

HUMAN INTESTINAL PARASITES

**Anna SZCZUDŁO, Łukasz LIS, Izabela WIERZBICKA, Dorian KOMAR, Gabriela KWIEK,
Edward HADAŚ**

Department of Biology and Medical Parasitology, Institute of Biostructural Foundations of Medical Sciences,
University of Medical Sciences, Poznan, Święcickiego 4, Poland.

ABSTRACT:

Intestinal parasites are a common health problem worldwide. It is a group of diverse organisms that constitute an important etiological factor of various diseases of the digestive system. Diseases caused by these organisms can lead to serious complications, including death. The following work describes the most important species of parasites that can be infected by humans living in the tropics. These include protozoa, flat worms (tapeworms and flukes) and nematodes. This study also describes the symptoms of diseases caused by these parasites and information on the epidemiology, prevention and control of the most important species of intestinal parasites.

Keywords: Intestinal parasites, parasitic diseases, prevention, eradication

Introduction

Diseases caused by intestinal parasites are still a problem worldwide, despite socio-economic development. Unfortunately, improving sanitary conditions and learning hygiene rules did not eliminate the threat completely. Tourism is of great importance as it facilitates the transmission of parasites.

Intestinal parasite infections can occur in various ways. They are often asymptomatic. However, in some cases they may cause diarrhea and vomiting. Untreated infections increase the risk of complications such as dehydration, abscesses, infections or the transfer of various forms of parasites to other organs. There are also cases of allergic reactions to parasites or substances produced by them.

Parasites enter the human body most often through contaminated food. Sometimes infections occur through contact with animals or other people, especially when traveling to the tropics and less developed countries. Despite the common occurrence of parasites, there are ways to prevent infections. These include primarily taking care of hygiene and avoiding eating contaminated food.

However, if prevention fails, effective methods of treating infections have been developed, thanks to which complications can be prevented. The most important intestinal

parasites affecting humans are described below, along with information on symptoms and treatment of infections. They belong to the group of protozoans, tapeworms, flukes and nematodes.

Protozoans

Entamoeba histolytica is an example of a homoxenic parasite that develops in only one host. Its development cycle includes only two stages - trophozoite and cyst. It occurs all over the world, but infections occur mainly in tropical and subtropical zones or in people traveling to these regions of the world [1].

Amoebic dysentery causes approximately 50 million infections and contributes to 100,000 deaths per year. Symptoms that may indicate the presence of this protozoan include abdominal pain, fever, diarrhea, chills and bloody stools. Prolonged intestinal symptoms may lead to dehydration and weight loss. Ulcers may be observed in endoscopic examinations of the large intestine. Complications that appear several months after infection may include liver abscesses resulting from the circulation of trophozoites in the portal system [2].

Humans are infected orally by eating food contaminated with cysts. Infection prevention includes washing hands, fruits and vegetables before eating them. You should drink and use boiled water, especially when traveling to tropical and subtropical countries. An important aspect is also the appropriate storage and disposal of sewage, which reduces the risk of food contamination.

In the treatment of amoebiasis, drugs are used to eliminate trophozoites and cysts in infected people and carriers [3].

Balantidium coli is a cosmopolitan parasite found all over the world. Man is its accidental host because it is specific to pigs. It causes balantidiosis, which is a zoonotic disease. An increased number of *B. coli* infections is observed in areas where pigs are raised [4, 5].

Balantidiosis are relatively rare - the incidence of infection is on average less than 1% worldwide, but the statistics are much worse in Latin America, where they amount to over 20%. Most often, they are asymptomatic. However, people with weakened immunity often experience symptoms resembling food poisoning, such as diarrhea, abdominal pain, vomiting, bloody stools, and weight loss. Complications are very rare and may include inflammation-like lung infections.

Prevention of *B. coli* infections primarily involves maintaining hygiene in contact with pigs. Cysts can also be found in contaminated water, so avoid drinking water from unknown sources or unboiled water.

Cyclospora cayetanensis is a protozoan that infects only humans, so it is monoxenic. This parasite is endemic in Latin America, especially Peru, and in Asia in Nepal, which is why its presence is most often found in tourists returning from these parts of the world.

Symptoms of infection include loss of appetite, abdominal pain, diarrhea, increased body temperature, weakness, nausea and weight loss. During diarrhea, life-threatening dehydration may occur. Sometimes cases of asymptomatic infection are also observed.

Invasion occurs via the fecal-oral route after ingestion of food or water contaminated with parasite oocysts. Prevention of *C. cayetanensis* infections includes washing fruit before consumption and observing hygiene, which reduces the risk of food contamination.

Weekly antibiotic therapy is effective in treating the infection [6].

Cryptosporidium parvum is a cosmopolitan species, cases of infection of which have been recorded in nearly 90 countries on all continents except Antarctica.

Currently, 3 out of 100,000 people are infected with *C. parvum*, and this number is most likely an underestimate and may actually be much higher [7]. This parasite is more common in developing countries where poor sanitary conditions favor the spread of *Cryptosporidium*. There are also groups that are more vulnerable to *Cryptosporidium* infections, including people with AIDS and malnourished children [8].

