# Parasitic Worms: A Threat to the Global World and Economy

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**Abstract:**

Parasitic worms are multicellular organisms with well-developed tissues and organs. The intensity of infection is commonly combine with the prevalence of parasitic worms. The number of eggs per gram (EPG) of feces for intestinal helminthes shows the intensity of infection. Based on EPG and their association with morbidity, they are categorize into causing light, moderate and heavy infection by the World Health Organization (WHO). Most parasitic worms show no or little effect but remain a continuous threat to the world and complete eradication of its spreading can never be meet. Thus, the neglected status of Helminthiasis should be addressee community levels and globally. For this, a detailed overview of the parasitic worms, their prevalence, the symptoms of being infected by the worms, ways of treating them and further prevention of spread of the infection is an absolute necessity.

**Keywords: Parasitic Worms, World Health Organization, Economy, Protozoans.**

**Introduction:**

An organism that lives within or on a host body and derives nutrition from them is call parasite. The parasite uses the resources of the host to maintain its own life cycle. Parasites are not diseases but have the ability to cause diseases.

The three main types of parasites are:

1. Protozoans: protozoans are single-celled organisms called the Plasmodium and they multiply within the host.

2. Helminthes: Helminths are worm parasites and most of them reside in the intestine while other parasitic worms reside in blood vessels such as the schistosomes.

3. Ectoparasites: They live outside of the host body but feed in them, like fleas and lies. In this review, we will further discuss the parasitic worms in detail, the infections caused by different types of these worms, the symptoms that they show in the body, and the possible treatments in such cases.

Parasitic worm poses a threat to global health and the economy ( **Hildersley et al.,2021**). The epidemiology of helminths and the diseases caused by it holds great importance due to its wide geographical distribution, especially different regions in Middle East, sub-Saharan Africa, Central America, South America, , Asia and the Caribbean ( **Pullan et al., 2010**). They afflict hundreds of millions of people all over the world, and their prevalence is higher in rural or developing regions. The risk is also greater in places where food and drinking water may be contaminated and sanitation is poor. Parasitic worms can affect humans and animals. Most of these parasitic worms are soil-transmitted, reside in the intestinal tract and infect the gastrointestinal tract of the host. Parasitic worms feed in the living host and derive nutrition from them. They absorb nutrition from the host but disrupt the ability of the host to absorb nutrients making them feel weak with painful, disfiguring and debilitating diseases. The parasitic worms, also known as the helminthes, cannot reproduce completely within the host body; some stages of the life cycle need to take place outside the body of the host. Helminths have the ability to manipulate the hosts'

immune response by secreting immunomodulatory products and thus can survive inside the host body for several years ( **Maizels et al.,2018**). The lifetime of the worms varies from one species to another, but generally ranges from 1−8 years. Figure 1 shows the lifecycle of a well−described helminthes.

