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The Epidemiology of an Outbreak of *Cyclospora cayetanensis* in North America

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Abstract

Considering the current 2026 outbreak of *Cyclospora cayetanensis* in the USA, we have retrieved data on a comparable outbreak that we studied in 1996 to establish reference lines of seasonal and place clustering for comparisons to establish guidelines useful for management of the present 2026 outbreak. Fecal samples from 5250 patients from 49 states, three Canadian provinces and five foreign countries were screened for intestinal parasites between January and December, 1996 at the Scottsdale, Arizona based Institute of Parasitic Diseases using a concentration-sedimentation technique. Single (140) and concurrent (85) infections of *Cyclospora cayetanensis* were diagnosed in 225 symptomatic or asymptomatic patients from 4121 samples from 26 states and two Canadian provinces with a prevalence of 4.3%. The remaining 1129 patients from the 23 other states and other locations tested negative for *C. cayetanensis*. Females were 2.5 times more frequently infected than males. Monthly prevalence peaked at 6.0% in September and sharply declined to 1.4% in February. Of the 140 singly infected patients, 128 experienced gastro-enteric and/or extra-intestinal symptoms; 12 (9%) were asymptomatic. The most common symptoms were bloating, diarrhea, flatulence, cramps, constipation, fatigue and allergies, respectively. Patients traveled most frequently to Mexico and Europe. Some patients (6%) lived with infected household contacts and 11% of them had previous parasitic infections with various protozoans and helminths. Clustering of infections in zip codes served by certain water treatment plants in the metropolitan Phoenix area suggest a potential of endemic infections of water sources in North America. Data available so far on the present 2026 outbreak especially symptomology and initial distribution appear to be compatible to those studied in 1996.

Keywords: *Cyclospora cayetanensis*; Fecal Specimens; Symptoms, Concentration-Sedimentation Technique; Distribution

Introduction

A number of outbreaks of Cyclosporiasis have been reported in the United States over the years. Extensive research was conducted by our team at the Parasitology Center, Inc. (PCI), Scottsdale, Arizona in 1996, an outbreak year, when we tested 5250 patients from all USA states and Canada. The current outbreak of July, 2026 in the USA, with a few intervening outbreaks in between, call for the understanding of reference lines covering the geographical distribution and host-related factors that can play an important role in the management of the present 2026 outbreak. Our 1996 study is being revisited below as patterns seem to repeat and much can be learned from previous experiences.

Parasitological investigations of large patient populations are rarely conducted in the US where the illusion of freedom from parasitic infections still predominates. Such investigations are considerably more common in most third world countries where endemic parasitosis are more readily

documented.

The 1996 study examined the results of routine examination of a large number of symptomatic and asymptomatic patients mostly from across the US for *Cyclospora cayetanensis*. Seasonal prevalence rates, patient's age and sex and intestinal and extra-intestinal symptoms as well as variables related to foreign travel, infected household contacts and previous parasitic infections are the primary focus of this report. Some of the above topics, e.g. seasonality, are reported in the US for the first time. This is the third in a series of articles [1,2] on intestinal parasites in US patients tested at our laboratory.

Materials and Methods

Fecal specimens were collected and examined for intestinal parasites for 12 months (January-December, 1996) at the Phoenix-based IPD, a branch of Parasitology Center, Inc. (PCI). IPD is a reference Parasitology center that is equipped to provide diagnostic services primarily based on microscopical examination. Positive identifications are documented with video prints of diagnosed organisms as viewed on video monitors connected to microscopes. Fecal specimens were collected and fixed in plastic Para-Pak-like containers by patients from the Phoenix area or mostly from out-of-state patients who received mailable kits (UROKEEP, Chandler, Arizona). Exceptionally, fresh samples were examined within a few hours of collection. Patients were routinely referred to IPD by physicians and health providers or via the Internet. Patients were required to follow a strict protocol for preparation and collection of two fecal specimens each after having provided information on age, sex, address, foreign travel, symptoms, past infections and treatments and household contacts with parasite or other infections.

Usually, two preserved specimens collected on two separate days were provided by local or mostly out-of-state patients. Specimens were routinely processed using a formalin-ethyl acetate concentration - sedimentation procedure or CONSED concentration reagent (Alpha Tec, Caliber Scientific, Vancouver, Washington) and examined as wet mounts that may be followed with confirmatory permanent smears (Trichrome Plus stain, Alpha Tec) when necessary. Positive results were quantified (average number of organisms per high power field on a scale of 1-4), entered on computerized patient's records and forwarded to referring physicians for treatment and follow-up.

