



Cryptosporidiosis Fact Sheet



What is cryptosporidiosis?

Cryptosporidiosis (crypto) is a disease caused by a small parasite called *Cryptosporidium*. People with crypto often have watery diarrhea, and may have nausea, vomiting, decreased appetite, and stomach cramps. People with normal immune systems who develop crypto usually get better on their own. In people with compromised immune systems, crypto can be chronic and life threatening.

How is cryptosporidiosis spread?

Cryptosporidium parasites can be found in the stools of humans and other animals that have been infected with the parasite. Food, water, and surfaces such as doorknobs, counter tops, and other objects can all become dirtied by stool that contains *Cryptosporidium*. A tiny amount of stool can contain many *Cryptosporidium* parasites, so something may look clean but still have *Cryptosporidium* on or in it. People can get sick with crypto when they eat *Cryptosporidium*. This can happen by swallowing dirty water or food or by touching something that has *Cryptosporidium* on it and then putting your fingers in your mouth. After being eaten, *Cryptosporidium* multiplies in the gut of humans and other animals and is shed through bowel movements. *Cryptosporidium* is resistant to chlorine and can live in chlorinated swimming pools for over six days.

Possible ways of getting cryptosporidiosis include:

- Rimming (kissing or licking the anal area);
- Other sexual contact;
- Travel to foreign countries, especially to areas where water treatment is less developed;
- Attending a day care center or being a household contact of children attending day care centers;
- Contact with domestic animals and livestock, especially if they are young and/or have diarrhea;
- Swallowing contaminated recreational water (swimming pools, water slides, lakes, streams, hot tubs, and common baths);
- Drinking or eating contaminated water or food;
- Other exposure to stool, for example, when caring for someone with diarrhea.

How is cryptosporidiosis diagnosed?

Cryptosporidiosis is diagnosed by a laboratory stool test. In the laboratory, technicians look for the *Cryptosporidium* parasite or for antibodies your body has made against the parasite. This parasite is too small to see without a microscope. The stool test for cryptosporidiosis is often not done as part of a routine stool exam and must be specifically requested by a clinician.

If I have cryptosporidiosis, how can I avoid spreading it?

If you have crypto, the best way to avoid spreading it to others is to carefully wash your hands in warm water and soap after using the toilet. For 2 weeks until after the symptoms have passed, it is also a good idea to avoid:

- Preparing food for others;
- Sexual contact;
- Swimming in or using recreational water (swimming pools, water slides, lakes, streams, hot tubs, and common baths).



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How can I avoid getting cryptosporidiosis?

In order to prevent getting crypto it is important to wash your hands after using the toilet, changing diapers, or having contact with domestic animals. It is also a good idea to:

- Practice safe sex by using barrier protection methods such as condoms or dental dams, and washing the genital and anal areas with warm water and soap;
- Avoid swallowing recreational water (swimming pools, water slides, lakes, streams, ponds, hot tubs, and common baths);
- Bring drinking water to a roiling boil for one minute or use water filters if you are unsure if the water is safe. The water filter should have an absolute pore size of 1 micron;
- Wash and/or peel all raw vegetable and fruits before eating with safe or treated water;
- If traveling in countries with minimal water treatment and sanitation systems, drink only safe or treated water and ice.

Is there treatment for cryptosporidiosis?

The FDA has approved nitazoxanide for the treatment of cryptosporidiosis in immunocompetent persons. Other medications may be prescribed in the treatment of cryptosporidiosis. If you think you have cryptosporidiosis contact your physician.

For more information call the San Francisco Department of Public Health, Communicable Disease Control Unit at (415) 554-2830, your local health department, or visit the Centers for Disease Control Website at <http://www.cdc.gov/crypto/>



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Agent

The etiologic agent of Cryptosporidiosis is *Cryptosporidium*, a protozoan parasite. Several species are infectious to humans but most infections are caused by *C. parvum*.

Symptoms

Severity and length of symptoms are correlated with immune status of the host. The parasite usually infects the intestinal tract. The infection may be asymptomatic or symptoms can include watery diarrhea, nausea, vomiting, anorexia, stomach cramps, and fever. Symptoms usually last for two weeks, but can last much longer in immunocompromised individuals. Extraintestinal infection can occur in persons with AIDS.

Transmission

Transmission occurs by the fecal-oral route. After an incubation period of about 7-12 days, infectious oocysts are shed in the feces. Transmission can occur through direct oral-fecal contact or can be fomite, food, or water (drinking or recreational) mediated. Transmission through anal/oral sexual contact and zoonotic transmission from farm animals can also occur.

High risk groups include:

- Household or sexual contacts of confirmed cases;
- Travelers to foreign countries, particularly to areas where water treatment infrastructure is less developed;
- Children attending day care centers and their household contacts;
- Healthcare and day care workers;
- Immunocompromised individuals.

Diagnosis

A stool sample must be submitted for microbiological analysis. Many labs do not routinely test for cryptosporidium oocysts when an ova and parasite exam is ordered; tests for cryptosporidiosis must be specifically requested.

Treatment

In late 2002 the FDA approved nitazoxanide to treat cryptosporidiosis in children 11 years old and younger. In 2005 this medication was additionally approved to treat cryptosporidiosis in immunocompetent adults. Most people with competent immune systems recover without treatment. In people with compromised immune systems cryptosporidiosis can be chronic and life threatening, and there is no approved treatment.

Prevention

To avoid infection patients should be advised to wash their hands after using the toilet, changing diapers, or having contact with domestic animals and before preparing food. Avoiding sexual contact with people who have diarrhea and avoiding ingesting recreational water (swimming pools, lakes, streams, ponds, hot tubs, and saunas) will also minimize spread. In places with inadequate water treatment it is important to boil water for one minute or use water filters that can filter out particles that are 1 micron in diameter.

Patients who have cryptosporidiosis should be counseled to wash their hands after using the toilet and



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before preparing food, and to avoid preparing food for others, sexual contact, and recreational water until two weeks after symptoms have resolved.

Importance of laboratory testing

Despite the lack of effective treatment, testing for cryptosporidiosis is important. Waterborne outbreaks of cryptosporidiosis have occurred in the U.S. If patients are not tested for cryptosporidiosis it is difficult for public health and water treatment workers to recognize that an outbreak is occurring and to take steps to mitigate the consequences. Second, although for most people cryptosporidiosis is a self-limiting illness, it can be life threatening to immunocompromised individuals. People who are unaware of their infection may not take the precautions necessary to prevent transmission of the parasite to their contacts, some of whom may be immunocompromised.

Reporting

Cryptosporidiosis is reportable by laboratories under Title 17 of the California Code of Regulations.

Further Information

Reviews

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- 2 Clark D. New insights into human cryptosporidiosis. Clinical Microbiology Reviews. 1999;12:554-63.
- 3 White A, Flanigan T. Cryptosporidiosis. Current Treatment Options in Infectious Disease. 2003;5:301-6.

CDC Diagnostic Information: <http://www.dpd.cdc.gov/dpdx/HTML/Cryptosporidiosis.htm>

Cryptosporidium

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This is the second edition of the February 2002 report on *Cryptosporidium* commissioned by the San Francisco Public Utilities Commission.

Part 1: Cryptosporidiosis: History, Biology and Epidemiology

This is the first of a two part document which summarizes information and current research issues on *Cryptosporidium* relevant to its public health significance in drinking water supplies. Part 1 describes the history, biology and epidemiology of *Cryptosporidium*. Part 2 describes drinking water regulation, detection, occurrence and disinfection techniques in regards to *Cryptosporidium* in the United States. Appendixes A and B describe *Cryptosporidium* testing in San Francisco waters and some remaining detection and risk assessment needs.

History

Cryptosporidium was first described in 1907 by Ernest Edward Tyzzer. His work was not regarded as important at the time, and half a century passed before *Cryptosporidium* became of minor interest in association with the incidence of cryptosporidiosis in turkeys. Interest in *Cryptosporidium* heightened in 1971 when it was found to be associated with diarrhea in cows. In 1976, the first cases of human cryptosporidiosis were documented.¹ After that, relatively few cases were reported until the early 1980s, when cryptosporidiosis was associated with protracted diarrhea in patients with Acquired Immune Deficiency Syndrome (AIDS).²⁻³ This finding stimulated intense medical and veterinary interest in the epidemiology, diagnosis, treatment, and prevention of cryptosporidiosis.

Since recognition as a human pathogen, *Cryptosporidium* oocysts have been identified in raw and treated drinking water and many outbreaks associated with drinking water have been documented.⁴⁻⁵ The first reported human outbreak of cryptosporidiosis due to water supply occurred in Texas in 1984.⁶ In 1987, Carrollton, Georgia experienced the second largest North American outbreak, over 13,000 people were affected.⁷ In April 1993, the largest North American outbreak affecting an estimated 400,000 people occurred in Milwaukee, Wisconsin.⁸ In early 1994, an outbreak in the Las Vegas, Nevada area affecting approximately 78 people was speculated to be caused by drinking water.⁹ In 1996, three outbreaks associated with unfiltered surface water systems occurred in Canada; the largest, in Kelowna, British Columbia involved approximately 4,000 cases.¹⁰ From 1988 through 1998, at least twenty-five outbreaks of *Cryptosporidium* associated with public drinking water supplies occurred in the United Kingdom.¹¹ Suspected causes of the outbreaks include treatment deficiencies and contamination of the distribution system.¹²⁻¹⁴ From April 2000 to April 2001, 3 separate cryptosporidiosis outbreaks affected more than 475 people in the greater Belfast area of Ireland. In two of the events contaminated sewage water entered the water distribution system.¹⁵ Most water supply related incidents of *Cryptosporidium* have occurred during the spring and in filtered supplies.

The Organism

Cryptosporidium is an oval-shaped protozoan parasite found in man, mammals, birds, fish, and reptiles. As of 2006, fourteen different *Cryptosporidium* species have been described and validated.¹⁶ Of the 14 species described, two, *Cryptosporidium parvum* and *hominis*, are responsible for the vast majority of human disease. In addition to these, 5 additional species, C.

meleagridis, *C. canis*, *C. felis*, *C. suis*, *C. muris*, and 2 genotypes, monkey and cervine, are known to cause disease in humans.¹⁷⁻²³

The parasite has a complicated life cycle (Figure 1) which goes through many forms and unlike other coccidian species, can complete its entire life cycle within a single host.

Thick-walled *Cryptosporidium* oocysts (3 to 6 µm in diameter) are stable in the environment and have been found to remain viable in water for up to 140 days.²⁴ Oocysts are resistant to disinfection with chlorine and chloramines. *Cryptosporidium* infection follows the ingestion of viable oocysts. Once in the gastrointestinal tract, oocysts release sporozoites which then invade the surrounding mucosal epithelial cells. Within the cell, the sporozoites move to the next developmental stage, and are known as trophozoites. Trophozoites undergo sexual and asexual reproduction. Asexual reproduction spreads the parasite to adjacent cells while sexual reproduction forms a zygote within a thick-walled shell. Before leaving the host, the zygote undergoes sporulation and is therefore capable of infection immediately following excretion in the fecal matter.²⁵

Reservoir

Human cryptosporidiosis is caused by a number of *Cryptosporidium* species whose animal reservoirs include cattle, mice, pigs, goats, horses, turkeys, cats, dogs, deer, monkeys and humans. (Table 1)

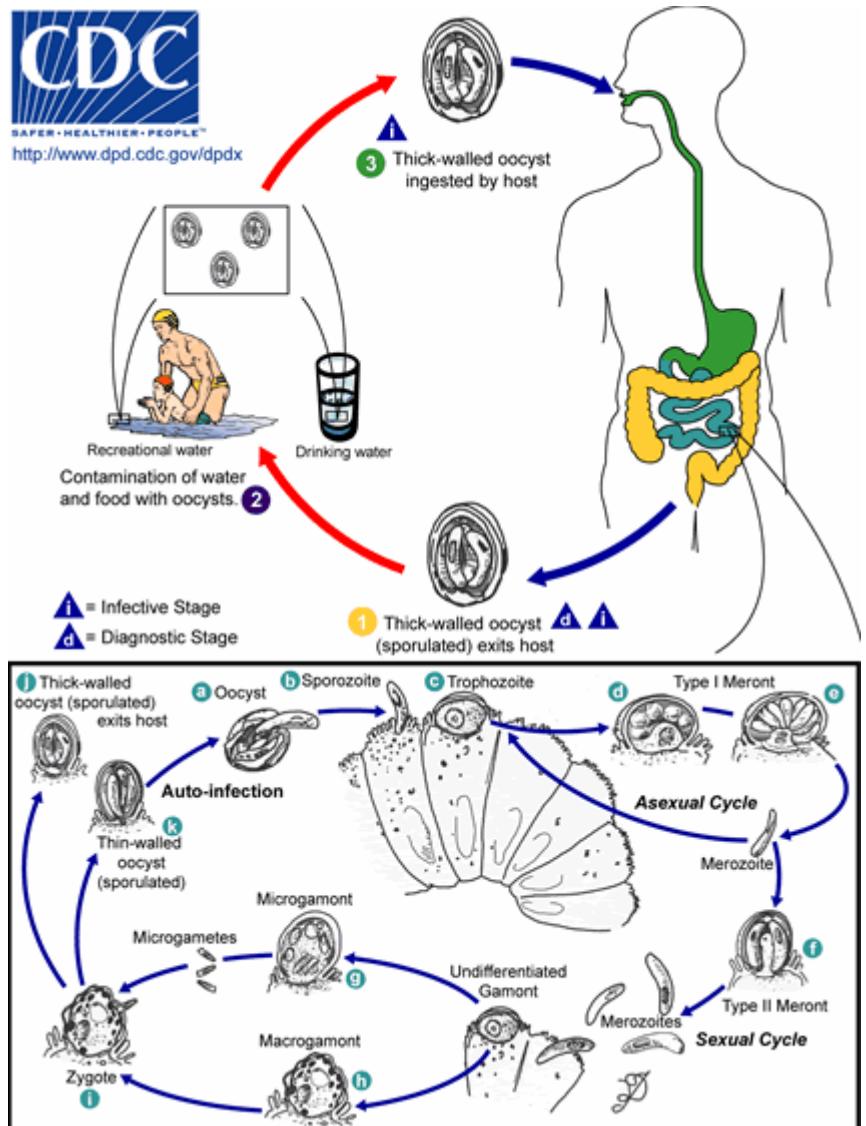


Figure 1. Diagram of the Life Cycle of *Cryptosporidium parvum*.

