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Review Article

Cryptosporidiosis: An Emerging Zoonotic Disease of Global Public Health Concern

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Abstract

Cryptosporidiosis is an infectious emerging zoonotic protozoan disease occurring in both human and animal populations all over the world. Cryptosporidiosis is caused by *Cryptosporidium*, a tiny parasite that affects humans as well many species of animals. Although *Cryptosporidium parvum* and *Cryptosporidium hominis* (formerly known as *C. parvum* anthroponotic genotype or genotype 1) are the most common species causing disease in human beings, *Cryptosporidium felis, Cryptosporidium meleagridis, Cryptosporidium canis,* and *Cryptosporidium muris* infections have also been reported. Waterborne transmission via drinking water or a swimming pool is common, and outbreaks have been reported in several countries. The most common symptom of cryptosporidiosis in humans is watery diarrhea. People with weakened immune systems are more susceptible to contract serious, long-term, and even fatal infections. The laboratory endeavor is required to make a precise diagnosis of the disease. The demonstration of oocysts of *Cryptosporidium* in the fecal samples is still used as a simple, easy, and cost-effective technique for the diagnosis of disease. As a preventative and control measure, appropriate hygienic practices must be practiced everywhere. Furthermore, the veterinarians play a crucial role in the treatment of disease in domestic animals.

Keywords: *Cryptosporidium*, Cryptosporidiosis, Parasite, Public health, Zoonoses

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Introduction

Cryptosporidiosis is a diarrheal disease that mostly affects young animals, children, and individuals who are immunocompromised (1). The disease is caused by *Cryptosporidium*, an intracellular protozoan parasite first discovered in mice by Tyzzer. The absence of sporocysts within the oocysts gave rise to the name *Cryptosporidium*, which is now placed in the phylum *Apicomplexa* and the family *Cryptosporiidae* (2). The first case of cryptosporidiosis in man was reported in 1976 (1). Cryptosporidiosis is a serious disease with high morbidity and fatality rates, particularly in the developing countries. The disease is more common in rural regions due to the higher risk of disease spread and the lack of sanitation (3). The disease spreads when susceptible people or animals swallow the oocyst, which is commonly found in the contaminated water or foods (4). *Cryptosporidium* oocysts are shed in large numbers in the feces of sick people or animals, and they are resistant to disinfection and environmental stressors. The oocysts can survive in temperatures ranging from 30˚C to -20˚C for up to two weeks. The poor water quality, animal contact, overcrowding, household diarrhea, and open defecation have all been identified as significant risk factors for cryptosporidiosis in low and middle-income countries. Human-to-human or direct contact with sick animals, dirty water, and food are the main mechanisms of transmission (5). The main objective of this article is to review cryptosporidiosis, which is an emerging life-threatening protozoa zoonosis of public health importance.

Epidemiology

Cryptosporidiosis is a disease caused by the intracellular parasite *Cryptosporidium*, which infects a wide range of vertebrate species around the world, including humans. *Cryptosporidium* can be found in polluted soil, water, food, and surfaces from diseased humans or animals (6). The disease is more prevalent in poor countries than in industrialized countries due to a lack of resources and awareness regarding disease prevention and control. Cryptosporidiosis is uncommon in immunocompetent persons, but it is responsible for 10%–15% of severe diarrhea cases in developing countries, particularly in malnourished children under the age of five. In a number of nations, cryptosporidiosis outbreaks have been connected to swimming pools or contaminated drinking water (7). Cryptosporidiosis is a disease that affects both

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wild and domestic animals. *Cryptosporidium* causes severe to fatal newborn diarrhea syndrome in farm animals and other young ruminants and has a financial impact (8).

Etiology

Many *Cryptosporidium* species infect both animals and humans. Disease outbreaks and morbidity in animals are caused by *Cryptosporidium parvum, Cryptosporidium andersoni, Cryptosporidium ubiquitum, Cryptosporidium fragile, Cryptosporidium ducismarci, Cryptosporidium serpentis, Cryptosporidium varanii, Cryptosporidium xiaoi, Cryptosporidium galli, Cryptosporidium baileyi*, and *Cryptosporidium meleagridis*. However, *C. parvum, Cryptosporidium hominis, C. meleagridis,* and *Cryptosporidium cuniculus* are the most common pathogenic species in humans, causing occasional cases and outbreaks. *C. parvum,* which is also the most significant zoonotic hazard to humans, is the most common cause of cryptosporidiosis in young mammalian cattle. *C. hominis,* mostly associated with human infection as well as non-zoonotic species and genotypes, is host-adapted with no evidence of animal-to-human transmission (9). *Cryptosporidium* is resistant to chlorine, is difficult to filter, and can be found in a wide range of animal species (10).

