

GUIDANCE FOR THE INVESTIGATION OF CRYPTOSPORIDIUM LINKED TO SWIMMING POOLS: MONITORING, RISK ASSESSMENT AND KEY PUBLIC HEALTH MESSAGES

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ABSTRACT

The protozoan parasite *Cryptosporidium* causes an acute gastrointestinal illness which can last for up to 3 weeks. In some immuno-compromised individuals illness can be life-threatening. Transmission is via the oocyst life cycle stage, which is shed in high numbers (10^6 – 10^7 per gram stool) during acute illness. The infectious dose is as low as 10 oocysts. Oocysts may continue being shed for two weeks after symptoms have ceased, with long-term asymptomatic carriage also reported. Cryptosporidiosis can be acquired through close contact with an infected person, animal, or faeces, or through consumption of contaminated food, drinking water or recreational waters.

Since 2001, swimming pools have been the most common setting for outbreaks of waterborne infectious intestinal disease in England and Wales, with *Cryptosporidium* as the leading cause. Unlike most other pathogens it is resistant to normal chlorine levels used for pool disinfection, and will therefore survive in pool water and present an infection risk unless removed. This relies on good circulation with optimal filtration and flocculation. Because this is a progressive treatment, bathers in the vicinity of faecal contamination by someone infected with *Cryptosporidium* will be at risk if they ingest the pool water. Risks to public health can be minimised by ensuring swimming pool construction, engineering, management, procedures and pool water circulation, treatment and disinfection are optimal and in accordance with current guidelines, detailed by the Pool Water Treatment Advisory Group. Guidance for public health professionals has been issued to assist in the investigation of cases linked to swimming pools by outlining the legal and regulatory framework, normal pool operating parameters and standards, emergency actions, and by providing sources of independent advice, information about establishing and investigating epidemiological links, and providing tools for investigating/inspecting swimming pools and illustrating key public health messages. Managing messages effectively is an important additional control measure. The guidance is available from www.publichealthwales.org/cryptopoolguidance/

Keywords | *Cryptosporidium*, swimming pools, public health, investigation, guidance

INTRODUCTION

Swimming pools are the most common setting for outbreaks of waterborne gastro-intestinal disease in England and Wales, with *Cryptosporidium* as the leading cause of disease (Smith et al., 2006). As a result of an increased number of investigations into cases of cryptosporidiosis linked to swimming pools, particularly during 2009 (Anon, 2009), the need for guidance for undertaking investigations was identified.

Cryptosporidium is a protozoan parasite and a major cause of acute gastroenteritis, characterised by watery diarrhoea, abdominal pain, and nausea and/or vomiting, often lasting up to three weeks. About one third of patients experience a relapse of symptoms (Hunter et al., 2004). The incubation period is 3 to 12 days, usually 5 to 7 days. All ages can be affected but more cases are reported among children, especially the under five year olds, than adults. Ingestion of fewer than 10 oocysts may be sufficient to cause infection and disease. There is no specific drug treatment licensed in the European Union.

The parasite presents specific infection control difficulties in swimming pools (Kebabjiam 1995). Unlike most other pathogens, it is resistant to chlorine disinfection which is the most commonly used disinfectant (Korich et al., 1990). Removal of *Cryptosporidium* from pool water by filtration is possible over time but only if there is good circulation and optimal filtration incorporating coagulation (Croll, 2004; Gregory, 2002). Pools with supplementary disinfection by ozone or UV may offer disinfection of *Cryptosporidium* as the water passes through the treatment plant if the dose and contact time are sufficient (Gregory, 2002).

Outbreaks of cryptosporidiosis linked to swimming pools were first recognised in the United States of America in 1988 (CDC, 1990; Sorvillo et al., 1992) and in the UK in Doncaster the same year (Joce et al., 1991). A review of global outbreaks of waterborne disease revealed that most cryptosporidiosis outbreaks were linked to recreational waters (Karanis et al., 2007). Increased awareness and recognition of the risks from swimming pools have led to an apparent increase in the number of recognised outbreaks and since 1999, swimming pools have been the most frequently identified setting for outbreaks of cryptosporidiosis in England and Wales (Smith et al., 2006; Nichols et al., 2006).

