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Gastrointestinal disorders due to parasites – a narrative review of the literature

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ABSTRACT
Intestinal parasites constitute a significant public health problem, particularly in developing countries. It is estimated that over 1.5 bln people worldwide are infected with intestinal parasites. These pathogens fall into 2 main groups: protozoa (e.g., *Giardia duodenalis, Entamoeba histolytica, Cryptosporidium*) and helminths – multicellular worms, which include roundworms (e.g., roundworm, pinworm, hookworm), tapeworms (*Taenia* spp.*, Diphyllobothrium latum*), and flukes (*Schistosoma* spp.).
Parasites cause illnesses with diverse clinical presentations, ranging from asymptomatic carriage to acute and chronic diarrhea, abdominal pain, malnutrition, and anemia. Some, such as *E. histolytica*, lead to invasive amoebiasis, while *T. solium* leads to neurocysticercosis, which contributes to epilepsy. Others, such as *Giardia*, disrupt intestinal absorption, leading to wasting, especially in children.
Diagnosis is primarily based on stool examination (microscopy, antigen testing, PCR). Treatment depends on the parasite – metronidazole, albendazole, praziquantel, and ivermectin are used, among others. Increasing attention is being paid to supporting treatment with probiotics and zinc supplementation, which improve therapeutic outcomes, especially in protozoal infections. The pathogenesis of infections includes mechanical intestinal damage, bleeding, nutrient utilization by parasites, and the induction of inflammatory responses and microbiome dysbiosis. Parasites lead to serious health consequences, particularly in children (deficiencies, impaired growth and development). Prevention relies on improved sanitation, access to clean water, health education, cooking meat, mass deworming in endemic areas, and basic personal hygiene. Effective vaccines do not exist, although research is ongoing.
Keywords: intestinal parasites; protozoa; helminths; parasite diagnosis; prevention of parasitic infections.

INTRODUCTION

The human digestive system plays a crucial role in maintaining the body's homeostasis, enabling digestion and absorption of nutrients and the elimination of metabolic waste products. However, its proper functioning can be disrupted by various factors, including parasitic infections, which pose a significant threat to public health worldwide. Gastrointestinal parasites are organisms that use humans as hosts, residing in their intestines and extracting nutrients from them, often leading to serious health consequences [1]. These infections can range from asymptomatic carriers to severe, chronic conditions that result in wasting. Parasites interfere with digestive mechanisms and nutrient absorption, which can lead to malnutrition, anemia, and general weakness. Additionally, many of them cause chronic inflammation and damage to the intestinal mucosa, contributing to disruptions in the gut microbiota and an increased risk of autoimmune and metabolic diseases [2]. Parasites can enter the human body in various ways, including through ingestion of contaminated food and water, contact with infected animals or soil, and person-to-person transmission. Populations most at risk of infestation include those living in poor sanitary conditions, preschool children, travelers to endemic areas, patients with compromised immune systems, and people working with farm animals [3].

METHODOLOGY OF THE LITERATURE REVIEW

This study was conducted as a narrative review of the scientific literature on gastrointestinal disorders caused by parasitic infections. The literature search was performed using selected scientific databases, including Google Scholar, ResearchGate, and PubMed. Publications written in English and published between 2010–2024 were included in order to reflect the current state of knowledge on intestinal parasitic infections and their impact on the gastrointestinal tract. The majority (79%) of the included studies were published between 2019–2024, ensuring that the analysis was based primarily on the most recent scientific evidence.

The search strategy was based on combinations of keywords such as: intestinal parasites, gastrointestinal parasites, protozoa, helminths, parasitic infections, diagnosis of parasitic infections, and prevention of parasitic diseases.

The selection process was conducted in two stages. In the first stage, titles and abstracts were screened to identify studies relevant to gastrointestinal parasitic infections. In the second stage, the full texts of publications potentially meeting the inclusion criteria were analyzed. The analysis included peer-reviewed articles, systematic reviews, meta-analyses, and clinical studies that provided reliable epidemiological, diagnostic, and therapeutic information related to gastrointestinal parasitoses. The selected publications constituted the basis for the narrative synthesis presented in this review.

