

Cyclospora infections in England and Wales: 1993 to 1998

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Summary: *The coccidian protozoon Cyclospora cayetanensis is a treatable cause of prolonged, watery diarrhoea in humans. Microbiology laboratories in England and Wales often restrict testing to those who have recently travelled abroad. Only 44 to 66 laboratory reports of C. cayetanensis are made in England and Wales each year and a large proportion are found to have visited developing countries. Large foodborne outbreaks of infection have arisen in North America among people who have not travelled abroad but no such outbreaks have been identified in the United Kingdom.*

Public health laboratories in England and Wales were surveyed in 1998 to investigate their procedures for identifying C. cayetanensis. Sixty-eight per cent actively looked for the protozoon, but only half used a recommended method of direct microscopy of formol ether concentrates. National external quality assurance results for all participating UK laboratories were reviewed to assess laboratory proficiency in identification. C. cayetanensis was correctly identified in a wet preparation by 58% of laboratories, the lowest rate for specimens containing a single parasite species.

Cyclosporiasis could be acquired in the UK from imported food, but current laboratory procedures might fail to identify it. Ascertainment must improve and awareness needs to be raised among food handlers, public and environmental health workers, laboratory staff, and general practitioners. We recommend that laboratories test all patients with watery diarrhoea for >1 week for cyclospora, use formol ether concentration and microscopy with a calibrated eyepiece graticule, and confirm diagnoses with the help of a reference laboratory.

Key words:

coccidiosis
 gastrointestinal diseases
 microbiological techniques
 parasitic diseases
 risk factors
 travel

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Introduction

Cyclospora cayetanensis causes prolonged, watery diarrhoea in humans^{1,2}. It was initially thought to be a cyanobacterium, or described as unidentified coccidia-like bodies (CLBs)³⁻⁶, but its ultrastructure is that of a coccidian protozoon. *Cyclospora* is a genus

with two sporocysts in the oocyst and two sporozoites in each sporocyst¹. Some *Cyclospora* species are associated mainly with rodents and insectivores but no animal reservoir for *C. cayetanensis* has been confirmed. The significance of reports of *C. cayetanensis* in dogs and poultry is unclear as cross transmission studies have been unsuccessful⁷⁻⁹. Molecular characterisation of isolates from non-human primates has shown them to be distinct from human isolates of *C. cayetanensis*¹⁰.

Oocysts of *C. cayetanensis* are round (8-10 µm) and have an internal morula (6-7 µm) with a number of inclusions¹¹. Oocysts are excreted unsporulated in human faeces but need to sporulate to be infective¹². Sporulation has been demonstrated under laboratory conditions after five to 11 days in distilled water or potassium dichromate at temperatures between 25 and 35°C¹¹. Survival and sporulation conditions in the environment have yet to be defined. The exact mechanism of transmission is not known but the need for a period of extrinsic sporulation makes direct ingestion of fresh faecal material an unlikely mode^{12,13}.

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Reported symptoms of cyclosporiasis include relapsing watery diarrhoea with explosive onset, lasting between one and eight weeks, vomiting, abdominal pain, fever, flatulence, bloating, anorexia, and weight loss^{6,14}. The infection occurs primarily in the small bowel and endogenous stages of the parasite may be found in duodenal aspirates and biopsies. Loss of columnar epithelium with vacuolisation and partial villous atrophy has been observed^{2,15}. Trimethoprim-sulphamethoxazole is an effective treatment¹².

Various laboratory techniques can be used to diagnose *C. cayetanensis* infection¹⁶; preferred methods are detailed in the PHLS Standard Operating Procedure¹⁷. In summary, identification is achieved by:

- ultraviolet (UV) epifluorescent microscopical examination of a wet preparation from a formol ether concentration of stool. The oocysts autofluoresce green using a 450-490nm dichroic mirror exciter filter and blue when using a 360nm filter.
- wet preparation examination by conventional phase contrast or Normaski (DIC) microscopy for oocyst morphology¹¹, but this is less sensitive than autofluorescence¹⁸.
- acid-fast stains, such as modified Ziehl-Neelsen (ZN) stains, to detect oocysts in smears from stool, but these lack sensitivity, specificity, and reliability. Oocysts appear somewhat similar to *Cryptosporidium parvum* (4µm) but are larger (8-10µm)^{5,11,19}.