Table 1: *Cryptosporidium* Species Known to Cause Disease in Human

<i>Cryptosporidium</i>	Major Host
Species	
hominis	Humans
parvum	Cattle, Other Ruminants, Humans
maleagridis	Turkeys, Humans
canis	Dogs
felis	Cats
suis	Pigs
muris	Rodents
Genotypes	
Monkey	Monkeys
Cervine	Deer

Occurrence

Human cryptosporidiosis has been identified on six continents. Varying geographic and temporal distribution of disease due to different species is well documented. In North America, South America, Australia, and Africa, *C. hominis* is responsible for 62% of human cryptosporidiosis; however, in Europe and England *C. parvum* is predominant.¹⁶ *C. meleagridis* is considered an emerging human pathogen; this species is responsible for almost 1% of infections in Britain and over 10% in Peru.^{17,26} Incidence of disease due to *C. parvum* generally peaks in the spring while that of *C. hominis* peaks in the fall.²⁷⁻²⁸

Cryptosporidiosis prevalence varies globally impart due to varying sanitary conditions and levels of animal contact. In developing countries *Cryptosporidium* infection is diagnosed in up to 37% of those with gastrointestinal complaints.²⁹⁻³¹ Prevalence tends to be lower in developed countries. For example, 0.99% of fecal samples from asymptomatic patients and 2.91% from symptomatic patients in Denmark, Finland, Norway, and Sweden tested positive for *Cryptosporidium*.³²

Immunocompromised populations are at increased risk for clinically significant cryptosporidiosis. In developing countries, *Cryptosporidium* oocysts have been identified in the stools samples of up to 73% of immunocompromised patients.^{30,33-34} The prevalence of cryptosporidiosis among HIV/AIDS patients decreased after increased use of Highly Active Anti-Retroviral Treatment among this population in the late 1990's. A study in New Orleans reported cryptosporidiosis prevalence of 20% among HIV patients in 1994. By 1998, the prevalence had fallen to 6%.³⁵ In 2004, the incidence rate of cryptosporidiosis among San Francisco residents with AIDS was 74 per 100,000.

In the U.S. an estimated 60,000 to 301,600 cases of cryptosporidiosis occur per year. In 2002, incidence varied by geographic location from less than 1 to almost 10 cases per 100,000 persons per year.³⁶ Preliminary data for 2005 from the Centers for Disease Control and Prevention's sentinel surveillance program, the Foodborne Disease Active Surveillance Network, estimate the nation-wide cryptosporidiosis incidence at 2.95 cases per 100,000 persons; this number includes cases from a large, late summer, recreational waterborne outbreak in New York State.³⁷ In five Bay Area Counties, Alameda, San Francisco, San Mateo, Santa Clara, and Tuolumne, the incidence of cryptosporidiosis in 2005 was 1.34 cases per 100,000 persons; incidence by county ranged from 0.63 to 3.5 cases per 100,000.³⁸

Seroprevalence studies indicating prior exposure suggest widespread *Cryptosporidium* exposures with or without clinical manifestations. Among developing countries in Latin America and Asia, 50 to 100% of children have developed *Cryptosporidium*-specific antibodies by the second decade of life.³⁹⁻⁴² Among developed countries, overall reported seroprevalences are generally lower with 15-20% of those tested showing positive results.^{41,43} However, studies in the U.S. and Europe have documented seroprevalences as high as 83%.⁴⁴⁻⁴⁵

Symptoms

In immunocompetent individuals, cryptosporidiosis results in a self-limiting but unpleasant diarrhea with an incubation period of 1 to 12 days. Some of the associated symptoms include anorexia, weight loss, dehydration, abdominal cramping, and vomiting. Infection with *C. hominis* is more likely to be associated with joint pain, dizzy spells, eye pains, recurrent headaches, and fatigue than infection with other species.⁴⁶ From the time of onset, symptoms last for one to four weeks.⁴⁷ Recurrent diarrhea following apparent recovery has been documented.^{46,48} Patients with depressed immunity due to disease (i.e., HIV infection, chemotherapy, etc.) or congenitally depressed immunity (e.g., hypogammaglobulinemia) experience similar symptoms but with a duration that can be much longer. In severe cases, infection may involve extraintestinal sites. In cases where suppression of the immune system cannot be reversed, symptoms may persist until death.⁴⁹ Asymptomatic infection is common, occurring in an estimated 30-40% of those infected, and may contribute to the spread of disease.⁵⁰⁻⁵¹

Sequelae

Few studies exist examining the long term health effects of *Cryptosporidium* infection. Like other diarrheal diseases, *Cryptosporidium* infections may impair growth and development in children.⁵²⁻⁵⁴ Also, some case reports indicate the possibility of cryptosporidiosis instigated enteropathic arthropathies such as reactive arthritis, Reiter Syndrome, and sacroiliitis.⁵⁵⁻⁵⁹

Transmission

Cryptosporidium is transmitted by the fecal-oral route through direct person-to-person or animal-to-person contact or by indirect contamination of food, water or fomites. Infective oocysts appear in the fecal matter of infected humans and animals with the onset of symptoms and may continue to be shed for days to weeks following symptom resolution.⁶⁰ Some evidence suggests that the duration of oocyst shedding is longer for those infected with *C. hominis* than *C. parvum*.⁶¹

Cryptosporidium transmission through contact with drinking and recreational water contaminated by human or animal waste is well documented. *Cryptosporidium* is the most common cause of outbreaks associated with public water supplies and swimming pools in the United Kingdom.⁶² In the U.S during the 1990s, *Cryptosporidium* was the causal agent for almost 38% of reported recreational water-associated and 9% of reported drinking water-associated gastroenteritis outbreaks of known or suspected etiology.³⁶ In the following years, 2001 and 2002, cryptosporidiosis accounted for 11 out of 12 recreational and 1 out of 24 drinking water U.S. outbreaks.⁶³⁻⁶⁴ No drinking water-associated *Cryptosporidium* outbreaks have been detected in the San Francisco Bay Area.

In a study of 66 water treatment plants in fourteen U.S. states and a Canadian province, 87% of all raw surface waters, including rivers, lakes and ponds, and 27% of all filtered drinking water

samples were positive for cryptosporidium oocysts.⁴⁻⁵ However microscopic examination revealed that most oocysts in the treated water were not viable.

While not as widespread as waterborne transmission, foodborne *Cryptosporidium* transmission has been documented. Outbreaks have occurred due to contaminated milk, apple cider, chicken salad and green onions.⁶⁵⁻⁶⁸ Also, while human cases have yet to be attributed to shellfish, studies have revealed the presence of *C. parvum*, *hominis*, and *meleagridis* in commercial shellfish.⁶⁹⁻⁷⁰

Person-to-person transmission is becoming relatively more important as measures reducing animal and contaminated water exposures are implemented.⁷¹ Transmission occurs easily within families, play groups, nursery schools, day care centers, hospitals, and other institutions where precautions are not taken.⁷²⁻⁷³ High risk sexual practices are also implicated in transmission.⁷⁵

Zoonotic transmission, especially due to contact with cattle, is an established mode of transmission for human cryptosporidiosis.^{74,76} Often, calves acquire infection within two weeks of birth.⁷⁷ Infected calves shed more oocysts than older infected cattle; as many as 6×10^{11} oocysts may be shed within the first month following birth.⁷⁸⁻⁷⁹

Only one report of suspected airborne transmission of cryptosporidiosis has been published.⁸⁰

Persons At-Risk

Certain groups, largely as a result of increased contact with cryptosporidiosis-infected animals and humans and individual susceptibilities, are at a higher risk of contagion. These groups are animal handlers, health care workers, day care center children and employees, travelers to developing countries, and immunocompromised individuals due to congenital deficiency, acquired deficiency, immunosuppressive therapy, or malnourishment.

Immunity

Exposure to *Cryptosporidium* does not necessarily lead to clinical disease. There is some indication that prior exposure results in protective immunity from cryptosporidiosis, though the duration of this immunity is unknown.⁸¹⁻⁸³

Treatment

Based predominately on the results of two double-blind, placebo-controlled, randomized, clinical trials, in 2002 the United States Food and Drug Administration approved nitazoxanide (NTZ), marketed under the brand name Alinia (Romark Laboratories), for the treatment of cryptosporidiosis infection in immunocompetent children between the ages of 1 and 12 years.⁸⁴⁻⁸⁵ The drug was further approved for use among immunocompetent teens and adults in 2005.⁸⁶⁻⁸⁷ NTZ is a nitrothiazole benzamide compound which exhibits broad spectrum anti-parasitic activity. NZT's anti-cryptosporidial activity likely results from its disruption of the pyruvate:

ferrodoxin oxidoreductase enzyme-dependent electron transfer reaction, which is essential in anaerobic energy metabolism.⁸⁸ Although cryptosporidiosis is self-limiting among immunocompetent individuals, treatment with nitazoxanide may reduce the duration of infective oocyst shedding.

As of 2006, no therapeutic drugs have proven consistently effective at alleviating symptoms and eradicating cryptosporidiosis infection among immunocompromised patients. Over 90 agents have been tested for anti-cryptosporidial activity. Studies investigating the activity of anti-parasitic drugs like nitazoxanide and paromomycin; macrolides like azithromycin, clarithromycin and roxithromycin; and more experimental treatments like hyperimmune bovine colostrum treatment against *Cryptosporidium* infection in immunocompromised individuals have been inconclusive.^{84-85,89-96}

Cryptosporidiosis is self limiting among HIV-infected people with CD4 counts greater than 200 cell/mm³, therefore immune system re-constitution with anti-retroviral treatment including protease inhibitors is effective at parasite eradication.⁹⁷⁻⁹⁸ When necessary, symptomatic treatment should include oral or IV fluids and electrolyte replacement. Anti-motility drugs, while not consistently effective, may be used with caution in young children.⁹⁹

Infectivity

Although uncertainty exists concerning the dose required to induce cryptosporidium infection, studies suggest that very small inocula are capable of inducing infection. DuPont and colleagues completed a *C. parvum* human feeding study among healthy volunteers which determined that the dose at which 20 percent of the subjects were infected was 30 oocysts while a 50 percent infection rate was achieved following ingestion of 132 oocysts.⁵⁰ Similar studies employing different *C. parvum* isolates recorded doses causing infection in fifty percent of the population from below 100 oocysts to higher than 1000.¹⁰⁰⁻¹⁰¹ Interestingly, infectious dose did not significantly affect the severity of symptoms, length of the incubation, or number of oocysts shed. The risk of infection following ingestion of any one oocyst has been estimated at 0.028.¹⁰² Because significant virulence differences exist between strains of *Cryptosporidium*, work with *C. parvum* isolates may not accurately describe the infectivity of other species.

Chapter 1 References

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Part 2: Cryptosporidiosis: Drinking Water Regulation, Detection, Occurrence and Disinfection

This is the second of a two part document which summarizes information and current research issues on *Cryptosporidium* relevant to its public health significance in drinking water supplies. Part 1 describes the history, biology and epidemiology of *Cryptosporidium*. Part 2 describes drinking water regulation, detection, occurrence and disinfection techniques in regards to *Cryptosporidium* in the United States. Appendixes A and B describe *Cryptosporidium* testing in San Francisco waters and some remaining detection and risk assessment needs.

Drinking Water Regulation

In the United States drinking water distributed by public water systems is protected and regulated by the Environmental Protection Agency (EPA).¹ A public water system is an entity that collects, disinfects, and distributes drinking water. In order to be monitored by the EPA, a water system must serve at least 25 people or have at least 15 service connections. Private drinking water systems, such as wells that serve single homes, are not monitored by the EPA. Bottled water is regulated by the Food and Drug Administration. Although the EPA is the agency in charge of setting drinking water regulations and standards, it allows states to monitor public water systems within their jurisdiction. States must abide by the regulations and standards set by the EPA or they can abide by their own, stricter standards. These regulations and standards are reviewed and sometimes changed as new information becomes available.

Congress passed the Safe Drinking Water Act (SDWA) in 1974. *Cryptosporidium* regulations were first included in the 1996 amendments to the SDWA.² Three subsequent rules -- The Interim Enhanced Surface Water Treatment Rule (IESWTR)(1998), the Long Term 1 Enhanced Surface Water Treatment Rule (LT1) (2002) and the Long Term 2 Enhanced Surface Water Treatment Rule (LT2) (2006) – were promulgated as a result of the 1996 amendments.³⁻⁵ IESWTR strengthened control on the allowed levels of microbial contaminants including *Cryptosporidium*. This rule calls for a 99% removal of *Cryptosporidium* and stricter filtration, turbidity, and disinfection standards. All public water systems serving 10,000 or more people using surface water must comply with this rule. Systems that do not use filtration are required to protect against watershed contamination with *Cryptosporidium*. Additionally, all finished water storage facilities are required to be built with covers. LT1 extends the requirements of the IESWTR to public water systems that serve fewer than 10,000 people. LT2 requires additional monitoring and water treatment for systems with high levels of *Cryptosporidium* in their water sources and for unfiltered water systems. Under LT2, public water systems are required to provide up to 3 log *Cryptosporidium* removal depending on historic source water parasite concentrations.

Cryptosporidium Detection in Drinking Water

The EPA has approved methods 1622 and 1623 for use in the detection of *Cryptosporidium* or *Cryptosporidium* and *Giardia* in surface waters, respectively.⁶ The steps involved in *Cryptosporidium* detection are as follows:

Sampling

A minimum of ten-liters of water are passed through a filter which retains oocysts, cysts and extraneous materials. Filtration may occur in the laboratory or in the field.

Elution and Centrifugation

Oocysts and extraneous material retained on the filter are eluted off using a detergent. The eluate is then centrifuged forcing the suspended particles, including oocysts, to form a pellet. The supernatant is aspirated.

Separation

To separate oocysts from unwanted matter, *Cryptosporidium* specific antibodies attached to magnets are combined with the re-suspended, pelleted material. Magnetism is then used to separate the oocyst-antibody complexes from the unwanted material. After separation, the magnet containing antibodies are released from the oocysts. Because the antibodies may cross react with other substances, some contamination may persist.

Identification

Following separation, *Cryptosporidium* oocysts are visualized with three microscopy techniques:

- Immuno-Fluorescence-- Fluorescently-labeled, monoclonal antibodies targeted towards *Cryptosporidium* oocyst cell wall antigens are applied to a solution containing the magnetically-separated oocysts. When the tagged antibodies attach to cell wall antigens, the perimeter of the oocyst shines a brilliant apple green color.
- DAPI—A nucleic acid stain known as DAPI or 4',6'-diamidino-2-phenylindole, allows for the visualization of the position and number of nuclei in the oocyst. DAPI staining causes the nucleic acid to stain blue.
- DIC- Differential Interference Contrast Microscopy is used to view the internal morphology or structure of the oocysts and to look for unusual characteristics.

Enumeration

Objects seen during microscopy which are the correct size, shape, color and morphology are counted and recorded as *Cryptosporidium* oocysts.

Cryptosporidium detection using EPA Methods 1622 and 1623 suffer from several limitations. Both are unable to distinguish between *Cryptosporidium* species, to assess the virulence of a particular strain of *Cryptosporidium*, or to indicate the viability or infectivity of the oocysts.⁷ Antibodies used for detection may cross-react with other organisms (e.g., yeasts) so that enumeration of oocysts may include species or other organisms that are not infectious to humans.

Furthermore, the average oocyst recovery rate for method 1623 is only 43% and rates vary among laboratories.⁸

Cryptosporidium Occurrence in Drinking Water

United States Source Waters

From July 1997 to December 1998 and from March 1999 to February 2000, the United States EPA estimated the concentration of *Cryptosporidium* oocysts in source waters serving filtered and unfiltered through two national monitoring studies, the Information Collection Rule (ICR) and the Information Collection Rule Supplemental Survey (ICRSS), respectively.⁹ Both studies estimated a median source water oocyst concentration of about 0.05 oocysts per liter; however, considerable variability was seen among sources. For instance, according to the ICRSS, flowing stream sources were more likely to test positive for *Cryptosporidium* than reservoirs and lakes; *cryptosporidium* oocysts concentrations in flowing streams (0.09 oocysts/ L) were more than double that of rivers and lakes (0.04 oocysts / L). Due to changes in methodology and sampling, data from the ICR and the ICRSS cannot be combined with or compared to each other and considerable questions on the actual occurrence of *Cryptosporidium* remain.