CLASSIFICATION OF GASTROINTESTINAL PARASITES

There are 3 main groups of gastrointestinal parasites:

1. *Protozoa* – microscopic single-celled organisms that can cause both acute and chronic infections. The most commonly diagnosed include *Giardia lamblia, Entamoeba histolytica,* and *Cryptosporidium* spp., which are responsible for diarrhea, dehydration, and malabsorption [4];
2. *Nematodes* – roundworms such as *Ascaris lumbricoides* (ascarid), *Trichuris trichiura* (whipworm), and *Strongyloides stercoralis* (intestinal worm). They can cause consequences such as intestinal obstruction, anemia, and malnutrition due to nutrient malabsorption [5];
3. Tapeworms and flukes (*Cestoda* and *Trematoda*) – flat parasites such as *Taenia* spp. (tapeworms), *Fasciola hepatica* (liver fluke), and *Echinococcus granulosus* (hydatid disease). Their presence can lead to serious damage to internal organs and cysts in the liver, lungs, or brain [2].

These parasites differ not only in their structure and life cycle but also in their mode of infection and the clinical symptoms they cause. Some, such as *Giardia lamblia*, are spread primarily through contaminated water and food, while others, such as tapeworms, require an intermediate host such as cattle or pigs for their mature forms to enter humans. Furthermore, many parasites possess complex adaptive mechanisms that allow them to survive in various environmental conditions and hide from the host's immune system [1]. The prevalence of specific parasite species depends on many factors, such as climatic conditions, hygiene levels, and access to healthcare. In developed countries, infections caused by protozoa and nematodes transmitted via the fecal-oral route predominate, while in tropical regions, tapeworm and fluke infections are more common, associated with local dietary habits and contact with livestock [3]. The development of modern diagnostic methods, such as molecular testing and serological techniques, enables increasingly effective detection of parasitic infections, but their widespread use in clinical practice remains a challenge. Early diagnosis and effective therapy are crucial for minimizing the negative impact of parasitic infestations on human health and limiting the transmission of these organisms within the population [4].

The scale of parasitic infestations in the world and in Europe

Gastrointestinal parasites are common worldwide, and their prevalence depends on sanitary, climatic, and socioeconomic conditions. According to the World Health Organization (WHO), up to 4.5 billion people worldwide may be infected with gastrointestinal parasites, representing nearly 60% of the population in developing countries [3]. The most commonly diagnosed infections are caused by roundworms, whipworms, and hookworms, which account for over 1.5 bln cases annually.

In Europe, parasitic infections occur considerably less frequently than in tropical and subtropical regions due to improved sanitation, access to clean water, and well-developed public health systems. Nevertheless, they remain an important epidemiological concern, particularly among travellers, migrants, and immunocompromised individuals. Soil-transmitted helminth infections continue to represent a substantial global health burden. Among them, *Ascaris lumbricoides* is one of the most prevalent parasitic infections worldwide. A recent systematic review and meta-analysis estimated the global pooled prevalence of ascariasis at approx. 11% of the world's population, corresponding to hundreds of millions of infected individuals globally [5]. The most commonly reported infestations include giardiasis, cryptosporidiosis, and enterobiasis, which affect both children and adults [4]. In developed countries, parasitic infections occur primarily through the consumption of contaminated water and undercooked meat, as well as contact with contaminated soil or animal feces.

The aim of this paper is to provide a narrative review of the literature analyzing the impact of parasites on the human digestive system. Particular attention will be paid to pathogenic mechanisms, nutrient malabsorption, and potential complications associated with parasitic infestation.

