Cryptosporidium and Giardia: Waterborne Parasites
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WATERBORNE PARASITES

Cryptosporidium and Giardia are single-celled, microscopic organisms and are disease-causing parasites that may infect people through contaminated drinking water and recreational waters. Symptoms resulting from infection include mild to severe diarrhea, abdominal cramps, weight loss, bloating, and vomiting. Chlorine, a commonly used disinfectant in water supplies, can eliminate Giardia from water sources, but may not eliminate Cryptosporidium. This publication describes these parasites and discusses them in terms of drinking water and the occurrence of waterborne disease outbreaks.

Cryptosporidium parvum (C. parvum)
Ingestion of C. parvum can lead to cryptosporidiosis, which is a temporary gastrointestinal distress that is usually overcome by immunocompetent hosts. However, for those with weakened or compromised immune systems cryptosporidiosis can be a very serious problem because no drug treatments are available to cure the disease. The infectious form of C. parvum, the oocyst, is four to five microns in diameter, about half the size of a red blood cell. The oocyst protects sporozoites inside from environmental stresses. The stresses that can be lethal to sporozoites include, desiccation, heat, and repeated freezing and thawing.

Once ingested by a host animal, the sporozoites emerge from the oocyst to reproduce. The number of oocysts needed to initiate an infection is small compared with the number of oocysts produced in the host animal during an illness. A dose of more than 100,000 cysts caused illness in at least 50% of a group of volunteers⁶. By comparison, a single infected animal can excrete billions of oocysts while sick with cryptosporidiosis.

DEFINITIONS:
Micron: unit of length equal to one millionth of a meter
Sporozoites: infective forms of Cryptosporidium that are protected in the oocyst and initiate the life cycle in a new host

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Giardia lamblia

*Giardia lamblia*, also called *G. intestinalis*, causes the medical condition giardiasis, which is also a form of gastrointestinal distress. *G. lamblia* occurs as an oval shaped cyst, eight to twelve microns long. Approximately one million cysts could fit under a fingernail. As with *C. parvum*, hosts may excrete very many cysts when infected and relatively few are needed to infect a new host. In a study with cysts, 100% of subjects who received 100 or more cysts in a single dose became ill. *G. lamblia* has been the most common cause of waterborne disease outbreaks since 1971. It is estimated that each year 4,600 people are hospitalized with giardiasis in the United States. Giardiasis can be cured with drug therapies in most people, but chronic infections can occur as well.

<table>
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<th>Table 1: COMMON SOURCES OF INFECTION WITH C. PARVUM &amp; G. LAMBLIA</th>
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<tr>
<td>Drinking contaminated water</td>
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<td>Eating raw or undercooked foods containing oocysts</td>
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<td>Contact with infected animal or human feces</td>
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<td>Hand-mouth transfer from contaminated surfaces</td>
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<td>Recreational contact</td>
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**POTENTIAL SOURCES**

There are many potential sources of *C. parvum* and *G. lamblia*. These include, domestic and wild animals, day-care centers, contaminated foods, and contaminated recreational and drinking waters.

**Animals**

*C. parvum* is capable of infecting many species, including dogs, calves, horses, and many herd animals such as deer and elk. There are other species of *Cryptosporidium* that are found in fish, birds, and reptiles. However, the other species are not likely to pose health threats to humans. *G. lamblia* is capable of infecting humans, dogs, cats, bears, muskrats, some birds, reptiles, llamas, rats, deer, mice, and many other animals. *Giardia* and *Cryptosporidium* may infect the same host simultaneously. The soil in the vicinity of an infected herd of cows, or even individual hosts, can be contaminated with fecal matter. If soil is moist and cool, cysts and oocysts can remain infective for several months. Dispersed and concentrated areas of animal waste are potential sources of oocysts and cysts. Farm drainage has been found to contain concentrations of 5,800 oocysts/l. Drainage from slaughterhouses is another potential source of oocysts. Young animals are at high risk for being infected, especially calves. The probability of finding oocysts in calves on dairy and beef farms is very high in large herds (100-200 cows) and about 80% in small herds (15-100 cows).