C. cayetanensis occurs worldwide¹² but appears not to be endemic in many developed countries, and screening studies undertaken in Europe¹⁹ and the United States (US)²⁰ show the incidence of infection to be low. In such countries *C. cayetanensis* is most often looked for and reported in travellers returning from abroad, but outbreaks of cyclosporiasis in the US and Canada associated with eating soft fruit and vegetables have occurred among people who have not travelled²¹⁻²⁵, and are reviewed in an accompanying paper (pages 50-5)²⁶. Such outbreaks of *C. cayetanensis* have not been reported in the United Kingdom (UK). This paper reviews current epidemiology and laboratory practice in England and Wales for detecting and reporting cases, and suggests how ascertainment may be improved.

Investigation

The detection and reporting of *C. cayetanensis* was investigated in three ways: surveillance, laboratory practice, and laboratory proficiency. Laboratory-based surveillance data from England and Wales from 1993 to 1998 were screened for duplicate reports and analysed by age and sex, season, reporting laboratory, and reports of foreign travel. A questionnaire sent to all 47 directors of public health laboratories (PHLs) and PHLS collaborating centres in England and Wales in October 1998 asked when the laboratory started looking for the parasite, what selection criteria were

used, and about diagnostic methods. To evaluate testing proficiency, results from the 299 laboratories that take part in the UK's National External Quality Assurance Scheme for Microbiology (NEQAS) were analysed for correct identifications of cyclospora. This scheme sent out a formalised faecal suspension for concentration in 1996 and a methanol-fixed faecal smear for staining in 1998, according to the availability of material.

Results

Surveillance

Laboratory reporting of *C. cayetanensis* started in England and Wales in 1993, since when 284 cases have been identified (44 to 66 sporadic cases reported annually to the PHLS Communicable Disease Surveillance Centre (CDSC). Most cases occur in June and July (figure 1). Recent foreign travel was reported in 61% (173/284) of cases and 39% (111/284) of cases were reported without documentation of risk factors (figure 1). The countries most often implicated (in descending order) were Nepal, Indonesia, India, Turkey, and the Dominican Republic. Most cases were adults (figure 2), which may mean simply that adults are more likely to travel to these destinations. One hundred and forty-three cases were males, 132 were females, and nine cases were reported without this information (figure 2). More cases were reported by the Hospital for Tropical Diseases, London (49 cases) and by laboratories in Berkshire (24) than elsewhere.

Laboratory practice

Forty-four completed questionnaires were returned, a response rate of 93%. Thirty PHLs that responded looked actively for *C. cayetanensis* and had done so for a median of 3.4 years (range 1 to 6). Twenty-one laboratories tested only if recent foreign travel was reported.

Twenty-two of the 30 PHLs that looked actively for *C. cayetanensis* relied on the modified ZN stain to screen simultaneously for *Cryptosporidium parvum*, and seven laboratories used the phenol auramine stain. One laboratory used microscopic examination of a wet preparation from a formol ether concentration for the initial screen, and 14 laboratories also used this method after an initial staining method of screening.

FIGURE 1 Cases of cyclosporiasis, by date of specimen: England and Wales, 1993 to 1998

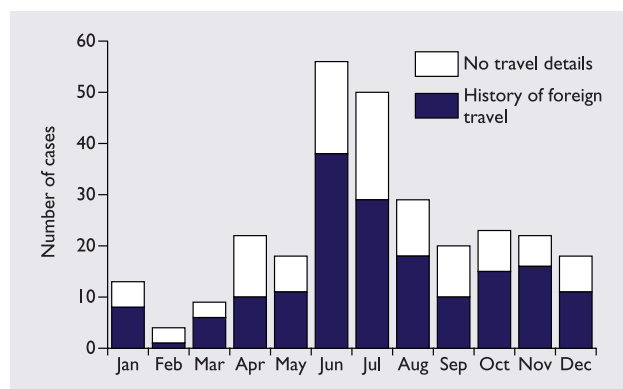
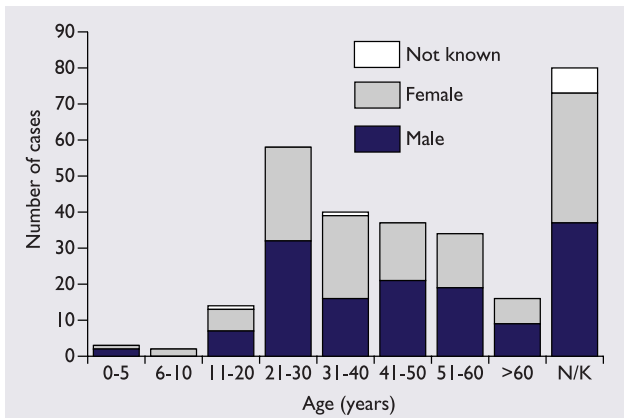


FIGURE 2 Cases of cyclosporiasis, by age and sex: England and Wales, 1993 to 1998



Only 13 laboratories looking for *C. cayetanensis* said they would send positives for confirmation to reference laboratories at the Hospital for Tropical Diseases and Rhyl PHL. Twenty-eight laboratories said they would inform CDSC of a positive result. Twenty-six laboratories had diagnosed fewer than five cases of cyclosporiasis since they had begun looking.