Most swimming pool-related outbreaks occur as a result of faecal contamination by bathers (Karanis et al., 2007). If *Cryptosporidium* contaminates a swimming pool, bathers are at risk of infection. Some groups of swimming pool users may be more predisposed to exposure than others. For example, children may spend long periods in the pool and are more likely than adults to intentionally or accidentally swallow water (Dufour et al., 2006). The size of the infection risk will depend on the design and construction of the pool, effectiveness of the treatment, management and operation of the pool, and the actions taken by lifeguards and operators following incidents such as faecal accidents. Well-designed, modern pools should have treatment that is capable of removing *Cryptosporidium* oocysts. However, even modern pools can be mismanaged in a way that allows water to become contaminated. Problems that have contributed to outbreaks of cryptosporidiosis include inadequate pool design and construction, including water features, sewage cross-connection, faecal release or contamination from bathers, inappropriate handling and disposal of stools, inappropriate response to faecal accidents, inadequate pool water circulation, coagulation and filtration, filter backwashing problems, inappropriate backwashing procedures, ozone or UV treatment not working properly (Anon 2000; Karanis et al., 2007).

Risks to public health can be reduced by making sure swimming pool construction, engineering, management, procedures, and pool water circulation, treatment and disinfection are optimal and in accordance with current guidelines, described in the Pool Water Treatment Advisory Group's "Swimming Pool Water Treatment and Quality Standards for Pools and Spas" (PWTAG 2009) and updates on the PWTAG website www.pwttag.org. Additionally, a proactive health protection approach can be taken to promote hygienic practices among bathers.

The purpose of the new guidance for public health professionals (Public Health Wales, 2011) is to assist in the investigation of cases of cryptosporidiosis linked to swimming pools by providing background information especially relating to swimming pools, outlining the legal and regulatory framework, normal pool operating parameters and standards, emergency actions, providing sources of independent advice, information about establishing and investigating epidemiological links, and providing tools for investigating/inspecting swimming pools and illustrating key public health messages. Managing such messages effectively is an important additional control measure. This paper describes how the guidance

was produced, the epidemiology of *Cryptosporidium* outbreaks linked to swimming pools in England and Wales, regulation of swimming pools in the UK, key elements of public health investigations and key messages for reducing the risk.

EPIDEMIOLOGY OF CRYPTOSPORIDIUM OUTBREAKS LINKED TO SWIMMING POOLS IN ENGLAND AND WALES

National outbreak surveillance for general outbreaks of infectious intestinal disease is undertaken in England and Wales by completion and return of standardised forms to the Health Protection Agency Centre for Infections (HPA CfI). Between 1992 and 2009, there were 63 reported outbreaks of cryptosporidiosis linked to swimming pools. A total of 1078 cases (range 2 to 158, mean 34, median 9 per outbreak) were reported with 642 (range 2 to 48, mean 11, median 7 per outbreak) laboratory confirmed *Cryptosporidium* infections. Twenty three cases were reported to be hospitalised. There were no deaths. Although outbreaks occurred at all times of the year, there is a seasonal distribution with most in August, September and October. Most were linked to swimming pools at leisure centres. Outbreaks lasted 1 to 153 days (mean 29 days, median 20 days). Typing data was available for 21 outbreaks and showed that most were caused by *C. hominis* (n=15 outbreaks) although *C. parvum* (n=3 outbreaks) was also involved and there were three outbreaks caused by both species. Not all isolates were typed but those that were have been shown to be representative of cases in general (Chalmers et al., 2009; Chalmers et al., 2010).

More detailed information about the swimming pools linked to outbreaks was analysed as part of a follow-up study undertaken in 2000 of the 18 outbreaks in the preceding 10 years (Anon, 2000). Most (n=14) of the outbreaks were associated with swimming pools on the basis of descriptive epidemiology, with analytical epidemiological evidence in only four outbreaks. This was often limited to identifying the swimming pool as a possible common factor among cases, although head immersion was significantly associated with illness in the Doncaster outbreak in 1988 (Joce et al., 1991). Sampling pool water or filter samples for *Cryptosporidium* revealed oocysts in six incidents, but approaches to sampling (for example, sample volume and analytical methods) were variable. The pools involved in outbreaks included those disinfected with chlorine or with additional ozone facilities, but the latter were often reported to be failing. Outbreaks occurred at pools considered by the investigating team to be poorly- and well-managed, indicating the vulnerability of swimming pools to *Cryptosporidium* contamination. However, details of pool water treatment and bacteriological monitoring were often sparse. Outbreaks were more frequently reported in learner or toddler pools than main pools, reflecting the vulnerability of the key user group (young children) who could also be the source of infection. Two thirds of the cases who swam were children, and one quarter were under five years old. Diarrhoea is more likely to be investigated in this age group than adults, and outbreaks of illness may be more readily noticed amongst groups of children. However, young children are more susceptible to infection. The distribution may also reflect the risk activities and behaviours of this particular age group. Recognised faecal accidents at the pool were reported prior to only four outbreaks although such contamination was suspected in a further five outbreaks. Reporting systems for faecal accidents were often lacking at the pools.

