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World Wide Epidemiology of Helminths Infection

Mohamed S. Abdeltawabi, Nahla El Seddik and
Hosni K. Salem

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Abstract

Helminths (from the Greek Helmins, meaning worm) include three groups of parasitic worm, large multicellular organisms with complex tissues and organs. Helminths do not replicate within the human host except *Strongyloides stercoralis*. Prevalence is commonly combined with worm burden (intensity of infection), which is commonly measured by the number of eggs per gram (EPGs) of faeces for intestinal helminths and schistosomes. Based on EPGs and their association with morbidity, individuals are classified into categories of light, moderate and heavy infection by the WHO. In the case of soil-transmitted helminths, the WHO recommends use of both prevalence and intensity of infection to classify communities into transmission categories—category I (high), category II (medium), and category III (low). The neglected status of the helminthiasis should be addressed on community levels and globally all over the world.

Keywords: epidemiology, helminths, infection, trematodes, cestodes, nematodes

1. Introduction, key determinants underlying the epidemiology of helminths infections

Helminths are worm-like parasites so they are commonly known as parasitic worms. They are classified mainly according to the morphology of the different stages; egg, larval and adult stages externally and internally [1].

Sexually, helminths have hermaphroditic species such as tapeworms and flukes except blood flukes. There also bisexual species like roundworms, the most common group worldwide is nematodes [1].

There are main three categories of helminths: trematodes (flukes), cestodes (tapeworms) and nematodes (roundworms) [1].

Studying epidemiology of helminths is highly important because they have a wide geographical distribution in different regions especially in sub-Saharan Africa, South America, Central America, Middle East, the Caribbean and Asia [2].

In 1998, the WHO Collaborating Centre for the Epidemiology of Intestinal Parasites at University of Oxford and WHO launched Global Atlas of Helminth Infections (GAHI) which is an initiative aimed at collating the available survey data as both a database and graphical tool (www.thiswormyworld.org) [2].

Based on GAHI, data collected between 1998 and 2010, on prevalence of helminths infections. Some data were collected older than these dates if no available data for a particular country.

Some countries were excluded based on their socioeconomic levels. And also three countries were excluded according to the comprehensive control such as Mauritius, Maldives and Mayotte. Seven countries in Oceania had no data, so they were assigned mean prevalence based on the regional data. Also eight countries had no data were assigned mean prevalence based on data of neighbouring countries with similar eco-epidemiological situation such as Georgia, Iraq and Turkmenistan data from Iran; Algeria data from Morocco; Syria and Tunisia data from Turkey; PDR Korea from Jilin Sheng (A province in China); and Timor Leste from Indonesia [2, 3].

Table 1 shows the distribution-prevalence of different helminths all over the world.

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

Table 1. The prevalence of human helminthiasis.

2. Epidemiology of trematodes (flukes)

2.1. Fasciola

They are highly distributed worldwide, and their reservoir hosts are not the human.

There are four species of Fasciola:

- *Fasciola hepatica*: It is found all over the world even in countries with high socioeconomic levels such as the USA and Europe. The unwashed watercress which is contaminated by the excreta of sheep is the mode of infection by eating it. It mainly affects the liver.
- *Fasciola gigantica*: It is found in Africa, Eastern Asia and Hawaii. Eating raw vegetables contaminated by the excreta of cattle and some mammals is the mode of infection. It mainly affects the liver.
- *Fasciolopsis buski*: It is found with high distribution in Far East and Indian Subcontinent especially Taiwan, Thailand, India and Bangladesh. Eating unwashed vegetables contaminated by human excreta or excreta of some pig mammals is the mode of infection. It mainly affects the intestine.
- Echinostoma species: They are found in South East Asia like Philippines and also in Japan. The mode of infection is ingestion of fresh water snails containing metacercaria. They mainly affect the intestine [1, 4].

2.2. Paragonimus westermani

It is a lung fluke which is found in South America and Eastern Asia. Eating raw seafood is the mode of infection. It mainly affects the lung and presents there encapsulated [1, 4].

2.3. Schistosomes

They are blood-dwelling trematodes. They have separate sexes.

It is estimated that 250 million people infected with Schistosomiasis by its major types: mansoni, haematobium and japonicum, more than 90% of them are in sub-Saharan Africa.

Also 500 million or more people are exposed to infection. The mode of infection is penetration of skin by cercaria. They mainly affect liver, lung, intestine and bladder.