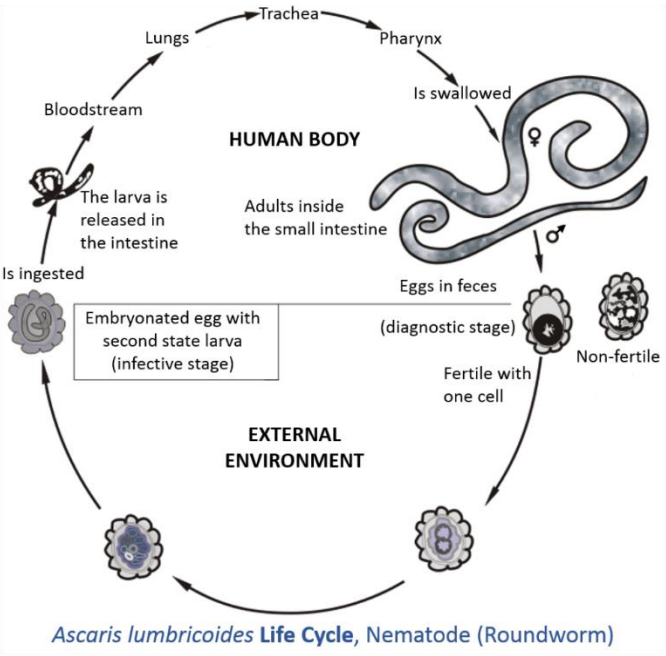


**Figure 1: Life cycle of *Ascaris lumbricoides***

**Prevalence and incidence of worm infections:**

The social and economic condition of an individual is an important factor in the prevalence of parasitic infections according to the research all over the world. Poor sanitization and environmental conditions are also important factors which play a role in the spread of the infections ( **Çeliksöz, et al., 2005& Téllez et al., 1997** ). Table: 1 below shows the distribution of different helminths all over the world ( **Abdeltawabi et al.,2017** ).

**Table 1: Human Helminthiasis and its prevalence.**

| Helminthiasis | Region |
|---|---|
| **Ascariasis *Ascariasis lumbricoides* (roundworm)** | Asia, Africa and Latin America. |
| **Trichuriasis *Trichuris trichiura (whipworm)*** | Asia, Africa and Latin America. |
| **Hookworm *Necator americanus;Ancylostoma duodenale*** | Asia, Africa and Latin America. |
| **Strongloidiasis *Strongyloides stercoralis* (threadworn)** | Asia, Africa and Latin America. |
| **LF *Wuchereria bancrofti; Brugia malayi*** | India , Southeast Asia and Sub-Saharan Africa |
| **Onchocerciasis (river blindness) *Onchocerca volvulus*** | Sub-Saharan Africa |
| ***Loiasis Loa loa*** | Sub-Saharan Africa |
| **Dracunculiasis (guinea worm) *Dracunculus medinensis*** | Sub-Saharan Africa |
| ***Schistosomiasis Schistosoma haematobium*** | Sub-Saharan Africa |
| ***Schictosoma mansoni*** | Sub-Saharan Africa and Eastern Brazil |
| ***Schistosoma japonicum* (blood flukes)** | China and Southeast Asia |
| ***Clonorchis sinensis* (liver fluke)** | Developing regions of East Asia |
| ***Opisthorchis viverrini* (liver fluke)** | Developing regions of East Asia |
| ***Paragonimus spp.* (lung flukes)** | Developing regions of East Asia |
| ***Fasciolopsis buski* (intestinal fluke)** | Developing regions of East Asia |
| ***Fasciola hepatica* (intestinal fluke)** | Developing regions of East Asia |
| **Cysticercosis Taenia solium(pork tapeworm)** | Sub-Saharan Africa and Sub-Saharan Africa |

One of the most common infections all over the world is the intestinal infections. Approximately 3.5 billion people are affected all over the world and 450 million people have moderate to severe symptoms of the infection and the majority of them are children. The intestinal parasitic infections are globally endemic and are also worldwide cause of morbidity and mortality. The prevalence of these infections is higher in developing countries due to improper personal hygiene and poor sanitary conditions. Other factors that influence the prevalence of infection are illiteracy, contaminated source of drinking water, poverty, tropical hot and humid weather etc. Parasitic infections are rare in the United States and are only seen in places where cattle and people are concentrated, sanitization is poor and places where immigrants stay. These infections are prevalent in China, Korea, Taiwan, Indonesia, and Thailand where there is a practice of eating raw and undercooked fish, meat, and vegetables. The prevalence of fluke infections is maximum in the monsoon season and minimum in winter and higher in semi-arid regions than in arid regions. Ascariasis is the most common helminth infection **(Figure 2)** ( **Kumar et al., 2014)** that is prevalent in children from tropical and developing countries ( **Wright et al., 2018)**. The use of untreated feces as fertilizers, soil contamination by human faeces, contaminated food and water are the main source of ascariasis.