United States Treated Waters

Cryptosporidium oocysts are rarely detected in treated waters in the United States. More than 1000 finished water samples were taken under the ICR from water treatment plants served by source waters with more than 10 oocysts/L.⁸ Of the over 1000 samples, *Cryptosporidium* oocysts were detected in 11 filtered water samples. The 11 positive samples were from seven water treatment plants, and all seven plants had filtration. Only one of the 11 positive samples contained intact oocysts with internal structures. The mean oocyst concentration for the 11 positive samples was 0.0057 oocysts/L.

Outbreaks have been more often associated with filtered waters than unfiltered waters, and usually with agricultural (particularly animal wastes) contamination of drinking water sources. In a filtration process, *Cryptosporidium* oocysts, *Giardia* cysts, other pathogens and debris are concentrated in the filters so that breakthrough of the accumulated material can result in a highly concentrated release of pathogens, and an increase in the actual number of oocysts in the water. These higher oocyst concentrations may increase the risk of *Cryptosporidium* infections.

Drinking Water Disinfection Techniques for Cryptosporidium

The two basic mechanisms for eliminating pathogenic organisms during water treatment are chemical inactivation and physical removal. The former is accomplished through disinfection, and the latter through coagulation and filtration.

Disinfection

Drinking water disinfection involves primary and secondary disinfection. Primary disinfection refers to any treatment that removes or inactivates pathogens potentially in drinking water. Secondary disinfection is the maintenance of a level of disinfectant in the distribution system to discourage subsequent contamination with viable microorganisms. Chlorine, monochloramine, chlorine dioxide, ozone and UV treatments and their effectiveness in *Cryptosporidium* inactivation are reviewed. Most studies on *Cryptosporidium* disinfection have used *C. parvum*; however, susceptibility to disinfection likely varies by strain and species.¹⁰

Table 1: Comparative Ct Values for *Cryptosporidium* inactivation¹²

Disinfectant	Ct Product
Chloramine	7,200
Chlorine	7,200
Chlorine Dioxide	78
Ozone	5-10

Assumes 1-log inactivation and 25oC.

Units in mg/l-min.

Chlorine and Monochloramine

Free chlorine and monochloramine are not effective for deactivating *Cryptosporidium* oocysts at practical concentrations and contact times used to disinfect drinking water. Concentrations exceeding 80 ppm with a contact time of 90 minutes are needed to deactivate 99 and 90% of cryptosporidium oocysts by chlorine and monochloramine, respectively.¹¹ The EPA has set drinking water maximum contaminant levels for each at 4 ppm.¹² Chlorine CT values required to inhibit viability, measured by excystation, are more than 15 times greater than those for reducing infectivity.¹³ Chlorine, and to a lesser extent chloramine, is very reactive and can combine with organic and inorganic substances naturally in water to produce trihalomethanes, haloacetic acids, haloacetonitriles, halopicrins, and nitrosodimethylamine.

Chlorine Dioxide

Chlorine dioxide is more effective at inactivating *Cryptosporidium* oocysts than free chlorine or chloramine.^{11,14} Although a 2 log inactivation of oocysts was found following treatment with 1.3 ppm chlorine dioxide for one hour, this concentration is above the EPA's maximum residual detection limit of 0.8 ppm for chlorine dioxide. Treatment with 0.6 ppm chlorine dioxide, decreased the viability of oocysts by 40% following one hour of treatment.¹¹ The practical application of chlorine dioxide as a disinfectant is limited as it breaks down into chlorite and chlorate which are known health hazards.

Ozone

Ozone is effective for inactivating *Cryptosporidium* oocysts though it must be combined with another disinfectant to provide residual disinfection during distribution. The concentration and time necessary for deactivation depends on parasite concentration. Water containing 10^4 oocysts required treatment with 1.11 ppm ozone for complete deactivation; oocysts concentration of 10^5 required 2.27 ppm ozone for 8 minutes.¹⁴ Ozone Ct values required to inhibit viability are 3 times higher than those required to inhibit infectivity.¹⁵ The use of ozone as a disinfection agent also confers improved water quality for example through the oxidation of synthetic compounds including pesticides and solvents.¹⁶ If

present in source waters, disinfection with ozone will convert bromide to bromate which may function as a genotoxic carcinogen.¹⁷

Because primary treatment with ozone does not confer subsequent disinfection during distribution, a secondary disinfectant must be used. Combined treatment may result in synergistic *Cryptosporidium* disinfection. Ozone treatment followed with monochloramine leads to increased oocysts deactivation. The degree of synergy seen between the two disinfection regimens may be modified by water quality characteristics such as turbidity, color, pH and carbon content.^{18,19} A similar study employing free chlorine instead of monochloramine found synergistic effects between ozone and chlorine only in waters with naturally low pH.²⁰ Water temperature may be important in the effectiveness of combined ozone and chlorine or monochloramine treatments.²¹⁻²² Low dose ozone treatment followed by UV may lead to improved disinfection of organisms including *Cryptosporidium*, to oxidation of micro-pollutants and to minimized bromate formation.²³

Ultraviolet Light

Ultraviolet light is effective at deactivating *Cryptosporidium*.²⁴⁻²⁵ A 2 log reduction in infectivity was seen following a dose of only 1.0 mWs/cm² at 20°C.²⁶ However, inhibition of oocyst viability, as measured by excystation, requires a dose 200 times that needed to inhibit infectivity. Wavelengths between 250 and 275 nm are more effective than those higher or lower in deactivation of oocysts and medium and low pressure UV lamps are equally effective in disinfection.²⁷⁻²⁸ While *Cryptosporidium* is able to repair UV-induced DNA damage through both photoreactivation and dark repair processes, recovery is not sufficient to restore infectivity.²⁹ No hazardous by-products are formed during disinfection with UV light.

Filtration

Cryptosporidium oocysts are resistant to disinfection with chlorine and monochloramine, the most common forms of drinking water disinfection used by U.S. public water systems, and many systems require filtration to remove *Cryptosporidium* from water supplies.

Conventional Filtration

Conventional filtration involves four steps: coagulation, flocculation, sedimentation and filtration. First, a coagulant such as alum is added to the water. This causes particles to coalesce forming floc which then settles to the bottom of a sedimentation basin. The water is then passed through a filter further removing debris. *Cryptosporidium* log removal rates for conventional filtration plants have been estimated from as low as 0.2 to over 5 logs.⁸

Direct Filtration

Like conventional filtration, direct filtration employs coagulation and flocculation, but filtration occurs without sedimentation. Log removal rates for direct filtration plants have been estimated from as low as 0.25 to almost 6 logs.⁸

Membrane Filtration

Membrane filtration involves forcing water through a membrane made with cellulose acetate or a polymer. Based on polymer size, there are three categories of membrane

filtration: microfiltration, ultrafiltration, and nanofiltration. Microfiltration is effective for *Cryptosporidium* removal with 6 to 7 log removal under ideal conditions and almost 5 under very bad conditions.⁸

Sand Filtration

In slow sand filtration water is passed directly through a compacted bed of small-grain sand. A layer known as the schmutzdecke layer removes most of the particles. This technique, while only appropriate for small water systems, can exceed a 3 log removal of *Cryptosporidium* oocysts.⁸

Diatomaceous Earth

Because of their low flow rates, diatomaceous earth filters are only used by small systems. Even under suboptimal treatment, *Cryptosporidium* removal is likely between 4 and 7 logs.⁸

Bag and Cartridge Filtration

Small systems can also use bag or cartridge filtration where water is forced through a porous bag or cartridge which retains any particulate matter. *Cryptosporidium* removal varies by type of filter and water quality; bag and cartridge filters achieve 0.5 to over 3.5 log removal.⁸

The effectiveness of filtration depends on water matrix conditions, water turbidity levels, and the stage of the filtration process. Breakthrough can occur as a result of a variety of factors including increased *Cryptosporidium* oocyst concentrations in source water, recycling filter washwater in the plant enabling concentrated slugs of *Cryptosporidium* to pass through the filters, operational factors such as improper filter washing, rapid flow changes, and improper coagulation. Most waterborne *Cryptosporidium* outbreaks have been associated with operational problems rather than inherent treatment deficiencies.

Dissolved Air Flotation

Because *Cryptosporidium* oocysts are buoyant, sedimentation may not completely remove them. An alternate method, dissolved air flotation, takes advantage of the buoyancy by releasing air dissolved in pressurized water into the flotation tank after flocculation has already occurred.⁸ The dissolved air forms small bubbles which collide with and attach to suspended particulate matter. Floating material is then removed.

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Appendix A: Historical Cryptosporidium Testing in San Francisco Source and Treated Waters

The San Francisco Public Utilities Commission (SFPUC) began monitoring for *Cryptosporidium* in January 1993. Sites included in the testing program are the Hetch Hetchy Water Supply, the Sunol Valley Water Treatment Plant, the Harry Tracy Water Treatment Plant, and the City of San Francisco Water Distribution System.

Since 1993, the SFPUC has employed three different *Cryptosporidium* detection methods.

- From January 1993 through October 1994, the SFPUC employed EPA Method 9711B. With this method, detected *Cryptosporidium* levels ranged from less than 0.1 to 0.8 oocysts per 100 liters in Hetch Hetchy water. *Cryptosporidium* was detected in approximately 30 percent of the samples collected.
- In November 1994 the SFPUC phased in the EPA's ICR method. Using this new method *Cryptosporidium* levels in Hetch Hetchy water ranged from 0.4 to 7 oocysts per 100 liters, approximately an order of magnitude greater than results obtained using Method 9711B. Oocysts continued to be detected in about 30 percent of samples even though the median detection limit increased from 0.1 to 1 oocyst per 100 liters with the method change. The difference in results is likely due to method changes rather than environmental changes such as increased watershed contamination.
- In September 2000, the SFPUC switched to EPA method 1623 for *Cryptosporidium* detection. Oocyst concentrations in Hetch Hetchy water found with this method are typically below 1 or 2 oocysts per 100 liters.

More information on the SFPUC's *Cryptosporidium* monitoring can be found online by going to www.sfwater.org and searching for "Waterborne Pathogens: Protozoan Parasites".

Cryptosporidium monitoring tests results can be viewed at:
http://sfwater.org/detail.cfm/MSC_ID/51/MTO_ID/71/MC_ID/10/C_ID/710

Appendix B: Detection and Risk Assessment Research Needs

While waterborne *Cryptosporidium* detection has improved over the last two decades, a number of important issues still remain. Below is a short list of research needs for cryptosporidium testing in drinking water.

Viability Assessment. Current methods for *Cryptosporidium* detection do not assess the viability or infectivity of oocysts. Inexpensive, easy to employ techniques applicable by water utility staff need to be developed.

Detection Method Consistency. Methods for detecting *Cryptosporidium* in source waters are highly variable and results are not readily reproduced within the same lab or between different laboratories. Developing new methods that enable more consistent and sensitive results is needed.

Detection Method Specificity. While only two- *Cryptosporidium hominis* and *parvum*--of the 14 identified *Cryptosporidium* species are responsible for the majority of human infection, current detection methods are unable distinguish between them. Detection methods able to distinguish among species could assist in risk assessment and source detection.

Detection Method Timeliness. It may take up to a week from the time a water sample is taken until cryptosporidium tests results are complete. Faster detection methods are necessary to prevent potential waterborne cryptosporidiosis exposure.

- For additional information on *Cryptosporidium* detection research needs see:

Weintraub, June M. (2006) Improving Cryptosporidium testing methods: a public health perspective. Journal of Water and Health. 4 Suppl 1:23-6.



Case Control Study of Cryptosporidiosis in People with AIDS in San Francisco

Research Summary and Fact Sheet For Clinicians



Aragon TJ, Novotny S, Enanoria W, Vugia DJ, Khalakdina A, Katz MH. Endemic cryptosporidiosis and exposure to municipal tap water in persons with acquired immunodeficiency syndrome (AIDS): a case-control study. BMC Public Health. 2003;3(1):2.

What we knew about cryptosporidiosis at the time of the study

- Cryptosporidiosis is a disease that causes diarrhea or stomach cramps caused by infection with the protozoan parasite *Cryptosporidium parvum*
- The strongest determinant of getting cryptosporidiosis is immunosuppression.
- Though the disease is self-limited in healthy persons, in those who are immunosuppressed, it may cause chronic debilitating illness.

What we have learned about cryptosporidiosis since this study was conducted

- Cryptosporidiosis has decreased dramatically among people with AIDS in San Francisco

	YEAR								
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Cases of cryptosporidiosis among people with AIDS in San Francisco	149	156	126	70	40	34	33	19	13
Number of people with AIDS	7201	7413	7480	7552	8005	8266	8473	8652	8919
Incidence (cases/10,000 persons living with AIDS/year)	206.9	210.4	168.4	92.7	50.0	41.1	38.9	22.0	14.6

- The decrease in cryptosporidiosis is due to the use of highly active antiretroviral therapy (**HAART**), which improves immune status and helps patients with compromised immune systems mount an appropriate immune response to infection with *C. parvum*.

Design and setting for this study

- This case-control study of the relationship between drinking tap water and cryptosporidiosis was conducted between 1996 and 1998, when HAART was first being introduced in the US.
- The study was conducted to investigate the risk of developing cryptosporidiosis from drinking tap water in non-outbreak settings

What the study found

- The study found that after adjusting for other risk factors, AIDS patients had increased odds of getting cryptosporidiosis if they drank tap water all the time, compared to those who did not drink tap water.

Implications for practice

- Because HAART was not available at the time of this study, the relevance of these results to practice today is unclear.
- Now that HAART is available, the MOST important intervention for reducing risk of cryptosporidiosis among AIDS patients is preserving or re-constituting one's immune competence with HAART.
- For those that want to reduce their risk further, the Centers for Disease Control has recommended that patients can consider tap water avoidance or boiling.
- In a non-outbreak setting, cryptosporidiosis is not associated with tap water consumption in immunocompetent persons.

This fact sheet was created in January 2003 by the San Francisco Department of Public Health Environmental Health Section in partnership with the San Francisco Public Utilities Commission. For more information, contact june.weintraub@sfdph.org, or visit the Public Utilities Commission website sfwater.org.



Cryptosporidiosis Fact Sheet for people with HIV



What is cryptosporidiosis?

Cryptosporidiosis is a disease caused by a protozoan parasite called *Cryptosporidium*. Not all individuals exposed to *Cryptosporidium* develop this disease. People with cryptosporidiosis generally have watery diarrhea, and may have nausea, vomiting, decreased appetite, and stomach cramps. People with competent immune systems who develop cryptosporidiosis generally get better on their own. In people with compromised immune systems cryptosporidiosis can be chronic and life threatening.

Cryptosporidiosis Surveillance

Surveillance for cryptosporidiosis began in the San Francisco Bay Area in 1996. From 1996 to 2000 San Francisco had much higher rates of cryptosporidiosis than the surrounding counties. Since 2000 cryptosporidiosis rates in San Francisco have been decreasing, likely because of the introduction of highly active anti-retroviral therapy (HAART) for people with HIV. HAART has helped many people to improve their immune status; this makes it easier to avoid cryptosporidiosis infection.

