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Unmasking the hidden culprits in the gut: a narrative review on the intestinal parasites

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Abstract

Background: Intestinal parasitic infections remain a major public health concern, particularly in low- and middle-income countries, where they contribute substantially to diarrhoeal disease, malnutrition, anaemia, impaired growth, and reduced quality of life. This review summarizes the epidemiology, clinical manifestations, diagnostic approaches, treatment strategies, and preventive measures for common intestinal parasitic infections.

Methods: Relevant literature, international guidelines, and recent evidence on protozoan and helminthic intestinal parasites were synthesized, with emphasis on conventional and emerging diagnostic techniques and current therapeutic recommendations.

Results: Soil-transmitted helminths and intestinal protozoa continue to affect more than one billion individuals worldwide, with children and socioeconomically disadvantaged populations bearing the greatest burden. Stool microscopy remains the cornerstone of diagnosis, while concentration techniques, permanent stains, antigen detection assays, and molecular methods, including polymerase chain reaction and loop-mediated isothermal amplification, provide improved sensitivity and specificity, particularly in low-intensity infections. Appropriate antiparasitic therapy, combined with nutritional support, sanitation, access to safe water, and health education, significantly reduces disease burden and transmission.

Conclusion: Early recognition, accurate laboratory diagnosis, prompt treatment, and integrated public health interventions are essential for controlling intestinal parasitic infections. Continued surveillance and expanded access to sensitive diagnostic technologies are critical for reducing morbidity and supporting global control efforts.

Keywords: Intestinal Parasitic Infections, Paediatric Patients, Neglected Tropical Diseases, Diarrhoea, Malnutrition, Deworming, India

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Background

Parasitism is a biological interaction between two different organisms in which one organism, the parasite, benefits at the expense of the other, the host. Parasites live on or within the host and derive nutrients essential for their survival. The three major groups of parasites of medical importance are protozoa, helminths, and ectoparasites. Parasitic infestations continue to pose a substantial public health challenge worldwide and are particularly prevalent in developing and underdeveloped countries. Nevertheless, they also represent an important health concern in developed nations due to globalization, increased international travel, migration, and the expanding international food trade [1]. Intestinal parasitic infections (IPIs) are among the oldest recognized infectious diseases affecting humans [2]. Throughout human evolution, numerous parasite species have coexisted with human populations during migration, hunting, and domestication, resulting in persistent host–parasite relationships. Today, IPIs remain major contributors to global morbidity and mortality, particularly among children living in resource-limited settings. In developing countries, infections caused by Ascaris lumbricoides, Entamoeba histolytica, Ancylostoma duodenale, and Trichuris trichiura are important causes of diarrhoeal illness, nutritional deficiencies, impaired physical growth, and developmental delay, thereby contributing substantially to childhood morbidity and, in severe cases, mortality [2].

Epidemiology and statistics related to intestinal parasitic infections

Besides being a common underlying cause of diarrhoea and dysentery, the intestinal parasites also consume the host's nutrients, often rendering the host anaemic with other nutritional deficiencies. Intestinal parasitosis doesn't just incapacitate one's health; it can also be fatal. Intestinal parasitic infections (IPIs) have a global mortality rate above 200,000 annually [3]. According to a Central Bureau of Health Intelligence (CBHI)

report, acute diarrhoeal diseases constituted the second highest number of total cases among top 5 most common communicable diseases in India, with an annual case load of 72 lakhs [4]. Another reason behind the prevalence of IPIs being comparatively higher in tropical and subtropical regions is poor maintenance of personal and environmental hygiene among the majority population [5]. It is estimated by the World Health Organization (WHO) that about 1.5 billion people of the world's population in 2021, including 267 million preschool children and 568 million school going children were infected with soil transmitted helminths like Ascaris lumbricoides, Trichuris trichiura, Ancylostoma duodenale and Necator americanus [6]. In many studies, boys tend to have a slightly higher prevalence of IPIs than girls, possibly due to more outdoor activity and greater exposure to environmental sources of infection [7].

When to Suspect an Intestinal Parasitic Infection?