Hosts

Cryptosporidium is a parasite identified in at least 155 mammalian species that causes widespread disease in animals. *Cryptosporidium* oocysts were also discovered in reptile feces. The majority of amphibian species investigated as well as more than 30 bird species have *Cryptosporidium* oocysts in their feces (7). *Cryptosporidium ovis* and *Cryptosporidium ryanae* are more common in post-weaned calves than *C. parvum*, although host-adapted cattle species have yet to be related to the disease. *C. ubiquitum* and *C. xiaoi* infect lambs and children. *C. ubiquitum* has been connected to the disease in post-weaned lambs, while *C. xiaoi* infection has been associated to the highest rates of neonatal diarrhea in goats. The most commonly reported species in dogs is *Cryptosporidium canis,* while the most commonly reported species in cats is *Cryptosporidium felis,* both of which have no clinical indications. Infectious pathogens infecting chickens include *C. baileyi, C. meleagridis,* and *C. galli* (8). The reservoirs of various *Cryptosporidium* species are listed in Table 1.

Table 1. *Cryptosporidium* Species With Their Reservoirs

Cryptosporidium Species	Reservoirs
C. hominis	Non-human primates
C. parvum	Ruminants
C. ubiquitum	Ruminants, rodents, carnivores
C. andersoni, C. bovis	Cattle
C. suis, C. scrofarum	Pigs, wild boar
C. wrairi	Guinea pigs
C. felis	Cat
C. canis	Dog
C. meleagridis, C. baileyi, C. galli	Birds
C. muris, C. viatorum	Rodents

Note. *C. hominis: Cryptosporidium hominis; C. parvum: Cryptosporidium parvum; C. ubiquitum: Cryptosporidium ubiquitum; C. andersoni: Cryptosporidium andersoni; C. bovis Cryptosporidium bovis; C. suis: Cryptosporidium suis; C. scrofarum: Cryptosporidium scrofarum; C. wrairi: Cryptosporidium wrairi; C. felis: Cryptosporidium felis; C. canis: Cryptosporidium canis; C. meleagridis: Cryptosporidium meleagridis; C. baileyi: Cryptosporidium baileyi; C. galli: Cryptosporidium galli; C. muris: Cryptosporidium muris; C. viatorum: Cryptosporidium viatorum*. Source (11).

Transmission

Cryptosporidiosis can be transmitted from person to person in a variety of ways (Figure 1). The contaminated food and drink, touching the mouth with contaminated hands, and oral-anal sexual contact can all spread the disease from person to person (1,12). The most prevalent causes of outbreaks include drinking water from a lake or river and swimming in a contaminated pool (12). In addition, inhaling oocysts from the contaminated air can infect the respiratory tract and produce respiratory symptoms in both animals and humans (13). Direct transmission from animal to animal, indirect transmission via fomites or human transmission, environmental pollution, and fecal contamination of feed or water supply are all possible ways for the spread of disease. *C. parvum* is not host-specific, and the infection can spread to other animals such as cats through contaminated food (8).

Clinical Spectrum

In Humans

Although 21 species have been related to human infection, the most prevalent ones found in intestinal infections are *C. hominis* and *C. parvum* with such symptoms as watery diarrhea, stomach pains, vomiting, nausea, dehydration, and weight loss (15). When exposed to *C. parvum,* those with CD4 T-cell count of less than 150/mL develop a persistent infection with severe and occasionally fatal diarrhea. Symptoms are normally self-limiting in immunocompetent people, whereas diarrhea and dehydration are the most severe in immunocompromised people. Further, disease may be fatal in immunocompromised patients having AIDS (1). *C. hominis* causes more severe clinical symptoms in humans compared to *C. parvum,* which has a longer period of symptoms and oocyst shedding (16).

In Animals

The main symptoms in animals are determined by the animals' immune system. Calves under the age of six weeks are the most susceptible to cryptosporidiosis. The most common symptom is pasty to watery diarrhoea, which may be followed by lethargy, inappetence, fever, dehydration, and/or poor health. Although the way