How can people with HIV prevent cryptosporidiosis?

Maintaining a strong immune system through the use of highly active anti-retroviral therapy (HAART) is the best way to prevent infection with cryptosporidiosis. In general the severity and length of disease is directly related to the level of immune suppression. The stronger one's immune system the less chance there is of becoming infected with *Cryptosporidium* and of developing a chronic illness. According to at least one study, drinking bottled water or filtered water lowers the risk of infection. Minimizing exposure to fecal matter by avoiding the behaviors listed below will also minimize the risk of infection.

How is *Cryptosporidium* transmitted?

Cryptosporidiosis is spread by ingesting *Cryptosporidium* oocysts. These oocysts replicate in the intestine of humans and other animals and are shed through bowel movements. Food, household surfaces, and water can all become contaminated with fecal matter containing oocysts.

Possible ways of getting cryptosporidiosis include:

- Anal-oral sexual contact (rimming);
- Contact with contaminated recreational water such as a swimming pools, hot tubs, water slides, lakes, or streams;
- Contact with domestic animals and livestock, especially if they are young and/or have diarrhea;
- Drinking contaminated water;
- Exposure to others' feces (for example, when caring for someone with diarrhea);
- Household contact with children attending day care centers;
- Other sexual contact that could involve exposure to feces;
- Travel to foreign countries, particularly to areas where water treatment infrastructure is less developed.

For more information:

- San Francisco City Clinic

Information about rimming and anal/oral sex may be found on the [STD Risk Chart](#)

- CDC Fact Sheets

[Guidance for people with severely weakened immune systems](#)

[Cryptosporidiosis resources for immunocompromised persons](#)



Drinking Water and Gastrointestinal Illness Research Summary and Fact Sheet for Clinicians



Colford JM, Saha SR, Wade TJ, Wright CC, Vu M, Charles S, Jensen P Hubbard A, Levy DA, Eisenberg JNS. A pilot randomized, controlled trial of an in-home drinking water intervention among HIV+ persons. J Water Health 03 (2005) 173-184

Background

This study builds on the results of an earlier study by [Aragon et al.](#), (2003) which found higher risk of cryptosporidiosis for people with AIDS who drank tap water.

Design and setting for this study

In this new study, 50 people who were HIV positive were randomized to either have an active water filter on their drinking water tap ($n=24$), or to have a sham filter ($n=26$). They kept diaries of highly credible gastrointestinal illness (HCGI) but were not formally diagnosed with cryptosporidiosis or any other pathogen. The study was conducted among HIV+ persons who did not necessarily have a diagnosis of AIDS.

What the study found

Forty-five people completed the study (21 with active filters, and 24 with sham filters). The adjusted relative risk of HCGI was 3.34 (95% CI: 0.99–11.21) times greater in those with the sham device compared to those with active water filters. This risk associated with drinking unfiltered tap water is consistent with the risks suggested by the earlier Aragon et al study.

Implications for public health practice

When the Aragon et al study was published, the public health community had [theorized](#) that the results might no longer be applicable because so many HIV positive people (including those diagnosed with AIDS) had started to use highly active antiretroviral therapy (HAART), which improves immune status and helps patients with compromised immune systems mount an appropriate immune response to infection with pathogens. This new study suggests that the risk may still be elevated, even with more widespread use of HAART.

An important consideration in interpreting this study is that this was a small pilot study, designed to test the study protocol and derive preliminary estimates of rates of disease in order to determine the sample size necessary to achieve statistical significance in a formal study. Possibly because of its small size, the randomization in this pilot study was not perfect: the people who had the sham device had lower mean CD4 counts and different medication usage compared to those who had the active filter. For example, use of any nucleoside reverse transcriptase inhibitor was by 95.2% of those who had an active filter, and 79.2% of those who had the sham filter. The study also reported a problem with confounding by baseline presence of HCGI, and this was dealt with in a statistically appropriate way.

From the public health standpoint, this study does not indicate a change in the current recommendation that people with HIV either boil, filter, or use bottled water.

- The MOST important intervention for reducing risk of waterborne gastrointestinal illness among HIV positive people continues to be preserving or re-constituting one's immune competence with HAART.
- For those that want to reduce their risk further, the Centers for Disease Control recommends that people who are HIV positive can consider tap water avoidance or boiling.
- In a non-outbreak setting, cryptosporidiosis and other waterborne gastrointestinal illnesses are not associated with tap water consumption in immunocompetent persons.

Epidemiologic and Risk Communication Issues in Developing a Cryptosporidium Detection Action Plan

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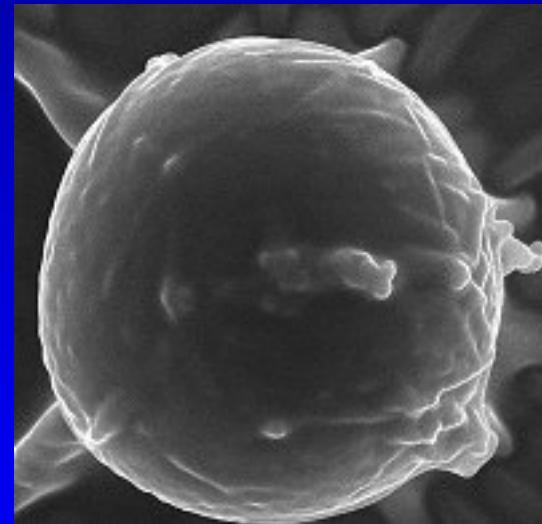
Presentation at International Society of Environmental
Epidemiologists Annual Conference August 2004

Outline

- Background
- Cryptosporidium Detection Action Plan
- Issues

Background: Cryptosporidium

- Cryptosporidium
 - Protozoan
 - Shed in the feces of infected animals and humans in the oocyst form
 - Present in many surface waters in the U.S.
 - Resistant to chlorination or chloramination



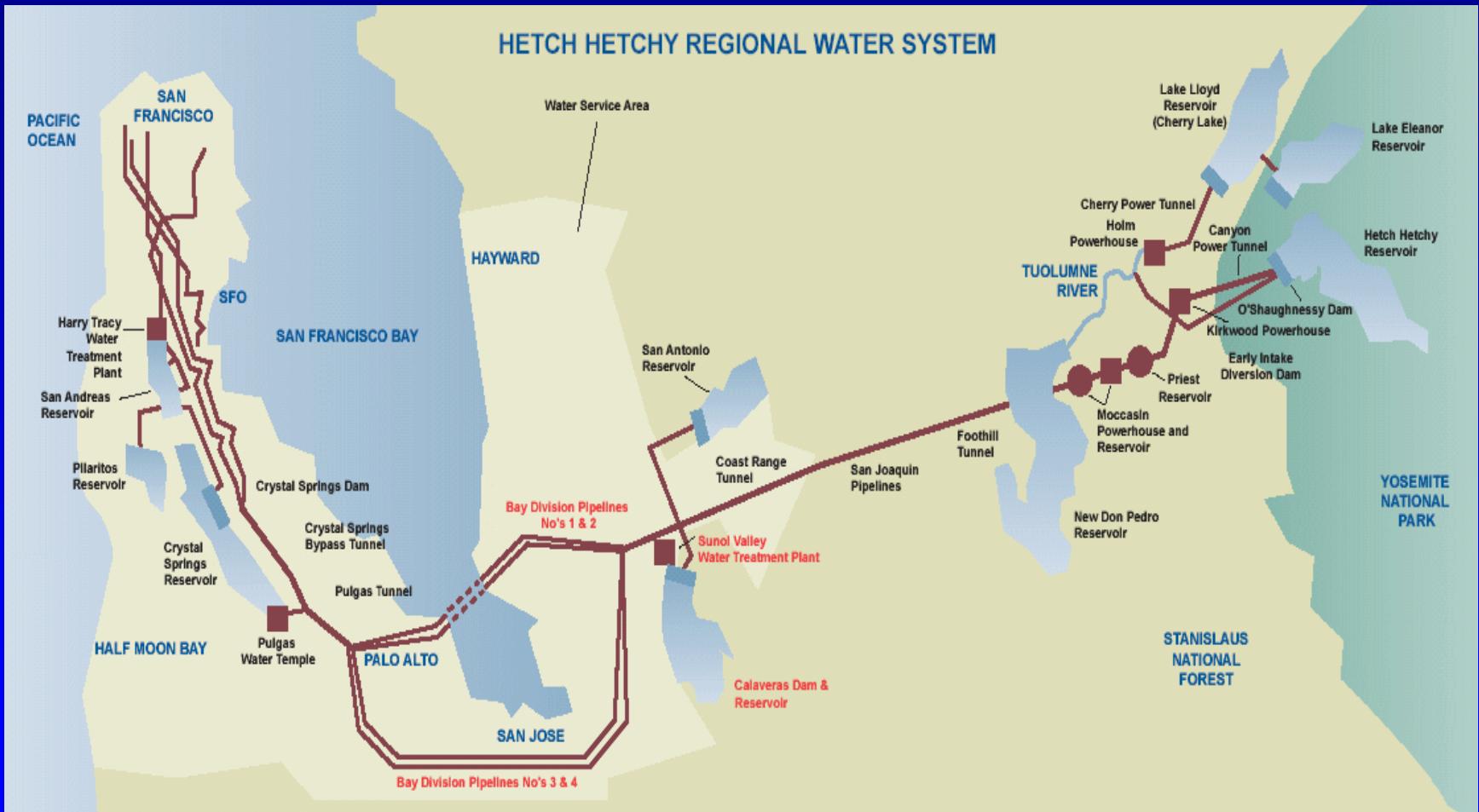
Background: Health Effects

- Cryptosporidiosis
 - Diarrheal disease
 - Children, elderly, immunocompromised most susceptible to cryptosporidiosis
 - Waterborne, but may also be foodborne or sexually transmitted

Background: Health Effects

- At what level are oocysts infective?
 - Once exposed to *Cryptosporidium*, a person will not always actually become infected
 - Not everyone who is infected actually becomes ill
 - Exposure to some strains of *Cryptosporidium* result in more severe disease than others
 - Is there a threshold below which there is no risk of disease?

Background: San Francisco Water System

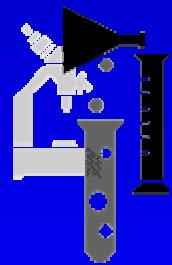


Cryptosporidium Detection Action Plan: Goals

- Assess actual risk to public health
- Address source of contamination
- Communicate with:
 - Public
 - Press
 - Sensitive subgroups
- Prevent outbreak

Cryptosporidium Detection Action Plan: Selecting an Action Level

Infectivity issues



Testing issues

Timing issues



Selecting an Action Level: Infectivity Issues

- What we know:
 - Cryptosporidium can occur in drinking water
 - Cryptosporidium can cause disease
- What we are not sure about:
 - What level of cryptosporidium oocysts cause disease

Selecting an Action Level: Testing and Timing Issues

- Testing limitations:
 - can not distinguish specific species
 - do not reveal whether the oocysts detected are viable
 - subject to variability in recovery
 - requires 100 Liter sample size
- Timing problems
 - Lag time between sample collection and test result

Tiered Response

- Some results are “noise”
- When levels are detected above the action level, this will trigger:
 - Interagency communication
 - Investigation
 - Public communication

Risk Communication Issues

Can we alert a sensitive group to take precautions and at the same time reassure the non-sensitive group?

Cryptosporidium Detection Action Plan

- What the public wants to know:
 - Is the water safe to drink?
 - can I let my pet drink it?
 - can I shower in it?
 - can I mix formula in it?
 - can my partner who has AIDS wash the dishes with it?
 - can I water the plants with it?

Deciding what, how and when to communicate

- How to balance information needs of various groups in the public, press, and agencies
- How to engender trust



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**San Francisco Bay Area
Cryptosporidiosis Surveillance Project**

**Timeliness of Cryptosporidiosis Notification
June 2003 - December 2005**

**Prepared by Michelle Kirian, MPH
San Francisco Department of Public Health
Environmental Health Section
May 2006**

Introduction

First recognized as a human pathogen in 1976, *Cryptosporidium* sp, is a protozoan parasite that normally causes mild diarrheal disease in healthy individuals but may be life threatening for the immunocompromised. *Cryptosporidium* oocysts appear in the stool 1 to 12 days post exposure with the onset of symptoms and can last for weeks following symptom resolution. Oocysts are infective immediately upon excretion, persist in the environment and are extremely resistant to disinfection with chlorine or monochloramine. Transmission occurs via direct oral-fecal contact or through contact with oocyst-infected human or animal waste contaminated fomites, food or water.¹ *Cryptosporidium* is one the most common causes of waterborne disease and oocysts are regularly detected in trace amounts in raw and treated drinking water.^{2,3}

The San Francisco Bay Area Cryptosporidiosis Surveillance Project (CSP), operating since June 1996, is a joint project between the San Francisco Public Utilities Commission (SFPUC) and Bay Area health departments. In 1989, the Environmental Protection Agency promulgated the Surface Water Treatment Rule mandating all drinking water systems supplied by surface water sources to add filtration to their water processing or to demonstrate the ability to provide high quality drinking water without filtration.⁴ At this time, only four large water systems in the country, including the SFPUC, have water of sufficiently high quality that filtration is not necessary. In lieu of filtration, water utilities must continuously demonstrate their water to be of the highest standards, maintain source water protection programs and monitor for waterborne illness among their customers. The San Francisco Bay Area Cryptosporidiosis Surveillance Project is an essential part of the SFPUC's water filtration avoidance agreement with the EPA.

At its inception, CSP, managed by the California Emerging Infections Program (CEIP), monitored cryptosporidiosis incidence in eight Bay Area counties: Alameda, Contra Costa, San Francisco, Marin, San Mateo, Santa Clara, Solano, and Sonoma.⁵ Surveillance began in Tuolumne County in June 1999. In 2002, CEIP discontinued surveillance in Marin, Solano, and Sonoma counties. Since June 2003, the San Francisco Department of Public Health (SFDPH) has been coordinating cryptosporidiosis surveillance for the four counties served by the SFPUC: Alameda, San Francisco, San Mateo, and Santa Clara, as well as Tuolumne County where the Hetch Hetchy reservoir, which provides 85% of SFPUC's source water, is located.

CSP is an active surveillance project, using phone, email, and fax to obtain reports of confirmed cryptosporidiosis from clinical laboratories. There are three main goals of the project: to enhance reporting of human cases of cryptosporidiosis, to monitor trends over time, and to detect increases in the number of reported cases or outbreaks early enough to allow timely investigation and possible intervention. In addition to human disease monitoring, CSP works closely with the SFPUC to address health risks associated with waterborne *Cryptosporidium* oocysts.

Cryptosporidiosis Surveillance Reporting

While Title 17, section 2505 of the California Code of Regulations mandates reporting of cryptosporidiosis cases to local health departments within one working day, participation in CSP is voluntary. CSP staff identified nineteen locally operated laboratories serving Tuolumne, Santa Clara and San Mateo Counties. (Table 1) Of these, thirteen laboratories report to CSP; six of the thirteen laboratories perform regular in-house testing for cryptosporidium, seven send specimens out to non-participating labs. Three additional laboratories send specimens to participating labs who report to CSP for them. Three laboratories, two of which are associated with participating health departments, declined to participate. No national laboratories have agreed to participate in CSP. Typical specimen processing time ranges from hours up to three days. Factors such as whether a laboratory has in-house testing capabilities and batch testing procedures influence the processing time. Upon confirmation of test results, participating laboratories fax case reports to CSP. CSP maintains regular monthly contact with the laboratories to obtain information regarding testing patterns.