OVERVIEW OF THE CLASSIFICATION OF PARASITES AFFECTING THE GASTROINTESTINAL TRACT

Gastrointestinal parasites pose a significant health problem, particularly in countries with poor hygiene and limited access to clean drinking water. They can lead to a wide spectrum of clinical symptoms, from mild digestive disturbances to severe complications such as malnutrition, anemia, intestinal mucosal damage, and internal organ involvement [6]. There are three main groups of gastrointestinal parasites: protozoa, roundworms, and flatworms.

Protozoan parasites

The most common intestinal protozoan parasites include *Giardia lamblia, Entamoeba histolytica,* and *Cryptosporidium* spp.

- *Giardia lamblia* causes giardiasis, characterized by chronic steatorrhea, flatulence, and nutrient malabsorption, leading to weight loss [7]. The parasite's trophozoites adhere to the mucosa of the small intestine, causing damage to the intestinal villi and reduced activity of brush border enzymes [6].
- *Entamoeba histolytica* is responsible for intestinal amoebiasis, which can manifest as acute amoebic dysentery or a chronic infection with recurrent diarrhea. In some patients, circulatory invasion and abscess formation occur, primarily in the liver [7]. *Cryptosporidium* spp. is particularly dangerous for immunocompromised individuals, causing cryptosporidiosis, a disease characterized by watery, persistent diarrhea accompanied by abdominal pain, dehydration, and electrolyte loss [6]. Infection occurs via the fecal-oral

route, and the parasite's oocysts are highly resistant to disinfectants, making it difficult to eliminate the pathogen from drinking water [7].

Roundworms

Intestinal roundworms are the most common group of gastrointestinal parasites. The most frequently diagnosed include *Ascaris lumbricoides* (the human roundworm), *Trichuris trichiura* (the whipworm), and *Strongyloides stercoralis* (the intestinal nematode).

- *Ascaris lumbricoides* is one of the largest human parasites, with adults reaching up to 35 cm in length. Infection occurs through the ingestion of eggs found in soil or contaminated food. Once inside the body, the larvae migrate through the lungs, which can lead to respiratory symptoms, and then settle in the small intestine, causing abdominal pain, intestinal obstruction, and, in severe infestations, malnutrition and stunted growth in children [8].
- *Trichuris trichiura* inhabits the large intestine, where it can cause trichuriasis – a chronic infection characterized by diarrhea, gastrointestinal bleeding, and, in severe cases, anemia and rectal prolapse [9].
- *Strongyloides stercoralis* has a unique ability to autoendoinvade, meaning it can persist in the host for many years. In immunocompetent individuals, the infection is mild or asymptomatic, but in immunosuppressed patients, it can lead to hyperinfection syndrome, causing severe diarrhea, sepsis, and multi-organ failure [8].

Flatworms

Flatworms are divided into tapeworms and flukes. Among them, *Fasciola hepatica*, *Taenia* spp., and *Echinococcus granulosus* are of particular clinical importance.

- *Fasciola hepatica* (liver fluke) causes fasciolosis, a zoonotic disease in which the parasite's larvae migrate to the liver and bile ducts, causing abdominal pain, fever, and chronic cholangitis, which can lead to liver fibrosis and cirrhosis [10].
- *Taenia saginata* (unarmed tapeworm) and *Taenia solium* (armed tapeworm) are parasites of the small intestine that can reach considerable size (up to 10 meters in length). Infection occurs through the consumption of raw or undercooked beef (*T. saginata*) or pork (*T. solium*). Symptoms are often nonspecific – abdominal pain, nausea, change in appetite – but in individuals with massive infestations, intestinal obstruction may occur [11].
- *Echinococcus granulosus* causes echinococcosis, a zoonosis in which tapeworm larvae settle in internal organs, forming hydatid cysts. In over 60% of cases, the liver is affected, where cysts can grow to a significant size and cause pressure on adjacent structures, leading to abdominal pain, jaundice, or complications such as cyst rupture and anaphylactic reaction [12] – Table 1.