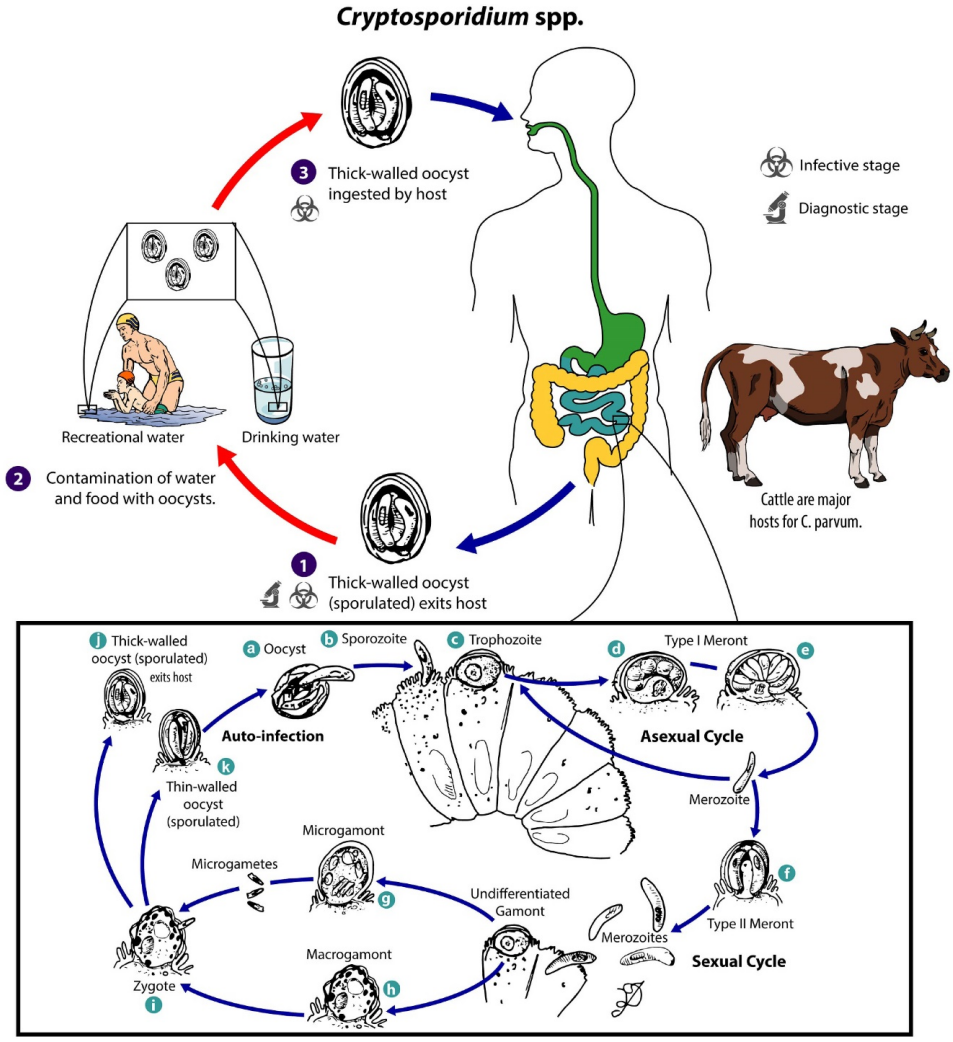

Figure 1. Presentation of Life Cycle and Transmission of *Cryptosporidium* From Animal to Humans. Pal (10).

animals respond to and recover from infection varies widely, the majority of infections are eliminated on their own after a few days. In some cases, the infection could be lethal (8). Cryptosporidiosis has been associated with a high rate of morbidity and mortality in both lambs and kids (17). The commonly observed symptoms include anorexia, apathy/depression, and abdominal pain as well as pasty to watery, yellow, and foul-smelling faeces (18). However, nasal discharge, sinusitis, dyspnea, pneumonia, and conjunctivitis are also recorded in animals (1). Subclinical infection is typical in animals over one month, although it can also afflict younger animals. The disease can still affect production, lead to lower body condition scores, slower growth, and lower carcass weight and dressing percentage at slaughter (19).

Diagnosis

The best diagnostic procedure for *Cryptosporidium* isolation and identification depends on the purpose as well as the diagnostic facilities, resources available resources (20). Wet mount followed by staining with a specific dye such as acid-fast dye, fluorescence, or immunofluorescence can be used to detect oocysts in stool samples (21). Acid-fast stained oocyst sporozoites are crescent-shaped and occasionally crimson with a diameter of 4-6 µm. modified Ziehl–Neelsen, modified dimethyl sulfoxide, safranin-methylene blue, and modified Koster are common acid-fast dyes. Although fluorochrome stains are getting increasingly sensitive, oocyst-like organisms in feces can still be stained (22). Oocysts are bound by fluorescent antibodies, and the disease is diagnosed by ELISA and PCR (1,20).