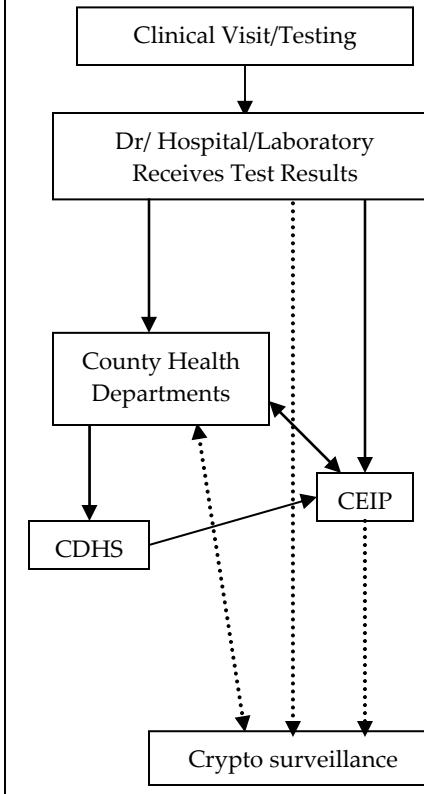
CEIP maintains the Foodborne Diseases Active Surveillance Network, an active laboratory surveillance system monitoring for a number of potentially foodborne pathogens including *Cryptosporidium*. The catchment area for this surveillance system includes San Francisco and Alameda Counties, where the majority of cryptosporidiosis cases in the five CSP-participating counties reside. To reduce the burden associated with reporting, laboratories serving clients in these counties report positive cryptosporidiosis cases to the respective health departments and CEIP only. Upon receipt of the reports, CEIP forwards cases onto CSP and to be thorough, to their respective county health departments. CEIP faxes copies of confidential morbidity reports to CSP on an ongoing basis. Additionally, once a month, CEIP mails CSP a file containing all cryptosporidiosis cases to-date. CEIP also forwards quarterly case lists to CSP from the California Department of Health Services (CDHS).

While CSP is a laboratory based surveillance system, cooperation with local health departments ensures more complete and timely reporting. Participation in CSP by the local health departments in the SFPUC service area varies. CSP maintains direct, reciprocal, contact with the San Mateo, Santa Clara and the Tuolumne County Health Departments; as cases occur and are reported, they are forwarded in between CSP and the respective health departments.

Table 1: Local Laboratory Participation: San Mateo, Santa Clara and Tuolumne Counties

Direct reporting	13
In-house testing	6
Sends out for testing	7
Report via other participating lab	3
Refused to participate	3
Total identified	19

Figure 1: Diagram of Information Flow to the Cryptosporidiosis Surveillance



Communication regarding case data in San Francisco County has varied during the past year due to staff and procedural changes. A CSP staff member travels to the offices of the San Francisco Communicable Disease Control Unit (CDCU) to interview positive cases from San Francisco County. This information is then forwarded to CSP to be included with the other counties' data. However, for the later half of 2005, CSP staff were not interviewing San Francisco residents and cases reports were not forwarded onto CSP. Instead, participating laboratories or CEIP reported San Francisco County cases. CSP has no formal case reporting relationship with Alameda County; CEIP or participating laboratories reported all cases from Alameda County.

One of the goals of public health surveillance is to detect cases and to discover their etiologies early enough to prevent subsequent exposure and illness. Therefore, reflection on the timeliness of any surveillance system should be a priority. The current analysis examines the time necessary for case reporting to CSP from all sources and also examines each source separately. At this time, completeness of reporting has not been assessed.

Methods

Data for the analysis were extracted from individual case and lab reports, CEIP monthly reports, and CEIP-forwarded CDHS case lists received by CSP with a specimen collection date in between June 2003, when CSP was moved to the San Francisco Department of Health, and December 2005. Because report arrival dates have not historically been recorded in the CSP database, the original case reports were examined to determine their arrival date to CSP. For the majority of case reports, a fax machine time stamp indicated the arrival date. For San Francisco case reports obtained through direct CSP/CDCU cooperation, the date of arrival to CDCU was used as the date of arrival to CSP. San Francisco reports that arrived in the absence of active CSP /CDCU case sharing were recorded only at their actual arrival to CSP. For mailed electronic CEIP data for which the exact date of arrival to CSP was not known, the file creation date for the earliest occurrence of a case was used. In the event that a case was reported more than once, only the earliest report was used. For the purposes of the analysis, reports generated following confirmatory or subsequent testing for an already reported patient were considered given the reports had unique specimen collection dates. Through 2005, CSP received a total of 143 case reports. Of these, 17 lacked date of arrival information and were excluded from the analysis. Table 2 shows the characteristics of the 17 excluded cases. The analysis includes one hundred and twenty-six case reports.

To determine the lag time in cryptosporidiosis case reporting, the median number of days lapsing from the date of specimen collection until arrival at CSP was determined. Generally, a date of diagnosis was not available; instead, the specimen collection date was employed as the earliest date possible

Table 2: Characteristics of the Excluded Cases.	
	Number of Cases
Informant	
CEIP	11
Unknown	6
Year	#
2003	10
2004	6
2005	1
County	#
San Francisco	8
Santa Clara	4
San Mateo	1
Alameda	4
Total	17

for reporting purposes. Informal interviews with participating laboratories revealed a zero to three day turn-around time for cryptosporidium specimens. Therefore, use of the specimen collection date generally overestimates the time to reporting.

Results

By Year

The overall median days-to-reporting for June 2003 through 2005, including 126 case reports, was 10 days. (Table 3) For the 65 cases with specimens taken in 2005, the median days-to-reporting was 11. Similarly, in 2004, the median number of days-to-reporting for the 52 case reports was 12. The median number of days-to-reporting for cases with specimens taken June through December 2003 was the lowest at 7 days; however, a limited number of cases, 19, were reported to CSP in 2003 and fewer than half, 9, had sufficient data to be included in the analysis.

To determine if time-to-reporting varied during 2005, data from that year was examined by quarters. (Table 4) Median time between lab diagnosis and report to CSP varied from 19 days in the first quarter to a low of 5 days in the third quarter.

By Informant

Reporting time by informant is shown in Table 5. CEIP reported 79 cases to CSP during the analysis period; the date of arrival was not available for 11 of these. For the 68 CEIP-reported cases with sufficient information, the median number of days for CEIP-reported cases to arrive to CSP was 24 days. Cases arriving to CSP via CDHS/CEIP required a median of 137 days to be reported. Laboratories reporting directly to CSP or through CSP/CDCU case sharing accounted for 49 case reports. The median number of days-to-reporting for laboratory generated reports was 6 days. Four cases were reported by a participating health department. The median number of days-to-reporting for health department-generated reports was 8 days. One case, reported 4 days post specimen collection was reported by a physician to CSP via CSP/CDCU case sharing.

Comparing data for 2004 and 2005, the median number of days-to-reporting for either CEIP or laboratory reported cases are similar. (Table 6) 2005 CEIP quarterly data ranged from 23 to 31 days except for in the third quarter when the median days-to-reporting was 5 days. In the first quarter the median days-to-reporting for laboratory reports was 14 days; for quarters 2 through 4 the median days-to-reporting ranged from 3 to 7.

Table 3: Median Days Between Specimen Collection and Report to CSP

Year	Days	Range	Number of Cases
2003-2005	10	0, 245	126
2003	7	0, 48	9
2004	12	1, 245	52
2005	11	1, 143	65

Table 4: 2005 Median Days Between Specimen Collection and Report to CSP by Quarter

Quarter	Days	Range	Number of Cases
Q 1	19	4, 112	15
Q 2	8	1, 128	18
Q 3	5	1, 79	18
Q 4	18	3, 143	14

Table 5: Median Days Between Specimen Collection and Report to CSP , By Informant 2003-2005

Informant	Days	Range	Number of Cases
Laboratory	6	0, 39	49
CEIP	24	1,245	68
Physician*	4	N/A	1
County Health Department**	8	3, 18	4
CDHS***	137	32, 233	4

* reported through CDCU

** all cases originated from San Mateo County

*** Reported through CEIP

By County:

San Mateo County had the quickest overall reporting with a median of 5 days-to-reporting. Santa Clara County had a median days-to-reporting of 7 days. Alameda County, with a median of 27 days-to-reporting had the slowest overall reporting to CSP. Despite increased communications between CSP and CDCU, San Francisco cases were reported at a median of 16 days-to-reporting post specimen collection. Time-to-reporting by County, informant and quarter for 2005 is shown in Table 7.

Time-to-reporting for San Francisco varied widely depending on the CSP informant. San Francisco cases reported by CEIP had a median days-to-reporting of 32 days post specimen collection while cases arriving directly from participating laboratories or indirectly through laboratories due to the active CSP/CDCU relationship were reported at a median of 11 days. Reporting times for San Francisco varied by quarter. The median days-to-reporting was highest in the second half of 2005 with a median of 51 days in quarter 3 and 89 days in quarter 4. This increase coincides with the change in the CSP/CDCU working relationship. In the second quarter, the median days-to-reporting was the lowest at 7 days.

Alameda cases were largely reported through CEIP and therefore reflect CEIP reporting times; however, diagnostic laboratories reported two cases and CDHS, via CEIP, reported another two cases. Cases reported by laboratories arrived at a median of 7 days post specimen collection while 50% of those through CEIP arrived in 27 days. The two cases arriving through CDHS took over 130 days to be reported to CSP. 2005 Alameda County data by quarter shows consistently high median number of days-to-reporting except for the 3rd quarter in which the two reported cases arrived in 3 and 4 days; CEIP reported both.

San Mateo County cases are typically reported first by participating laboratories or by the San Mateo Department of Public Health. The median number of days-to-reporting from all sources for San Mateo County were considerably low; the median number of days-to-reporting by laboratory informant was 3 days, by health department was 7.5 days and the only case arriving via CEIP took 7 days to be reported to CSP. Time-to-reporting for San Mateo cases was consistently low throughout 2005.

In 2005, cases from Santa Clara County were reported by CEIP, participating laboratories, and CDHS. Cases reported directly by laboratories arrived the fastest with a median of four days-to-reporting. CEIP cases were reported at a median of 7 days post collection. One case, reported by the CDHS via CEIP was reported 32 days post specimen collection. Except for the

Table 6: Median Days Between Specimen Collection and Report to CSP, for cases reported by CEIP and Laboratories, by Year and Quarters

	Days	Range	Number of Cases
CEIP			
2005	25	3, 128	28
2004	28	3, 245	32
2005 Q1	31	17, 112	6
2005 Q2	23	7, 128	9
2005 Q3	5	3, 79	5
2005 Q4	26	7, 106	8
Laboratory			
2005	7	1, 32	29
2004	4	1, 39	19
2005 Q1	14	5, 30	8
2005 Q2	4	1, 15	9
2005 Q3	3	1, 32	9
2005 Q4	7	3, 9	3

first quarter of 2005, reporting times for Santa Clara County were low with median days-to-reporting at 5 or 6 days per quarter.

From June 2003 through 2005, CSP did not receive any case reports for Tuolumne County residents. Tuolumne County reported one cryptosporidiosis case since surveillance began in 1996.

Table 7: 2005 Median Days Between Specimen Collection and Report to CSP, by County, Informant and Quarter

County	Days	Range	Number of Cases
San Francisco			
CEIP	32	7, 106	14
Laboratory ^a	11	1, 32	13
DPH ^b	N/A	N/A	N/A
CDHS ^c	N/A	N/A	N/A
Physician ^d	4	N/A	1
Q 1	18	4, 41	10
Q 2	7	1, 29	9
Q 3	51	11, 79	4
Q 4	89	7, 106	5
2005 Q1-Q4	16	1, 79	28
San Mateo			
CEIP	7	NA	1
Laboratory	3	1, 12	7
DPH	7	3, 18	4
CDHS	N/A	N/A	N/A
Physician	N/A	N/A	N/A
Q 1	N/A	N/A	0
Q 2	7	N/A	1
Q 3	3	1,12	9
Q 4	12	7, 18	2
2005 Q1-Q4	5	1,18	12
Santa Clara			
CEIP	7	5, 12	3
Laboratory	4	1, 30	7
DPH	N/A	N/A	N/A
CDHS	32	32	1
Physician	N/A	N/A	N/A
Q 1	29	29, 30	2
Q 2	6	1, 12	4
Q 3	5	3, 32	3
Q 4	5	3, 7	2
2005 Q1-Q4	7	1, 32	11
Alameda			
CEIP	27	3, 128	10
Laboratory	7.5	7, 8	2
DPH	N/A	N/A	N/A
CDHS	137	131, 143	2
Physician	N/A	N/A	N/A
Q 1	26	8, 112	3
Q 2	34	7, 128	4
Q 3	4	3, 5	2
Q 4	34	8, 143	5
2005 Q1-Q4	27	3, 143	14

a Includes reports from participating laboratories and laboratory reports arriving through the CDCU.

b Due to the nature of the CSP/CDCU relationship all laboratory and physician generated reports arriving via CDCU are included with their respective categories.

c. CDHS cases are reported to CSP through the CEIP.

d The sole physician reported cases arrived via the CDCU.

Discussion:

Cryptosporidiosis outbreaks associated with drinking and recreational water prompted the adoption of amendments to the Safe Drinking Water Act specifically targeting *Cryptosporidium*. The water filtration avoidance granted by the Environmental Protection Agency to the San Francisco Public Utilities Commission stipulates cryptosporidiosis surveillance among those served by the utility. To fulfill this obligation, The San Francisco Department of Public Health Environmental Health Section, with funding from the SFPUC, coordinates the five-county surveillance system.

One of the goals of the San Francisco Bay Area Cryptosporidiosis Surveillance Project is to detect increases in the number of reported cases or outbreaks early enough to allow timely investigation and possible intervention. In order to do this, the surveillance system must consistently receive case reports as quickly as possible. Reporting data from June 2003- December 2005 show large disparities in time-to-reporting across participating counties and informants. Time-to-reporting for each county reflects the number of steps involved; cases reports arrive to CSP faster from counties with more direct laboratory and health department participation. As would be expected, reporting times for primary informants (laboratories and physicians) is considerably faster than secondary and tertiary informants (health departments, CEIP). Reports arriving via secondary and tertiary informants are often two to four times slower than those from primary informants.