The invasive form of *C. parvum* is the oocyst. After entering the lumen of the small intestine, 4 sporozoites are released from the oocysts, which then enter the epithelial cells lining the lumen of the intestine. This leads to cell damage and death. The intestinal villi are shortened, interfering with the absorption of water and salt, and the secretion of prostaglandins increases [9]. All these processes lead to symptoms that appear after an incubation period of about 14 days. Symptoms of cryptosporidiosis include: watery diarrhea, vomiting, abdominal pain, malaise, and after a long time, weight loss. In immunocompetent patients, the symptoms disappear spontaneously after some time, while in people with a weakened immune system, diarrhea becomes chronic. In such patients, infection of the bile ducts is also possible, leading to jaundice and pancreatitis [10].

C. parvum infection occurs via the fecal-oral route, so it is possible as a result of direct contact with an organism infected by this species of parasite. Both humans and some animals, e.g. cattle, can be carriers of *C. parvum* (calves are more likely to be carriers than adult cows).

More often, however, infection occurs without direct contact, as a result of drinking water or food containing oocysts.

The basis for preventing *C. parvum* infection is compliance with personal hygiene rules. It is also recommended to limit contact with people or animals suffering from cryptosporidiosis [11]. Boiling water and thoroughly washing vegetables and fruits also prevent the spread of the disease. It is also necessary to treat water. Although there have been cases of epidemics caused by contaminated tap water [12].

Symptomatic treatment and fluid and electrolyte supplementation are of great importance in the treatment of cryptosporidiosis.

Giardia intestinalis is a cosmopolitan parasite. It is one of the most common intestinal parasites [13]. Most epidemics occur as a result of consumption of contaminated water (74.8% in the USA), especially in developing countries, poorer sanitary conditions favor the spread of the pathogen. Approximately 15.7% of mass infections in the USA are the result of consumption of infected food, 2.5% are the result of direct contact between people. 1.2% of *G. intestinalis* outbreaks were related to zoonotic infections [14]. Other animals that cause diseases in humans may be carriers of *G. intestinalis*, e.g. cows, dogs, cats, beavers.

G. intestinalis trophozoites cause damage to the brush border of enterocytes. Disturbance of the microvilli structure impairs the absorption of nutrients from the intestinal lumen. This leads to symptoms of giardiasis in patients, which include: watery diarrhea, nausea, vomiting, abdominal pain and weight loss [15]. Not every infection results in symptomatic giardiasis. Approximately 50% - 75% of infections lead to asymptomatic carriage.

The parasite spreads via the fecal-oral route. *G. intestinalis* cysts can survive in the external environment and cause infections by ingesting water or food containing the cysts. It is also possible to transmit the disease through direct contact between people, between family members and children in nurseries or kindergartens [16].

As in the case of other diseases spread by the fecal-oral route, the basis for preventing infection is compliance with hygiene rules, in particular hand hygiene. This applies to people working with large numbers of children. People with symptoms of *G. intestinalis* infection should avoid using public swimming pools until 2 weeks after the diarrhea ends. Boiling drinking water and food is effective in preventing *G. intestinalis* infection [17].

Antiparasitic treatment is recommended for every patient diagnosed with *G. intestinalis* infection. The therapy is considered successful if a week after discontinuing the drugs, there are no *G. intestinalis* in the patient's stool [18].

Encephalitozoon intestinalis, E. cuniculi, Enterocytozoon bieneusi belong to a group of approximately 1,300 species of microorganisms that are obligate intracellular parasites. Representatives of microsporidia can be found all over the world except Antarctica. Of the hundreds of microsporidia species described, 17 can cause infections in humans.

The most common species found in humans are *E. intestinalis*, *E. cuniculi* and *Enterocytozoon bieneusi*, responsible for 80-90% of all infections. The disease caused by microsporidia is called microsporidiosis. The first confirmed case of this disease dates back to 1959. Microsporidiosis occurred sporadically in humans until the spread of HIV. Nowadays, the number of cases of microsporidiosis is increasing, most of them are AIDS patients or other patients with a weakened immune system, but there are also cases of the disease in immunocompetent people [19].

Microsporidia are organisms with no tissue specificity and can cause a variety of symptoms. The clinical form of microsporidiosis depends on the species, route of invasion and activity of the patient's immune system. In immunocompetent people, it takes the form of mild, self-limiting diarrhea. A serious course occurs in people with a weakened immune system (AIDS patients, transplant recipients); in this group, microsporidia cause chronic intestinal inflammation accompanied by diarrhea, malabsorption disorders and malnutrition. Cases of inflammation of the lungs, liver, kidneys, heart muscles, brain caused by microsporidia have also been described, and even generalized infections in which microsporidia attack cells of several organs at the same time [20, 21].

Despite numerous studies, the mode of transmission of these organisms in humans has not been fully understood. The invasive form of microsporidia are spores that are highly resistant to unfavorable environmental conditions. Getting a spore into the eye or a wound, drinking contaminated water or food, or having sexual intercourse with an infected person can lead to microsporidiosis. The source of disputes in the human environment may be both humans and animals. Species that cause infections in humans have also been detected in other animals, e.g. *Encephalitozoon intestinalis* in pigeons, *Encephalitozoon cuniculi* in rabbits and dogs, and *Tubulinosema* and *Anncaliia* in insects. From the body of infected organisms, spores in urine or feces can enter water and food [19].

Prevention, as in the case of other parasites spread by the fecal-oral route, is based on compliance with the rules of personal hygiene. Boiling water, washing vegetables and fruit, and thoroughly cooking food.