There are three major species of Schistosomes:

- *Schistosoma haematobium*: It is found in Africa, Middle East and India. It affects the urinary tract.
- *Schistosoma mansoni*: It is found Central and West Africa, Egypt, Brazil, the Arabian Peninsula, Surinam, Venezuela, Madagascar and the West Indies. It affects the intestine and the liver. Also the infection starts with Katayama fever.
- *Schistosoma japonicum*: It is found in China, Japan, Indonesia and the Philippines.

There are also another two species but they have the same symptoms like *Schistosoma mansoni*:

- *Schistosoma intercalatum*: It is found in Central and West Africa.
- *Schistosoma mekongi*: It is found in Mekong River basin in Southeast Asia [1, 4].
- **Figure 1** showing the current global distribution of schistosomiasis worldwide [5].



Figure 1. Map of the current global distribution of schistosomiasis. Source: US Centers for Disease Control and Prevention, <<http://wwwnc.cdc.gov/travel/yellowbook/2012/chapter-3-infectious-diseases-related-to-travel/schistosomiasis#2696>> [5].

2.4. The oriental liver flukes

They are found in the Far East and Europe. The mode of infection is eating raw fish. They affect the liver.

There are three main species: *Clonorchis sinensis*, *Opisthorchis felinus* and *Opisthorchis viverrini* [4].

2.5. *Heterophyes heterophyes*

It is found in the Far East. The mode of infection is eating raw or pickled fish. It affects the small intestine [1].

2.6. *Metagonimus yokogawai*

It is found in the Far East. Eating raw or pickled fish is the mode of infection. It affects the small intestine [1].

Table 2 showing the diseases caused by flukes in the bile duct.

	Clonorchiasis	Opisthorchiasis	Fascioliasis
Parasite	<i>Clonorchis sinensis</i>	<i>Opisthorchis felineus</i>	<i>Fasciola hepatica</i>
Other mammalian hosts	Dogs, cats, pigs	Dogs, cats, foxes, pigs	Sheep, cattle
Mode of spread	Ova in faeces, water	As for <i>C. sinensis</i>	Ova in faeces on to wet pasture
1st intermediate host	Snails	Snails	Snails
2nd intermediate host	Freshwater fish	Freshwater fish	Encysts on vegetation
Geographical distribution	Far East, especially S. China	Far East, especially NE Thailand	Cosmopolitan, including UK
Pathology	<i>E. coli</i> cholangitis, abscesses, biliary carcinoma	As for <i>C. sinensis</i>	Toxaemia, cholangitis, eosinophilia
Symptoms	Often symptom-free, recurrent jaundice	As for <i>C. sinensis</i>	Unexplained fever, tender liver, may be ectopic, e.g. subcutaneous fluke
Diagnosis	Ova in stool or duodenal aspirate	As for <i>C. sinensis</i>	As for <i>C. sinensis</i> , also serology
Prevention	Cook fish	Cook fish	Avoid contaminated watercress
Treatment	Praziquantel 25 mg/kg 8-hourly for 2 days	As for <i>C. sinensis</i> but for 1 day only	Triclabendazole 10 mg/kg single dose; repeat treatment may be required

Table 2. The diseases caused by flukes in the bile duct.

3. Epidemiology of Cestode (tapeworms)

Table 3 shows the prevalence of human Cestodiasis around the world.

Adult Cestodiasis of Mankind		
Scientific name	Site of infection	Distribution
<i>Diphyllobothrium latum</i>	Small intestine	Argentina, Europe, Japan, Siberia, Great Lakes area, the USA
<i>Taenia saginata</i>	Small intestine	Everywhere
<i>Taenia solium</i>	Small intestine	Everywhere
<i>Hymenolepis nana</i>	Small intestine	Everywhere

Table 3. The prevalence of human Cestodiasis (tapeworms).

3.1. *Taenia* species

They are the most common cestodes infect humans. They affect the intestine especially the duodenum.

There are two species of *Taenia*:

- *Taenia saginata*: It has a cosmopolitan distribution, but is more commonly found in developing countries due to poor socioeconomic levels and bad hygiene. The mode of infection is eating improperly cooked beef.
- *Taenia solium*: It is almost not present in the USA and Europe. The mode of infection is eating improperly cooked pork [6].

3.2. Hymenolepididae

They have a cosmopolitan distribution. The mode of infection by them is eating raw vegetables. They affect the small intestine.

There are four species of Hymenolepididae:

- *Hymenolepis nana*: It is thought to be the most common Cestode in the world. It affects children more than adults.
- *Hymenolepis diminuta*: It has a cosmopolitan distribution but it is found infrequently in humans.
- *Hymenolepis microstoma* and *Hymenolepis citelli*: They have been used extensively for studies on Cestodes [6].

