Cryptosporidiosis surveillance and water-borne outbreaks in Europe

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Cryptosporidium causes diarrhoeal disease that can be particularly severe in immuno-compromised individuals. Cryptosporidiosis is a notifiable disease at European Union level, and surveillance data are collected through the European Basic Surveillance Network. The disease distribution in Europe for 2005 showed 7,960 cryptosporidiosis cases reported from 16 countries. The crude incidence rate was 1.9 cases per 100,000, although there were considerable differences in the rates of cryptosporidiosis between countries. Infection was more commonly reported in young children. A pronounced seasonal peak was observed in the autumn of 2005, with 59% of the cases reported between August and November, although Ireland and Spain experienced a peak in spring and summer, respectively. Cryptosporidiosis outbreak investigations and analytic studies have associated the disease with drinking water supplies, animal contact, travel, and swimming pools. Contamination of the source water for drinking water supplies, as well as inadequate water treatment can be responsible for cryptosporidiosis outbreaks. Routine cryptosporidiosis surveillance from North West England over 17 years showed that the cases occurred predominantly in spring and autumn. British drinking water regulations and improvements in drinking water treatment have coincided with a decline in cryptosporidiosis incidence. Improvements in cryptosporidiosis surveillance such as detection, recording and reporting will help to recognise outbreaks and monitor interventions.

Introduction

Cryptosporidium is a genus of protozoan parasites. Some species infect mammals including cattle, sheep, rodents, cats and dogs, but also birds, fish and reptiles. It can cause diarrhoea in humans, and protracted diarrhoea in people with an immune deficiency. Faecal-oral transmission can occur directly through person-to-person and animal-to-person routes or indirectly through environmental vehicles including water and food. Outbreaks have been reported in healthcare facilities and daycare centres, within households, among bathers and water sports participants in lakes and swimming pools, and in municipalities with contaminated public water supplies or people served by private water supplies [1]. The disease in humans is predominantly caused by the species *Cryptosporidium hominis* and *C. parvum*, although a number of other species are also pathogenic for humans.

Cryptosporidium oocysts can resist harsh environmental conditions (heat, cold or chemical insult) for extended periods of time and can survive for months in moist soil or water. Furthermore, oocysts can survive most common water disinfection procedures, including chlorination [2]. Water distribution systems and swimming pools are particularly vulnerable to contamination with *Cryptosporidium* and thus pose a considerable threat to public health. Oocysts can, however, be effectively removed by well operated filtration, or killed by UV treatment.

Surveillance of cryptosporidiosis in Europe

Data on cryptosporidiosis cases are collected and recorded by health agencies in several European countries, and the confirmed cases from 16 countries reported to the European Basic Surveillance Network (BSN) in 2005 are presented in Table 1. The reporting is based on the case definition described in EC decision 2002/253/EC, i.e. a clinical description characterised by diarrhoea, abdominal cramps, loss of appetite, nausea and vomiting, or laboratory confirmation of oocysts in stool, intestinal fluid or small-bowel biopsy specimens, or antigen in stool. A total of 7,960 cases were reported to the BSN in 2005, with 70% reported from the United Kingdom. However, the highest incidence was observed in Ireland with 13.7 cases per 100,000. Only five of the 16 countries reported age specific incidence, which revealed an elevated risk among individuals younger than five years of age (5.7 cases per 100,000) and five to 14-year-olds (2.5 cases per 100,000) compared to older age groups (incidence =<1 cases per 100,000) (Figure 1).

Table 1

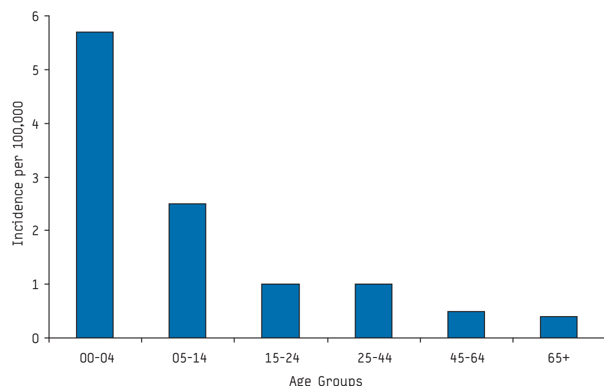
Reported cryptosporidiosis cases and incidence by country, 2005 (Source: Basic Surveillance Network).