Tapeworms

Taenia solium, as a mature form, is a flatworm specific to humans. The intermediate host is pigs. It occurs all over the world except Antarctica, but the highest probability of infection with this parasite occurs in Latin American, African and eastern Asian countries. In Europe, the risk is negligible. The “armed” tapeworm can cause mild abdominal symptoms such as nausea and diarrhea, which is associated with the passage of proglottids. Infection can also lead to weight loss. Infection with this tapeworm occurs after eating undercooked or raw pork with larvae. Additionally, as a result of poor personal hygiene, humans may become infected with eggs excreted in the feces or tapeworm segments may enter the stomach through vomiting [22].

Cysticercosis manifests itself rapidly, with convulsions, headaches, nausea, and visual disturbances. The key element of prevention is thorough thermal processing of pork, as well as veterinary control of meat reaching consumers [23]. Special precautions should be taken when traveling to countries known to be endemic to *T. solium*. Treatment of tapeworm is based on the administration of antiparasitic drugs. Preventing the spread of tapeworms involves composting human waste.

Taenia saginata also belongs to flatworms specific to humans. The intermediate host is cattle. It is a cosmopolitan species found mainly in Eastern European countries, the Philippines and the Americas [24]. It causes tapeworm, which manifests itself as general weakness, discomfort, paroxysmal abdominal pain, anemia, skin rash and a number of digestive system ailments [25]. Infection occurs through the oral route by consuming raw beef with larvae. To protect against *T. saginata* infection, beef intended for consumption should be subjected to appropriate thermal treatment. Veterinary inspection of beef intended for food is also important. To reduce the spread of tapeworms, human feces should be properly disposed of and infected people should be treated. Pharmacological treatment involves administering an appropriate antiparasitic drug.

Diphyllobothrium latum is a flatworm with a wide range of definitive hosts. It occurs focally in Europe, North America, Asia, the Arctic, Uganda and Chile, especially around lakes and estuaries. Diphyllobothriasis infection occurs through consumption of raw or undercooked freshwater fish, including cyprinids [26]. The infection is asymptomatic for a long time. Later, gastrointestinal symptoms, intestinal obstruction, diarrhea, abdominal pain, weight loss, and sometimes even megaloblastic anemia caused by vitamin B₁₂ deficiency appear [27]. Preventive activities consist primarily in educating people and promoting changes in culinary habits,

stopping eating raw or semi-raw fish. However, the prevention of infection with the cutworm is difficult because it has a large reservoir of potential intermediate hosts [28]. Treatment of diphyllobotriasis is also an important element in preventing the spread of the parasite. The patient receives the antiparasitic drug niclosamide or praziquantel [29]. If anemia occurs as a result of infection with the flea beetle, vitamin B12 deficiency should be corrected with appropriate supplements after the parasite has been eliminated.

Hymenolepis nana is another flatworm specific to humans. The entire development cycle takes place in one host. It is a cosmopolitan parasite, but it is more common in countries with a warm climate, e.g. the Mediterranean and Black Sea, southeast Asia, Central and South America [30]. This is due to the sensitivity of eggs to low temperatures. In these countries, the level of infestation in children can reach up to 10%.

Dwarf tapeworm causes hymenolepiosis, which is usually asymptomatic. However, if symptoms of intense invasion occur, they include abdominal pain, vomiting, loss of appetite, headache, balance disorders, anorexia, anorexia, and general weakness [31]. In some people, this parasite can cause weight loss, and in people with weakened immunity, infection with it can last for years [32]. Infection most often occurs as a result of eating food or water contaminated with parasite eggs.

The main assumptions of prevention include ensuring that food and water intended for consumption are not contaminated with invasive eggs. Additionally, in countries with a higher risk of infection, you should not eat food or drink water from an unverified source. This tapeworm has a short lifespan, so it often heals on its own without the need for drug therapy.

Fluke

Fasciolopsis buski is a trematode parasite responsible for intestinal fasciolosis [33] This fasciolosis is an endemic disease limited to Southeast Asia and Indonesia [34]. Studies on the incidence of this parasite in Thailand indicate that most cases occur in people aged 10 to 15, and the number of infected patients decreases as the age of people in the analyzed population increases [35].

It is a disease characterized by diarrhea, abdominal pain, fever, intestinal obstruction and ascites, but it can also be asymptomatic.

The invasive form is metacercariae, which settle on plants and can enter the human body by being eaten, where they mature into an adult form in the small intestine, which then produces

eggs [36]. Preventing a parasite infection involves food inspection. There are usually 15 to 20 metacercariae on one plant, but their number can be up to 200 [37].

To remove metacercariae from plant surfaces, plants can be dried, as the parasite's metacercariae cannot survive in a dry environment. At 27°C., the metacercelium of *Fasciolopsis buski* will die within 19 hours, and when exposed to solar radiation, they will not survive longer than 30 minutes. Another method to prevent infection is to place the plants in boiling water for two minutes, which will kill the metacercariae living on the plants.

The basic method of reducing infections is not to eat directly collected aquatic plants without heat treatment.

Gastrodiscoides hominis is a fluke, mainly a parasite of pigs, but it can also infect humans. The occurrence of this parasite has been reported in India, Pakistan, Myanmar, Vietnam, China, Kazakhstan and Russia [38]. A study of children in Assam, a town in northern India, showed an exceptionally high prevalence of this parasite among humans, the results showed that 41% of the subjects were carriers of this parasite [37]. Infected people may be exposed to mucous diarrhea, abdominal pain, or fever.