3.3. Diphyllbothriidae

There are three species of Diphyllbothriidae:

- *Diphyllbothrium latum*: It has a cosmopolitan distribution but it is found mostly in countries bordering the Baltic Sea in Europe. The mode of infection is eating raw fish. It affects the small intestine.
- *Diphyllbothrium dendriticum* and *Diphyllbothrium ditremum* are mainly parasites of fish-eating mammals and birds [7].

3.4. Dipylidium caninum

Rarely, human is infected with *Dipylidium caninum*. Almost all reported cases are children. The mode of infection is eating raw vegetables. It affects the small intestine [7].

3.5. Larval cestodes

- *Echinococcus granulosus*: It is a larval stage of dog cestode. It causes Echinococcosis which is also known as hydatid disease due to development of hydatid cysts. These cysts can be located in the liver, the lung, the brain and the kidney. This disease is found commonly in Africa, the Middle East, South America and Australia. The mode of infection is eating raw vegetables.

- *Echinococcus multilocularis*: It is found in Europe, in the highlands like Switzerland, and also it is found in Alaska and Canada. The mode of infection is eating raw vegetables. Cysts are formed in the liver but they can later be located in the lung or the brain.
- *Multiceps multiceps*: It has a cosmopolitan distribution but mainly presents in the UK and the USA. The mode of infection is eating raw vegetables. Cysts are formed and located mainly in the spinal cord, the brain and the subcutaneous tissue [6].

4. Epidemiology of nematodes (roundworms)

Table 4 shows the prevalence of nematodes around the world.

Disease	Major etiologic agent	Global prevalence	Regions of highest prevalence
Soil-transmitted nematodes			
Ascariasis	<i>Ascariasis lumbricoides</i> (roundworm)	807 million	Developing regions of Asia, Africa, and Latin America
Trichuriasis	<i>Trichuris trichiura</i> (whipworm)	604 million	Developing regions of Asia, Africa, and Latin America
Hookworm	<i>Necator americanus</i> , <i>Ancylostoma duodenale</i>	576 million	Developing regions of Asia, Africa, and Latin America (especially areas of rural poverty)
Strongyloidiasis	<i>Strongyloides stercoralis</i> (thread worm)	30–100 million	Developing regions of Asia, Africa, and Latin America (especially areas of rural poverty)
Filarial nematodes			
LF	<i>Wuchereria bancrofti</i> , <i>Brugia malayi</i>	120 million	Developing regions of India, Southeast Asia, and sub-Saharan Africa
Onchocerciasis (river blindness)	<i>Onchocerca volvulus</i>	37 million	Sub-Saharan Africa
Loiasis	<i>Loa loa</i>	13 million	Sub-Saharan Africa
Dracunculiasis (guinea worm)	<i>Dracunculus medinensis</i>	0.01 million	Sub-Saharan Africa

Table 4. Global prevalence of nematodes (roundworms).

4.1. *Ascaris lumbricoides*

It is the largest intestinal nematodes found in humans. It has a cosmopolitan distribution, but it is more common in tropical and subtropical zones. The mode of infection is eating of raw vegetables. It affects the intestine and the lung [8].

4.2. Hookworm species

They are considered most destructive parasitic helminths infect human. Penetration of skin by Filariform larva is the mode of infection.

- *Necator americanus*: It is a New World hookworm. It is found in Far East, Asia, Africa, South America, and Oceania. It affects the small intestine.
- *Ancylostoma duodenale*: It is an Old World hookworm. It is found in the Middle East, North China, Europe, the Mediterranean countries, Africa, Asia and South America. It affects the small intestine.
- Cutaneous Larva migrans (*Ancylostoma braziliense* or *Ancylostoma caninum*): The mode of infection is contacting with hookworms larva of the dog or cat. They affect the skin [8].

Figure 2 showing the life cycle of *Ancylostoma*.