Country	Confirmed Cases	Incidence*
Belgium	357	3.4
Cyprus	0	0.0
Czech republic	1	0.0
Estonia	0	0.0
Germany	1284	1.6
Hungary	0	0.0
Ireland	565	13.7
Latvia	0	0.0
Lithuania	0	0.0
Malta	6	1.5
Poland	0	0.0
Slovakia	0	0.0
Slovenia	9	0.5
Spain	108	0.3
Sweden	69	0.8
United Kingdom	5561	9.3
Total	**7960**	**1.9**

*Incidence per 100,000 population (confirmed cases only).

FIGURE 1

Age-specific incidence rates of confirmed cryptosporidiosis cases, 2005. (Source: basic Surveillance Network).



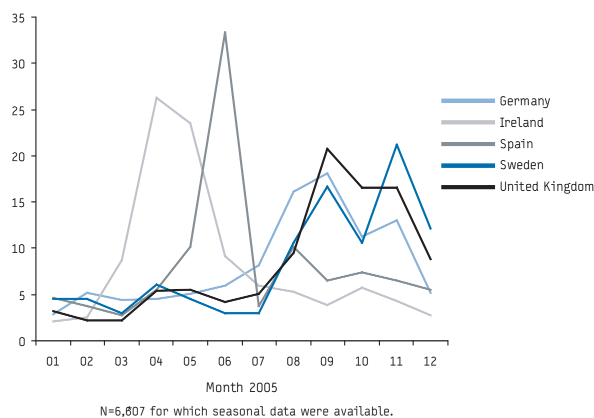
It is difficult to compare counts and incidence between countries due to differences in detection, investigation, case definitions, recording and the procedural/legal basis of reporting. The extent to which routine diagnostic laboratories around Europe screen for *Cryptosporidium* is unclear, but it is likely that there are substantial differences in ascertainment between countries. Furthermore, the reported cases are likely to underestimate the actual burden of cryptosporidiosis due to the insensitivity of passive surveillance. Thus, the currently available data represent only 60% of European countries, and are likely to be biased by the conditions of reporting.

Seasonality

Figure 2 illustrates the percentage of cryptosporidiosis cases per month for individual countries. While this shows differences between months, the data are for a single year only and do not necessarily reflect regular seasonal trends. A peak is observed in the autumn for most countries. However, Ireland saw an increase in spring, and the number of cases in Spain peaked in summer.

FIGURE 2

Monthly percentage of total annual cryptosporidiosis notifications* for selected countries, 2005 (Source Basic Surveillance Network)

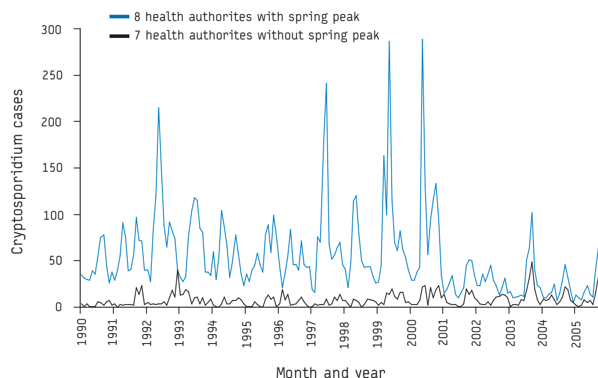


N=6,807 for which seasonal data were available.