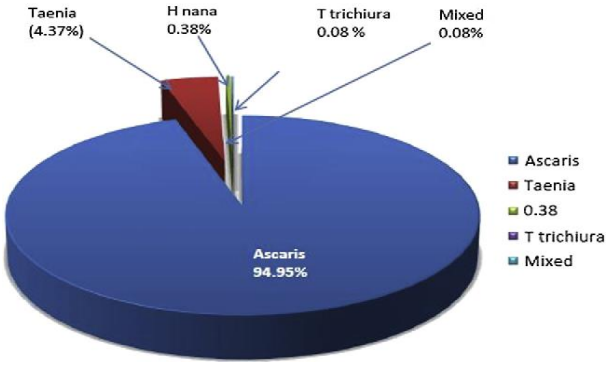

**Figure 2. Relative prevalence of intestinal parasites in the northern part of India, which is highly endemic for parasitic worm infections.**

**Table 2 below depicts the prevalence of parasitic infection by sex and age in the northern parts of India and Table 3 shows the monthly prevalence of infection ( Kumar et al., 2014).**

| Age in years | Total Sample | Male Positive | % | Total Sample | Female Positive | % | Total Sample | Total Positive | % |
|---|---|---|---|---|---|---|---|---|---|
| 0–09 | 4 | 3 | 75.00 | 2 | 2 | 100.00 | 6 | 5 | 83.33 |
| 10–19 | 9 | 4 | 44.44 | 8 | 3 | 37.50 | 17 | 7 | 41.18 |
| 20–29 | 1170 | 706 | 60.34 | 41 | 29 | 70.73 | 1211 | 735 | 60.69 |
| 30–39 | 1006 | 427 | 42.45 | 14 | 6 | 42.86 | 1020 | 433 | 42.45 |
| 40–49 | 457 | 162 | 35.45 | 6 | 2 | 33.33 | 463 | 164 | 35.42 |
| >50 | 10 | 3 | 30.00 | 5 | 2 | 40.00 | 15 | 5 | 33.33 |
| Total | 2656 | 1305 | 49.13 | 76 | 44 | 57.89 | 2732 | 1349 | 49.38 |

**Table 3: Intestinal parasite prevalence in different seasons.**

| SN | Season | Total Sample | Total Parasite | Prevalence ratio |
|---|---|---|---|---|
| 1 | Monsoon | 785 | 370 | 47.1 |
| 2 | Autumn | 389 | 313 | 80.5 |
| 3 | Winter | 521 | 275 | 52.7 |
| 4 | Spring | 472 | 207 | 43.9 |
| 5 | Summer | 565 | 284 | 50.3 |

**Types of parasitic worms:**

The three main types of parasitic worms are Tapeworms (Cestodes), roundworms (Nematodes) and Flukes (Trematodes) ( **Baron S,1996**). Tapeworms and flukes are hermaphrodite while roundworms have their sex-differentiated.

**Tapeworms:** Tapeworms are flat, segmented parasitic worms that generally look like long white ribbons. They can be as long as 80 feet and can live in a human for up to 30 years (**Hepato,2008**). Tapeworms embed their head into the intestinal wall and from there certain types of worms can produce eggs that mature into larvae that can migrate to the rest of the body. People can develop tapeworms from raw or undercooked meat from a contaminated animal or contaminated water with tapeworm eggs or larvae. The estimated number of species of tapeworm is 6000 of which 40 are known to infect humans ( **Lamothe & Prieto,1988**).

**Flukes or flatworms:** Flukes are parasites of various mammals including humans. Flukes are another type of flatworms that infect animals more than humans. They are hermaphrodites, that is they complete set of both the male and female reproductive systems. Freshwater plants like watercress are the main source of flukes in humans and they can also get infected from contaminated water ( **Bermejo et al.,2019**). After ingestion,

liver flukes move from intestines to bile ducts in the liver, live, and grow in the liver. They have a complex life cycle requiring two-three different hosts, with a free-living larval stage in water. The adult parasites can live for 20-30 years. 4-6 months after settling in the bile ducts, they start producing eggs which are carried to the intestine ( **Tarrytown,2008**). The estimated number of species is less than 15,000 of which 16 are known to infect humans ( **Phiri et al.,2000**).

Some of the clinically significant pathogenic liver flukes are: *Fasciola* species (*hepatica and gigantica*), *Clonorchis sinensis*, and various *Opisthorchis* species (*viverrini, felineus*). The intestinal flukes that infect humans are *Metagonimus yokogawai, Fasciolopis buski, Heterophyes heterophyes.* Genus *Paragonimusare* has eight pathogenic species that cause disease in humans. The most prevalent is *P. westermanii* and it is endemic to the Far East ( **Chai et al.,2007**).