Laboratory proficiency

Fifty-eight per cent (173/299) of laboratories that took part in the UK NEQAS identified *C. cayetanensis* correctly in a wet preparation from a formol ether faecal concentrate, but 42% (126) reported the wrong parasite or no parasites at all. Fewer laboratories (258) examined the methanol fixed faecal smear and reported their findings. Seventy-six per cent (197) reported the correct result and 24% (61) reported the wrong parasite or no parasites at all. *C. cayetanensis* was most commonly mistaken for *Entamoeba* species (both *hartmanni* and *histolytica*) on the wet preparation. Incorrect identification was less common on the smear, but *Cryptosporidium parvum*, *Isospora belli*, and *Blastocystis hominis* were reported in error. The rate of correct identification of *C. cayetanensis* was the lowest of all single parasite samples distributed by the NEQAS scheme.

Discussion

The number of laboratory reports of *C. cayetanensis* in England and Wales is stable and small. This may reflect the low prevalence of the parasite, but ascertainment may be poor and could be improved by the use of appropriate laboratory methods. The survey of laboratory practice revealed various protocols for the identification of *C. cayetanensis*. Nearly three quarters relied on modified ZN for initial screening. This lacks sensitivity, especially as the test is usually done on unconcentrated samples. Cyclospora oocysts stain variably or not at all with ZN, but non-staining oocysts can be seen in the background, especially if DIC microscopy is used (David Casemore, personal communication). A further seven PHLs used phenol auramine staining, but cyclospora oocysts fluoresce poorly or not at all with this stain, making the method

unsuitable¹⁸. The best method for identification of this protozoon is by the detection of autofluorescing oocysts in formol ether concentrates. Direct microscopy may be positive but, depending on the number of oocysts in a specimen, 50% to 75% of infections are likely to be missed without concentration (Tony Moody, personal communication). Concentration is a basic laboratory technique but, like microscopy, it consumes time and money if large numbers of specimens are to be tested. How should specimens be selected for this procedure? Seventy per cent of PHLs used a report of recent foreign travel as a selection criterion, but recent outbreaks of cyclosporiasis in North America among people who had not travelled abroad²⁶ lead us to believe that all specimens from patients who have had watery diarrhoea for more than a week should be tested.

We recommend confirmation of identification by a reference laboratory to provide a good quality service, since the NEQAS identified poor laboratory performance, particularly in the reporting of the presence of parasites. The performance of laboratories in quality assurance for parasitology is otherwise comparable with that for general microbiology. Definitive confirmation of *C. cayetanensis* is by observation of sporulated oocysts containing two sporocysts, each with two sporozoites, but this requires sporulation to be induced. Measurement of oocysts using a calibrated eyepiece graticule and autofluorescence are good markers, however. UV microscopes can be fitted with appropriate filters (340nm or 450-490nm) to detect autofluorescing oocysts. It is essential to use a positive control, such as a specimen previously confirmed by a reference laboratory.

No monoclonal antibodies are currently available commercially but *C. cayetanensis* has recently been cultured with mice in severe combined immunodeficiency, which suggests that such a diagnostic tool may become available. Monoclonal immunofluorescence antibody tests or enzyme linked immunosorbent assays are expensive and are unlikely to be adopted widely even if reagents become available. In the meantime a combination of microscopical techniques, well trained laboratory staff, and a lower threshold for examination should increase ascertainment.

The Hospital for Tropical Diseases, London reported the most cases, many of which had been referred from other laboratories. Hospital laboratories in Berkshire also reported frequently, possibly because staff there have had a particular interest in cyclospora¹⁹. The numbers are small, but the monthly distribution of cases is broadly similar to that seen with salmonellas and campylobacters, peaking in June and July. This is in contrast to *Cryptosporidium parvum*, which is least common in these months, and peaks in spring and early autumn. There is an unexplained but marked seasonality of cyclosporiasis in endemic areas: in Lima, Peru (a desert region) cases occur strictly between December and July¹² and in Kathmandu,

Nepal most cases occur in the rainy season, from May to July²⁷. The use of reported foreign travel as a selection criterion for testing has perhaps exaggerated its role, and underestimated the possibility that foodborne cyclosporiasis may be acquired in the UK. An accompanying paper reviews outbreaks of cyclosporiasis in North America associated with imported foods²⁶. There may be risks to the UK, but seasonal patterns of importation of the implicated vehicles of infection (mainly raspberries from Guatemala) differ. Nevertheless, the amount of soft fruit being imported into the UK is increasing and other vehicles of infection, such as basil and lettuce, have been identified²⁶.