Treatment

There is no effective treatment; however, nitazoxanide (500 mg BID for 3 days in adults, 100 mg BID for 3 days in children 1-3 years, and 200 mg BID for 3 days in children 4-11 years) is beneficial in immunocompetent people. Supportive treatment with opium tincture or loperamide as well as antidiarrheal medications are necessary for severe diarrheic patients (23). The infected animals should be treated with symptomatic treatment such as oral or parenteral fluid, electrolyte replenishment, nutritional support, and anti-diarrheal medication because there is no approved treatment for them (24). It is necessary to develop safe, effective, and cheap chemotherapeutic

agents for the treatment of disease in humans and animals.

Prevention and Control

Understanding the distribution of *Cryptosporidium* species and subtypes, mechanisms of transmission, and sources of infection is crucial for disease prevention and control. The main prevention methods include drinking treated water, eating cooked food when traveling to areas where food supplies are unsafe, treating swimming pool water with cleaning agents, not allowing diarrheal patients to swim, washing hands after visiting toilets or changing diapers for children, and having safe sex by using protection methods (25,26). Since it is difficult to treat cryptosporidiosis, reducing the amount of oocysts may assist to decrease the severity of the infection and allow for the development of immunity in young animals and children through proper colostrum feeding. When dealing with diarrheal children and animals, more caution is required in terms of personal cleanliness (24). It is advised that immunocompromised persons and infants should not handle the animals suffering from diarrhea (1).

Conclusion

Cryptosporidium is a gastrointestinal parasite that affects humans and animals worldwide. The most prevalent and ubiquitous *Cryptosporidium* zoonotic species are *C. hominis* and *C. parvum.* The disease can be transmitted directly or indirectly from animals to humans. Oocysts are distributed via the fecal-oral route. It is an opportunistic infection that can cause many problems from diarrhea to life-threatening death in immunocompromised people. *Cryptosporidium* parasites can be found in both wild and domestic animals, making them a potential biological reservoir. The oocysts are resistant to the environment and can be easily transmitted to humans through contaminated water and foods. Control and prevention require high levels of personal hygiene. It is emphasized to carry out further work on the pathogenesis, epidemiology, diagnostic methods, and vaccinology.

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Authors' Contributions

All the authors contributed equally to the completion of this study. They read the final manuscript and approved it before the final submission.

Conflict of Interests

There was no conflict of interests among the authors.

Ethical issues

Ethical issues have been fully observed while collecting information and writing this article.

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References

1. Pal M. *Zoonoses*. 2nd ed. Jaipur, India; Satyam Publishers: 2007.
2. Xiao L, Fayer R, Ryan U, Upton SJ. *Cryptosporidium* taxonomy: recent advances and implications for public health. *Clin Microbiol Rev* 2004;17(1):72-97. doi: 10.1128/cmr.17.1.72-97.2004
3. Kotloff KL. The burden and etiology of diarrheal illness in developing countries. *Pediatr Clin North Am* 2017;64(4):799-814. doi: 10.1016/j.pcl.2017.03.006
4. Pal M, Bulcha MR, Lema AG, Bulcha SR. Cryptospordiosis: an infectious emerging protozoan zoonosis of public health significance. *MOJ Biol Med* 2021;6(4):161-3.
5. Gaibova H, Mamedova S. Anthropogenic influence on the formation of intestinal coccidia (Sporozoa, Apicomplexa) in reptiles of Azerbaijan. *Amur Zool J* 2020;11:1-4.
6. Feng Y, Xiao L. Molecular epidemiology of cryptosporidiosis in China. *Front Microbiol* 2017;8:1701. doi: 10.3389/fmicb.2017.01701
7. Lebbad M, Winiecka-Krusnell J, Stensvold CR, Beser J. High Diversity of *Cryptosporidium* species and subtypes identified in cryptosporidiosis acquired in Sweden and abroad. *Pathogens* 2021;10(5):523. doi: 10.3390/pathogens10050523
8. Tomazic M, Garro C, Schnittger L. *Cryptosporidium*. In: Florin-Christensen M, Schnittger L, eds. *Parasitic Protozoa of Farm Animals and Pets*. Cham, Switzerland: Springer; 2018.
9. Gaibova H, Iskenderova N, Gurbanova T. Review of the modern state of the emeridcoccides of terrestrial vertebrates of Azerbaijan. In: Proceedings of the XIX International Scientific Conference with Elements of the Scientific School of Young Scientists. Makhachkala, Russia: Biological diversity Caucasus and South Russia; 2017. p. 423-5.
10. Pal M, Tafese W, Tilahun G, Anberber M. Cryptosporidiosis: an emerging food and waterborne protozoan disease of global significance. *Beverage & Food World* 2016;43(1):43-5.
11. Ryan U, Zahedi A, Feng Y, Xiao L. An update on zoonotic *Cryptosporidium* species and genotypes in humans. *Animals (Basel)* 2021;11(11):3307. doi: 10.3390/ani11113307
12. Efstratiou A, Ongerth J, Karanis P. Evolution of monitoring for *Giardia* and *Cryptosporidium* in water. *Water Res* 2017;123:96-112. doi: 10.1016/j.watres.2017.06.042
13. Mor SM, Ascolillo LR, Nakato R, Ndeezi G, Tumwine JK, Okwera A, et al. Expectoration of *Cryptosporidium* parasites in sputum of human immunodeficiency virus-positive and -negative adults. *Am J Trop Med Hyg* 2018;98(4):1086-90. doi: 10.4269/ajtmh.17-0741
14. Center for Disease Control and Prevention (CDC). *Cryptosporidiosis*. Atlanta, USA: CDC; 2019.
15. Holubová N, Zikmundová V, Limpouchová Z, Sak B, Konečný R, Hlásková L, et al. *Cryptosporidium proventriculi* sp. n. (Apicomplexa: Cryptosporidiidae) in Psittaciformes birds. *Eur J Protistol* 2019;69:70-87. doi: 10.1016/j.ejop.2019.03.001
16. Bushen OY, Kohli A, Pinkerton RC, Dupnik K, Newman RD, Sears CL, et al. Heavy cryptosporidial infections in children in northeast Brazil: comparison of *Cryptosporidium hominis and Cryptosporidium parvum*. *Trans R Soc Trop Med Hyg* 2007;101(4):378-84. doi: 10.1016/j.trstmh.2006.06.005
17. Cacciò SM, Sannella AR, Mariano V, Valentini S, Berti F, Tosini F, et al. A rare *Cryptosporidium parvum* genotype associated with infection of lambs and zoonotic transmission in Italy. *Vet Parasitol* 2013;191(1-2):128-31. doi: 10.1016/j.