Patients with IPI often develop symptoms like loose stools, abdominal pain, nausea, weakness, perianal itch and nutritional disorders such as iron deficiency anaemia, protein energy malnutrition and vitamin A deficiency, which in chronic cases may even lead to growth stunting. Infections with Ascaris can lead to intestinal obstruction, while Giardia infections are commonly associated with chronic diarrhoea and malabsorption [8]. Helminths like Diphyllobothrium latum are commonly associated with macrocytic anaemia due to vitamin B12 deficiency. Ancylostoma duodenale, Necator americanus are often associated with iron deficiency anaemia. Very often, IPIs and gastrointestinal infections due to other pathogens may show similar symptoms, thus prompting the prescription of empirical and symptomatic treatment, skipping stool microscopy. This can obscure the actual burden of intestinal parasites and the morbidity and mortality caused by them [9]. Therefore, many times IPIs go undiagnosed making the parasites hidden culprits in the gut. Blood investigation reports showing anaemia and/ eosinophilia may also indicate IPI. In a study carried out in Barcelona, an annual detection rate of 0.2 new diagnosed cases per 10,000 inhabitants per year and 1 case per 10,000 immigrants per year was found [10]. These values probably underestimate the actual burden of the IPIs because these patients were referred mainly for eosinophilia and not typical gastrointestinal symptoms [10]. In another study, a total of 18% children diagnosed with IPIs were also diagnosed with anaemia after a six-month follow-up study [13]. The proposed etiopathogenesis of anaemia in a person harboring these parasites is that intestinal parasites cause decrease in nutritional uptake, occult intestinal bleeds, destruction of RBCs in the spleen and autoimmune reactions leading to chronic inflammation thus, ultimately developing anaemia [11]. In a study, the main parasites associated with anaemia were Giardia lamblia and Strongyloides stercoralis, 23.4% of patients with IPI presented with eosinophilia and Strongyloides stercoralis was the commonly associated parasite with it [12].

How does one become vulnerable to IPIs?

Lack of education and mass awareness about hand-washing, usage of soap, washing of raw fruits and vegetables, poor sanitation in the community accelerates transmission of parasites with increased incidence of infestation with or without clinical signs and symptoms. The faeco-oral route is the most common mode of transmission for many protozoa and helminths, including Ascaris lumbricoides, Trichuris trichiura, Giardia lamblia and Entamoeba histolytica. Children ingest parasitic ova and cysts through contaminated hands, food, water, soil or surfaces. Cutaneous penetration by larvae of hookworms like Ancylostoma duodenale and Necator americanus often takes place while walking or playing barefoot in soil contaminated with faecal matter [13]. People harboring parasitic infestation sub clinically are not only at a risk of developing full-fledged symptoms later but are also a threat for the people living close to them. Children are particularly vulnerable to IPIs due to their developing immune systems, hand-to-mouth actions and high nutritional needs. Malnutrition plays a significant role in increasing the severity and prevalence of parasitic infestations. Malnourished children have a weakened immune system, which makes them more susceptible to not only acquiring the parasitic infestations, but also sustaining them chronically. Recent studies have shown a high prevalence of IPIs in children worldwide. According to a study conducted in Rwanda in 2020, the prevalence of IPIs in children aged 12 months to 59 months was 53.2% [14]. Another study conducted in Ethiopia graphically represented the trends of species specific intestinal parasitic infections from 2011 to 2020 [15].

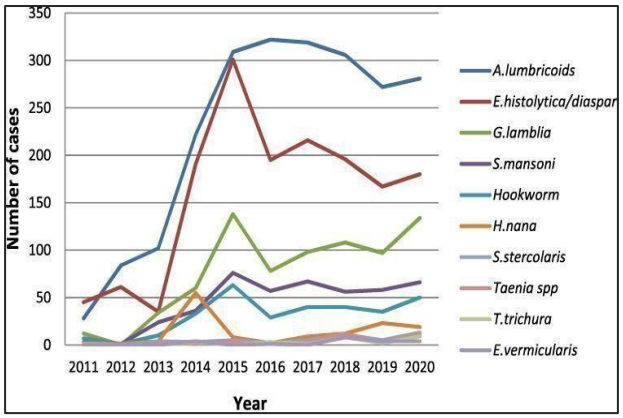

Figure1. Species trends of intestinal parasites at Grarigy Health Centre, Northwest Ethiopia, 2011–2020 [15].

In India, parasitic infections across regions creates significant hurdles in eliminating IPIs. In South India, prevalence of Necator americanus and Ancylostoma duodenale infestation is higher as compared to Trichuris trichiura and Ascaris lumbricoides [16]. However, according to a study conducted in the Kashmir valley, the prevalence of intestinal helminthic infections was in the order: Ascaris lumbricoides, Trichuris trichiura, Enterobius vermicularis and Taenia saginata [17]. The prevalence of IPIs is closely linked to socioeconomic factors such as access to clean water, sanitation facilities and nutrition. Awareness, education and hygiene practices are often the deciding factors in such routes of transmission. For example, children in rural and underdeveloped areas are at a greater risk of acquiring parasitic infections due to poor hygiene practices and unsafe water sources. In contrast, children living in urban areas with better infrastructure have a relatively lower incidence [8]. In his book Peter J. Hotez talks about bacterial and parasitic infections being the most common in third-world countries. The Neglected Tropical Diseases (NTDs) constitute a major reason for poverty in Africa, Asia and Central and South America [18].