Protozoa are rarely shown to cause foodborne infection but prolonged watery diarrhoea should alert investigators to the possibility of *C. cayetanensis* infection. It is reassuring that 93% laboratories testing for *C. cayetanensis* would report a positive result to CDSC. Consultants in communicable disease control and environmental health officers should also be informed, and need to be aware of the potential for this organism to cause outbreaks.

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Foodborne outbreaks of cyclosporiasis have arisen in North America. Is the United Kingdom at risk?

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Summary: *Cyclospora cayetanensis* is a parasitic protozoon that causes prolonged watery diarrhoea. It is endemic in some developing countries, and recent foreign travel is often used as a selection criterion for screening in the United Kingdom (UK). Epidemiological investigations of outbreaks of cyclosporiasis among people in the United States and Canada who had not travelled abroad showed the infection to be foodborne and often associated with foods eaten raw. These included raspberries imported from Guatemala, and pesto (made with basil) and lettuce from other sources. Such foods are also being imported in increasing amounts to the UK, but no outbreaks have been documented, perhaps because none has occurred or because of poor ascertainment. This paper reviews the outbreaks reported from North America, evaluates the risks to the UK population, and suggests how surveillance could be improved.

Key words:

basil
coccidiosis
disease outbreaks
food poisoning
fruit
gastrointestinal diseases
lettuce
water pollutants

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Introduction

Cyclospora cayetanensis is a protozoon parasite, endemic in some developing countries, and a cause of human diarrhoeal illness¹. Outbreaks in the United States (US) and Canada have affected people who have not travelled abroad and illness has been associated with eating imported foods, particularly raw fruits and vegetables, whereas sporadic cases have tended to be travellers returning to North America from abroad². Direct spread of the parasite from person to person is unlikely since oocysts require an exogenous maturation period in a suitable environment for the development of sporocysts containing infectious sporozoites¹. Thus a vehicle of infection must be suspected. Outbreaks have been reported from elsewhere – for example, Nepal³ – but not from other developed countries. In England and Wales, cases of cyclosporiasis appear to occur sporadically and report having travelled abroad, particularly to developing countries, although this is often a criterion for

laboratory testing⁴. Similar foods to those implicated in the North American outbreaks are imported to the UK, but outbreaks have yet to be detected in the UK. The reasons for this are not known, but laboratory ascertainment is sub-optimal, as shown in a companion paper⁴. Are unrecognised outbreaks of cyclosporiasis occurring in the UK? This paper addresses this question by reviewing reports of North American outbreaks, investigating the importation of fruit and vegetables from developing countries, and evaluating the risks of infection in the UK.

Review of North American outbreaks of cyclosporiasis

Identification of outbreak reports

Medline was searched to identify outbreaks of cyclosporiasis published before 1999, using the term 'cyclospora', and supplementary searching was undertaken by hand. If further information was needed, we wrote to the authors. Thirteen published reports of eight outbreaks in North America were identified. At least 1965 cases arose in 141 clusters within the outbreaks. The reports were analysed to see by what mechanism the outbreak or cluster was identified, when and where it occurred, the precise setting, and the case definition, number of cases, attack rate, evidence of vehicles of infection, incubation period, and duration of illness (table 1).

The outbreaks

The search identified only three published reports of outbreaks of cyclosporiasis in North America before 1996, all in the US. The first outbreak was in Chicago in 1990, where 23 cases were associated with a hospital dormitory water supply⁵. The second was at a country

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TABLE 1 Outbreaks of cyclosporiasis reported in North America