Figure 2: Days-to-Reporting June 2003 – December 2005 All Reports

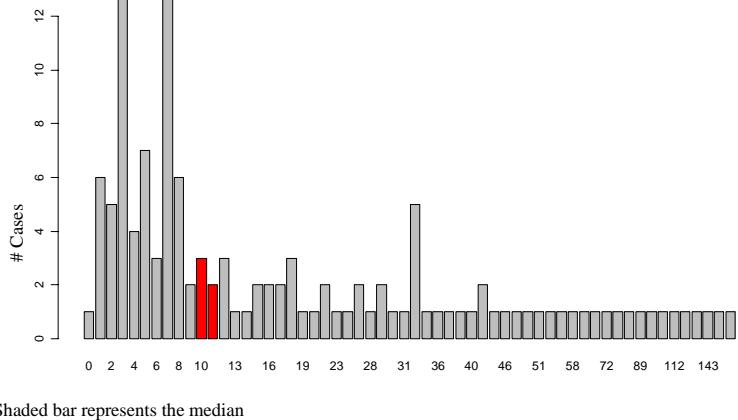
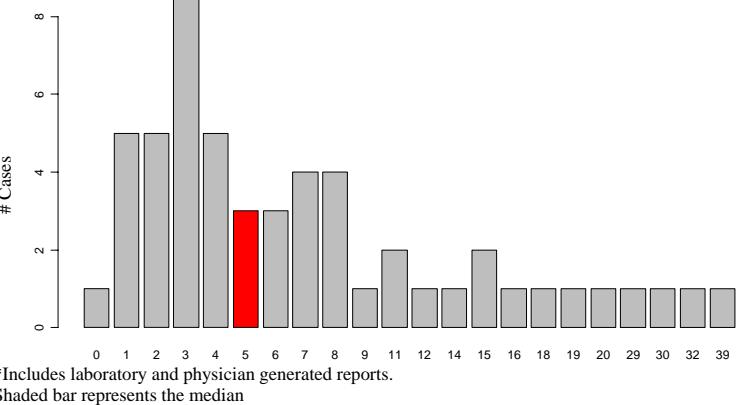
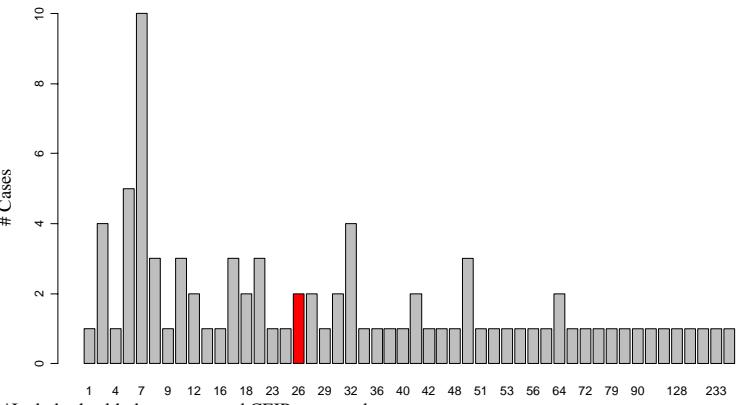


Figure 3: Days to Reporting June 2003- December 2005 Primary Informants*



*Includes laboratory and physician generated reports.
Shaded bar represents the median

Figure 4: Days to Reporting June 2003- December 2005 Secondary and Tertiary Informants**



**Includes health department and CEIP generated reports.
Shaded bar represents the median

The extra time involved in specimen processing and results delivery influences the reporting times. If laboratories take two days for laboratory specimen processing, and one day for notification, a time-to-reporting of three days post specimen collection should be attainable for laboratory reporting. Allowing an extra two days for delivery from secondary and tertiary informants to CSP, a maximum of five days after specimen collection should be feasible. For cryptosporidiosis surveillance through 2005, 43%, of the cases reported by primary informants arrived within three days and 14% of secondary and tertiary informants reported cases within five days. (Figures 3 and 4) Considerable improvements can be made in cryptosporidiosis reporting in the Bay Area.

The data used in the analysis have several limitations. Cryptosporidiosis is a rare disease and few cases are reported. Because of the small number of cases, calculations may not be stable, especially for sub-analyses. In the above calculations, the date laboratory tests were completed was generally not available and therefore, the specimen date was substituted as the earliest possible date for case reporting. Use of the specimen collection date overestimates time-to-reporting. An additional source of bias is that all calendar days, regardless of whether laboratories or health departments were open, were included in the time calculations, possibly leading to an overestimation. In determining the date of arrival for cases to CSP, cases reported during active CSP/CDCU case sharing were assigned the date of arrival to CDCU and electronic case files arriving via mail for which no other date was available were assigned the date of file creation. These methods for determining date of arrival likely underestimate the time actually necessary for reporting.

In surveillance, case finding/reporting is limited by a number of controllable and uncontrollable factors. The next step, which will be the topic of the upcoming seminar, is to determine how cryptosporidiosis case reporting can be brought up to speed.

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**San Francisco Bay Area
Cryptosporidiosis Surveillance Project**

**Timeliness of Cryptosporidiosis Notification
2005 & 2006**

**Prepared by Michelle Kirian
February 2007**

Introduction

First recognized as a human pathogen in 1976, *Cryptosporidium* is a protozoan parasite that normally causes mild diarrheal disease in healthy individuals but may be life threatening for the immunocompromised. *Cryptosporidium* oocysts appear in the stool 1 to 12 days post exposure with the onset of symptoms and can last for weeks following symptom resolution. Oocysts are infective immediately upon excretion, persist in the environment and are extremely resistant to disinfection with chlorine or monochloramine. Transmission occurs via direct oral-fecal contact or through contact with oocyst-infected human or animal waste contaminated fomites, food or water.¹ *Cryptosporidium* is one the most common causes of waterborne disease and oocysts have been detected in trace amounts in raw and treated drinking water.^{2,3}

The San Francisco Bay Area Cryptosporidiosis Surveillance Project (CSP), operating since June 1996, is a joint project between the San Francisco Public Utilities Commission (SFPUC) and Bay Area health departments. In 1989, the Environmental Protection Agency promulgated the Surface Water Treatment Rule mandating all drinking water systems supplied by surface water sources to add filtration to their water processing or to demonstrate the ability to provide high quality drinking water without filtration.⁴ SFPUC is one of 5 large water utilities with a surface water supply of sufficiently high quality that filtration is not necessary. In lieu of filtration, water utilities must continuously demonstrate their water to be of the highest standards, maintain source water protection programs and monitor for waterborne illness among their customers. The San Francisco Bay Area Cryptosporidiosis Surveillance Project is an essential part of the SFPUC's water filtration avoidance agreement with the EPA.

At its inception, CSP was managed by the California Emerging Infections Program (CEIP) and monitored cryptosporidiosis incidence in eight Bay Area counties: Alameda, Contra Costa, San Francisco, Marin, San Mateo, Santa Clara, Solano, and Sonoma.⁵ Surveillance began in Tuolumne County in June 1999. In 2002, CEIP discontinued surveillance in Marin, Solano, and Sonoma counties. Since June 2003, the San Francisco Department of Public Health (SFDPH) has been coordinating cryptosporidiosis surveillance for the four counties served by the SFPUC: Alameda, San Francisco, San Mateo, Santa Clara, and Tuolumne County where the Hetch Hetchy reservoir, which provides 85% of SFPUC's source water, is located.

CSP is an active surveillance project, using phone, email, and fax to obtain laboratory reports of confirmed cryptosporidiosis. There are three main goals of the project: to enhance reporting of human cases of cryptosporidiosis, to monitor trends over time, and to detect increases in the number of reported cases or outbreaks early enough to allow timely investigation and possible intervention. In addition to human disease monitoring, CSP works closely with the SFPUC to address health risks associated with waterborne *Cryptosporidium* oocysts.

Cryptosporidiosis Surveillance Reporting

While Title 17, section 2505 of the California Code of Regulations mandates reporting of cryptosporidiosis cases to local health departments within one working day, participation in CSP is voluntary. CSP staff identified nineteen locally operated laboratories serving Tuolumne, Santa Clara and San Mateo Counties. (Table 1) Of these, thirteen laboratories report to CSP; six of the thirteen laboratories perform regular in-house testing for *Cryptosporidium*, seven send specimens out to non-participating labs. Three additional laboratories send specimens to participating labs who report to CSP for them. Three laboratories, two of which are associated with participating health departments, declined to participate. No national laboratories have agreed to participate in CSP. Typical specimen processing time ranges from hours up to three days. Factors such as whether a laboratory has in-house testing capabilities and batch testing procedures influence the processing time. Upon confirmation of test results, participating laboratories fax case reports to CSP. CSP maintains regular monthly contact with the laboratories to obtain information regarding testing patterns.

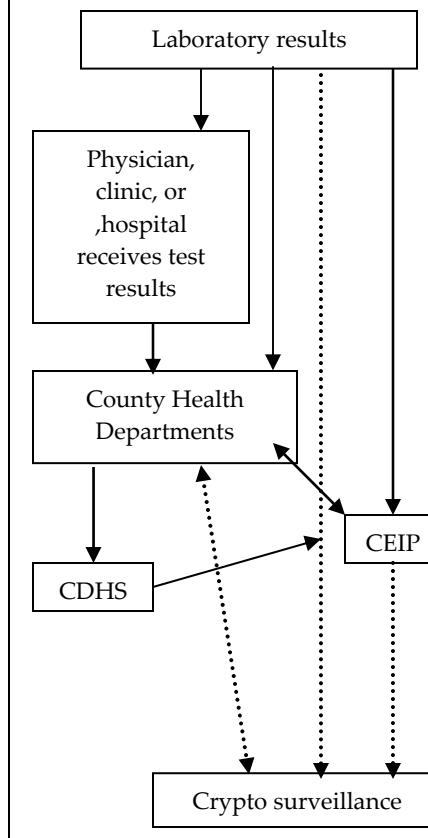
CEIP maintains the Foodborne Diseases Active Surveillance Network, an active laboratory surveillance system monitoring for a number of potentially foodborne pathogens including *Cryptosporidium*. The catchment area for this surveillance system includes San Francisco and Alameda Counties, where the majority of cryptosporidiosis cases in the five CSP-participating counties reside. To reduce the burden associated with reporting, laboratories serving clients in these counties report positive cryptosporidiosis cases to the respective health departments and CEIP only. Upon receipt of the reports, CEIP forwards cases to CSP and to their respective county health departments. CEIP faxes copies of confidential morbidity reports to CSP on an ongoing basis. Additionally, once a month, CEIP mails CSP a file containing all cryptosporidiosis cases to-date. CEIP also forwards quarterly case lists to CSP from the California Department of Health Services (CDHS).

While CSP is a laboratory based surveillance system, cooperation with local health departments ensures more complete and timely reporting. Participation in CSP by the local health departments in the SFPUC service area varies. CSP maintains direct, reciprocal, contact with the San Mateo, Santa Clara and the Tuolumne County Health Departments; as cases occur and are reported, they are forwarded in between CSP and the respective health departments. Case

Table 1: Local Laboratory Participation: San Mateo, Santa Clara and Tuolumne Counties

Direct reporting	
In-house testing	6
Sends out for testing	7
Report via other participating lab	3
Refused to participate	3
Total	19

Figure 1: Diagram of Information Flow to the Cryptosporidiosis Surveillance



reports from San Francisco County are retrieved weekly in person from the offices of the San Francisco Communicable Disease Control Unit (CDCU). Due to staffing and procedural changes occurring in the third quarter of 2005 and lasting through the first half of the first quarter of 2006, most of San Francisco County cases during that time were reported to CSP by participating laboratories or CEIP. CSP has no formal case reporting relationship with Alameda County; participating laboratories or CEIP reports most cases from Alameda County.

One of the goals of public health surveillance is to detect cases and to discover their etiologies early enough to prevent subsequent exposure and illness. Therefore, reflection on the timeliness of any surveillance system should be a priority. This analysis examines the time necessary for case reporting to CSP in 2005 and 2006 from all sources and also examines each source separately. This report also includes an assessment of the completeness of reporting to CSP in 2006.

Methods

Data for the analysis were extracted from individual case and lab reports, CEIP monthly reports, and CEIP-forwarded CDHS case lists received by CSP with a specimen collection date between January 1, 2005 and December 31, 2006. For San Francisco case reports obtained through direct CSP/CDCU cooperation, the date of arrival to CDCU was used as the date of arrival to CSP. San Francisco reports that arrived in the absence of active CSP /CDCU case sharing were recorded only at their actual arrival to CSP. For mailed electronic CEIP data for which the exact date of arrival to CSP was not known, the file creation date for the earliest occurrence of a case was used. In the event that a case was reported more than once, only the earliest report was used. For the purposes of the analysis, reports generated following confirmatory or subsequent testing for an already-reported patient were considered given the reports had unique specimen collection dates. In 2005 and 2006, CSP received a total of 177 case reports. Of these, one case reported by CEIP, a resident of San Francisco in 2005, lacked date of arrival information and was excluded from the analysis. The analysis includes one hundred and seventy-six case reports.

To determine the lag time in cryptosporidiosis case reporting, the median number of days from the date of specimen collection to arrival at CSP was determined. Generally, a date of diagnosis was not available; instead, the specimen collection date was employed as the earliest date possible for reporting purposes. Informal interviews with participating laboratories revealed a zero to three day turn-around time for *Cryptosporidium* specimens. Therefore, the specimen collection date generally overestimates the time to reporting.

Completeness of reporting in 2006 was assessed by comparing cases reported to CSP to those reported to CDHS. CDHS cryptosporidiosis reports sent to CSP via CEIP were used to determine which cases were reported to CDHS. The total number of cryptosporidiosis cases in the five participating Bay Area counties, including those not reported, was estimated using the following formula: $N = n_{CSPonly} + n_{CDHSonly} + n_{CDHS\&CSP} + (n_{CSPonly} * n_{CDHSonly}) / n_{CDHS\&CSP}$

Results

By Year

The overall median days-to-reporting for 2006 for 113 cases, was 4 days. (Table 2) This represents a substantial decrease in reporting time over 2005 when the median days-to-reporting for 63 case reports was 10 days. Figures 2 and 3 show frequencies for days-to-reporting in 2006 and 2005.

By Quarter

To determine if time-to-reporting varied throughout the year, data were examined by quarters. (Table 3)

Median time between lab diagnosis and report to CSP in 2005 varied from 19 days in the first quarter to a low of 5 days in the third quarter. In 2006, following a high of 29 days-to-reporting in the first quarter, the median days-to-reporting fell to 8 days in the second quarter and then to 4 days for both the third and forth quarters. The reduction in days-to-reporting between the first and second quarter is partially due to a restoration of case sharing between CSP and CDCU; CEIP reported all 11 San Francisco cases in the first quarter but only 2 during quarters two through four. Increased awareness following a late summer cryptosporidiosis outbreak in Santa Clara County may have kept reporting time low throughout the second half of 2006.⁶

By Informant

The median days-to-reporting for most informant types fell in 2006 as compared to 2005. The exception was physician-reported cases, which increased from 4 days in 2005 to 22 days in 2006. Reporting time by informant is shown in Table 4. In 2006, most cases were reported to CSP by participating laboratories or via a county health department; 37 of the 39 County health department reported cases were reported by the Santa Clara County Department of Health. The median days-to-reporting for laboratory and health

department reported cases was 4 days each. CEIP reported 26 cases to CSP; the median number of days for CEIP-reported cases to arrive to CSP was 12 days. In 2006, only 1 case was reported to the CDHS prior to CSP; the case was reported 17 days following specimen collection.

Table 2: Median Days Between Specimen Collection and Report to CSP

Year	Days	Range	Number of Cases
2005	10	1, 143	63
2006	4	1, 64	113

Reporting time varied significantly between 2005 and 2006.