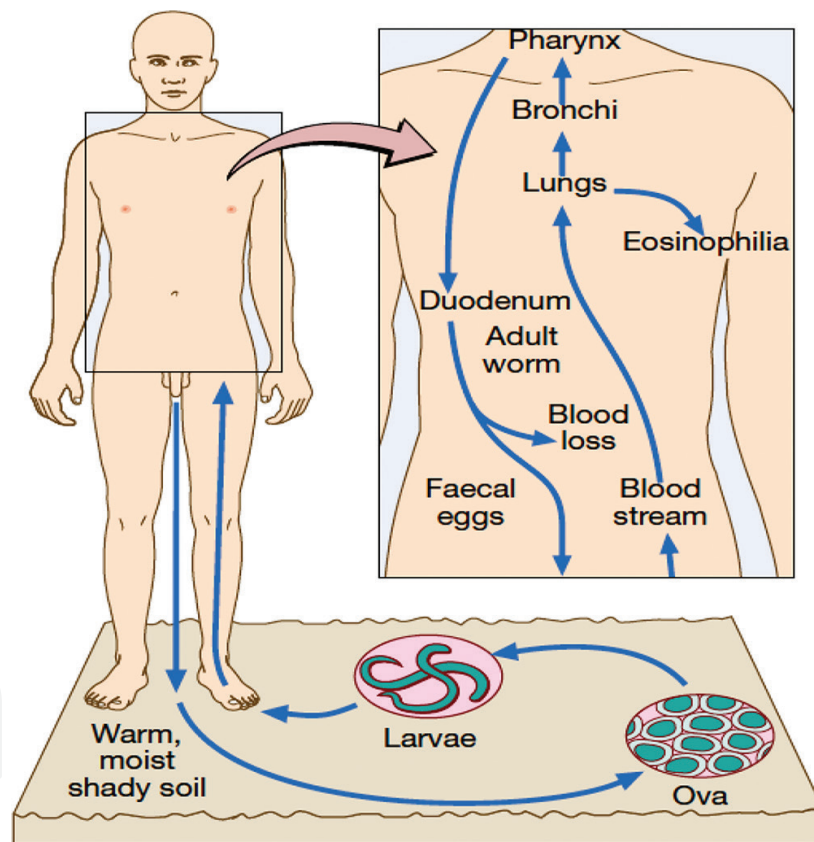


Figure 2. The life cycle of *Ancylostoma*.

4.3. *Trichuris trichiura*

It is known as the whipworm. Children are most commonly affected. It is found in tropical zones with poor sanitation. The mode of infection is eating raw vegetables. It affects the caecum and the upper part of the colon [1].

4.4. *Strongyloides stercoralis*

It is found in sub-tropical zones. Most of the 52 species of *Strongyloides* do not infect humans. *S stercoralis* is the most common human pathogen. Other species include *S myopotami* and *S procyonis*. These species have animal hosts and are thus responsible for zoonotic infections. Infections are initiated when exposed skin contacts contaminated soil. Autoinfection commonly occurs allowing infection to persist decades. Hyperinfection is typically triggered by drug-induced or disease-associated defects in cellular immunity, which allows a massive increase in parasite burden and dissemination to nearly all organ systems [9].

4.5. *Angiostrongylus (Parastrongylus) cantonensis*

It is also known as the rat nematodes. It is found in the Pacific areas, Central America and Cuba. The mode of infection is eating raw vegetables. It causes eosinophilic meningitis [1].

4.6. *Angiostrongylus (Parastrongylus) costaricensis*

It is found mainly in Costa Rica, but also some cases have been reported in Mexico, Central and South America. The mode of infection is eating raw vegetables. It affects the bowel wall [1].

4.7. Anisakiasis

It is found in Netherlands, North America, Canada, Chile, and the UK with the increasing spread of popularity of 'sushi'. There are two species causing human anisakiasis: *Anisakis simplex* and *Pseudoterranova osculatum*. The mode of infection is eating raw fish. It affects the intestine [1].

4.8. *Gnathostoma spinigerum*

It is found in Japan, China, the Far East and the Philippines; the mode of infection is eating raw freshwater fish. It affects the intestine and the cutaneous tissues [1].

4.9. *Trichinella spiralis*

It has a cosmopolitan distribution, and it is most commonly found in China and Europe. The mode of infection is eating raw pork. It affects the small intestine, the blood and the central nervous system.

According to the zones, temperature and infectivity, there are four types of it: *Trichinella spiralis spiralis*, *Trichinella spiralis nelson*, *Trichinella spiralis nativa* and *Trichinella spiralis pseudospiralis* [1].

4.10. *Wuchereria bancrofti*

It causes lymphatic filariasis. It is found in tropics and subtropics zones.

The mode of transmission is puncturing the skin by the vector, a mosquito.

Mosquitoes responsible for its transmission are *Culex quinquefasciatus*, *Anopheles gambiae* and *Anopheles funestus*.

It causes Lymphangitis commonly in the lower extremities and obstruction of the genital organs.

There are two strains of *Wuchereria bancrofti*:

- The nocturnal periodic strain which is found in Africa, India and the Far East.
- The sub-periodic strain which is found in the Pacific region [1].