TABLE 1. Characteristics of selected parasites, taking into account the symptoms of infection and the pathogenetic mechanism

Parasite group	Examples	Diseases	Main symptoms	Pathogenetic mechanism	Sources
Protozoan parasites	*Giardia lamblia*	giardiasis	chronic fatty diarrhea, bloating, weight loss	damage to intestinal villi, impaired fat absorption	Hemphill & Müller, 2019
	Entamoeba histolytica	amebiasis	bloody diarrhea, abdominal pain, liver abscesses	proteolytic enzymes destroying colon tissue	Hemphill & Müller, 2019
	Cryptosporidium spp.	cryptosporidiosis	watery diarrhea, dehydration	dysfunction of enterocyte transport	Ahmed, 2023
Nematodes (roundworms)	*Ascaris lumbricoides*	ascariasis	abdominal pain, cough, intestinal obstruction	larvae migration through lungs, malnutrition	Else et al., 2020
	Trichuris trichiura	trichuriasis	diarrhea, intestinal bleeding, anemia	damage to colonic mucosa, blood loss	Bathohakse et al., 2024
	Strongyloides stercoralis	strongyloidiasis	diarrhea, constipation, hyperinfection in immunocompromised individuals	autoinfection, tissue penetration	Else et al., 2020
Trematodes (flukes)	*Fasciola hepatica*	fascioliasis	pain in the right upper quadrant, fever, jaundice	migration to liver and bile ducts	Caravedo & Cabada, 2020
	Taenia spp.	taeniasis	abdominal pain, nausea, intestinal obstruction	competition for nutrients, mechanical irritation of intestine	Jurkiewicz & Pysiewicz, 2025
	Echinococcus granulosus	echinococcosis (hydatid disease)	liver and lung cysts, risk of rupture and anaphylactic shock	formation of hydatid cysts in organs	Almulhim & John, 2023

Mechanical damage to the intestinal mucosa and gastrointestinal tract

Parasites can mechanically damage the intestinal epithelium, causing direct tissue damage and disruption of the intestinal barrier:

- *Entamoeba histolytica* produces proteolytic enzymes (including cysteine proteases) that degrade protective mucus and destroy epithelial cells, leading to the formation of ulcers in the colon [7]. This damage can lead to bloody diarrhea and, if the liver is affected, to the formation of amoebic abscesses [6];
- *Ascaris lumbricoides* (human roundworm) can lead to intestinal obstruction due to the accumulation of large numbers of parasites in the intestinal lumen. In some cases, complications such as perforation of the intestinal wall and acute appendicitis caused by migrating roundworms have been reported [8];
- *Echinococcus granulosus* (hydatid disease) in its larval stage forms hydatid cysts which, as they grow, can cause pressure on the structures of the digestive tract, leading to intestinal transit disorders and chronic pain [12].

Impaired absorption of nutrients

Gastrointestinal parasites often interfere with the body's ability to absorb nutrients, which can lead to malnutrition, anemia, and micronutrient deficiencies.

- *Giardia lamblia* infection disrupts intestinal absorption mainly through damage to the intestinal villi and impairment of brush border enzymes. In children, chronic giardiasis can result in delayed growth and development [7].
- *Trichuris trichiura* (whipworm) contributes to chronic blood loss through small lesions in the colonic mucosa, leading to iron deficiency anemia and weakness [9].
- *Taenia* spp. (tapeworms) compete with the host organism for nutrients, which may result in vitamin deficiencies (e.g. vitamin B_{12}), which may lead to megaloblastic anemia and general weakness [11].

Triggering inflammation and immune responses

Parasitic infestations lead to immune activation, which can result in both acute and chronic inflammation in the gastrointestinal tract:

- *Cryptosporidium* spp. leads to a strong inflammatory response in the intestinal epithelium, resulting in increased chloride and water secretion into the intestinal lumen and, consequently, severe secretory diarrhea [6];
- in the acute phase, *Fasciola hepatica* (liver fluke) induces eosinophil migration and inflammation of the liver and bile ducts, leading to tissue damage and bile duct fibrosis [10];
- *Strongyloides stercoralis* can cause chronic intestinal inflammation, which in immunosuppressed individuals progresses to hyperinfection syndrome, leading to severe multi-organ complications such as sepsis and respiratory failure [8].