Results

Of 5250 fecal specimens tested at IPD in 1996, 4121 were examined from 26 states and two Canadian provinces from which 225 (159 females, 66 males aged 1-79 years) were positive for *C. cayetanensis* infections at intensities varying between one and 4/4. The overall prevalence was 4.3%. Of the positive cases, 85 (38%) were concurrently infected with *Blastocystis hominis* (34 cases, 31%), *Entamoeba hartmanni* (28, 25%), *E. histolytica/E. dispar* (25, 23%), *E. coli* (15, 14%), *Cryptosporidium parvum* (6, 5%), *Dientamoeba fragilis* (1, 1%), or *Iodamoeba butschlii* (1, 1%) (Table 1). Few patients were concurrently infected with more than one of the above listed species.

The 225 patients testing positive were from 26 states and from British Columbia and Ontario, Canada from which 4121 samples were examined. Most of these patients resided in Arizona (762) and California (1459) (Table 2). State prevalence in larger samples (more than 100 examined) varied between 1.2 and 9.5% with most, frequent infections being from Arizona (9.5%), California (5.4%) and Colorado (6.0%) (Table 1).

The residences of 739 of the 762 Arizona patients tested could be traced to 190 known zip codes statewide. Positive cases were found in the Phoenix metropolitan area including the cities of Chandler (1 infected/19 tested), Fountain Hills (1/11), Gilbert (2/15), Glendale (9/70), Mesa (3/52), Phoenix (33/237), Scottsdale (9/139) and Tempe (1/21), as well as elsewhere in Arizona in Cave Creek (1/14), Fort Thomas (2/3), Fresno (1/1), Payson (2/3), Peoria (1/8), Prescott (3/17), Sedona (1/6), Tucson (1/10), and Wickenburg (2/2). In the metropolitan area of Phoenix, a clustering of cases (28/96, 29%) was observed within six zip codes served routinely by two water treatment plants and an occasional seasonal operation involving two other plants.

The remaining 1129 patients testing negative for *C. cayetanensis* included 641 with incomplete addresses and 488 others from the following areas (in alphabetical order): AA-military address (1 patient), Alberta, Canada (4), Alaska (6), Alabama (11), Arkansas (44), Austria (1), Australia (1), Washington, D.C. (2), Delaware (7), Germany (1), Iowa (81), Kansas (11), Kentucky (2), Louisiana (44), Maryland (4), Maine (1), Minnesota (39), Missouri (28), Mississippi (1), Mexico (2), Nebraska (5), Oklahoma (3), Puerto Rico (4), Rhode Island (1), South Carolina (5), South Dakota (2), Tennessee (6), Vermont (7), Wisconsin (160), West Virginia (2) and Wyoming (2). The only state from which no samples were examined was North Dakota.

The monthly prevalence from all states with positive cases combined showed a modest peak of 6.0% in September and declines of 1.4% and 2.8% in February and December, respectively (Table 2). These moderate oscillations were not related to the number of patients examined seasonably from states with normally high or low prevalence rates.

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The 140 singly infected patients were screened for symptoms associated with their *C. cayetanensis* infections. Twelve patients (9%) had no symptoms. The remaining 128 singly infected patients were symptomatic. The most common enteric symptoms were bloating (in 21% of the 128 patients), diarrhea (13%), flatulence (13%), cramps (11%) and constipation (9%). Other less frequent enteric symptoms (1-2%) included maldigestion, irritable bowel syndrome, sore throat, bleeding, vomiting, rectal irritation and mucus. The most common extra-intestinal symptom was fatigue (mostly chronic fatigue syn-drome) (20%). Other symptoms (in descending order of frequency were allergies (including food allergies) (13%), pain (especially in joints) (6%), central nervous system dysfunctions (6%), nausea (5%), skin rash (5%), muscle spasms and soreness (4%), headache (3%), fever (3%), discomfort (2%), weight loss (2%), anemia (1%), fibromyalgia (1%) and respiratory difficulties (1%).

Of the 140 singly infected males and females, 23 (16%) recently traveled to Mexico, 26 (19%) to Europe one-half of whom visited southern Europe, 14 (10%) to Russia and Far East, 13 (9%) to Central America and Caribbean, 7 (5%) to Canada, 5 (4%) to Israel and Egypt, 4 (3%) to the Indian subcontinent, 4 (3%) to South America, 3 (2%) to Micronesia and Hawaii and 1 (1%) to Alaska. One additional patient's only possible geographical exposure was working in an Indian reservation for 26 years.

Of the 140 singly infected patients, 13 (9%) lived with household contacts that were infected with various protozoan species not limited to *C. cayetanensis*. Of the 140 and 85 singly and concurrently infected patients, 28 (20%) and 32 (38%), respectively, had 83 previous intestinal parasitic infections within the last 5 years; some patients had multiple previous infections. Those 83 infections comprised of *E. histolytica* (25%), *E. coli* (2%), *E. hartmanni* (4%), *B. hominis* (11%), *Giardia lamblia* (10%), *C. cayetanensis* (10%), *Endolimax nana* (4%), *C. parvum* (4%), *Trichomonas hominis* (l %), *Enterobius vermicularis* (4%), *Ascaris lumbricoides* (4%), *Taenia sp*. (2%), *Strongyloides stercoralis* (1%) and unidentified species (20%).