Table 3: Median Days Between Specimen Collection and Report to CSP by Quarter

Year	Quarter	Days	Range	Number of Cases
2005	Q 1	19	4, 112	15
	Q 2	8	1, 128	18
	Q 3	5	1, 79	18
	Q 4	12	3, 143	12
2006	Q 1	29	4, 64	20
	Q 2	8	1, 22	8
	Q 3	4	1, 14	75
	Q 4	4	1, 19	10

Table 4: Median Days Between Specimen Collection and Report to CSP , By Informant 2006

Year	Informant	Days	Range	Number of Cases
2005	Laboratory	7	1, 32	30
	CEIP	23	3, 128	25
	Physician*	4	N/A	1
	County Health Department ^{**}	8	3, 18	4
	CDHS***	131	32, 143	3
2006	Laboratory	4	1,19	46
	CEIP	12	2, 64	26
	Physician*	22	N/A	1
	County Health Department ^{**}	4	1, 14	39
	CDHS***	17	N/A	1

* Reported through the CDCU

** Includes cases from Alameda, San Mateo, and Santa Clara Counties

*** Reported through CEIP

^{**} Includes cases from San Mateo County

By County:

Like 2005, in 2006 San Mateo County had the quickest overall reporting with a median of 3 days-to-reporting. Santa Clara County had a median days-to-reporting of 4 days. The median days-to-reporting for Alameda County in 2006 was 5; in 2005 it took over 27 days for 50% of cases to be reported from Alameda County. San Francisco County, with a median of 12 days-to-reporting had the slowest overall reporting to CSP. Time-to-reporting by County, informant and quarter for 2006 and 2005 is shown in Table 5.

Time-to-reporting for San Francisco varied widely depending on the CSP informant. In 2006, the overall reporting time for San Francisco was 12 days, however, the median days-to-reporting for quarters 2 through 4, after CSP/ CDCU cooperation was enhanced, was only 8 days. The median days-to-reporting for laboratory-reported cases was 4 days. In both 2005 and 2006, San Francisco cases reported by CEIP had a median days-to-reporting of more than 30 days post specimen collection. San Francisco County reporting times by informant and quarter were lower in 2006 than 2005.

In 2006 CEIP reported most of the cases from Alameda County; cases reported through CEIP arrived at a median of 6 days post specimen collection. Five cases were reported by diagnostic laboratories with a median days-to-reporting of 5 days, and only one was reported directly from the Alameda County Department of Public Health. One case arriving through CDHS took 17 days to be reported to CSP. 2006 Alameda County data by quarter shows a large reduction in days-to-reporting following the first quarter.

San Mateo County cases are typically reported first by participating laboratories. Year to year, the median number of days-to-reporting from all sources for San Mateo County is consistently low. In 2006, the median number of days-to-reporting by laboratory informant was 3 days, by health department was 5 days and the only case arriving via CEIP took 8 days to be reported to CSP.

In 2006 Santa Clara County Public Health Department reported the majority of cryptosporidiosis cases, 37, to CSP from that county. CEIP and participating laboratories also reported cases. Cases reported directly by laboratories or via the health department arrived with a median of 4 days-to-reporting. CEIP cases were reported at a median of 6 days post collection. Throughout 2006, reporting times for Santa Clara County were low with median days-to-reporting between 1 and 6 days per quarter.

Table 5: Median Days Between Specimen Collection and Report to CSP, by County, Informant and Quarter							
County		Days (2006)	Range (2006)	Number of Cases (2006)	Days (2005)	Range (2005)	Number of Cases (2005)
San Francisco	CEIP	33	10, 64	13	32	7, 106	14
	Laboratory ^a	4	1, 19	14	11	1, 32	13
	DPH ^b	N/A	N/A	N/A	N/A	N/A	N/A
	CDHS ^c	N/A	N/A	0	N/A	N/A	N/A
	Physician ^d	22	N/A	1	4	N/A	1
	Q 1	41	10, 64	11	18	4, 41	10
	Q 2	10	2, 22	5	7	1, 29	8
	Q 3	4	2, 13	9	51	11, 79	4
	Q 4	11	2, 32	3	89	7, 106	5
	Q1-Q4	12	1, 64	28	15	1, 90	27
San Mateo	CEIP	8	NA	1	7	NA	1
	Laboratory	3	1, 10	14	3	1, 12	7
	DPH	5	N/A	1	7	3, 18	4
	CDHS ^c	N/A	N/A	0	N/A	N/A	N/A
	Physician	N/A	N/A	N/A	N/A	N/A	N/A
	Q 1	7	5, 8	2	N/A	N/A	0
	Q 2	N/A	N/A	0	7	N/A	1
	Q 3	2	2, 10	9	3	1,12	9
	Q 4	4	1, 4	4	12	7, 18	2
	Q1-Q4	3	1, 10	15	5	1,18	12
Santa Clara	CEIP	6	3, 7	3	7	5, 12	3
	Laboratory	4	2, 8	12	4	1, 30	7
	DPH	4	1, 14	37	N/A	N/A	N/A
	CDHS ^c	N/A	N/A	0	32	32	1
	Physician	N/A	N/A	N/A	N/A	N/A	N/A
	Q 1	6	4, 8	4	29	29, 30	2
	Q 2	1	N/A	1	6	1, 12	4
	Q 3	4	1, 14	45	5	3, 32	3
	Q 4	6	3, 7	3	5	3, 7	2
	Q1-Q4	4	1, 14	53	7	1, 32	11
Alameda	CEIP	6	3, 28	9	26	3, 128	9
	Laboratory	5	1, 7	6	8	7, 8	2
	DPH	2	2	1	N/A	N/A	N/A
	CDHS ^c	17	N/A	1	137	131, 143	2
	Physician	N/A	N/A	N/A	N/A	N/A	N/A
	Q 1	21	17,28	3	26	8, 112	3
	Q 2	4	2, 6	2	34	7, 128	4
	Q 3	5	1,14	12	4	3, 5	2
	Q 4	0	N/A	0	75	8, 143	4
	Q1-Q4	5	1, 28	17	26	3, 143	13

a Includes reports from participating laboratories and laboratory reports arriving through the CDCU.

b Due to the nature of the CSP/CDCU relationship all laboratory and physician generated reports arriving via CDCU are included with their respective categories.

c. CDHS cases are reported to CSP through the CEIP.

d The sole physician reported case arrived via the CDCU.

In 2005 and 2006, CSP did not receive any case reports for Tuolumne County residents. Tuolumne County has reported only one cryptosporidiosis case since surveillance began in 1996.

Reporting Completeness 2006

Of the 113 case reports sent to CSP in 2006, only 1 arrived solely via the CDHS. Another 12 case reports were reported to CSP but not to CDHS. In comparing CSP data to CDHS case data, it appears that over 99% of cryptosporidiosis cases in the CSP study area were captured through surveillance.

Discussion:

After the first quarter of 2006, quarterly median reporting times fell and remained at a low of 4 days. The reduction in reporting times may be attributed to a number of factors. During the first quarter of 2006, direct CSP-CDCU cooperation was re-established enabling direct reporting of San Francisco cases. Also, in February and again in October CSP held two emergency preparedness activities which likely increased reporting awareness among participants including local health departments and CEIP. Additionally, the multi-county cryptosporidiosis outbreak in August through October 2006 likely resulted in faster reporting in the third and fourth quarters.

The data used in the analysis have several limitations. Cryptosporidiosis is a rare disease and few cases are reported. Because of the small number of cases, calculations may not be stable, especially for sub-analyses. In the calculations for this analysis, the date laboratory tests were completed was generally not available and therefore, the specimen date was substituted as the earliest possible date for case reporting. Use of the specimen collection date overestimates time-to-reporting. An additional source of bias is that all calendar days, regardless of whether laboratories or health departments were open, were included in the time calculations, possibly leading to an overestimation. In determining the date of arrival for cases to CSP, cases reported during active CSP/CDCU case sharing were assigned the date of arrival to CDCU and electronic case files arriving via mail for which no other date was available were assigned the date of file creation. These methods for determining date of arrival likely underestimate the time actually necessary for reporting. Notwithstanding these limitations, cryptosporidiosis case reporting to CSP in all counties and by all informants required less time in 2006 than in 2005.

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Testing patterns for cryptosporidiosis

A survey of physicians in three California counties

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Abstract

Background

Cryptosporidium is a parasite which can cause chronic diarrhea, especially in immunocompromised patients. Transmission occurs through the fecal-oral route. In the San Francisco Bay Area cryptosporidiosis incidence is monitored through active laboratory based surveillance. A survey was designed to examine clinician understanding of laboratory practices, common symptoms, and risk factors of cryptosporidiosis, and barriers to testing.

Methods

A random sample of physicians from two counties and all physicians from a third county were selected to participate in the survey. A two page self administered questionnaire was mailed to the physicians in June 2004 and again in September 2004.

Results

The majority of respondents stated that they did not specifically request a cryptosporidiosis test when requesting an ova and parasite stool examination. Most did not know whether or not the lab that they used performed *Cryptosporidium* tests automatically on all O and P specimens. A substantial portion of respondents correctly identified symptoms such as diarrhea, anorexia, malaise, and abdominal cramps and patient characteristics such as being immunocompromised or a male who has sex with men as somewhat or very important when considering a possible diagnosis of cryptosporidiosis. The most important factors that prevented respondents from ordering cryptosporidiosis tests was that cryptosporidiosis was perceived to be self-limiting and rare, and that no treatment was known to be available.

Conclusions

The level of understanding of cryptosporidiosis symptoms and risk factors among physicians was high. However, many reported not requesting *Cryptosporidium* tests when requesting an O and P examination. Reasons for not ordering a *Cryptosporidium* test included the perception that cryptosporidiosis is rare, self limiting, of little risk to others, and that no treatment is available. Cryptosporidiosis may be rare partially because it is rarely tested for.

Cryptosporidiosis is usually self limiting but it can be chronic and life threatening for immunocompromised patients. Testing of people in sensitive settings can help to limit the spread of the parasite, and routine testing would help to identify an outbreak should one occur. Education of local clinicians about the importance of cryptosporidiosis testing despite low perceived risk to individual patients or contacts may be useful.

Background

Cryptosporidium is an intracellular protozoan parasite which in immunocompetent humans can cause watery diarrhea, abdominal cramping, and nausea that generally lasts from 3 to 25 days [¹]. In immunocompromised patients the diarrhea can be chronic and life threatening [²]. Transmission occurs through the fecal oral route and can be person-to-person, food-borne, water-borne, fomite mediated, or zoonotic (through contact with domestic animals) [³].

Cryptosporidiosis outbreaks have occurred through exposure to contaminated recreational water [^{4,5}], food [^{6,7}], drinking water [⁸⁻¹²], and farm animals [^{13,14}]. Transmission has also occurred among household contacts [¹⁵].

Active laboratory based surveillance for cryptosporidiosis has been in place in the Bay Area since 1996. This surveillance system relies on reports from clinical laboratories serving the Bay Area. This type of surveillance may underestimate the incidence of cryptosporidiosis in the community for several reasons: patients generally do not seek care for acute diarrhea; when they do seek care not all physicians request stool samples for laboratory analysis; and when physicians do send stools for routine analysis it is often not examined for *Cryptosporidium* oocysts. Only one laboratory of the 18 that participate in the Bay Area active surveillance includes *Cryptosporidium* testing on the standard O and P. Moreover, most laboratories in the U.S. do not include *Cryptosporidium* testing on the standard O and P. [¹⁶] Previous work in Connecticut showed that the majority of primary care physicians do not order a cryptosporidiosis test when indicated, and that physicians are unaware that most laboratories do not perform cryptosporidiosis detection as part of the ova and parasite exam [¹⁷]. Additionally, a related study showed that labs tended to under report the positive cases that were identified [¹⁸]. Because the applicability of these previous studies to our locality was not known, we conducted a survey of local physicians. The survey had several objectives:

- examine clinician understanding of laboratory practices,
- examine clinician understanding of common symptoms of cryptosporidiosis,
- examine clinician perceptions of risk factors of cryptosporidiosis,
- assess changes in testing patterns that may be occurring because of the recent approval a new pharmacological agent.

Methods

Survey Instrument

The survey instrument was a two page self administered questionnaire of nine questions. Multiple choice questions asked for information regarding type of practice (Private practice, Group practice, HMO based practice, Hospital based practice, or Other), specialty practiced (Internal medicine, Pediatrics, Gastroenterology, Infectious disease, Family medicine, or Other), and labs used when testing for cryptosporidiosis.

Additional questions asked for information regarding testing practices and knowledge of symptoms and risk factors for cryptosporidiosis. To assess testing practices a question asked if the clinician specifically requests a *Cryptosporidium* test when ordering an ova and parasite (O and P) stool examination (Yes, No, Sometimes, Don't Know) and another asked if the lab used automatically performs *Cryptosporidium* tests on submitted O and P samples (Yes, No, Don't Know). To determine what symptoms and risk factors clinicians considered when deciding to test for cryptosporidiosis, questions asked respondents to rate symptoms and patients characteristics when deciding whether or not to order a *Cryptosporidium* test (Not Important, Somewhat Important, Very Important, Don't Know) and asked respondents if they would order tests for patients with specific characteristics if they presented with watery diarrhea (Always, Sometimes, Never, or Don't Know). Barriers to *Cryptosporidium* testing were assessed by asking about the importance of a list of possible barriers (Not Important, Somewhat Important, Very Important, or Don't Know). Finally the effects of nitazoxanide [^{19,20}] on testing patterns were assessed by asking what effect the availability of this medication would have on testing frequency (Increase, Decrease, or No change).

Sample Frame

A list of doctors in San Mateo, Santa Clara, and Tuolumne counties was obtained from a SBC yellow pages web page [²¹] using a PERL script. The list was imported to Excel. Physicians with specialty information were included only if their specialty was one of the following: internal medicine, pediatrics, gastroenterology, infectious disease, and family practice. The SBC list was supplemented by department of public health information in San Mateo and Tuolumne counties. In Santa Clara County the medical association provided a list of physicians. The sample frame included 572 physicians in San Mateo County, 62 physicians in Tuolumne County, and 1706 physicians in Santa Clara County.

Final Survey Sample

Because of its much smaller sample frame, Tuolumne County was oversampled. 100% of the Tuolumne County physicians in the sample frame were chosen to participate in the survey. The random number generator function in Excel was used to choose a random 18% sample of physicians from San Mateo and Santa Clara counties. The survey was mailed out to a final sample that consisted of 510 physicians; 159 (31% of the final sample) from San Mateo County, 289 (56% of the final sample) from Santa Clara County, and 62 (12% of the final sample) from Tuolumne County. Surveys were mailed in June 2004, with a second follow-up mailing to non-respondents in September 2004.

Weighted Analysis

The survey was analyzed using the “survey” package in R 2.0.1 [²²] to account for the differential sampling probabilities across county strata. Responses from Tuolumne physicians were given a weight of 0.18 to account for oversampling of Tuolumne County physicians.

Results

Response Rate

Overall, 27% of the surveys (n=136) were returned. Of these, 63 responses were excluded because the physician practiced in a specialty other than internal medicine, pediatrics, gastroenterology, infectious disease, and family practice. The final analytical sample included 73 responses; 20 (27%) from San Mateo County, 43 (59%) from Santa Clara County and 10 (14%) from Tuolumne County. There were no large differences between the unweighted percentage from each county in the analytical sample and final survey sample indicating that response rates were consistent across counties.