Setting, place and date (reference)	Description (detection; median incubation period; duration of illness)	Number of cases (confirmed)	Epidemiological studies (study type; risk factors identified and levels of association; environmental sampling)
Hospital dormitory, Chicago, July 1990 ⁵	Diarrhoea in house physicians notified to the infectious disease department. Routine use of acid-fast stain on all faecal specimens identified <i>Cyanobacteria</i> -like bodies (later confirmed as cyclospora). Median duration of diarrhoea 5 days (range 3–18). Oocysts detected for up to 8 weeks.	23 (10)	Retrospective cohort study: risk factors for illness were drinking tap water from the physician's dormitory (AR=21%; RR=11.6, CI=2.7–103) and attending a house party in the dormitory (AR=20%; RR=13.7, CI=3.2–122). Cyclospora not detected in 50mL water samples from the dormitory supply.
Country club, New York, June 1995 ⁶	Diarrhoeal illness among members	33 (7)	Retrospective cohort study: illness associated with drinking from portable coolers on the golf course (AR=29%; RR=5.1, CI=3.1–6.9). Full details not yet published.
Community, Palm Beach, Florida June 1995 ⁷	Six cases detected in two weeks at a hospital that had examined all stool specimens for ova and parasites since 1992. Only two previous cases. Enhanced surveillance set up on 22 June. 57 cases confirmed by the end of the year; 45 considered part of the outbreak.	45 (45)	Matched case control study: ingestion of fresh raspberries (OR=6.0, CI=1.1–31.7) and bare handed contact with soil or manure (OR=10.7, CI=2.3–50.3) identified as risk factors. In multivariate analysis only contact with soil was independently associated with illness. Cohort studies for two events within the community outbreak found no exposure significantly associated with illness, but fresh raspberries and strawberries were the only food common to both events.
North America, 1996 ⁸	725/1465 cases of cyclosporiasis reported to CDC and Health Canada in 1996 were from 55 event-associated clusters in May and June. Median attack rate 56% (range 19%–100%). Median attack rate among those who had probably/definitely eaten berries including raspberries 93% (30–100%). Median incubation period 7 days (range 1 to 14, by definition <15). Median duration of diarrhoea 10 days (range 1 to 60).	725 (238)	Raspberries definitely served at 50 events and probably at a further four. In 27/41 events followed up with epidemiological studies (excluding the 6 events with an undefined p value) the association between cyclosporiasis and consumption of raspberries was significant ($P<0.05$).
Luncheon party, Charleston, South Carolina, May 1996 ^{8,14**}	Local department of health and environmental control notified. Median incubation period 7 days (range 1 to 23). Illness lasted 22 weeks in 28/35 cases.	38 (11)	Retrospective cohort study: univariate analysis showed that eating raspberries (AR=89%; RR=5.6, CI=2.3–13.7), strawberries (AR=69%; RR=2.2, CI=1.0–5.1) and potato salad (AR=84%; RR=1.9, CI=1.3–2.7) were associated with illness.
Wedding party, Boston, Massachusetts May 1996 ^{8,13**}	Diarrhoeal illness in those who attended. Median incubation period 7 days (range 2 to 11)	57 (12)	Cohort study: illness significantly associated only with a berries and cream dessert after stratified analysis (AR=73%; RR=2.1, 95%CI=1.4–3.2). The dessert contained strawberries from California, blueberries from Florida, blackberries from Guatemala, and raspberries from either Guatemala or Chile.
North America, 1997 ⁹	762/1012 cases of cyclosporiasis reported to CDC and Health Canada belonged to 41 clusters in April and May 1997. Median incubation period 7 days (1–14, by definition <15). Event specific attack rate 66% (13%–100%). Attack rate for those who ate raspberries 92% (33%–100%).	762 (192)	Fresh raspberries were the only food common to all 41 events. Event-specific p values for associations between raspberry-containing items and cyclosporiasis were significant for 15/37 events investigated.
Wedding, Westchester County, New York, May 1997 ^{9,15***}	The county health department informed of cases. Median incubation period 8 days (range 3–11).	20 (4)	Cohort study: eating raspberries associated with illness in univariate analysis (AR=36%; RR=10.1 CI=3.1–32.8) and remained significant in multiple logistic regression.
Florida, March/April 1997 ¹¹	Two clusters of cyclosporiasis in two restaurants in different cities in Florida.	not stated	Little information available: the first was associated with eating mesclun (spring mix, field greens, or baby greens) from an undetermined source. Mesclun was the suspected vehicle of infection in the second.
North Virginia, Washington DC, and Baltimore, July 1997 ^{12*}	25 confirmed cluster associated with events in June and July. One cluster identified when a company doctor in Alexandria reported that many employees at a corporate luncheon had become ill. Median incubation period 8 days (range 3–12).	48 (17)	Eating pesto (made with basil) salad at the lunch was significantly associated with illness (AR=98%; RR 5.9, $p<0.001$).
Canadian outbreak in 1998 ¹⁰	13 clusters of event-associated cyclosporiasis in May and June, one event has been described: A case of cyclosporiasis reported to Toronto Public Health had attended a dinner in a hotel. Six others also reported diarrhoeal illness. Median incubation period 8 days (range 1–12). Mean duration of illness 7 days (range 1–34).	192 (46) 29 (3)	Fresh raspberries were the only food common to all events. The median event-specific attack rate for raspberries was 100% (26%–100%). Raspberries from 8 events investigated were traced back to Guatemala. Eating a mixed berry garnish (AR=26%; RR=5.2, $p=0.04$) and eating raspberries were associated with illness (AR=26%; RR=4.6, CI=1.2–18.3).