Changes in the gut microbiome due to parasitic infestation

The presence of parasites in the intestine can disrupt the balance of the intestinal microbiota, which affects the functioning of the immune system and may promote further bacterial infections:

- *Giardia lamblia* disrupts the composition of the intestinal microbiota, reducing the number of beneficial bacteria of the genera *Lactobacillus* and *Bifidobacterium*, which can lead to long-term digestive disorders even after the infection has subsided [7];
- *Entamoeba histolytica* damages the intestinal barrier, which can facilitate the penetration of bacteria into the bloodstream and lead to secondary bacterial infections and sepsis [6];
- *Cryptosporidium* spp. alters the balance between microorganisms in the intestine, promoting the growth of pathogenic bacteria and affecting the composition of bacterial metabolites, which may contribute to the development of chronic inflammatory bowel diseases [6].

DIAGNOSTICS OF PARASITIC INFECTIONS

Diagnosing gastrointestinal parasitic infections involves a range of laboratory methods with varying sensitivity and specificity. Traditional microscopic methods are still widely used, but they are increasingly being supplemented or replaced by serological tests and modern molecular techniques, such as polymerase chain reaction (PCR) and RT-PCR (reverse transcription PCR). The choice of appropriate method depends on the suspected pathogen, the stage of infection, and the availability of laboratory techniques [13].

Microscopic methods and staining techniques

Microscopy is the basic and longest-used method for diagnosing intestinal parasites. It allows for the direct observation of eggs, cysts, trophozoites, or larvae in stool, urine, or tissue samples [14]. Its effectiveness depends on the experience of the laboratory diagnostician and the quality of the sample. Traditional light microscopy uses direct preparations and concentrating methods such as flotation (used to detect helminth eggs) and sedimentation (preferred for diagnosing flukes) [15]. Various staining techniques are used to increase parasite detection. Detection of protozoa such as *Giardia lamblia* and *Entamoeba histolytica* is aided by trichrome or chlorazole black staining, which allows for the visualization of the internal structures of cysts and trophozoites [16]. *Cryptosporidium* spp. and *Cyclospora cayetanensis* oocysts are detected using the modified Ziehl-Neelsen method, in which they stain red against unstained stool [15]. Microscopy, although inexpensive and widely available, has significant limitations. The sensitivity of a single stool test is low, especially in cases of low parasitic infestation intensity, so analysis of at least three samples collected at intervals is recommended [14]. Furthermore, microscopic identification of some species, such as *Entamoeba histolytica* and *Entamoeba dispar*, is impossible without additional molecular tests [13].

Serological tests and immunological tests

Immunological diagnostics involves the detection of antibodies against parasites and parasitic antigens in samples of stool, blood, or other body fluids. Serological tests are particularly useful in the diagnosis of invasive parasitoses such as echinococcosis (*Echinococcus granulosus*), toxoplasmosis (*Toxoplasma gondii*), and cysticercosis (*Taenia solium*) [13]. In chronic infections, high antibody titers can persist long after the parasite has been eliminated, which is a limitation of this method [16]. Enzyme-linked immunosorbent assays (ELISAs) are widely used due to their high sensitivity and specificity. They enable the detection of parasitic antigens, for example, in the diagnosis of giardia (*Giardia lamblia*) and cryptosporidiosis (*Cryptosporidium parvum*), which allows for the confirmation of active infection [15]. Comparative studies have shown that ELISA tests have higher sensitivity than a single microscopic examination, especially in detecting low-intensity infections [14]. Rapid immunochromatographic diagnostic tests (RDTs) are also available, which allow for the detection of parasite antigens within a few minutes. Such tests are often used in the diagnosis of *Giardia* and *Cryptosporidiosis*, especially in field settings and in developing countries [15]. Their main drawback is their limited diagnostic scope – each test is designed to detect one or more specific parasites, which requires prior suspicion of a specific infection [13].