**Day Care**

Fecal-oral contact is one of the most direct routes of infection, because the parasites are spread in large numbers directly from infected hosts. Children’s day care centers have frequent outbreaks of cryptosporidiosis and giardiasis. It is estimated that 7-54% of children in childcare settings may be infected with *Giardia* and *Cryptosporidium*. The spread of the pathogens is high among children ages several months. Infection rates are highest among children ages...

DEFINITIONS:

*Gastrointestinal*: referring to the stomach, small intestine, large intestine, colon, and rectum
*Chronic*: constantly troubling; marked by a long duration and/or frequent recurrence
*Trophozoites*: active and feeding forms of *Giardia*
*Domestic animals*: animals raised to live and breed in a tame environment
*Drainage*: water that flows from a saturated area
highest among children who are not toilet-trained. Toddlers are at a high risk of being infected because of their high level of interaction. Childcare providers are at a high risk if they are involved with changing diapers. Personal hygiene is essential in these settings.

**Food**

Theoretically, any food could be a potential source of *Cryptosporidium* or *Giardia* if handled by an infected person. The foods with the highest chance of carrying the parasites are salad vegetables fertilized with contaminated manure.

**Recreational Water**

Recreational water is a very common source associated with outbreaks of *Giardia* and *Cryptosporidium*. Between 1999-2000, 23 states reported 59 outbreaks related to recreational water usage. Giardiasis rates are highest among children from 0-5 years of age, due to frequent use of recreational water. Outbreaks of *Cryptosporidium* and *Giardia* often occur from mid summer to early fall, which corresponds with exposure through recreational swimming. When people are infected and continue to swim, this increases the likelihood of contamination. In the summer of 2000, five outbreaks of *Cryptosporidium* were linked to swimming pools. In Delaware County, Ohio, 700 clinical cases of *Cryptosporidiosis* were reported from late June through September. An outbreak in Colorado caused 112 to become ill after attending a private pool party. Another outbreak in mid June 2000, in Nebraska at a private swimming club, also caused many people to become ill.

**WATERBORNE OUTBREAKS**

Outbreaks associated with contaminated drinking water are usually larger than those caused by contaminated recreational water. Between 1997-2000, 13 waterborne-disease outbreaks caused by *Cryptosporidium* and *Giardia* were reported to the Center for Disease Control and Prevention (CDC) (see Table 2). Seven of these outbreaks were from parasites. Ten outbreaks were caused by exposure to *Giardia*. In these, 52 people from five states were reported ill.

**Giardia**

The National Giardiasis Surveillance System collects data on giardiasis cases. Forty-three states are required to report outbreaks. The purpose of this system is to estimate the number of cases in the United States and to look for demographic, seasonal, and geographic patterns of giardiasis. In Nevada alone, 247 cases were reported in 1997. Between 1999-2000, there were four outbreaks linked to water well systems, and two linked to surface water systems. Other types of water treatment failures were the cause of two more outbreaks of *Giardia*.

**Cryptosporidium**

Between 1990-2000, at least ten *Cryptosporidium* outbreaks associated with contaminated drinking water were reported in the United States. The largest outbreak caused by contaminated drinking water was reported in 1993. In Milwaukee, Wisconsin, an estimated 400,000 people were ill with cryptosporidiosis. Ineffective treatment procedures led to the United States’ largest outbreak of waterborne disease.