REGULATION OF SWIMMING POOLS AND ADVISORY GUIDELINES IN THE UK

There are no specific regulations governing swimming pools, although in the UK the Health and Safety at Work etc Act 1974 applies, and includes public safety by requiring employers to conduct their undertaking in such a way as to ensure, so far as is reasonably practicable, that the public is not exposed to risks to health and safety. In addition, the following also apply in the UK:

- The Health & Safety Executive (HSE) guidance, HSG179 Managing Health and Safety in Swimming Pools, 2003.
- The Control of Substances Hazardous to Health Regulations 2002.
- The European Committee for Standardisation.
- British Standards Institute codes of practice PAS39:2003 (Management of public swimming pools, water treatment systems water treatment plant and heating and ventilation) and PAS65:2004 (Management Of Public Swimming Pools).

- British Standard BS EN 15288-1:2008/A1 Swimming pools Part 1: Safety Requirements for Design.
- BS EN 15288-2:2008/Swimming pools Part 2:2008 Safety Requirements for Operation.
- The World Health Organization (WHO) Guidelines for Safe Recreational Waters Volume 2: Swimming Pools and Similar Water Environments, 2006.

Furthermore, Health Protection Regulations 2010 have made *Cryptosporidium* notifiable by diagnostic laboratories. Notification requires an urgent response when the notification forms part of known cluster of cases, is known to be a food handler or there is evidence of an increase above expected numbers of cases. The Health Protection (Local Authority Powers) Regulations 2010 update the powers and duties of local authorities relating to their health protection role, and enable Local Authorities to make formal requests for cooperation of an individual person, or a group of people, to take, or refrain from taking, any action to protect human health. The request must be for the purpose of preventing, protecting against, controlling, or providing a public health response to infection or contamination that presents, or could present, a significant harm to human health. In the context of cryptosporidiosis associated with the use of pools, dependent on specific circumstances it may be pertinent to use this power:

- to request that cases of cryptosporidiosis refrain from using swimming pools until 14 days after their last symptoms (Anon 2004).
- to request pool operators to undertake remedial works to the pool water treatment or filtration system.
- to request closure of a pool.

PUBLIC HEALTH INVESTIGATIONS

If there is evidence that there is a cluster of illness linked to the pool water, the Local Authority Environmental Health Officers and a Consultant in Communicable Disease Control jointly consider the facts (in consultation with a microbiologist) and decide whether to declare an outbreak and convene a multi-agency Outbreak Control Team (OCT). It will be the responsibility of the OCT to advise on the closure of the pool and agree criteria for re-opening. In Wales, all outbreaks are managed, recorded and reported under the model Draft Communicable Disease Outbreak Plan for Wales (The Wales Outbreak Plan) (WAG, 2010), and in England, under the Incident and Emergency Response Plan (HPA, 2008). There is no standardised 'trigger' value for the number of cases which should arouse suspicion, and prompt further investigation of, the potential association of cryptosporidiosis with a swimming pool. Further investigation should be undertaken if any of the following occurs:

- Two or more cases of cryptosporidiosis report a history of swimming at a specific swimming pool (or pool complex) within a couple of weeks.
- There is an increase in the proportion of all cryptosporidiosis cases reporting a history of swimming within a defined time period.
- The repeated occurrence of cases linked to a single pool over an extended period may indicate a particular ongoing risk (e.g. contaminated filter) that needs investigation.
- A group of cases are identified who attended the same function e.g. a swimming lesson or swimming pool party.
- There is an increase in the number or proportion of cases occurring among young children.

For *Cryptosporidium* it will be prudent to eliminate the possibility that the water supply had been contaminated, by requesting water quality data from the water company.

On the basis of descriptive epidemiology, hypotheses on the source of infection and mode of transmission should be generated. Analytical epidemiology is a useful adjunct to outbreak investigation. Studies can be conducted to capture additional information not routinely sought. For example, they can be used to investigate hypothesised associations between specific pool-related features and risk of developing cryptosporidiosis.

For all analytical studies, a protocol should be written. In the context of an outbreak investigation, the two most common types of study undertaken are case-control and cohort.

Cohort studies are feasible only for well defined populations (where a complete list exists, for exam-

ple where cases occur among a school class) of sufficient size. Case control studies are useful when the population at risk is not well defined, such as when cases of cryptosporidiosis are occurring among apparently unconnected members of the public. They can be conducted on a smaller number of cases than cohort studies.

In some of the outbreaks reviewed in 2000 (Anon, 2000), the evidence for association with the pool was not strong and there could be other exposure risks at the pool facility such as food consumption or changing room/toilet hygiene which should also be considered during outbreak investigations. While good descriptive epidemiology may itself identify a link with a swimming pool without the need for more complex epidemiological investigation, analytical studies may be required to provide epidemiological evidence for a common source of disease or specified risk factor which would enable appropriate action to protect the health of the public. In addition, analytical studies may provide information about transmission or particular risk factors in such settings leading to general improvements at these facilities. Because many pool related outbreaks involve only a small number of cases the power of a study may not be sufficient to show statistical significance. This can be important in deciding whether such a study is warranted.