People become infected with it by eating metacercariae along with infected fish or vegetables. The metacercariae eventually reach the cecum, where they mature and, after self-fertilization, lay eggs that are excreted with the feces.

The basic method of preventing infection is to refrain from eating unprocessed food straight from water; it is possible to reduce the risk of infection by holding vegetables in boiling water. Educational campaigns should also be carried out in areas where there is a risk of infection, aimed at making the community aware of the need to apply hygiene rules that can prevent infections. This is especially difficult in places where there is no wide access to treated water and there are habits of consuming raw plants passed down from generation to generation [39].

To combat *G. hominis*, it is necessary to act on four levels: environmental pollution should be limited, prevention principles should be followed to limit the spread of the disease by humans, the spread of the parasitic disease among animals should also be limited, and the population of the intermediate host, which are molluscs, should be controlled [39].

Heterophyes heterophyes is a parasitic intestinal fluke of humans, carnivorous mammals and birds, found in the Far East and the Mediterranean basin, as well as in Greenland [40]. In Europe, research distinguishes Greece as an important hotspot of this parasite on the old continent [41]. It is one of the smallest human flukes. The disease caused by *Heterophyes heterophyes* is called heterophyosis.

H. heterophyes parasitizes in the small intestine, where it produces eggs that are excreted from the host's body along with the feces. Humans become infected orally by eating undercooked or raw fish containing *H. heterophyes* metacercariae. In the human body, parasites reach sexual maturity within one week.

To protect against infection, avoid eating raw or undercooked fish. According to research, it is enough to heat the fish at 70 degrees Celsius for 10-15 minutes to inactivate the metacercariae [41].

An important element of infection prevention is the education of residents in areas where the parasite occurs. It is also important not to discharge feces into lakes and rivers, which prevents the development of the parasite.

Nematodes

Ascaris lumbricoides It is estimated that approximately 1 billion people worldwide are infected with human roundworm. This parasite is most abundant in tropical and subtropical climates, including: in South America, East Asia and Sub-Saharan Africa [42].

Ascaris lumbricoides eggs are excreted with the host's feces into the ground, where after a few weeks they transform into invasive eggs. People become infected with them by ingesting them with infected vegetables or water. However, eggs can also be found on cutlery, hands or money [42, 43].

The infection is usually asymptomatic. Symptoms are mainly related to the migration of the larvae to the lungs and back to the intestine. Initially, when the parasites are in the lungs, respiratory symptoms may appear: fever, shortness of breath, dry cough, wheezing [44]. The larvae move from the lungs to the throat, are swallowed and reach the small intestine, where they transform into adults.

The main symptoms of human roundworm infection manifested in the digestive system are nausea, vomiting and abdominal pain [44]. Symptoms such as insomnia, hives, allergic reactions and epilepsy-like symptoms are also possible.

To prevent infection, you should pay special attention to personal hygiene - washing your hands before eating, trying to avoid contamination of used items with soil that may contain parasite eggs. It is also important to wash vegetables and fruits before eating them [16]. The main method of treatment is the use of antiparasitic drugs. Prevention of *A. lumbricoides* infection is the disposal of human excrement.

Strongyloides stercoralis causes strongyloidiasis [45]. In 2013, it was estimated that approximately 370 million people were infected with this roundworm [46]. It is endemic to Africa, Southeast Asia and South America [47].

Humans are infected actively through larvae that live in the soil and can enter the human body by penetrating the skin and mucous membranes. Then they move to the lungs, where they mature to the L3 stage, and after reaching the trachea, they are swallowed. The strongyloidiasis settles in the small intestine where it lays eggs, which hatch into rhabdit-like larvae that are excreted in the feces. Some of them in the intestinal lumen may mature into invasive Filaria-like larvae and pierce the intestinal mucosa, leading to autoinvasion [48].

The infection is often asymptomatic, but skin symptoms may appear, such as itching, swelling or the so-called "larva currens" caused by the migration of the parasite. Respiratory problems such as a burning sensation, cough and pneumonia-like symptoms are also uncommon. The appearance of the parasite in the intestine may manifest itself in abdominal pain, sepsis or ulcers [49].

The most effective way to protect against *Strongyloides* infection is to wash hands and maintain personal hygiene [48], and wear shoes.

Ancylostoma duodenale is estimated to affect approximately 1.5 billion people worldwide [50]. It occurs in many places, including: Southern Europe, Africa, China and Japan [2].

Hookworm eggs are shed in the host's feces. Under appropriate conditions, they can transform into rhabdit-like larvae in the intestine or in the ground, and then into Filaria-like larvae that can actively penetrate the skin into the blood vessels [50]. The larvae migrate with the blood to the alveoli of the lungs, from where they move to the trachea and then to the small intestine. There they mature and reproduce [51].

In the initial stages of infection, when the parasite enters the body, symptoms such as skin irritation and itching or coughing appear. The last phase, when the hookworm is in the intestine, is manifested by abdominal pain and geophagia. In severe cases it causes anemia.

To avoid infection with this parasite, wear shoes and maintain hygiene. Proper disposal of animal and human waste is also important [50]. In case of infection, antiparasitic drugs are administered [52].