**DEFINITIONS**

**Hygiene**: practices of cleanliness that are conducive to good health

**Clinical**: involving diagnosing or directly observing a patient

**Waterbone-Disease Outbreak**: at least two people with a similar illness associated with drinking water and evidence that water is the probable source of the contaminant that caused the illness

**Demographic**: pertaining to the dynamic balance of a population, with regard to density
**Table 2: Waterborne-disease outbreaks associated with drinking water—United States 1997-2000**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>STATE</th>
<th>INFECTIOUS AGENT</th>
<th>NUMBER OF CASES</th>
<th>TYPE OF SYSTEM*</th>
<th>LIKELY CAUSE**</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>New York</td>
<td>Giardia</td>
<td>50</td>
<td>Community</td>
<td>3</td>
<td>Lake</td>
</tr>
<tr>
<td>1997</td>
<td>Oregon</td>
<td>Giardia</td>
<td>100</td>
<td>Noncommunity</td>
<td>4</td>
<td>Well/Spring</td>
</tr>
<tr>
<td>1998</td>
<td>Florida (May)</td>
<td>Giardia</td>
<td>7</td>
<td>Community</td>
<td>2</td>
<td>Well</td>
</tr>
<tr>
<td>1998</td>
<td>Florida (Dec)</td>
<td>Giardia</td>
<td>2</td>
<td>Individual</td>
<td>2</td>
<td>Well</td>
</tr>
<tr>
<td>1998</td>
<td>New Mexico</td>
<td>Cryptosporidium</td>
<td>32</td>
<td>Individual</td>
<td>5</td>
<td>Well</td>
</tr>
<tr>
<td>1998</td>
<td>Texas</td>
<td>Cryptosporidium</td>
<td>1400</td>
<td>Community</td>
<td>3</td>
<td>Well</td>
</tr>
<tr>
<td>1999</td>
<td>Florida</td>
<td>Giardia</td>
<td>2</td>
<td>Individual</td>
<td>2</td>
<td>Well</td>
</tr>
<tr>
<td>2000</td>
<td>Colorado</td>
<td>Giardia</td>
<td>27</td>
<td>Noncommunity</td>
<td>3</td>
<td>River</td>
</tr>
<tr>
<td>2000</td>
<td>Florida</td>
<td>Giardia</td>
<td>2</td>
<td>Individual</td>
<td>4</td>
<td>Well</td>
</tr>
<tr>
<td>2000</td>
<td>Florida</td>
<td>Cryptosporidium</td>
<td>5</td>
<td>Community</td>
<td>4</td>
<td>Well</td>
</tr>
<tr>
<td>2000</td>
<td>Minnesota</td>
<td>Giardia</td>
<td>12</td>
<td>Noncommunity</td>
<td>2</td>
<td>Well</td>
</tr>
<tr>
<td>2000</td>
<td>New Hampshire</td>
<td>Giardia</td>
<td>5</td>
<td>Individual</td>
<td>3</td>
<td>Well</td>
</tr>
<tr>
<td>2000</td>
<td>New Mexico</td>
<td>Giardia</td>
<td>4</td>
<td>Individual</td>
<td>5</td>
<td>River</td>
</tr>
</tbody>
</table>

* A community system has at least 15 service connection and serves more than twenty-five of the same people at least sixty days during the year. A noncommunity system serves more than twenty-five people per day but does not serve the same people year round.

** 2=untreated ground water; 3=improper treatment; 4=contamination in the distribution system; 5=unknown or miscellaneous deficiency (Barwick$^3$, Lee$^9$)

**PREVENTION**

Several strategies can be used to minimize the potential for *Giardia* and *Cryptosporidium* contaminations of water supplies. These include eliminating sources, containing and managing wastes and enhancing natural disinfection. These may be applied in combination with water treatment to ensure that water is safe to drink. Each is discussed below.