State/province	Number of samples		Prevalence (%)	Month infected
	Tested	Positive		
Arizona	762	72	9.5	01-Dec
British Columbia	10	3	37.5	10-Dec
California	1459	79	5.4	01-Dec
Colorado	149	9	6	1, 4-9, 11
Connecticut	28	3	10.7	1, 10, 12
Florida	130	6	4.6	1, 4, 6, 10, 11
Georgia	27	1	3.7	11
Hawaii	7	1	14.3	9
Idaho	19	1	5.3	5
Illinois	98	1	1	4
Indiana	78	1	1.3	8
Massachusetts	42	4	9.5	4, 5, 8, 9
Michigan	29	1	3.4	12
Montana	40	1	2.5	11
Nevada	99	7	7.1	1,2,8,9, 12
New Hampshire	6	1	16.7	7
New Jersey	70	2	2.8	5, 9
New Mexico	193	9	4.7	1, 2, 4, 5, 7-9, 11
New York	242	7	2.9	1, 2, 8, 9, 12
North Carolina	29	1	3.4	7
Ohio	23	1	4.3	10
Ontario	3	1	33.3	8

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Oregon	246	3	1.2	5, 10, 11
Pennsylvania	151	5	3.3	3,5, 7,9
Texas	119	2	1.7	6, 10
Utah	6	1	16.7	10
Virginia	12	1	8.3	4
Washington	44	1	2.3	11
Total	4121	225	5.5	1-12
Other locations	1129	0		
Grand total	5250	225	4.3	1-12

Table 1: Distribution of *Cyclospora cayetanensis* diagnosed at PCI, January-December, 1996.

No. examined		No. infected			Prevalence (%)
		Single	Multiple*	Total	
January	598	14	14	28	4.7
February	663	5	4	9	1.4
March	4.05	12	6	18	4.4
April	436	18	6	24	5.5
May	393	12	7	19	4.8
June	370	12	5	17	4.6
July	370	8	6	14	3.8
August	405	14	6	20	4.9
September	349	10	11	21	6
October	443	11	11	22	5
November	391	17	4	21	5.4
December	427	7	5	12	2.8
Total	5250	140	85	225	4.3

*Concurrent infections commonly involved *Blastocystis hominis, Cryptosporidium paruum, Dientamoeba fragilis, Entamoeba coli, E. hartmanni, E. histolytica/E. dispar* and *Iodamoeba butschlii*; see text.

Table 2: Monthly prevalences of infection with *Cyclospora cayetanensis* among 5250 patients tested at IPD, January-December, 1996.

Of the 140 singly infected patients, 13 (9%) lived with household contacts that were infected with various protozoan species not limited to *C. cayetanensis*. Of the 140 and 85 singly and concurrently infected patients, 28 (20%) and 32 (38%), respectively, had 83 previous intestinal parasitic infections within the last 5 years; some patients had multiple previous infections. Those 83 infections comprised of *E. histolytica* (25%), *E. coli* (2%), *E. hartmanni* (4%), *B. hominis* (11%), *Giardia lamblia* (10%), *C. cayetanensis* (10%), *Endolimax nana* (4%), *C. parvum* (4%), *Trichomonas hominis* (l %), *Enterobius vermicularis* (4%), *Ascaris lumbricoides* (4%), *Taenia sp*. (2%), *Strongyloides stercoralis* (1%) and unidentified species (20%).

Discussion

Prevalence studies of *C. cayetanensis* are rare in the US and other developed countries. The 4.3% prevalence found in this study is markedly higher than prevalences of 0.5% and 0.3% for specimens received in laboratories in Chicago and Burlington (Massachusetts) [3,4]. It is suggested that the latter low US prevalences represent an under diagnosis as has been reported by Soave [5] for a number of reasons including the intermit-tent shedding of *C. cayetanensis* in the stool [2]. Considerably higher prevalences were reported in endemic regions such as Nepal (11-12%) [6,7], Peru (6-18%) [8] and Haiti (11%) [9].

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Patients of all ages (1-79) tested positive but considerably more females than males were infected. This observation is compatible with other findings of the IPD [2] and in Canada [10] and Africa [11].

Our 1996 study of *C. cayetanensis* in 26 states (Table 1) is the most comprehensive yet from the US at that time. Considering only samples of 100 or more patients tested, warmer states (Arizona, California, Colorado, Florida, New Mexico) show the highest prevalence rates of 9.5%, 5.4%, 6.0%, 4.6% and 4.7%, respectively. The only exception is Texas with 1.7% prevalence. Low prevalences of 2.9%, 1.2% and 3.3% are reported for the colder states of New York, Oregon and Pennsylvania, respectively. Environmental temperature may affect the generation cycle of the extra-human stages of *C. cayetanensis*. Patients from some Southern states, e.g. Arkansas and Louisiana (n = 44 in each) were, however, negative.