Necator americanus is the cause of the occurrence 95% of infections caused by hookworms, especially in school-age children from rural areas [53]. Due to the fact that it occurs mainly in North and South America and Australia, this parasite is known as the "New World hookworm". It occurs in tropical climates - it can also be found in Africa and Asia [54]. Humans

become infected through contact with soil, in which rhabdit-like larvae hatch and can pierce the skin. In this way they enter the blood vessels from where they pass to the lungs. They travel through the alveoli to the trachea and then to the small intestine, where they attach to the wall, mature and reproduce [55].

During the parasite's migration, breathing difficulties, coughing and vomiting may occur [56]. If the larva fails to penetrate the skin, it will remain in the skin, causing cutaneous larva migrans syndrome. It manifests itself with skin lesions with redness, swelling and itching [57].

The main ways to avoid infection are by wearing shoes, washing hands, and drinking clean water [58]. In case of infection, antihelmintics are administered (59).

Enterobius vermicularis causes threadworms. It occurs all over the world and it is estimated that throughout Europe, up to several dozen percent of children are infected with it each year [60].

People become infected by transferring pinworm eggs on unwashed hands, food or objects to the mouth, from where the parasites enter the small intestine where they transform into mature forms. At night, females migrate to the anus area where they lay eggs, which can be carried from there on the host's hands to the mouth, leading to autoinvasion. Retroinvasion may also occur if larvae from the anus return to the small intestine. [61].

Symptoms depend on the host's immunity and the number of individuals. Mainly you may notice itching around the anus. In addition, abdominal pain and nausea may occur [40].

The most important method of prevention is hygiene. You should wash your hands after relieving yourself and before eating. If infection occurs, washing in the morning can remove eggs from the anal area to prevent autoinfestation, and bedding, pajamas, and towels should be changed daily (62). Antiparasitic drugs are used for treatment [61].

Trichuris trichiura occurs all over the world. It is estimated that between 450 million and 1 billion children are infected. Trichuris eggs are shed in the host's feces into the soil, where they become invasive eggs [63]. Infection occurs via the fecal-oral route by consuming contaminated food or water containing invasive parasite eggs. The larvae hatch in the small intestine, from where they move to the large intestine, where they insert into its mucosa.

Typical symptoms are abdominal pain, constipation and diarrhea. With a higher number of parasites, anal prolapse may occur, and in children it may also result in growth arrest, impaired cognitive development and anemia (64). The best way to prevent it is to maintain personal hygiene. It is also important to wash vegetables and fruits before eating them [65].

Antihelmintics are used for treatment, but *T. trichiura* may often be more resistant to them than other parasites, making it difficult to cure [64].

Trichinella spiralis is infected around the world 10 thousand people a year. This parasite causes trichinosis and occurs all over the world, in all climates [66]. However, it is rarely found in tropical climates [67].

Infection occurs by eating raw meat containing encysted larvae. After being eaten, the larvae settle in the mucosa of the small intestine where they mature and then reproduce [68].

T. spiralis infection can be divided into two phases: the intestinal phase and the muscular phase. The intestinal phase may be asymptomatic or may include, among others: abdominal pain, diarrhea or constipation or fatigue. The extraintestinal phase begins 2 to 6 weeks after the larvae have been eaten. The severity of intestinal symptoms is influenced by the host's immunity, age and sex [69].

To avoid infection with this parasite, you should eat meat that has undergone appropriate heat treatment (cooking for at least a minute at a temperature of at least 71 degrees Celsius or freezing) or, if you want to eat raw meat, choose only those that have been tested [70].

The main preparations used to treat trichinellosis are antihelmintics. If administered within 3 days of infection, they can prevent the formation of encysted forms in the muscles [71].

SUMMARY

The problem of parasites, despite their better and better understanding, still poses a serious threat to many people who do not follow the recommendations regarding proper hygiene. Particularly vulnerable are those areas of the globe where sanitary conditions have not improved for decades, these are poor areas and where knowledge about the threats resulting from infection with intestinal parasites is not completely widespread.

In view of these facts, actions aimed at preventing humans from becoming infected with the described parasites should be intensified. These activities must be specifically targeted at those areas where the described threat is the greatest, i.e. places where intestinal parasites occur.

Conflicts of Interest – None

REFERENCES

- [1] Servián A., Helman E., Iglesias M.d.R., Panti-May J. A., Zonta M.L., Navone G.T. 2022. Prevalence of Human Intestinal *Entamoeba* spp. in the Americas: A Systematic Review and Meta-Analysis, 1990–2022. *Pathogens*, 11(11): article number 1365.