**Roundworms**: Roundworms, as the name indicates have a long and round shaped body. They vary in length from a few mm to up to 2 m. Children are more prevalent to the infection than adults and it occurs more commonly in the warm tropical countries. They usually reside in the human gut. However, often they can move from the gut to other parts of the body. The larvae and eggs of roundworms are often found in infected stool and soil. Roundworms need the body of a host to mature into egg-laying adults ( **Keiser et al.,2020**). They often enter the body through the mouth by touching soil or poop infected with its larvae and not washing hands and can enter the body through the skin. Hookworms and Pinworms are the most common forms of roundworms. Pinworms are comparatively harmless but roundworm infections can cause severe diarrhea, abdominal pain and fever. There are less than 25,000 registered species of

roundworms of which 12,000 are known to infect humans ( **Maizels et al.,2018** ).

**Pathophysiology of parasitic worms:**

The symptoms that generate after an infection caused by a parasitic worm can vary from no symptom to very mild, mild to severe, and even sometimes fatal ( **Acka et al.,2010** ). The most common symptoms are loss of weight and appetite, weakness, fever, fatigue, nausea, diarrhea, abdominal pain.

In addition to these symptoms, some may develop other symptoms which are specific to the type of parasitic worm infecting an individual.

**Symptoms specific to tapeworm infections:**

The symptoms specific to tapeworm infection include inflammation of the intestine, Vitamin B12 deficiency in some cases, malnutrition, dizziness, convulsions, altered appetite and vomiting. Some other complications caused by tapeworm infections are: *Cysticercosis:* Ingestion of a pork tapeworm egg can cause infection as the larvae move from the intestine tp infect other tissues or organs causing lesions and cysts ( **García et al.,2003**).

*Neurocysticercosis:* This is also caused due to tapeworm infection from pork. It severely affects the nervous system and different parts of brain causing symptoms like headache, meningitis, vision problems. In very severe cases it also fatal ( **Nash,2011**).

*Echinococcosis, or hydatid disease:* In this case, the larvae infect different organs after leaving the gut. The most commonly affected organ is the liver. The infection can be manifested as large cysts that pressurize neighbouring blood vessels and affecting blood circulation. In severe cases patient may need to resort to surgical intervention or liver transplantation.

**Symptoms specific to fluke infections:**

The common symptoms of a liver fluke infection include enlarged liver, jaundice, nausea, vomiting, fever, hives, malaise, weight loss, decreased appetite, abdominal pain, constipation, itching of the skin, intolerance towards fatty foods. Some complications can arise due to severe fluke infection. These are stone formation, pancreatitis, and repetitive infection of the biliary system leading to bile duct cancer (cholangiocarcinoma), liver fibrosis. Liver flukes can sometimes also infect the walls of the intestine, lungs, skin, or throat ( **Alama et al.,2019**).

**Symptoms specific to roundworm infections:**

*Ascariasis:* This may not have any symptoms, but sometimes they may show symptoms like restlessness, cough, asthma, vomiting, disturbed sleep, severe abdominal pain, wheezing, malnutrition and delay of growth ( **Bharti et al.,2018**).

*Infection from hookworm:* This also may not show any symptoms but if they do, it includes anemia, colic (a lot of crying and fussiness in a healthy baby), nausea, diarrhea, severe abdominal cramps.

*Infection from pinworm:* It also has mild to no symptoms at all, the mild symptoms being itching around the anus and vagina, which becomes intense when the pinworm lays eggs.

*Strongyloidiasis:* Mild infection may develop symptoms like burning in the abdomen, nausea and vomiting, rounds of diarrhea and constipation while severe symptoms include anemia, chronic diarrhea and weight loss ( **Ganesh & Cruz,2011**).

*Trichinellosis:* Mild symptoms include diarrhea and stomach cramp and when trichinosis enters the muscles it causes eye infection, rashes, high fever, swelling of eyes and face, muscle pain and body aches ( **Gottstein & Nöckler,2009**).