Sampling and testing for *Cryptosporidium* may be helpful during an outbreak investigation, but the results will only represent the status of the water at the time of sampling which is likely to be many days or even weeks after the cases were exposed to the parasite. Further, *Cryptosporidium* is not a routine parameter tested for during pool monitoring, and there are no quantitative standards for the detection of oocysts in swimming pool-related samples. Human infectivity and dose response studies suggest that single numbers of oocysts ingested may be sufficient to cause disease (DuPont et al., 1995), so low numbers are unacceptable. However, current tests are for the detection of the parasite only and provide no information about the viability or infectivity of the oocysts detected.

Few structured surveys of swimming pools for *Cryptosporidium* have been published, but the parasite has been detected in all studies undertaken so far. In the Netherlands, filter backwash water from 7 pools were sampled over a period of 1 year and *Cryptosporidium* was detected in 6% of 153 samples (Schets et al., 2004). In Italy, 1 study found 6/21 water samples from 7 pools were positive, with the isolations centred on 2 of the pools in the study (Oliveri et al., 2006). In another study in Italy, water from 4/10 pools was positive for *Cryptosporidium* (Bonadoma et al., 2004). In France 6 pools were sampled 8 time during one year and one sample was positive for *Cryptosporidium*. In the USA, 160 pools were tested by sampling filter backwash and 3 were positive for *Cryptosporidium* spp (Shields et al., 2008). However, it is difficult to compare results as all studies used different methods of sampling and analysis.

REDUCING THE RISK OF CRYPTOSPORIDIOSIS FROM SWIMMING POOLS

The lack of effective residual disinfection in swimming pools for *Cryptosporidium* means that key elements of the design, construction, management and bather behaviour need to be addressed to reduce the risk of cryptosporidiosis from swimming pools. While there are limited options for intervention, there are key defences against *Cryptosporidium*:

- Keeping *Cryptosporidium* out of the pool by encouraging bather hygiene and reporting faecal accidents.
- Good pool management to ensure that any contamination is dealt with promptly and appropriately.
- Adequate pool water circulation, coagulation and filtration to remove contamination.
- Good filter backwashing practice and procedures.
- Adequate pool design and construction to prevent cross connections and spread of contamination.
- Circulation, filtration and treatment for learner pools that is separate from the main pool.

Filter backwashing is of particular concern because the process can allow some material (including oocysts) to get into the pool water. The risk to health can be mitigated by undertaking the backwashing at the end of the day, as this allows the water to be re-cleaned by overnight filtration.

The following evidence relating to cryptosporidiosis (Nichols et al., 2006) forms the basis for managing and targeted public health messages:

1. Swimming pools within the UK contribute to an increase in cryptosporidiosis within local communities during late summer/autumn.
2. There is a strong suggestion of a link between infections in returning tourists and subsequent swimming pool outbreaks in the UK.
3. There is an increase in cryptosporidiosis following Easter and August bank holidays.
4. Cryptosporidiosis is more commonly associated with children under 5, is more commonly reported in boys than girls and for adults illness is more commonly reported in females of child bearing age.

Further, there is a marked increase in the use of pools by school children, families and summer camps in the school summer holidays. Thus, the key messages to bathers on prevention of swimming pool contamination are:

- Shower, with soap, before using the swimming pool. Nude showering is preferable.
- Make sure there is no faecal matter adhering to the skin – clean hands and clean bottoms please!
- Always wash your hands after changing nappies or using the toilet.
- Take children to the toilet before swimming and offer frequent toilet breaks
- Children who are not potty or toilet trained must wear waterproof swim nappies when using the swimming pool. They should never swim in the nude or wearing ordinary nappies.
- Use the nappy changing facilities provided. Nappies must never be changed in the swimming pool areas.
- Do not swallow the swimming pool water.
- People with diarrhoea must not swim.
- People who have had diarrhoea must not swim for 48 hours after symptoms have ceased.
- People who have had a cryptosporidiosis diagnosis must not swim for 2 weeks after the symptoms have ceased.

CONCLUSIONS

Although there are limited options for interventions to reduce the burden of cryptosporidiosis from swimming pools, design, construction, management and operation of swimming pools according to PWTAG guidelines and education of pool users regarding hygiene, with enforcement of exclusion policies, will contribute to disease reduction. The guidance is available from www.publichealthwales.org/cryptopoolguidance/

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