Clinching the diagnosis

The diagnosis of IPIs in children is a critical step towards reducing morbidity and breaking the transmission cycle, especially in endemic regions. Due to the nonspecific clinical manifestations and frequent misdiagnosis, accurate laboratory confirmation is often required. The diagnostic approach involves a spectrum of methodologies, ranging from traditional microscopic techniques to advanced molecular assays.

A strategic combination of these methods improves diagnostic yield and enables species-specific detection, which is vital for effective treatment and control. The most basic yet irreplaceable diagnostic technique is routine microscopy of the stool samples. Stool samples can be visualized under a microscope in three ways: by wet mount preparation, by staining the slides and by UV fluorescence microscopy. By preparation and microscopy of wet mount, protozoan trophozoites, cysts, oocysts and helminthic eggs and larvae may be detected and identified on the basis of motility and bile staining. Trophozoites of Giardia lamblia show falling leaf like motility whereas the eggs of Trichuris trichiura appear bile stained with a mucus plug at both ends. Staining, despite inhibiting motility, is used for identification of protozoan trophozoites and cysts and for confirmation of species. Slides can be stained using temporary stains like iodine or permanent stains like Wheatley trichrome [19]. Lugol's iodine is often used to stain the smears. Iodine is one of the oldest reagents used for staining in microscopy [20]. Affinity of iodine towards glycogen is exploited for staining of trophozoites, ova and cysts of parasites [20]. Due to interaction with karyosome, axoneme and median bodies, cysts of Giardia lamblia are deeply stained brown by iodine [21]. Trophozoites of Giardia lamblia disintegrates quickly so a better way to permanently stain the trophozoites is by 1% methylene blue dye. However, it does not stain the cysts [22].

In case of Entamoeba histolytica, nuclear chromatin granules are faintly stained while karyosome is left unstained by iodine [23]. Cyclospora oocysts can be demonstrated in wet preparations using UV fluorescence microscopy in which they tend to glow pale blue [19]. This property is called autofluorescence. Using autofluorescence is one of the easiest methods for detection of Cyclospora. [19]. Another method for staining Cyclospora oocysts involves staining with safranin dye [19]. The oocysts of Cryptosporidium are difficult to stain with routine methods like trichrome, so modified acid-fast stain is used. The oocysts take up bright red stain against the green background [19]. Giardia lamblia and Strongyloides stercoralis are shed irregularly in stools. This may lead to false negative results which do not rule out the infestation [19]. Detection of parasites can be improved, thus increasing the sensitivity of the technique, by means of stool concentration methods [19]. Stool concentration techniques include sedimentation and flotation. In sedimentation, the stool sample is suspended in a solution of comparatively low specific gravity, making the ova and cysts settle down as sediment. Whereas, in flotation technique it's vice versa. Stool sample is suspended in a solution of higher specific gravity making the ova and cysts to float up [19]. Reagents used for sedimentation include formol ether and warm water (Baermann method) while those for flotation include saturated salt solution and zinc sulphate solution [19]. The common advantage of both concentration techniques is increased probability of detection of parasites. Flotation is relatively easier to perform but has a few disadvantages. Walls of ova and cysts often collapse as they float up to the surface, making identification difficult. Sedimentation is relatively difficult to perform as ova and cysts have to be scooped up from the bottom but identification is easier with this technique. Hence sedimentation is often preferred for concentration [19]. Sedimentation can be used to detect heavy eggs like those of

Ascaris lumbricoides, operculated eggs of trematodes and larvae of Strongyloides stercoralis. Flotation can be used for non-operculated eggs of trematodes like Schistosoma mansoni, cestodes and nematodes [24]. Immunoassays particularly Enzyme linked Immunosorbent Assays (ELISA) and immunochromatographic rapid tests have emerged as effective tools for detecting specific parasite antigens in stool (coproantigens). These tests are especially valuable for diagnosing protozoan infections like Cryptosporidium parvum as they tend to have very high sensitivity and specificity, lying between 93% to 100% [25]. ELISA-based antigen detection is increasingly adopted in both hospital and community-based screening due to its rapid turnaround time, reproducibility and higher sensitivity [26].