AR – attack rate; RR – relative risk; CI – 95% confidence interval; OR – odds ratio

*Preliminary findings from one cluster have been published; **Figures a subset of reference 8; ***Figures a subset of reference 9

club in New York state in 1995⁶. The third outbreak also occurred in 1995. This was a community outbreak of 45 cases in Florida, and bare handed contact with soil and the consumption of imported raspberries were implicated as vehicles of infection⁷. Two clusters associated with particular events were noted in the published report. No significant associations were found between illness and exposures examined, but fresh raspberries and strawberries were the only food items common to both events.

In 1996 and 1997, many clusters of cases occurred, which were considered to be part of two extensive outbreaks associated with imported raspberries (table 1)^{8,9}. The 1996 outbreak consisted of 55 clusters and 725 cases of cyclosporiasis with onset between 1 May and 31 August⁸. No further clusters were reported during the autumn and winter. The clusters arose east of the Rocky Mountains, with the exception of one in Colorado, and in two Canadian provinces (Quebec and Ontario). Imported raspberries were served at events associated with 54 of the 55 clusters. Guatemala was confirmed as the source of the berries in 29 clusters, and was probably the source in a further six. The geographical locations of the clusters reflected the distribution pattern of imported raspberries in North America.

In 1997, despite interventions by the Guatemalan Berry Commission to improve sanitation and hygiene at the berry farms, 41 event-associated clusters occurred throughout North America between 1 April and 26 May, in which 762 cases of cyclosporiasis were identified⁹. The only food item common to all the events was raspberries, and these were suspected in 23 events and known in eight events to have come from Guatemala. Statistical associations between illness and eating raspberries were documented for 15 events. On 29 May the Guatemalan Berry Commission suspended exports to the US until 14 August, after which a new growing season began. Raspberries were not exported to the US from Guatemala during the spring growing season of 1998 and no further clusters of cases associated with raspberries were reported in the US. Canada continued to import Guatemalan raspberries, however, and an outbreak of 13 event-associated clusters and 192 cases occurred in Ontario in May 1998¹⁰. Fresh raspberries were the only food common to all events, and were associated with illness at the one event about which a report was published¹⁰. Guatemala was the country of origin of raspberries in all eight events for which the source was traced. The Canadian Food Inspection Agency subsequently suspended the importation of raspberries from Guatemala.

Two further outbreaks in the US in 1997 were attributed to other foods, not imported from Guatemala. In one the suspected vehicle of infection was mesclun (mixed baby lettuce)¹¹. In the other, pesto (made with basil) salad was associated with illness in many clusters of cases, preliminary information about one of which has been published¹².

Outbreak detection and case definitions

Outbreaks of cyclosporiasis were identified either

when clusters of diarrhoeal illness were reported in cohorts of people, such as those attending a wedding party¹³, and/or when laboratories routinely screening faecal specimens identified oocysts in increased numbers of faecal specimens⁵. Laboratories taking part in enhanced surveillance schemes detected and reported index cases of some clusters to public health authorities (table 2). Case definitions in outbreak or cluster investigations were diarrhoeal or gastrointestinal illness, with an outbreak or cluster requiring at least one case of laboratory confirmed cyclospora infection. Illness in the 14 days before the outbreak of cluster events was often part of the case definition. As with other intestinal parasitic infections, confirmation may not be obtained for each case unless specimens are obtained from the same patient at two or three day intervals since, although oocysts may be excreted for some time (up to 8 weeks in one outbreak⁵) shedding may be intermittent^{13a}. Median incubation periods in the published reports were between six and eight days (range 1 to 23). The median duration of illness was five to 10 days (range 1 to 60). In one cluster 80% cases were ill for over two weeks¹⁴, and in another 61% cases had symptoms for over three weeks¹³. Relapsing or recurring symptoms were observed in 89% of patients in one cluster¹³ and described in another¹⁴. As the median incubation period is about seven days, exposure history questionnaires need to cover 14 days before the onset of illness, but this may also cause problems with recall. In addition, the foods associated with illness (berries, lettuce, pesto (made with basil)) are often served as sauces and garnishes, which may not be recalled.