vetpar.2012.08.010
18. de Graaf DC, Vanopdenbosch E, Ortega-Mora LM, Abbassi H, Peeters JE. A review of the importance of cryptosporidiosis in farm animals. *Int J Parasitol* 1999;29(8):1269-87. doi: 10.1016/s0020-7519(99)00076-4
19. Sweeny JP, Ryan UM, Robertson ID, Yang R, Bell K, Jacobson C. Longitudinal investigation of protozoan parasites in meat lamb farms in southern Western Australia. *Prev Vet Med* 2011;101(3-4):192-203. doi: 10.1016/j.prevetmed.2011.05.016
20. Ahmed SA, Karanis P. Comparison of current methods used to detect *Cryptosporidium* oocysts in stools. *Int J Hyg Environ Health* 2018;221(5):743-63. doi: 10.1016/j.ijheh.2018.04.006
21. Sarkar R, Kattula D, Francis MR, Ajjampur SS, Prabakaran AD, Jayavelu N, et al. Risk factors for cryptosporidiosis among children in a semi urban slum in southern India: a nested case-control study. *Am J Trop Med Hyg* 2014;91(6):1128-37. doi: 10.4269/ajtmh.14-0304
22. Alles AJ, Waldron MA, Sierra LS, Mattia AR. Prospective comparison of direct immunofluorescence and conventional staining methods for detection of *Giardia* and *Cryptosporidium* spp. in human fecal specimens. *J Clin Microbiol* 1995;33(6):1632-4. doi: 10.1128/jcm.33.6.1632-1634.1995
23. Sparks H, Nair G, Castellanos-Gonzalez A, White AC Jr. Treatment of *Cryptosporidium*: what we know, gaps, and the way forward. *Curr Trop Med Rep* 2015;2(3):181-7. doi: 10.1007/s40475-015-0056-9
24. Innes EA, Chalmers RM, Wells B, Pawlowic MC. A one health approach to tackle cryptosporidiosis. *Trends Parasitol* 2020;36(3):290-303. doi: 10.1016/j.pt.2019.12.016
25. Firouzivand Y, Garedaghi Y, Hassanzadeh Khanmiri H. Prevalence of *Cryptosporidium* in children under 13 years of age with acute diarrhea in Tabriz, Iran. *Int J Med Parasitol Epidemiol Sci* 2022;3(2);35-38. doi 10.34172/ijmpes.2021.05
26. Manyazewal A, Francesca S, Pal M, Gezahegn M, Tesfaye M, Lucy M, et al. Prevalence, risk factors and molecular characterization of *Cryptosporidium* infection in cattle in Addis Ababa and its environs, Ethiopia. *Vet Parasitol Reg Stud Reports* 2018;13:79-84. doi: 10.1016/j.vprsr.2018.03.005