- [2] Kucik C.J., Martin G.L., Sortor B.V. 2004. Common intestinal parasites. *American Family Physician*, 69(5): 1161-1168.
- [3] Kantor M., Abrantes A., Estevez A., Schiller A., Torrent J., Gascon J., Hernandez R., Ochner C. 2018. *Entamoeba histolytica*: Updates in Clinical Manifestation, Pathogenesis, and Vaccine Development. *Canadian Journal of Gastroenterology and Hepatology*, 2, 2018: article number 4601420.
- [4] Schuster F.L and Ramirez-Avila L. 2008. Current world status of *Balantidium coli*. *Clinical Microbiology Reviews* 21(4): 626-38. Doi: 10.1128/CMR.00021-08.
- [5] Ponce-Gordo F, García-Rodríguez J.J. 2021. *Balantioides coli*. *Research in Veterinary Science*, 135: 424-431. Doi: 10.1016/j.rvsc.2020.10.028.
- [6] Ortega Y.R., Sanchez R. 2010. Update on *Cyclospora cayentanensis*, a food-borne and waterborne parasite, *Clinical Microbiology Reviews*, 23(1): 218–234.
- [7] Gerace E., Di Marco Lo Presti V., Biondo C. 2019. *Cryptosporidium* infection: epidemiology, pathogenesis, and differential diagnosis; *European Journal of Microbiology and Immunology*, 9(4): 119–123. Doi: org/10.1556/1886.2019.00019.
- [8] Fayer R., Morgan U., Upton S.J. 2000. Epidemiology of *Cryptosporidium*: transmission, detection and identification. *International Journal for Parasitology*, 30(12-13): 1305-1322. Doi: org/10.1016/S0020-7519(00)00135-1.
- [9] McCole D.F., Eckmann L., Laurent F., Kagnoff M.F. 2000. Intestinal Epithelial Cell Apoptosis following *Cryptosporidium parvum* Infection. *Infection and Immunity*, 68(3): 1710-1713. Doi: org/10.1128/IAI.68.3.1710-1713.2000.
- [10] Laurent F., McCole D.F. 1999. Pathogenesis of *Cryptosporidium parvum* infection. *Microbes and Infection*, 1(2): 141-148. Doi: org/10.1016/S1286-4579(99)80005-7.
- [11] Wesołowska M., Mowszet K., Wróbel G., Jankowski S. 2004. Kryptosporidioza u dzieci z przewlekłą biegunką. *Wiadomości Parazytologiczne*, 50(3): 393-396.
- [12] Chen X.M., Keithly J.S., Paya C.V., La Russo N.F. 2002. Cryptosporidiosis, *The New England Journal of Medicine*, 346(22): 1723-1731. Doi: 10.1056/NEJMra013170
- [13] Molina N., Minvielle M., Grenóvero S., Salomón C., Basualdo J. 2011. High prevalences of infection with *Giardia intestinalis* genotype B among children in urban and rural areas of Argentina; *Annals of Tropical Medicine & Parasitology*, 105(4): 299-309. Doi:org/10.1179/136485911X12987676649665.
- [14] Adam E.A., Yoder J.S., Gould L.H., Hlavsa M.C., Gargano J.W. 2016. Giardiasis outbreaks in the United States, 1971–2011; *Epidemiology & Infection*, 144(13): 2790-2801. Doi: org/10.1017/S0950268815003040.
- [15] Vivancos V., González-Alvarez I., Bermejo M., Gonzalez-Alvarez M. 2018. Giardiasis: characteristics, pathogenesis and new insights about treatment. *Current Topics in Medicinal Chemistry*, 18(15): 1287-1303. Doi: org/10.2174/1568026618666181002095314.
- [16] Własienko A., Kuchar E. 2017. Diagnosis, treatment and prevention of the most common parasitic diseases in children: current problems of the pediatrician and family doctor. *Lekarz POZ*, 2(3): 154-160.
- [17] Leung A.K.C., Leung A.A.M., Wong A.H.C., Sergi C.M., Kam J.K.M. 2019. Giardiasis: an overview. *Recent Patents on Inflammation & Allergy Drug Discovery*, 13(2): 134-143. Doi: org/10.2174/1872213X13666190618124901.