Molecular diagnostics (PCR, RT-PCR)

Molecular diagnostics is currently the most sensitive method for detecting parasites. Polymerase chain reaction techniques and its variants, such as real-time PCR (qPCR) and RT-PCR, amplify specific fragments of parasite DNA or RNA [16]. These methods are primarily used to detect protozoa such as *Cryptosporidium* spp., *Giardia lamblia*, and *Entamoeba histolytica*, as well as certain helminths, such as *Strongyloides stercoralis* [14].

Multiplex PCR enables the simultaneous detection of multiple pathogens in a single sample, increasing diagnostic efficiency, especially in patients with nonspecific symptoms [15]. Studies have shown that PCR can detect infection even when traditional microscopic and serological methods yield negative results [16]. Additionally, PCR allows for the differentiation of morphologically similar species, such as *Entamoeba histolytica* and *Entamoeba dispar*, which is crucial in the diagnosis of amoebiasis [13]. Molecular diagnostics is limited by its high cost and the need for advanced laboratory equipment. Furthermore, the effectiveness of the method depends on the quality of DNA isolation, and inhibitors present in stool can affect PCR results [15]. Despite these challenges, PCR is becoming increasingly available for routine diagnostics, especially in developed countries, where it is replacing microscopy as the first-line method for detecting gastrointestinal parasites [16] – Table 2.

TREATMENT AND PREVENTION OF PARASITIC INFECTIONS

Treatment of parasitic infections relies on the use of specific medications, the effectiveness of which varies depending on the type of parasite. Metronidazole remains the standard treatment for giardiasis and amoebiasis, but tinidazole demonstrates higher efficacy and better patient tolerability [17]. The alternative albendazole has been shown to be effective in treating giardiasis, although slightly less effective than metronidazole. For amoebiasis (*Entamoeba histolytica*), the WHO recommends

TABLE 2. Comparison of the main laboratory methods used in the diagnosis of gastrointestinal parasitic infections

Diagnostic method	Principle	Diagnostic performance	Key advantages	Main limitations
Light microscopy (direct smear, concentration techniques)	direct visualization of eggs, cysts, trophozoites or larvae in stool samples	moderate sensitivity; high specificity when morphology is clear; sensitivity increases with multiple samples	low cost, widely available, allows direct observation of parasite morphology	low sensitivity in low-intensity infections; requires experienced personnel; cannot differentiate some morphologically similar species
Staining techniques (e.g., trichrome, modified Ziehl–Neelsen)	staining enhances visualization of protozoan structures or oocysts	higher sensitivity than unstained microscopy for protozoa	improves detection of protozoa such as *Giardia*, *Cryptosporidium*, *Cyclospora*	additional laboratory processing; still limited sensitivity in low parasite burden
Serological and antigen detection tests (ELISA)	detection of parasite-specific antibodies or antigens in blood or stool	high sensitivity and specificity; higher sensitivity than single microscopic examination	allows detection of active infection (antigen tests); standardized and suitable for large sample numbers	antibodies may persist after infection; tests usually target specific parasites
Rapid diagnostic tests (RDTs)	immunochromatographic detection of parasite antigens	moderate–high sensitivity depending on test	rapid results (minutes); simple and suitable for field settings	limited diagnostic scope; detects only selected parasites
Molecular diagnostics (PCR, qPCR, RT-PCR)	amplification of parasite DNA/RNA sequences	very high sensitivity and specificity; detects low parasite loads	enables species differentiation and detection of mixed infections	high cost; requires specialized laboratory equipment

combination therapy: metronidazole/tinidazole, followed by paromomycin to eliminate cysts [18].

Albendazole and mebendazole are standard medications for treating gastrointestinal helminthiasis. Albendazole is superior to mebendazole in eliminating hookworms (*Ancylostoma*, *Necator*) [19]. However, for whipworms (*Trichuris trichiura*), their effectiveness is low, which is why the WHO recommends combination therapy (albendazole + ivermectin) in endemic regions [18].