*Infection from whipworm:* Only severe infection can show symptoms like bloody stool, diarrhea, weight loss, anemia, stomach pain.

In rare ocassion, roundworms can cause a severe illness. For example, large numbers of worms can block the gut. In some people, roundworms can severely affect the pancreas or liver or can be the cause of onset of serious allergic reaction.

**Diagnosis of parasitic worms:**

The parasitic worms can be diagnose by a simple fecal test, blood tests, and different kinds of imaging. However, there are tests specific to each type of these parasitic worms by which the infection can be diagnose.

***Diagnosis of tapeworms:***

1. Stool test: For diagnosis of intestinal infection, stool is take for microscopic examination of the presence of eggs or segments of tapeworm in feces. Because the eggs or the body segments are passe with stool in intervals, two to three samples might be required to detect the parasite in time intervals. Eggs are sometimes present at the anus, so, a piece of transparent adhesive tape may be presses to the anus eggs are collected for microscopic identification. This is called the tape test ( **García et al.,2003**).
2. Blood tests: For tissue invasive infection, presence of antibodies may denote tapeworm infection.
3. Imaging: Certain types of imaging, such as Xrays, CT or MRI scans, or ultrasounds of cysts, may suggest invasive tapeworm infection.

***Diagnosis of flukes:***

1. Blood tests: The presence of antibodies specific to flukes helps in identifying the disease. Raise in the count of White Blood Cells also denote the presence of an infection in the body.

2. Stool test: A stool test is due to trace the presence of fluke eggs in the stool.
3. Imaging: Different imaging techniques like magnetic resonance imaging (MRI), cholangiography, computed tomography (CT) endoscopic retrograde cholangiopancreatography (ERCP), and can be used to detect any damage caused to the liver and bile duct. Sometimes endoscopy is also done from the mouth to the stomach to diagnose liver fluke infections.

***Diagnosis of roundworms:***

1. Worms from body openings: In case of heavy infestations, worms can come out from mouth or nostrils with cough or with vomiting. In such a case, taking the worm to the clinician for identification can be done ( **Lamberton,2015**).
2. Stool test: Mature female worms lay eggs in the intestine, which can travel through the digestive system and thus be found in the stool. However, the eggs need a minimum of 40 days to be able to identify in the stool and infection with male worms cannot be diagnose from a stool test.
3. Blood test: An increase in the count of White Blood Cells denote infection but cannot specify the type of infection for which the count increases.
4. Imaging: Upon infection, worms can be visible in the X-ray of the abdomen; a chest X-ray also can reveal the presence of larvae in the lungs. An ultrasound also shows the presence of larva in the pancreas or liver where sound waves are send to create images of internal organs. CT scans and MRI can also be done to get a detailed image of the internal structures and detect worms that are blocking ducts in the liver or pancreas.

**Treatment :**

Medication is the most common way to treat any kind of parasitic worm infection but the type of treatment depends on the species that have caused the infection and the site of infection.

*Treatment for tapeworms*

Most tapeworm infections do not need treatment as they are eliminate from the body by themselves. Some do not even realize that they are infecte, as they do not generate any of the symptoms. Upon diagnosis, the most commonly used oral medications are 1. Praziquantel, 2. Albendazole, and 3. Nitazoxanide for intestinal infections ( **Lloyd et al.,2014**). Treatment of invasive infection depends on location of infection and its severity. Treatments generally done are:

1. Anthelmintic drugs shrink the tapeworm cysts and this can be diagnose by imaging to see if the drug is effective.
2. The dying tapeworms can cause swelling in tissues or organs and thus the doctor can prescribe anti-inflammatory therapy / corticosteroid medication like prednisone or dexamethasone. In case of seizures, anti-epileptic medication is required.
3. Some invasive infections cause fluid accumulation in the brain, which is hydrocephalus. A permanent tube or shunt is place in the head to drain off the fluid in such cases.
4. Cysts in the eyes, lungs, liver are remove by surgery. Sometimes drainage tube are an alternative to surgery to allow through washing off the area with anti-parasitic solutions.