- [18] Wiercińska-Drapała A. 2010. Giardioza - obraz kliniczny, rozpoznawanie i leczenie; *Gastroenterologia Kliniczna*, 2(3): 98-102.
- [19] Han B., Pan G., Weiss L.M. 2021, Microsporidiosis in Humans; *Clinical Microbiology Reviews*, 34(4): article number e00010-20. Doi: org/10.1128/CMR.00010-20.
- [20] Shadduck J.A., Greeley E. 1989. Microsporidia and human infections. *Clinical Microbiology Reviews*, 2(2): 158-165. doi: org/10.1128/CMR.2.2.158
- [21] Weber R., Bryan R.T., Schwartz D.A., Owen R.L. 1994. Human microsporidial infections. *Clinical Microbiology Reviews*, 7(4): 426-461. Doi: org/10.1128/CMR.7.4.426.
- [22] Laranjo-González M., Devleeschauwer B., Trevisan C., Allepuz A., Sotiraki S., Abraham A., Afonso M. B., Blocher J., Cardoso L., Correia da Costa J.M., Dorny P., Gabriël S., Gomes J., Gómez-Morales M.Á., Jokelainen P., Kaminski M., Krt B., Magnussen P., Robertson L.J., Schmidt V., Schmutzhard E., Smit G.S.A., Šoba B., Stensvold C.R., Starič J., Troell K., Rataj A.V., Vieira-Pinto M., Vilhena M., Wardrop N.A., Winkler A.S., Dermauw V. 2017. Epidemiology of taeniosis/cysticercosis in Europe, a systematic review: Western Europe. *Parasites & Vectors* 10(1): article number 349. doi: 10.1186/s13071-017-2280-8.
- [23] Lesh E.J., Brady M.F. 2022. Tapeworm, StatPearls Publishing.
- [24] Braae U.C., Thomas L.F., Robertson L.J., Dermauw V., Dorny P., Willingham A.L., Saratsis A., Devleeschauwer B. 2018. Epidemiology of *Taenia saginata* taeniosis/cysticercosis: a systematic review of the distribution in the Americas. *Parasites & Vectors*, 11(1): article number 518. Doi: 10.1186/s13071-018-3079-y.
- [25] Symeonidou I., Arsenopoulos K., Tzilves D., Soba B., Gabriël S., Papadopoulos E. 2018. Human taeniasis/cysticercosis: a potentially emerging parasitic disease in Europe. *Annals Gastroenterology*, 31(4): 406-412. Doi: 10.20524/aog.2018.0260.
- [26] Lee K.W., Suhk H.C., Pai K.S., Shin H.J., Jung S.Y., Han E.T., Chai J.Y. 2001. *Diphyllobothrium latum* infection after eating domestic salmon flesh. *Korean Journal of Parasitology*, 39(4): 319-321. Doi:10.3347/kjp.2001.39.4.319.
- [27] An Y.C., Sung C.C., Wang C.C., Lin H.C., Chen K.Y., Ku F.M., Chen R.M., Chen M.L., Huang K.Y. 2017. Molecular Identification of *Diphyllobothrium latum* from a Pediatric Case in Taiwan. *Korean Journal of Parasitology*, 55(4): 425-428. Doi: 10.3347/kjp.2017.55.4.425.
- [28] Choi H.J., Lee J., Yang H.J. 2012. Four human cases of *Diphyllobothrium latum* infection. *Korean Journal of Parasitology*, 50(2): 143-146. Doi:10.3347/kjp.2012.50.2.143.
- [29] Lee S.H., Park H., Yu S.T. 2015. *Diphyllobothrium latum* infection in a child with recurrent abdominal pain. *Korean Journal Pediatrics*, 58(11): 451-453.
- [30] Cabada M.M., Morales M.L., Lopez M., Reynolds S.T., Vilchez E.C., Lescano A.G., Gotuzzo E., Garcia H.H., White A.C. 2016. *Hymenolepis nana* impact among children in the highlands of Cusco, Peru: An emerging neglected parasite infection. *American Journal of Tropical Medicine and Hygiene*, 95(5): 1031-1036. Doi: 10.4269/ajtmh.16-0237.
- [31] Kandi V., Koka S.S., Bhoomigari M.R. 2019. Hymenolepiasis in a pregnant Wwoman: A case report of *Hymenolepis nana* Infection. *Cureus*, 11(1): article number e3810. Doi: 10.7759/cureus.3810.

- [32] Kim B.J., Song K.S., Kong H.H., Cha H.J., Ock M. 2014. Heavy *Hymenolepis nana* infection possibly through organic foods: report of a case. *Korean Journal of Parasitology*, 52(1): 85-87. Doi: 10.3347/kjp.2014.52.1.85.
- [33] Mas-Coma S. 2014. Helminth-Trematode: *Fasciolopsis buski*, *Encyclopedia of Food Safety*, 2: 146-157.
- [34] Graczyk T., Gilman R., Fried B. 2001, Fasciolopsiasis: is it a controllable food-borne disease? *Parasitology Research*, 87(1): 80-83.
- [35] Manning G., Brockelman W., Viyanant V. 1971. An analysis of the prevalence of *Fasciolopsis buski* in central thailand using catalytic models, *American Journal of Epidemiology*, 93(50): 354–360.
- [36] McPherson R. 2021. Henry's Clinical Diagnosis and Management by Laboratory Methods, Elsevier, 24th edition, pp. 1290-1351.
- [37] Mas-Coma S., Bargues M., Valero M. 2018. Human fascioliasis infection sources, their diversity, incidence factors, analytical methods and prevention measures, *Parasitology*, 145(13): 1665–1699.
- [38]. Dada-Adegbola H., Falade C., Abiodun O. 2004. *Gastrodiscoides hominis* infection in a Nigerian-case report, *West African Journal of Medicine*, 23(2): 185-186.
- [39] Mas-Coma S., Bargues M., Valero M. 2005. Fascioliasis and other plant-borne trematode zoonoses. *International Journal for Parasitology*, 35(11-12): 1255-1278.
- [40] Deryło A. Ed. 2002. Parazytologia i akarontomologia medyczna, Warszawa, Wydawnictwo Naukowe PWN.
- [41] Taraschewski H., Nicolaidou A. 1987. *Heterophyes* species in Greece: record of *H. heterophyes*, *H. aequalis* and *H. dispar* from the first intermediate host, *Pirenella conica*, *Journal of Helminthology*, 61(1): 28–32.
- [42] de Lima Corvino D.F., Horrall S. (2022). Ascariasis. In: StatPearls. Treasure Island (FL): StatPearls Publishing
- [43] Hagel I., Giusti T. 2010. *Ascaris lumbricoides*: An overview of therapeutic targets, *Infectious Disorders - Drug Targets*, 10(5): 349-367. Doi: org/10.2174/187152610793180876.
- [44] Bell D.R. 1985. Soil transmitted helminths. In: *Lecture Notes on Tropical Medicine*. Boston, Blackwell Science; pp.167-192.
- [45] Vanderkooi M. 2000. Village Medical Manual (5th ed.). Pasadena: William Carey Library.
- [46] Bisoffi Z., Buonfrate D., Montresor A., Requena-Mendez A., Munoz J., Krolewiecki J., Gotuzzo E., Mena M.A., Chiodini P.L., Anselmi M., Moreira J., Albonico M. 2013. *Strongyloides stercoralis*: a plea for action. *PLOS Neglected Tropical Diseases*, 7(5): article number e2214. Doi:10.1371/journal.pntd.0002214.
- [47] Varatharajalu R., Kakuturu R. 2016. *Strongyloides stercoralis*: current perspectives. *Reports in Parasitology*, 5: 23-33. Doi.org/10.2147/RIP.S75839.
- [48] Mora Carpio A.L., Meseha M. 2022. *Strongyloides stercoralis*. In: StatPearls. Treasure Island (FL): StatPearls Publishing; October 13.
- [49] Thamwiwat A., Mejia, R., Nutman T.B., Bates J.T. 2014. Strongyloidiasis as a cause of chronic diarrhea, identified using next-generation *Strongyloides stercoralis*-specific immunoassays. *Current Tropical Medicine Reports*, 1: 145–147. doi: org/10.1007/s40475-014-0026-7.
- [50] Aziz M.H., Ramphul K. 2022. *Ancylostoma*. In: StatPearls. Treasure Island (FL): StatPearls Publishing; June 14.
- [51] Beigal Y., Greenburg Z., Ostfeld I. 2000. Letting the Patient off the Hook. *The New England Journal of Medicine*, 342(22): 1658-1661.
- [52] Sen-Hai Y., Ze-Xiao J., Long-Qi X. 1995. Infantile worm disease in China. *Acta Tropica*, 59(4): 265-270.