Molecular techniques such as polymerase chain reaction (PCR) and loop-mediated amplification (LAMP) are now considered gold standards for the diagnosis of low-intensity and mixed parasitic infestations. These techniques offer species-specific detection with improved sensitivity and specificity and are particularly important for distinguishing pathogenic Entamoeba histolytica from non-pathogenic Entamoeba dispar and Entamoeba moshkovskii [27]. Real-time PCR assays have been validated for detecting multiple parasites from a single sample, with studies demonstrating over 95% sensitivity for Giardia, Cryptosporidium and Strongyloides species [28,29]. Loop-mediated amplification (LAMP) assay is a recently developed technique showing promise for field-based diagnosis [30]. It is a colorimetric isothermal assay targeting various gene sequences to identify different soil-transmitted helminths [30]. A recent study using a target sequence of beta tubulin gene identified Necator americanus, Trichuris trichiura and Ascaris lumbricoides with the LAMP assay [30]. Serologic assays, including enzyme immunoassays and indirect hemagglutination, are primarily employed for the diagnosis of tissue-invading parasites like Strongyloides stercoralis which may not be detectable in stool samples due to low parasite load and irregular passage in stools. These methods though useful, tend to show cross reactivity with other parasites like Wuchereria bancrofti [31,32]. Though not routinely used for diagnosis, imaging may aid in identifying complications of parasitic infections and response to treatment. For instance, ultrasonography may reveal worm boluses in Ascaris-induced intestinal obstruction or hepatomegaly or abscess formation in Entamoeba histolytica infections [33,34].

Computed tomography is comparatively more sensitive for early abscess detection than ultrasonography [34]. An advanced diagnostic technique for parasites is DNA barcoding.[35] It involves a database comprising of more than 1400 parasite species such as Ascaris lumbricoides, Ancylostoma duodenale, Necator americanus etc. [35]. However, it cannot detect parasites without mitochondria like Entamoeba histolytica, Giardia lamblia, Cryptosporidium etc. This technique has high accuracy, sensitivity and can also be used with low parasitic load [35].

How does one protect oneself and others?

Prevention of intestinal parasitic infestations in children requires integration of behavioral, social, environmental, pharmacological and policy level interventions.

Prevention and control strategies ranging from individual to community level are required. Inadequate sanitation, unsafe drinking water and poor hand hygiene are primary transmission routes for helminths and protozoa alike. The most basic yet very effective strategy for control is WASH intervention i.e. Water, Sanitation and Hand hygiene. Improved sanitation (e.g., latrine use, sewage systems) can significantly reduce helminth infection. Regular handwashing with soap reduces the risk of IPIs significantly, especially among school-age children. Health education programs for behavioral changes, help in increasing awareness about the transmission routes, symptoms and prevention techniques. School-based health education programs involving peer education in which children and adolescents learn by discussing with peers rather than by being taught by teachers or other adults may increase hygiene knowledge thus helping in reducing incidence of infection [36]. Community-led total sanitation (CLTS) has been effective in changing open defecation behavior [37]. The WHO recommends preventive chemotherapy through mass drug administration (MDA) in areas where prevalence exceeds 20%. Single dose albendazole or mebendazole is administered annually or biannually [38].

A study conducted in West Africa showed that MDA of ivermectin with albendazole reduced the crude prevalence of hookworms from 23.9% to 5.5% in annual administration and from 12.4% to 1.9% in semiannual administration areas [39]. Single dose of albendazole 400mg can be used to limit transmission if given as community-wide MDA rather than school-based MDA [40]. Micronutrient deficiencies can exacerbate both susceptibility to and effects of IPIs. Supplementation with vitamin A, zinc and iron has been shown to boost immunity and reduce the severity of infection [41]. Incidence of giardiasis is reduced with combined therapy of Vitamin A and zinc [42]. Administration of zinc alone increases the incidence of Ascaris lumbricoides but decreases that of Entamoeba histolytica [43]. 'One health approach' is important to control transmission of zoonotic parasites such as Giardia lamblia and Cryptosporidium. This is an integrated approach involving human medicine, veterinary medicine and environmental sciences.[43] Other ways to intercept both faeco-oral as well as cutaneous transmission of parasites include soil treatment and improved sanitation to prevent environmental contamination. Programs like the WHO's Neglected Tropical Diseases (NTD) Roadmap 2030 emphasize a multi-sectoral approach combining WASH, MDA, education and nutrition thus forming an integrated, sustainable and equity-based approach. The NTD Roadmap strategizes an approach to combat neglected tropical diseases like soil transmitted helminthiasis, schistosomiasis and food borne trematodiasis [44].

What to do in case of infection?