Testing practices and knowledge

The majority of respondents (89%) stated that they did not specifically request a cryptosporidiosis test when requesting an ova and parasite stool examination. Most (62%) did not know whether or not the lab that they used performed *Cryptosporidium* tests automatically on all O and P specimens and 26% stated that their lab did not perform these tests. (Table 1).

Symptoms and patient characteristics

When asked to rate the importance of symptoms and patient characteristics when considering a diagnosis of cryptosporidiosis, a substantial portion of respondents correctly identified diarrhea (78%), anorexia (74%), malaise (68%), and abdominal cramps (77%) as symptoms that are somewhat or very important when considering a possible diagnosis of cryptosporidiosis. A smaller portion identified nausea (57%), vomiting (52%), or fever (60%), as somewhat or very important when considering a possible diagnosis of cryptosporidiosis (Table 2).

Over 80% of the respondents identified patient characteristics such as being immunocompromised or a male who has sex with men (MSM) as being risk factors that are somewhat or very important when considering a possible diagnosis of cryptosporidiosis. The majority of respondents also identified food handlers, people having household or occupational contact with feces, children attending day care, and people with contact with domestic animals, who have traveled abroad, or attended a recreational swimming spot in the past month as somewhat or very important characteristics when considering a possible diagnosis of cryptosporidiosis (Table 2).

Watery diarrhea and characteristics for testing

When presented with a scenario of a patient presenting with watery diarrhea and a number of characteristics, most responders indicated that they would sometimes or always order a test for cryptosporidiosis if the patient was also immunocompromised (86%), was a MSM (86%), worked as a food handler (75%), had household or occupational contact with feces (76%), or was a child attending day care (59%) (Table 3). Most respondents also indicated that they would sometimes or always order a test for cryptosporidiosis if the patient had contact with domestic animals, had traveled abroad, or had attended a recreational swimming spot within the past month.

Barriers to testing

As shown in Table 4, the most important factors that prevented respondents from ordering cryptosporidiosis tests was that cryptosporidiosis was perceived to be self-limiting (55%) and rare (52%), and that no treatment was known to be available (49%). Costs to the patient (48%) and a low perceived risk to others (48%) were also important factors that discouraged testing.

Treatment

Respondents were asked about the effect that the availability of a treatment (nitazoxanide) may have on their testing patterns. Most respondents (61%) indicated that nitazoxanide would have no effect on their testing patterns.

Discussion

Most respondents indicated that they do not request a *Cryptosporidium* test when submitting a sample for an O and P exam. Furthermore, the majority of respondents indicated that either their lab does not automatically perform crypto testing when an O and P is requested or that they were not sure whether or not the lab automatically performed the tests. This supports work done in Connecticut which showed that majority of primary care physicians do not order a cryptosporidiosis test when indicated, and that physicians are unaware that most laboratories do not perform cryptosporidiosis detection as part of the ova and parasite exam. [¹⁷]

There appears to be a discrepancy between knowledge and practice patterns. Despite the high numbers of clinicians indicating that they do not request *Cryptosporidium* tests, it appears that the general understanding of common symptoms and risk factors for cryptosporidiosis is quite high. One explanation for this inconsistency may be that while physicians know that, for example, a patient with watery diarrhea and a specific risk factor such as being immunocompromised should be tested for cryptosporidiosis, they do not often see patients who they consider to be high risk.

Many respondents indicated that reasons for not testing for cryptosporidiosis included the perception that cryptosporidiosis is rare, self-limiting, of little risk to others, and that no

treatment is available. The perception that cryptosporidiosis is rare is self-fulfilling since clinicians are reluctant to test for a disease that they perceive as being rare, thus ensuring its continued rarity. In immunocompetent patients, cryptosporidiosis is usually self-limiting and until recently there has not been an FDA approved treatment for this parasite.

Respondents also mentioned a low perceived risk to others as a reason for not testing for cryptosporidiosis. However, cryptosporidiosis is a communicable disease and there is a risk of transmission to household and sexual contacts of the case. Additionally cases who work as food handlers, in healthcare, or in day cares pose a risk to the population that they serve. Children with cryptosporidiosis who attend day care while ill can also spread the parasite. Finally, outbreaks of cryptosporidiosis can result from many people being exposed to a common contaminated food, recreational water, or drinking water source. Lack of testing for cryptosporidiosis at the individual patient level can delay the recognition that an outbreak is occurring and can hamper investigation once an outbreak is identified.

This study had several limitations. The sampling frame for this survey was identified using a novel method of extracting data from the online SBC yellow pages using a PERL script. It is unclear if the physicians listed in the online yellow pages are representative of all physicians in each county. To address that possibility, the list was supplemented with information from health departments in San Mateo and Tuolumne County and from the medical association of Santa Clara County. Nonetheless, it is possible that there are important differences between physicians who were and were not included in our study, which could bias our results. If physicians who did not respond had different testing knowledge and practice patterns, laboratories used, or knowledge of symptoms and risk factors of cryptosporidiosis, our results would be biased. Additionally, the low response rate, and the high number of ineligible responses further undermines confidence in the validity of the survey responses.

Conclusions

Results from this survey must be interpreted with caution due to the limitations mentioned. The level of understanding of cryptosporidiosis symptoms and risk factors among physicians who responded was quite high. However, many reported not requesting *Cryptosporidium* tests when requesting an O and P examination. The reasons for not ordering a *Cryptosporidium* test included the perception that cryptosporidiosis is rare, self limiting, of little risk to others, and that no treatment is available. Cryptosporidiosis may be rare partially because it is rarely tested for. Although cryptosporidiosis is usually self limiting for most people it can be chronic and life threatening for immunocompromised patients. Testing of people in sensitive settings or occupations can help to limit the spread of the parasite in these settings, and routine testing would help to identify an outbreak and its source should one occur. Education of local clinicians about the importance of cryptosporidiosis testing despite low perceived risk to individual patients or contacts may be useful.

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Tables

Table 1 - Laboratory practices N (%)

Request crypto with standard O and P?	
No	58 (89.2)
Yes	3 (4.6)
Sometimes	3 (4.6)
Missing	1 (1.5)
Lab performs crypto test automatically with order of standard O and P	
No	17 (26.2)
Yes	6 (9.2)
Don't Know	40 (61.5)
Missing	2 (3.1)

Table 2 - Importance of criteria when considering cryptosporidiosis diagnosis N (%)

	Not important	Somewhat/Very Important	Don't Know	Missing
Symptoms				
Diarrhea	3 (4.6)	51 (78.5)	7 (10.8)	4 (6.2)
Nausea	11 (16.9)	37 (56.9)	10 (15.4)	6 (9.2)
Vomiting	12 (18.5)	34 (52.3)	11 (16.9)	7 (10.8)
Anorexia	3 (4.6)	48 (73.8)	9 (13.8)	5 (7.7)
Malaise	4 (6.2)	44 (67.7)	9 (13.8)	7 (10.8)
Fever	11 (16.9)	39 (60.0)	10 (15.4)	5 (7.7)
Abdominal cramps	2 (3.1)	50 (76.9)	9 (13.8)	4 (6.2)
Patient characteristics				
Immunocompromised	0 (0.0)	57 (87.4)	4 (6.5)	4 (6.2)
MSM	0.2 (0.3)	54 (82.5)	7 (11.1)	4 (6.2)
Food handler	3 (4.9)	48 (73.2)	9 (14.2)	5 (7.7)
Household or occupational contact with feces	1 (1.5)	50 (76.6)	9 (14.2)	5 (7.7)
Day care	6 (9.5)	43 (66.8)	10 (16.0)	5 (7.7)
In the past month:				
Contact with domestic animals	8 (12.9)	38 (58.5)	13 (19.4)	6 (9.2)
Travelled to a foreign country	6 (9.5)	41 (63.7)	11 (17.5)	6 (9.2)
Recreational swimming	9 (14.5)	39 (60.6)	10 (15.7)	6 (9.2)

Table 3 - Request a stool sample in a patient presenting with the following characteristics N(%)

Watery diarrhea and:	Never	Sometimes/ Always	Don't Know	Missing
Immunocompromised	2 (3.4)	56 (85.8)	3 (4.6)	4 (6.2)
MSM	2 (3.4)	56 (85.8)	3 (4.6)	4 (6.2)
Food handler	6 (9.5)	49 (74.8)	5 (7.7)	5 (8.0)
Household or occupational contact with feces	5 (8.0)	50 (76.3)	5 (7.7)	5 (8.0)
Day care	10 (15.7)	38 (59.1)	10 (15.4)	6 (9.8)
In the past month:				
Contact with domestic animals	10 (15.7)	41 (63.7)	7 (11.1)	6 (9.5)
Traveled to a foreign country	10 (15.7)	42 (64.0)	7 (10.8)	6 (9.5)
Recreational swimming	13 (20.6)	39 (60.3)	7 (11.1)	5 (8.0)

Table 4 - Barriers to testing N(%)

	Not important	Somewhat/ Very Important		Don't Know	Missing
Self Limiting	5 (7.7)	36 (55.4)	13 (19.7)	11 (17.2)	
No Treatment	12 (18.8)	32 (48.9)	11 (16.6)	10 (15.7)	
Cost to Patient	17 (26.5)	31 (47.7)	8 (11.7)	9 (14.2)	
Cost to insurance	26 (39.4)	22 (33.2)	9 (13.2)	9 (14.2)	
Low risk to others	13 (20.3)	31 (47.7)	10 (14.8)	11 (17.2)	
Rare	11 (16.9)	34 (52.3)	9 (13.5)	11 (17.2)	
Don't know how to order	31 (47.4)	12 (19.1)	4 (5.5)	18 (28.0)	



City and County of San Francisco
DEPARTMENT OF PUBLIC HEALTH
ENVIRONMENTAL HEALTH SECTION

Gavin Newsom, Mayor
Mitchell H. Katz, MD, Director of Health
Rajiv Bhatia, MD, MPH, Director of EH

June 18, 2010

Mike Marshall
Executive Director
Restore Hetch Hetchy
by email: mike@hetchhetchy.org

Re: Cryptosporidiosis and Giardiasis rates in San Francisco

Dear Mr. Marshall,

I am responding to your email of June 10, 2010 inquiring about the relatively higher rates of reported cases of cryptosporidiosis and giardiasis in San Francisco compared to other jurisdictions in California and about the relationship between these higher rates and the public water supply.

I've been privileged to serve as the Department's expert on water quality and health since 2001, regularly monitoring both water quality data and disease surveillance data. As part of this work, I oversee an active waterborne disease surveillance program which is the only one of its kind in California. During that time, San Francisco water has met all EPA water quality standards, and we have not recorded a disease outbreak linked to the public water supply.

As you may know, the city employs several lines of defense against waterborne diseases. The watershed protection program ensures that all source water is protected from contamination by *Cryptosporidium* and *Giardia*. In addition, *Giardia* is susceptible to chlorine-based disinfection, and our water system is routinely tested for chlorine residual throughout the distribution system. Therefore we have good assurance that the chlorine levels deactivate the very low levels of *Giardia* that may be present in the source water. Water supplies are regularly monitored for both *Giardia* and *Cryptosporidium*, and most samples are non-detects. Finally, our Department has a unique and pro-active public health disease surveillance program, and the Department works actively with the SFPUC to identify and address any potential threats to safe drinking water in San Francisco.

As reported by California Department of Public Health (CDPH) in 2008 San Francisco's crude rate of cryptosporidiosis was 2.0/100,000 and giardiasis was 21.2/100,000; indeed these crude rates are much higher than most other jurisdictions in California. For example, in Los Angeles County the rates are 0.5/100,000 and 3.9/100,000, respectively. These differences in reported case rates are well known among public health professionals, and in our professional judgment should be attributed to several factors aside from drinking water quality. These include:

- 1. More active public health surveillance systems;**
- 2. Better access to and utilization of health care; and/or**
- 3. Immune status and exposure to non-drinking water risk factors.**

1. PUBLIC SURVEILLANCE RESOURCES

The San Francisco Department of Public Health surveillance for communicable and infectious disease is extremely active and well resourced and we have confidence of near complete ascertainment of cases in our jurisdiction. Conversely cases are likely to be underreported in other jurisdictions. According to CDPH: “[Incidence rate comparisons between geographic entities and over time should be done with caution.](#)” CDPH further explains that differences in completeness of reporting and random variability of rates make such comparisons untenable. In a recent report of cryptosporidiosis, the Centers for Disease Control and Prevention similarly cautions: “[State incidence figures should be compared with caution because individual state surveillance systems have varying capabilities to detect cases, and reporting might vary.](#)”

2. ACCESS TO HEALTH CARE:

In San Francisco, health care has been widely available to people regardless of their ability to pay or legal documentation. According to the [California Health Interview Survey](#), in 2007, **92% of San Francisco residents had some health insurance coverage, compared to 84% in Los Angeles County.** In addition, compared to other jurisdictions, undocumented people in San Francisco may be more likely to seek health care when they are ill. Depending on how the population figures are counted, outside of San Francisco these people likely contribute to the denominator in an incidence calculation, but not to the numerator if they rarely get confirmed diagnoses, which could cause an underestimate of the disease incidences in jurisdictions outside of San Francisco.

3. IMMUNE STATUS AND OTHER RISK FACTORS FOR CRYPTOSPORIDIOSIS

Depressed immune status is an important risk factor for cryptosporidiosis, and people living with AIDS comprise an important susceptible population. Again, comparing to Los Angeles as an example, San Francisco has a comparatively higher proportion of people living with AIDS. According to Avert.org, in 2007 there were 73% more new AIDS cases in San Francisco compared to Los Angeles (26.0/100,000 new cases of AIDS in San Francisco compared to 15.0/100,000 in Los Angeles).

In 2008, the San Francisco Bay Area Cryptosporidiosis Surveillance Project interviewed 14 of the 16 cases among San Francisco residents reported to CDPH. Most cases had identifiable risk factors for cryptosporidiosis such as contact with a suspect case, travel to a foreign country, sexual activity, depressed immune status, or contact with a recreational body of water. Similar results were found among the 22 San Francisco cases reported in 2009.

If you are interested in further information, our surveillance reports may be found at http://www.sfpches.org/water/water_publications.htm. A CDC summary of cryptosporidiosis in the U.S. for the period 2006-2008 is available at: (http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5906a1.htm?s_cid=ss5906a1_x).

As you may know, the SFPUC is engaged in a very large Water System Improvement Program. One of the projects involves the construction of a new ultraviolet disinfection facility to treat the Hetch Hetchy supply, which is planned to go into operation in 2011. The new facility is designed to ensure a 99% reduction of *Cryptosporidium* and *Giardia*, thus adding to the reliability of our high quality water.

Thank you very much for your inquiry. We remain committed to surveillance of all potentially waterborne diseases and we stay apprised of emerging trends and research so that we can anticipate and respond to issues relevant to the provision of safe drinking water. Please let me know if you have any further questions.

Very truly yours,

June M. Weintraub, Sc.D.
Senior Epidemiologist

cc: Andrew DeGraca, Director, Water Quality Division, SFPUC
Rajiv Bhatia, Director, Environmental and Occupational Health, SFDPH
Duc Vugia, Chief, Infectious Diseases Branch, California Department of Public Health
Betty Graham, San Francisco District Engineer, California Department of Public Health