**Eliminating Sources**

Many types of mammals, especially young mammals, can be infected by *Cryptosporidium* oocysts, which in turn can initiate infections in humans. The chances of contaminating water supplies can be minimized by eliminating sources of potential contamination—especially in critical areas that may affect water supplies. Examples of this strategy could include transporting sewage effluent out of a watershed and prohibiting livestock and pets in specific areas. If potential sources are eliminated or prohibited in areas that are most likely to contribute runoff to surface water bodies, then the chances of contamination will be reduced significantly. One of the difficulties of protecting water supplies with this strategy is that it can be extremely expensive to transport sewage effluent out of a watershed, especially if the population is large, and may require changes in zoning or land use codes to keep pets and livestock out of areas where they are currently al-

**DEFINITIONS:**

Surface water bodies: includes all water found on the Earth’s surface; rivers, ponds, streams, wetlands, lakes, and marshes. Water can be ice or snow, and marine and coastal waters
It is also difficult to eliminate all potential sources of these parasites, because wild animals, such as mice may be infected and excreting cysts and oocysts. Another practice that is often applied involves capturing stormwater runoff and either treating it prior to releasing it, or allowing natural stresses and processes to eliminate harmful microorganisms. Sand filters can be constructed to clarify stormwater and remove many types of sediments\textsuperscript{15}.

**Containing and Managing Wastes**

In many agricultural operations, animal wastes are collected, stored temporarily and used as a soil amendment when weather and land use conditions permit. When no storms threaten, or conditions for runoff due to snow melt are not imminent, stored wastes may be injected or tilled into soil to add needed plant nutrients. Similarly, pet wastes can be collected by owners and disposed of properly. This means that pet owners carry plastic bags or other suitable containers while exercising pets and that they pick up wastes immediately. The bagged wastes can then be disposed of in collected trash.

One of the most frequently applied methods for encouraging pet owners to collect wastes is education. Education can include posting signs in pet recreation areas and circulating information through internet, print, radio, and television media. Regulations and ordinances are an alternative method for ensuring the pickup of pet waste. However, regulations of this type tend to be difficult to enforce because enforcement requires careful surveillance, inspection and authority to fine. Education can make people aware of the potential effects of pet wastes on public water supplies and may be an effective way of increasing public awareness.

**Enhancing Natural Disinfection and Attenuation**

Because Cryptosporidium and Giardia are dormant outside a host, environmental stresses kill cysts and oocysts over time if they are not ingested by a new host. These include temperature stresses (such as freezing and thawing and high temperatures) and dry conditions. When management practices such as grassed buffer or filter strips are put in place to protect water supplies, they lie between potential sources of microorganisms and surface water bodies\textsuperscript{17}. The vegetated strips are designed to capture microorganisms or slow their travel. Research conducted in California with buffer strips showed that 90-99\% of *C. parvum* oocysts were removed from surface and shallow subsurface flow per meter of buffer strip\textsuperscript{1}. When captured or slowed, environmental stresses can reduce numbers of oocysts and cysts. Constructed wetlands can also reduce numbers of microorganisms in water, though they may be quite difficult to construct and maintain\textsuperscript{16}. Unfortunately, because they serve as ideal habitat for many types of wildlife they may also inadvertently become sources of microbial contamination.

Buffers and filter strips must be maintained to remain effective. This may involve regular inspection and mowing and periodic reconstruction. They also involve setting aside land that may be useful for other purposes. One of the advantages of buffer strips is that they can be applied in areas where no other types of control can be applied. These include areas where wildlife may be the only potential source of cysts and oocysts. Another advantage is that buffer and filter strips have been shown to be effective in removing other types of contaminants, including sediment and chemicals attached to sediment.

**DEFINITIONS:**

- **Sediments:** mineral or organic particles carried by water, wind, and ice
- **Till:** to work soil by plowing, sowing, cultivating
- **Dormant:** state of temporary inactivity; having biological activity suspended
- **Wetlands:** areas that are saturated with surface or ground water and support plants adapted to such soil conditions\textsuperscript{16}
REFERENCES


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This publication produced with support from:

The Nevada Agricultural Experiment Station at the University of Nevada, the Drinking Water Revolving Loan Fund administered by the Nevada Division of Environmental Protection and a Regional Water Quality Coordination Grant provided by the U.S. Department of Agriculture’s Cooperative State Research, Extension and Education Service.