Treatment of IPIs in children involves a parasite-specific, symptom-guided and often community-based approach. Most parasitic infestations can be cured by simple medication such as administration of anti-parasitic drugs along with anti-spasmodic drugs for alleviating both the root cause as well as symptoms like abdominal pain and cramps. Antiparasitic drugs such as Albendazole and Mebendazole are commonly used as first line single dose treatments for Ascaris lumbricoides, Trichuris trichiura and hookworms in children [41]. A single oral dose of 400mg of Albendazole in children above 2 years and 200 mg in children below 2 years is effective for ascariasis. Mebendazole can be given as an oral dose of 100 mg twice daily for 3 days or as a single oral dose of 500mg [45]. In case of Trichuris trichiura a 3-day course of 400 mg Albendazole once a day or 100mg Mebendazole twice a day or in combination with ivermectin improves outcomes [45].

Hookworms are moderately responsive to albendazole but may require repeated dosing in high-burden areas [45]. Strongyloides stercoralis requires ivermectin for 1-2 days, which is more effective than albendazole [46]. In immunocompromised children, screening may be needed to prevent hyperinfection by Strongyloides stercoralis [47]. Enterobius vermicularis is treated with a single dose of mebendazole or albendazole repeated after 2 weeks to prevent reinfestation. Household treatment and hygiene are essential to control recurrence [46]. Taenia saginata and Taenia solium infestations are treated with niclosamide or praziquantel, with attention to neurocysticercosis screening in endemic regions [45]. First-line treatment for giardiasis in children is tinidazole at 50 mg/kg single dose with food [48]. For Entamoeba histolytica, metronidazole (15 mg/kg divided into 3 doses, for 5-7 days) is followed by a luminal agent such as paromomycin or diloxanide furoate to eradicate cysts and prevent relapse [48]. In cases of Cryptosporidiosis, treatment is largely based on immune status of the patient. In immunocompetent children, nitazoxanide is effective. In malnourished or immunocompromised children (e.g., HIV-positive), supportive care along with administration of antiretroviral therapy (ART) is essential [49]. The Government of India launched the National Deworming Day program under the National Health Mission in 2015 where in Albendazole 400 mg tablets are distributed twice a year on 10th February and 10th August, to the beneficiaries which are all children of age 1 to 19 years. It is one of the largest public health initiatives in the world.

Conclusion

Acute diarrhoeal diseases rank second among the top 10 communicable diseases in India according to a CBHI report published in 2021. Infections of Ascaris lumbricoides, Entamoeba histolytica, Ancylostoma duodenale, Trichuris trichiura are particularly common in children of developing and underdeveloped countries due to poor sanitation, improper hygiene and malnutrition. Children are easy targets owing to their immature immune systems and frequent hand-to-mouth behavior along with negligence of hand washing. Delayed or misdiagnosis may lead to anaemia, growth retardation and even cognitive decline in children. Thus, mass screening and rapid diagnostic techniques are important to study the patterns of IPIs to improve interventions to prevent and control IPIs. The lab diagnosis of intestinal parasites includes a vast array of tests ranging from simple microscopy to autofluorescence, from PCR to ELISA and many recent techniques too, such as LAMP and DNA Barcoding. For the eradication of IPIs the Government of India has launched a National Deworming Programme under which Albendazole tablets of 400mg are being distributed to children aged 1-19 years on a biannual basis. It is one of the largest public health initiatives in the world.

Abbreviation

CDC	Centers for Disease Control
IPIs	Intestinal Parasitic Infections
CBHI	Central Bureau of Health Intelligence
WHO	World Health Organization
NTDs	Neglected Tropical Diseases
ELISA	Enzyme linked Immunosorbent Assays
PCR	Polymerase Chain Reaction
LAMP	Loop-mediated Amplification
FIT	Faecal Immunochemical Tests
CLTS	Community-Led Total Sanitation
MDA	Mass Drug Administration
WASH	Water, Sanitation and Hand hygiene
ART	Antiretroviral Therapy (ART)

Declaration

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Availability of data and materials
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Authors' contributions
Authors' contributions: Shubhangi Ahuja (SA) did the practical work, data analysis and drafted the manuscript. Lekha Tuli (LT) designed the study, supervised the study, conceived the idea, and curated the manuscript. Ankita Verma (AV) edited the manuscript. Nitin Tiwari (NT) edited the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate
We conducted the research in accordance with the Declaration of Helsinki. Ethical clearance was obtained from the Institutional Ethics Committee (IEC) of Autonomous State Medical College, Firozabad, -283203 (U.P.), India before the initiation of the study [Ref. No. – ASMC/IEC/PR/57 on 30/05/2025].

Consent for publication
Not applicable

Competing interest
The author declares that he has no competing interests.

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