***Treatment for flukes:***

The drug praziquantel is the first-line therapy for all intestinal flukes and Paragonimus infections ( **Chai,2013**). The drug causes spastic paralysis and disintegration of the worms. For cerebral disease, a course of

corticosteroid may be given with praziquantel to avoid inflammatory response to the body. Triclabendazole and nitazoxanide is the drug of choice for fascioliasis. Surgery is sometimes required for complications like cholangitis, where the bile duct is blocked ( **Alama et al.,2019**).

***Treatment for roundworms:***

The most common type of roundworm infection affecting humans is Ascariasis. Medication is the primary treatment for ascariasis infection. The most common anti-parasitic medications are Albendazole, Ivermectin, and Mebendazole ( **Lloyd et al.,2014**). Medication if taken for two-three days generally kills the adult worms. Rarely do Ascaris worms because any blockage but intestinal blockage or bile duct blockage, and appendicitis are complications that may require surgery.

**Preventive measures towards parasitic worms**

***Tapeworms:***

- ✓ Avoid raw fish and meat.
- ✓ Thoroughly cook fish and meat as the heat helps in killing the pathogen.
- ✓ Freeze the meat to −4 °C for 24 h before cooking to kill the eggs.
- ✓ Wash hands properly before cooking or eating food.
- ✓ When traveling to different places always use chemically treated water to wash fruits and vegetables.

***Flukes:***

- ✓ Avoid eating raw watercress or other water plants from areas where sheep or cattle may be infected.
- ✓ Thoroughly washing and cooking freshwater fish or shrimp to avoid liver fluke infection.
- ✓ Avoid smoked, pickled, uncooked fish or raw vegetables from endemic areas.

- ✓ Avoid food and water from places with poor sanitization while traveling.
- ✓ Freezing fish at −4 °C for 7 days helps kill the pathogen.

***Roundworms:***

- ✓ Do not eat raw fruits and vegetables from areas with poor sanitization and avoid eating the raw or undercooked meat.
- ✓ Drinking packaged water while traveling to places.
- ✓ Cleaning up pets' poop and encouraging children not to play in those areas.
- ✓ Washing off hands properly after any outdoor activities.
- ✓ Teaching children not to play with dirt or soil.
- ✓ Maintain good hygiene.

**Conclusion:**

Changes have come in several countries due to the efforts made in identifying, treating, and preventing the diseases caused due to parasitic worms. However, some negative circumstances that influence the problem are climate changes, wars, illiteracy and poverty. Long-term control measures can improve the sanitary and living conditions like provision of a hygienic environment, treatment of infected individuals and supply of clean water and food. Health education program can further enhance the impact of these control measures. These programs encourage reduction in water, food, and soil contamination and morbidity. With an existing understanding on the ecology of helminths and the available low-cost drugs; the goal to reduce helminthiasis is achievable.

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## الديدان الطفيلية: تهديد للعالم والاقتصاد العالميين

**الملخص:**

الديدان الطفيلية هي كائنات متعدّدة الخلايا ذات أنسجة وأعضاء متطورة، عادة ما يتم الجمع بين شدّة العدوى وانتشار الديدان الطفيلية حيث يوضح عدد البيض لكل جرام من البراز للديدان المعوية شدة الإصابة ومدى ارتباطها بالمرض، وتم تصنيفهم إلى التسبب في عدوى خفيفة ومتوسطة وثقيلة من قبل منظمة الصحة العالمية، لا تظهر معظم الديدان الطفيلية أي تأثير أو تُظهر تأثيرًا ضئيلًا ولكنها تظل تهديدًا مستمرًا للعالم ولا يمكن أبدًا القضاء على انتشارها تمامًا.

وبالتالي يجب أن تكون الحالة المهملة لداء الديدان الطفيلية على مستوى المجتمع المعني وعلى الصعيد العالمي، لهذا فإنّ نظرة عامة مفصلة عن الديدان الطفيلية ومدى انتشارها، وأعراض الإصابة بالديدان، وطرق علاجها والمزيد من الوقاية من انتشار العدوى هي ضرورة مطلقة.

**الكلمات المفتاحية:** الديدان الطفيلية، منظمة الصحة العالمية، الاقتصاد، البروتوزوا.