The place clustering of infections in zip codes served by certain surface water treatment plants in the metropolitan Phoenix area suggests a potential of infection of water sources. Water-borne infections with *C. cayetanensis*, often incriminating tap water, have been previously reported [5,12-14] causing *C. cayetanensis* to be considered in community-acquired diarrhea [4] particularly that the organism is resistant to chlorination [5]. Other possible sources of infections cannot be accounted for.

The monthly prevalence was highest (6.0%) in September and lowest (1.4% and 2.8%) in February and December (Table 2). Seasonal periodicity correlated to environmental temperature may be involved. The heterogeneity of the geographical locations from which monthly samples were obtained should, however, be considered. Excess numbers of *C. cayetanensis* infections, primarily in non-travelers, were reported in New York and Florida in May, June and July, 1995 [5], consistent with the seasonality documented in Nepal [7]. At IPD, infections were diagnosed during all months of the year (Table 2) including in Florida and New York during winter months (Table 1).

The fact that 12 (9%) of the 140 singly infected patients did not have any symptoms, documents the wide range of pathogenicity of *C. cayetanensis* which was observed to vary between short-lived subclinical self-limited infection and long term overt clinical disease which may be intermittent in nature [2,5,13,15,16]. Enteric symptoms documented in this study were comparable to those reported by other authors [3,5,12,13,16,17]. Very few reports document extra-intestinal symptoms. None of these reports lists any such symptoms other than those observed in the IPD patients.

Foreign travel probably contributed to the prevalence of infection observed in this study. Patients traveling to endemic areas in Mexico (19%), the Caribbean, Central and South America (8%), Far East (9%), among other areas, may have acquired their infections there. This relationship has been previously documented [2,5,6,17,18].

The relationship between parasite-infected household contacts and increased risk of parasitic infections has been demonstrated [2,11]. Such association may have been involved in the infection of some of the 13 (9%) of the 140 patients singly infected with *C. cayetanensis*.

A relationship between current infection with *C. cayetanensis* and previous (within the last 5 years) parasitic infections was observed. The same relationship was incriminated as a factor in the etiology of traveler's diarrhea [19]. The most common pathogens represented in previous infections were *E. histolytica, B. hominis, G. lamblia* and *C. cayetanensis*. The adverse effect of the first three pathogens on host immune system [20-23] would render hosts more susceptible to new infections compared to those with no history of previous infections. Amin [1] found immune compromised patients to be more susceptible to parasitic infections than the immune competent.

Conclusions

Our 1996 research elucidated seasonal patterns and geographical clustering that are new and worthwhile considering in the management of the ongoing 2026 outbreak. For instance, place clustering of cases in zip codes served by certain surface water treatment plants in the metropolitan Phoenix area suggested a potential of infection of water sources. Water-borne infections with *C. cayetanensis*, often incriminating tap water, have been previously reported [5,12-14] causing *C. cayetanensis* to be considered in community-acquired diarrhea [4] particularly that the organism is resistant to chlorination [5]. A large prevalence of infected cases had prior infections with other species of protozoans. Cases from 26 of 49 states and 2 Canadian provinces were found singly or concurrently infected with *C. cayetanensis* during all months of the year with a modest peak of 6.0% in September and declines of 1.4% and 2.8% in February and December, respectively.

Between 1996 and 2020, 38 major cyclosporiasis outbreaks linked to consumption of ready to eat fresh fruits and vegetables in the USA, Canada, and Mexico were reported by Hadjilouka and Tsaltas [24]. These authors referred to the global distribution of cyclosporiasis which is considered a severe gastroenteric disease especially for immunocompromised patients, children, and the elderly [24].

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Currently 19 *Cyclospora* species are known to be causative agents of disease in various animal species [25] contributing to global gastroenteritis spread [26]. Phylogenetic analysis of the *C. cayetanensis* small subunit rRNA (SSU rRNA) gene sequences and mitochondrial genome have demonstrated that this organism is closely related to the *Eimeria* genus [27, 28]. "The Lack of geographic segregation and existence of genetically homogeneous *C. cayetanensis* parasites has also been demonstrated" [29, 30]. Human infection, especially symptomatic cases present via produce consumption or contact with fecally contaminated water, sewage, and soil [31] as our findings demonstrated with the clustering of cases served by surface water treatment plants.

Compliance with Ethical Standards

Conflict of interest: The author declares no conflicts of interest.

Ethical approval: The authors declare that they have observed all applicable ethical standards.

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