For certain countries, the available data are sparse (reflecting limitations in laboratory testing and surveillance in these countries). Surveillance data for multiple years would be necessary to confirm the seasonality of the results, but such data are not available on a European level. An attenuated increase in spring cases is observed in the United Kingdom and Sweden. Evidence from England and Wales suggests that cases of cryptosporidiosis in the spring have mainly been caused by *C. parvum*, while cases in the autumn are frequently caused by *C. hominis* [3,4]. The seasonality of cryptosporidiosis has changed over the years within England and Wales and the spring peak has substantially decreased since 2001 [3,4]. The autumn cases may be caused by holiday travel and swimming pool use, but the evidence is poor.

FIGURE 3

Cryptosporidium cases in two groups of Health Authorities in North West England 1990-2005.



Routine surveillance in North West England over 17 years showed that the majority of cases occurred in spring and autumn [4,5]. The introduction of *Cryptosporidium* drinking water regulations in 1999 that came into effect in 2000/01 together with substantial additional investment in drinking water treatment has led to a reduction in the cases in the spring, but had only a negligible effect on the cases in late summer. Data from eight health authorities in North West England that had previously had regular spring increases have shown a dramatic reduction in these spring cases since 2001, compared to seven control health authorities, where there had never been a regular spring increase (Figure 3). This suggests that improved water treatment such as filtration of previously unfiltered water has resulted in a substantial reduction in the disease [4,5].

Major documented outbreaks via public water supplies

A relatively small proportion (2%) of the sporadic and epidemic cases of gastrointestinal infections suffered in Europe is estimated to be waterborne [1], and the case count differs by country (Table 1). The number of reported waterborne infections varies greatly and is probably affected by the quality of the public water supply and sewage disposal systems, and the nature of the surveillance systems for these diseases. Several *Cryptosporidium* outbreaks associated with public water supplies in Europe have been reported in the literature and selected examples are presented in Table 2.

Table 2

Selected reports of Cryptosporidium outbreaks associated with drinking water

Country	Study description	Ref
Denmark	A nosocomial outbreak of cryptosporidiosis involved 18 HIV-positive patients who were admitted as in-patients to a Hospital in Copenhagen in 1991. The source of the outbreak was identified as ice from an ice machine, contaminated by a patient with cryptosporidiosis picking out ice for cold drinks. Of the infected HIV-positive patients, eight died after prolonged diarrhoea.	6
England and Wales	In 2000, 58 cases were confirmed after heavy rainfall and flood alerts. Cryptosporidium oocysts infiltrated the reservoir from springs and persistence in the water distribution system after the municipality had chosen a different water source. This persistence may have been due to oocysts being entrapped within biofilm on the surface of the water pipes.	7
England and Wales	After heavy precipitation a Cryptosporidium outbreak involving 47 cases occurred in North West England in 1993 one water source was found to drain surface water directly from a field containing livestock faeces, thereby bypassing natural sandstone filtration. A case-control study showed significant association with drinking unboiled tap water, and after withdrawal of the original water supply, the outbreak rapidly subsided.	8
France	An outbreak in 2001 in Dracy Le Fort, Burgundy caused gastroenteritis in 563 of the 1,100 inhabitants. C. hominis was detected in 19 patients. Tap water consumption was the only risk factor associated with the cases, and oocysts were identified in the water-supply.	9
Ireland	A rise in the number of laboratory-notified cases of cryptosporidiosis in 2007 alerted public health officials of an outbreak involving 182 cases in the city and county of Galway. Exceedences to the guideline of less than one oocyst/10 litres observed in the final treated water was linked to the heavy precipitation of historic proportions and the water source reaching the highest lake level on record.	10
Italy	A waterborne outbreak occurred in a drug rehabilitation community in Northern Italy in 1995. The attack rate was 13.6% among HIV-negative individuals and 30.7% among HIV-positive individuals, although in the latter, it varied according to CD4 cell count. Oocysts were identified in sediment from drinking water storage tanks.	11
Northern Ireland	Between 2000 and 2001, 347 laboratory-confirmed cases were linked to contamination of the drinking water supply. Human sewage from a septic tank and wastewater from a blocked drain seeped into the drinking water distribution system.	12
Northern Ireland	In 2002, an increase in Cryptosporidium cases (29 confirmed cases, linked to the same water supply) was noted by the health board. Oocysts were detected in raw and treated water, and in the environment surrounding the lake in the watershed. An epidemiologic, environmental, and microbiological investigation indicated agricultural practices which could have resulted in contamination of the water source with manure.	13
Russia	In 1999, the seroprevalence of Cryptosporidium was assessed in 50 community-recruited adults and 50 blood donors from Cherepovets, Russia. Over a follow-up period, drinking non-boiled water from shallow draw-wells was associated with an increase in seropositive blood samples.	14
Scotland	An outbreak of waterborne cryptosporidiosis in Ayrshire in 1988 affected 27 people. Hundreds of people had suffered from diarrhoea. Cryptosporidium oocysts were detected in the water supply, and the contamination had originated in a break-pressure tank.	15
Spain	An outbreak in 1998 in Guadarrama (Madrid, Spain) affected 21 children. Cryptosporidium oocysts were detected in eight cases. A case control study found a statistically significant association between tap water consumption and gastroenteritis. Deficiencies were observed in water treatment but no oocysts were found in the water.	16
Sweden	In 1991, a cross-connection to a contaminated creek led to contamination of the community water supply, causing 600 infections including cryptosporidiosis.	17

