup> Whereas this definition refers to the minimum positive symptom in patients with "spasticity," it does not refer at all to the other components of the upper-motor-neuron syndrome<sup>2</sup> that are usually most troubling to patients. These components include positive symptoms, such as flexor spasms, and a multitude of negative symptoms designated somewhat inadequately as weakness and loss of dexterity.

Treatments for spasticity can therefore be clinically useful even though they do not alter enhanced stretch reflexes (i.e., they do not affect "spasticity," strictly speaking). On the other hand, therapeutic maneuvers that only diminish stretch reflexes may not be particularly helpful to the patient. Within the larger group of disorders of motor control, spasticity is differentiated from other types of increased resistance to passive stretch of muscle, which may be due to true contracture (fibrosis or ankylosis of joints), to pure dystonias (simply "abnormal tone") such as dystonia musculorum deformans, or to the rigidity of Parkinson's disease, which is not a function of the velocity with which the muscle is stretched. In these other types of increased muscle stiffness, there is no evidence, such as increased stretch reflexes or a Babinski response, for a lesion of the descending corticospinal pathway. Muscle spasms, whether observed with cramps, "torn muscles," or lower-back pain, are to be differentiated from spasticity.

It must be emphasized that spasticity is not one particular disorder of motor control. It is a term that is loosely and often erroneously applied to various disorders of motor control resulting from lesions (usually affecting several neuronal systems) that occur at different levels of the neuraxis, produce different functional problems for the patient, and respond, if at all, to different types of therapy. Like other simple descriptive terms — e.g., "muscular weakness" applied to the end result of such widely differing disease processes as neurasthenic depression on the one hand and myasthenia gravis or stroke on the other hand — "spasticity" is a term that we have inherited. Scholastic debates about such definitions are fruitless; new, rational nomenclature will be applied to each disorder of motor control once physiologic understanding of normal movement in all its complexity has been reached and the pathophysiology of these disorders can be understood. Meanwhile, we use the term "spasticity" as a synonym for "the upper motor-neuron syndrome" — that is, abnormal signs and symptoms in patients with various types of lesions of motor pathways within the central nervous system (CNS), with abnormally enhanced muscle-stretch reflexes and a Babinski response. Because damage in patients with spasticity is almost never limited to the corticospinal (pyramidal) tract, we prefer not to use the term "pyramidal syndrome."

Muscle spindles are complex, fusiform sensory structures within muscle, serving to signal changes in muscle length (Fig. 1). Their primary sensory endings (distal terminations of large myelinated Ia af-

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