For the treatment of tapeworms and flukes, praziquantel is primarily used, which at a dose of 10 mg/kg provides almost 100% efficacy in eliminating *Taenia solium* [20]. Albendazole or niclosamide are alternatives, which are slightly less effective [20].

Treatment of parasitic infections is effective, but frequent reinfections limit the long-term effects of therapy. Therefore, the WHO emphasizes the importance of preventive sanitation and hygiene, especially in endemic areas [21].

Improving sanitation reduces parasite transmission. Meta-analyses indicate that access to toilets reduces the risk of *Ascaris* infection by 27%, *Trichuris* by 20%, and hookworm infection by 35% [22].

Regular mass deworming (MDA) of at-risk populations (children, women of reproductive age) is a key WHO strategy [18]. A field study in Thailand showed that adding hygiene education to MDA reduced the incidence of parasite infection from 36% to 23% within 6 months, while chemotherapy alone did not produce a lasting improvement. Antiparasitic chemotherapy (MDA) refers to the prophylactic administration of anthelmintic drugs to entire populations or at-risk groups, regardless of individual parasite test results. Results showed that chemotherapy alone was insufficient to sustainably reduce the number of infections, while combining MDA with hygiene education provided better, more lasting results. Pharmacological treatment without changes in hygiene behaviors is insufficient to effectively and sustainably reduce parasitic infections [23].

Intestinal parasites disrupt nutrient absorption and the intestinal microbiota, which can lead to malnutrition and weakened immunity. Zinc supplementation (20 mg/day for 10–14 days) reduces the duration of diarrhea in children by approx. 15% and supports epithelial regeneration [24]. World Health Organization also recommends vitamin A and iron supplementation for at-risk groups [25]. A growing body of research indicates that probiotics can support parasite elimination and microflora restoration [26, 27]. *Lactobacillus* and *Saccharomyces boulardii* reduce the symptoms of giardiasis, and in animal models, probiotics reduced parasite burden by 50–70% [27]. Adding probiotics to standard giardiasis treatment shortened the duration of symptoms and reduced cyst shedding [26].

The impact of parasites on the human digestive tract

Gastrointestinal parasites can trigger a range of pathogenic mechanisms, including mechanical damage to the intestinal mucosa, impaired nutrient absorption, inflammation, and changes in the gut microbiome [6]. Protozoa such as *Giardia lamblia* adhere to the small intestinal mucosa, damaging the intestinal villi and leading to their atrophy and increased intestinal barrier permeability, resulting in diarrhea and malnutrition [6, 28]. *Entamoeba histolytica*, on the other hand, produces proteolytic enzymes (including cysteine proteases) that destroy the intestinal epithelium, causing bloody diarrhea and ulceration [28]. Intestinal worms such as *Ancylostoma duodenale* and *Necator americanus* (hookworms) mechanically attach to the intestinal wall, leading to tissue damage and chronic blood loss, which can result in iron deficiency anemia [29]. *Trichuris trichiura* (whipworm) penetrates the colonic mucosa through its anterior part, causing chronic microtrauma, inflammation, and diarrhea [6]. Parasitic infestations lead to malnutrition by reducing nutrient absorption. *Giardia lamblia* interferes with the function of brush border enzymes, which disrupts the digestion and absorption of fats and carbohydrates [30]. Whipworm causes chronic bleeding from the colon, leading to iron deficiency anemia [31]. Tapeworms such as *Taenia* spp. compete with their hosts for nutrients, particularly vitamin B_{12}, which can result in megaloblastic anemia [32].

Some parasites stimulate the immune system, leading to chronic inflammation. *Cryptosporidium* spp. triggers an immune response that leads to increased secretion of chloride and water into the intestinal lumen, causing severe secretory diarrhea [33]. *Fasciola hepatica* stimulates inflammation in the liver and biliary tract, which can lead to fibrosis of the bile ducts [34].