Attack rates in the North American outbreaks

Attack rates for the events in individual reports ranged from 14%¹⁵ to 89%¹². For activities associated with illness, attack rates were 20% for drinking dormitory tap water, 20% for attending a dormitory party⁵, and 29% for drinking water from coolers on a golf course⁶. The median attack rates in multi-state outbreaks in 1996 and 1997 were 56% (range 19%-100%) and 66% (range 13%-100%), respectively. Median attack rates associated with eating berry items containing or possibly containing raspberries were 93% (range 30%-100%) in 1996⁸ and 92% (range 33%-100%) in 1997⁹. In the outbreak in Toronto, the attack rates for mixed berry garnish and raspberries were 26% and 29% respectively¹⁰. The high attack rates and small numbers of raspberries reported to have been eaten⁹ suggest that the infectious dose is low, that large numbers of parasites contaminated individual raspberries, or both. The attack rate associated with eating pesto salad was 98%¹².

Outbreak control

The reports of the first two outbreaks in North America showed epidemiological evidence for waterborne infection^{5,6}, and waterborne outbreaks have occurred elsewhere (particularly in endemic regions)^{3,16}, but food items (mainly berries, particularly Guatemalan

TABLE 2 Enhanced laboratory based surveillance systems for cyclospora in the United States*

Name	Description of the system
1996 Sentinel Site Surveillance System	<ul style="list-style-type: none"> Laboratories selected on volume and parasitological expertise at sites involved in the 1996 outbreak. Since February 1997. Weekly (April to August) or monthly (rest of year) notification of numbers of stools tested and number containing cyclospora, to local public health office and thence to CDC.
CDC/US Dept. of Agriculture /Food and Drug Administration Foodborne Diseases Active Surveillance Network 'Foodnet'	<ul style="list-style-type: none"> CDC's Emerging Infections Programme. Cyclospora included since 1997. Sentinel networks in eight states and active surveillance of laboratories in the catchment area. Weekly notification to the network and regular notification of numbers of positive stools to CDC.
Public Health Laboratory Information System (PHLIS) state/municipality network	<ul style="list-style-type: none"> 37 state and 10 large metropolitan public health laboratories (those which test for parasitic diseases or with PHLIS capacity). Weekly reporting of numbers of positive stools to CDC.

* (Vance Dietz and Barbara Herwaldt (CDC, Atlanta), personal communication)

raspberries) have been identified as the main vehicle for cyclospora infection in outbreaks and among sporadic cases in North America^{8,9,17}. The suspension of imports from the spring growing season in Guatemala to the US in 1997 proved to be an effective public health measure since no further clusters of cases associated with eating berries occurred. Canada continued to import raspberries during 1998 and an outbreak occurred in Ontario. Enhanced laboratory based surveillance systems for cyclospora have been set up in the US (table 2). In 1998, the US Council of State and Territorial Epidemiologists passed a resolution recommending that cyclosporiasis be made a nationally notifiable disease.

The risk of outbreaks of foodborne cyclosporiasis in the UK

Evidence that raspberries have served as a vehicle for *C. cayetanensis* in outbreaks in North America is relevant to the UK since the importation of fresh raspberries has risen in recent years from 679 tonnes in 1992 to 1514 tonnes in 1998 (table 3). The proportion from Guatemala rose from none in 1992 to 8% of raspberry imports in 1997 (70 tonnes). Even when the proportion is small, there may be a risk since the infectious dose for *C. cayetanensis* appears to be low and berry-specific attack rates were high in the North American outbreaks. The seasonal distribution of cases in North America in 1996 suggested that raspberries from the second growing season each year were not a risk factor for illness⁸. Peak rates of illness in May coincided with the peak proportion of berries imported from Guatemala, and also reflected their regional distribution⁸. It is not known how the fruit becomes contaminated, or at what stage of production, but there is evidence of seasonal distribution of human carriage in Guatemala: prevalence there peaks between May and August¹⁸. Peak imports of fresh raspberries to the UK from Guatemala are generally from the apparently 'low risk' second growing season. In 1996 imports peaked in November and December, in 1997 between January and April and again from

September to December, and in 1998 between January and April and October to December (Simon Pearsall, Ministry of Agriculture, Fisheries and Food, personal communication). There is currently no evidence that the UK should restrict the importation of soft fruit from Guatemala on the basis of proven infections, but consistent associations between illness and the consumption of Guatemalan raspberries in North America indicates a potential problem.