In 208 of 710 waterborne disease outbreaks officially reported in Europe between 1986 and 1996, the causative agent was identified through epidemiological investigations; of these, Cryptosporidium was implicated in one outbreak in Croatia, 13 in England, one in Spain, and one in Sweden [1]. Cryptosporidium has been linked to drinking water supplies in a number of European Union member states. This issue was examined as part of the European project MedVetNet called Cryptnet (http://www.cryptosporidium.it/index.php?id=04). A recent report on cryptosporidiosis in England and Wales identified 149 cryptosporidiosis outbreaks between 1983 and 2005, 55 of which were linked to municipal drinking water supply, six to private water supplies, 43 to swimming pools, and 16 to contact with animals [3].

Preventing cryptosporidiosis infections

In most European countries chlorine is used to disinfect drinking water and to prevent bacterial growth in the water distribution system. Alternative methods such as ozone (O_3) or UV are also very effective processes of inactivation. In addition, chlorine dioxide is currently used in drinking water in Belgium, France, Germany and Italy to inactivate *Cryptosporidium*. Although standard chemical disinfection has limitations, flocculation (a process by which fine particulates are caused to clump together into floc) and filtration can remove *Cryptosporidium* oocysts if carried out properly. Particles suspended in water tend to be negatively charged and repel each other. Coagulation with aluminium sulfate, iron (II) sulphate or iron (III) chloride eliminates this natural charge so that oocysts attract each other and coagulate, building larger particles that will eventually precipitate. Sedimentation and filtration can then provide

an effective barrier for *Cryptosporidium*. Membrane filtration can further improve the quality of the drinking water. Heavy rainfall can cause water drainage systems to overflow and strain water treatment capacity, leading to *Cryptosporidium* contamination of the water supply, treatment plant, or distribution network [2]. Water catchment management and temporary abandonment of water sources have both been useful in reducing the contamination of source waters, and the World Health Organization (WHO) Water Safety Plans are being used to improve drinking water quality.

In summary, cryptosporidiosis can be a life-threatening disease in immuno-compromised individuals and is of concern in young children. The seasonal BSN data and the longitudinal surveillance from England indicate recurrent exposure of the general public to *Cryptosporidium*. However, evidence from North West England shows that improvements in drinking water treatment can substantially reduce the number of cryptosporidiosis cases. These data illustrate opportunities for communicable disease control of this rarely reported, but potentially severe disease. Improvements in investigation, detection, case definition, recording and reporting of cryptosporidiosis are important in assessing the disease burden and in identifying outbreaks. Targeted interventions such as upgrading drinking water treatment plants require timely and complete surveillance data in order to assess risks using Water Safety Plans and to monitor the effectiveness of interventions [18,19].

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