- [53] Bleakley H. 2007. Disease and development: evidence from hookworm Eradication in the American South. *The Quarterly Journal of Economics*. 122(1): 73-117. doi:10.1162/qjec.121.1.73.
- [54] Behnke J., Clercq D., Sacko M., Gilbert F., Ouattara D. 2000. The epidemiology of human hookworm infections in the southern region of Mali.. *Tropical Medicine and International Health*, 5(5): 343-354.
- [55] Hotez P.J., Bethony J., Bottazzi M.E., Brooker S., Buss P. 2005. Hookworm: The great infection of mankind. *PLOS Medicine* 2(3): article number e67. doi:10.1371/journal.pmed.0020067. ISSN 1549-1676. PMC 1069663. PMID 15783256.
- [56] Loukas A., Hotez P.J., Diemert D., Yazdanbakhsh M., McCarty J.S., Correa-Oliveira R., Bethony J.M. 2016. Hookworm infection. *Nature Reviews Disease Primers* 2: article number 16088. Doi:10.1038/nrdp.2016.88.
- [57] Heukelbach J., Feldmeier H. 2008. Epidemiological and clinical characteristics of hookworm-related cutaneous larva migrans. *The Lancet, Infectious Diseases*. 8(5): 302-309. Doi:10.1016/S1473-3099(08)70098-7.
- [58] Jourdan P.M., Lamberton P.H.L., Fenwick A., Addiss D.G. 2018. Soil-transmitted helminth infections. *Lancet*, 391(10117): 252-265. Doi:10.1016/S0140-6736(17)31930-X
- [59] Bethony J., Brooker S., Albonico M., Geiger S.M., Loukas A., Diemert D., Hotez P.J. 2006. Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. *Lancet*, 367(9521): 1521-32. Doi:10.1016/S0140-6736(06)68653-4.
- [60] Hadaś E., Derda M. 2014. Pasożyty – zagrożenie nadal aktualne, *Problemy Higieny i Epidemiologii*, 95(1): 6-13.
- [61] Rawla P., Sharma S. 2022. *Enterobius vermicularis*. In: StatPearls. Treasure Island (FL): StatPearls Publishing; October 9.
- [62] Cook G.C. 1994. *Enterobius vermicularis* infection. *Gut*, 35(9): 1159-1162.
- [63] Hayes K.S., Bancroft A.J., Goldrick M., Portsmouth C., Roberts I.S., Grensis R.K. 2010. Exploitation of the intestinal microflora by the parasitic nematode *Trichuris muris*. *Science* 328(5984): 1391-1394. Doi:10.1126/science.1187703.
- [64] Viswanath A., Yarrarapu S.N.S., Williams M. 2022. *Trichuris Trichiura*. StatPearls Publishing.
- [65] Else K.J., Keiser J., Holland C.V., Grensis R.K. 2020. Whipworm and roundworm infections. *Nature Reviews Disease Primers*, 6(1): article number 44. Doi:10.1038/s41572-020-0171-3
- [66] Furhad S., Bokhari A.A. 2022. Trichinosis. In: StatPearls. Treasure Island (FL): StatPearls Publishing.
- [67] Farrar J. 2013. Manson's tropical diseases (23 ed.). Philadelphia: Saunders pp. 791–94. ISBN 978-0-7020-5101-2.
- [68] Reisner E., Reisner H. 2023. Crowley's, an introduction to human disease: Pathology and pathophysiology correlations. Tenth ed. Jones and Bartlett Learning.
- [69] Capó V., Despommier D.D. 1996. Clinical aspects of infection with *Trichinella* spp. *Clinical Microbiology Review*, 9(1): 47-54. Doi:10.1128/CMR.9.1.47
- [70] Gottstein B., Pozio E., Nöckler K. 2009. Epidemiology, diagnosis, treatment, and control of trichinellosis. *Clinical Microbiology Reviews*, 22(1): 127-145. Doi:10.1128/CMR.00026-08.
- [71] John D.T., Petri W.A. 2006. Markell and Voge's Medical Parasitology. 9th ed. Philadelphia: Saunders.