Other food vehicles identified in North American outbreak included mesclun lettuce and pesto (containing basil) of unstated origin. These foods are eaten raw and, like soft berries, leaves are difficult to wash effectively without damaging the produce. It is rare for environmental screening to result in isolation of *C. cayetanensis*, but oocysts have been detected on vegetables from markets in Peru¹⁹ and Nepal²⁰, and it has been demonstrated experimentally that *C. cayetanensis* oocysts remain on the surface of vegetables after washing¹⁹. Waterborne infection was suggested in the first two outbreaks in the US^{5,6} but this vehicle was not implicated in later outbreaks.

Current methods for the recovery and detection of *C. cayetanensis* from environmental and food samples are poor, but other quality indicators – for example, faecal organisms – may be useful. Indicators with

TABLE 3 Fresh raspberries imported to the United States and United Kingdom

Imports (tonnes) from Guatemala / total imports (tonnes) (%)		
Year	United States*	United Kingdom†
1992	2 / 6881 (<1)	0 / 679 (0)
1993	37 / 5896 (1)	2 / 405 (<1)
1994	102 / 7430 (1)	6 / 528 (1)
1995	164 / 8026 (2)	10 / 1071 (1)
1996	322 / 6406 (5)	34 / 550 (6)
1997	129 / 5978 (2)	70 / 915 (8)
1998	8 / 4537 (<1)	43 / 1514 (3)

* US Department of Agriculture, Agriculture and Trade outlook branch

† MAFF, Statistics (Commodities and Food) Branch C. Eurostat\comtext (CD Rom)

similar survival characteristics to *C. cayetanensis* need to be found. Sporulation times and conditions and environmental survival of the parasite need to be studied in order to identify vehicles of infection and routes of transmission.

Non-food vehicles of infection have been suggested for *C. cayetanensis*, which has raised the possibility of indigenous sources in developed countries. Bare handed contact with soil was a risk factor in a community outbreak in Florida⁷. This is a biologically plausible mode of transmission of *C. cayetanensis*, but it is not clear how the soil become infected. Animal reservoirs have not been confirmed, and the role of water as a vehicle for human infection and for contamination of produce needs to be investigated.

Conclusion

No outbreaks of cyclosporiasis had been reported in the UK by the end of 1999, but the food vehicles implicated in the North American outbreaks are also eaten in the UK. The surveillance system in England and Wales could allow outbreaks to remain undetected since awareness of cyclospora is low, laboratory screening needs to be improved, and selection criteria for testing need to be broadened⁴.

An increased number of cases of diarrhoea in the community could indicate an outbreak but people might not consult their general practitioners, although the prolonged diarrhoea associated with cyclosporiasis might prompt cases to seek medical help. An outbreak associated with an event might come to the attention of environmental health officers, but the organism would have to be identified. The PHLS Communicable Disease Surveillance Centre's database of outbreaks of gastrointestinal illness shows that the proportion of outbreaks in which no organism has been identified rose from 15% in 1992 to 30% in 1997 (unpublished data), and emerging pathogens such as cyclospora may be contributing to this. The study of infectious intestinal disease in England and Wales did not report any cases of *C. cayetanensis* infection, but used auramine-stained smears²¹, which are inappropriate for its detection⁴.

Better surveillance would provide a background against which to measure any apparent increase. While screening all faecal specimens for the parasite may not be fruitful in terms of effort for results, screening those with prolonged watery diarrhoea as well as those who report foreign travel may be. Only four cases of cyclosporiasis were identified when all faecal specimens submitted to one district general hospital from October 1993 to September 1994 (6151 from 5374 patients) were screened²². Since then, however, the number of cases worldwide has increased. The events in Florida in 1995, when a community outbreak was detected by a hospital screening all faecal specimens for the parasite⁷, demonstrated the value of enhanced surveillance against a background of an unidentified community outbreak. Enhancement of surveillance may lead to a spurious increase in incidence (pseudo-outbreaks) and

clusters of false positive cases²³ and confirmation by a reference laboratory should be included in the diagnostic protocol⁴.

A specific scheme for testing specimens of watery diarrhoea could be set up in the UK, in which all such specimens would be submitted to specifically funded sites for testing. Enhanced surveillance of cases could be used to identify common exposures and generate hypotheses for further investigation using case control studies. The value of improved surveillance will only be seen if cases and suspected vehicles are investigated swiftly.

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