Parasites can affect the balance of intestinal microflora, which disrupts intestinal function and promotes bacterial infections. *Giardia lamblia* infections lead to a reduction in the population of *Lactobacillus* and *Bifidobacterium* bacteria, which complicates recovery after parasite elimination [30]. The presence of helminths, however, often increases the diversity of the microbiota, which can have both positive and negative consequences for gut health [29].

Early diagnosis of parasitic infestations is crucial for implementing effective treatment. Microscopic examination of stool remains the primary diagnostic method, enabling the identification of parasite cysts, eggs, and larvae [31]. However, its effectiveness depends on the intensity of the infection and the experience of the diagnostician. Staining methods are used to increase sensitivity, for example, the modified Ziehl–Neelsen method is effective in detecting *Cryptosporidium* spp. [32].

Immunoassays such as ELISA allow for the detection of parasite antigens in stool or antibodies in serum, which is useful in the diagnosis of *Giardia lamblia* and *Cryptosporidium* spp. [35].

Polymerase chain reaction and RT-PCR techniques demonstrate the highest sensitivity and specificity in detecting parasites, especially in cases of low infection intensity [33]. Multiplex PCR allows for the simultaneous detection of multiple pathogens and is increasingly used in the diagnosis of intestinal protozoa [32].

Challenges in prevention

The greatest challenges in parasite control are reinfections and the development of drug resistance. In endemic areas, mass deworming programs and improved sanitation are necessary [36]. Resistance to albendazole and mebendazole is becoming a problem, requiring monitoring of treatment effectiveness and potential changes to therapeutic regimens [37].

Despite significant progress in gastrointestinal parasite research, many areas still require further investigation. Particularly important directions for future research include:

- **studies into the mechanisms of parasite-gut microbiota interactions.** Previous studies indicate that parasites can alter the composition of the gut microbiota, but the precise mechanisms of these interactions remain unclear [30]. Understanding how parasites affect the gut ecosystem could help develop new therapeutic strategies based on microbiome modulation;
- **monitoring parasite drug resistance.** The increasing incidence of *Giardia lamblia* resistance to metronidazole and reports of reduced efficacy of albendazole in treating nematodes indicate the need to explore new alternative therapies [20, 37];
- **develop new therapeutic strategies, including probiotic and immunomodulatory therapies.** A growing body of research indicates that probiotics can support parasite treatment by competing for nutrients and modulating the immune response [38]. However, further clinical trials are needed to confirm the effectiveness of such therapies;
- **improve diagnostic methods and the availability of molecular testing.** Although PCR and serological tests are effective, access to these technologies is limited in many developing regions. The development of cheaper, portable diagnostic tests could significantly improve the detection of parasitic infections at the population level [32].

SUMMARY

Gastrointestinal parasites pose a significant threat to public health, particularly in developing countries, where poor hygiene and lack of access to clean water facilitate their transmission [3]. Parasitic infections lead to a wide spectrum of symptoms – from asymptomatic carriage, through chronic digestive and malabsorption disorders, to serious systemic complications [6, 28].

This paper discusses the most important groups of parasites affecting the gastrointestinal tract. The importance of early and accurate diagnosis is emphasized. Modern diagnostic methods, particularly PCR and antigen detection assays, significantly improve the sensitivity of parasite detection compared with traditional microscopy [32, 33]. Serological diagnostics (e.g., ELISA) and rapid tests (RDT) support the identification of active infections [13, 15].

In terms of treatment, albendazole, metronidazole, and praziquantel have been shown to be effective, taking into account the emerging resistance of some parasites to treatment [20, 37]. Attention has also been paid to the role of supportive supplementation and probiotic therapy in patient recovery, particularly in the case of *Giardia lamblia* infection, where restoring the microflora may reduce the risk of symptom recurrence [27, 38]. In light of the available epidemiological and clinical data, it is necessary to continue research into the mechanisms of pathogenesis and to develop more effective and accessible diagnostic and therapeutic tools.

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