4.11. *Brugia malayi*

It is found in South East Asia. There are two strains of *Brugia malayi*:

- The nocturnal periodic strain which is spread widely in Asia.
- The sub-periodic strain which is found in Malaysia, Indonesia and the Philippines.

The mode of transmission is puncturing the skin by the vector, *Mansonia*.

It affects the lymph vessels causing the same clinical picture of *Wuchereria bancrofti* [1].

4.12. *Brugia timori*

It is found in Indonesia. The mode of transmission is puncturing the skin by the vector, *Mansonia*. It affects the lymph vessels [1].

4.13. *Loa loa*

It is known as the African eye worm as it is found in West and Central Africa. The mode of transmission is puncturing the skin by the vector, *Chrysops* species.

It affects the skin causing Calabar swellings, which are inflammatory swellings resulting in a localized subcutaneous oedema [1].

4.14. *Mansonella* species

It is found in tropics and subtropics zones. The mode of transmission is puncturing the skin by the vector, *Culicoides* species. It affects the skin.

There are three species of *Mansonella*: *Mansonella perstans*, *Mansonella ozzardi* and *Mansonella streptocerca* [1, 8].

4.15. *Onchocerca volvulus*

It is found in central and West Africa. It is found also in South America.

The mode of transmission is puncturing the skin by the vector, *Simulium* (black flies), especially *Simulium damnosum*. It affects the skin and the eye [1, 8].

4.16. *Dracunculus medinensis*

It is found in Iran, India and Ghana in zones of little clean drinking water. The mode of transmission is ingestion of unclean water containing Cyclops.

It affects intestine and the lung [8].

4.17. *Capillaria philippinensis*

It is found in mainly Philippines and Thailand, but there were also some few unusual reports from Japan, Taiwan, Egypt and Iran. The source of infection is eating raw or improperly cooked fish. It affects the intestine [9–11].

4.18. *Enterobius vermicularis*

It has a cosmopolitan distribution. The modes of transmission are finger suckling, nail biting and eat raw vegetables.

It affects the small intestine [9–11].

According to a study performed in April 2008, the epidemiology of nematodes in developing regions of Asia, Africa, Latin and America as follows: *Ascaris lumbricoides* (807 millions), *Trichuris trichiura* (604 millions), hookworm (576 millions) and *Strongyloides stercoralis* (30–100 millions) [11].

Here are some examples of Nematodes' prevalence in different parts of the world:

a. Mazandaran province, northern Iran

Data analysis performed after examining unwashed raw vegetables for soil transmitted helminths showed below:

- The overall prevalence = 14.89%
- Contamination in warm seasons = 20.5%
- Contamination in cold seasons = 9.32%
- The prevalence of contamination is higher in leafy vegetables than root vegetables [12].
- The most common found species are as follows: *Ascaris lumbricoides*, *Trichuris trichiura*, hookworm, *Toxocara canis*, *Taenia solium* and *Hymenolepis nana* with prevalence: 3.36, 2.2, 2.9, 1.68, 0.9 and 2.2%, respectively.

b. Kampala, Uganda

Cross sectional survey in September and October 2013 applied on five groups of people:

- Workers maintaining wastewater facilities.
- Workers managing faecal sludge.
- Urban farmers.

- Slum dwellers at risk of flooding.
- Slum dwellers without work of flooding.
- They were tested using Kato-Katz stool sampling which showed:
- Highest prevalence in urban farmers = 75.9%
- Lowest prevalence in workers managing faecal sludge = 35.8%
- Hookworm is the predominant by 27.8%
- In urban farmers, the prevalence of *Trichuris*, *Schistosoma mansoni* and *Ascaris* was 15% and above [13].

c. Bungoma county, Western Kenya

Cross sectional study held in 2016 by examining cryopreserved stool samples of 796 persons with age ranges from 2 to 81 years revealed; prevalence of *Ascaris lumbricoides* (17%) and *Trichuris trichiura*, *Ancylostoma* and *Strongyloides* (less than 1.0%) [14].

d. Tezi Town, Puge county of Liangshan prefecture, Southwestern China

Cross sectional study from October 23 to November 3, 2014 showed prevalence of *Ascaris lumbricoides* (13.5%), *Trichuris trichiura* (30.6%) and both(7.1%) [15].

Mansonella ozzardi is a rare nematode but mainly present in The Americas from southern Mexico to northwestern Argentina with prevalence rate (0–46%) [16].

5. Future perspectives

There is being some changes in several countries due to the efforts to treat actively these parasites. Nevertheless, some negative circumstances such as wars, climate changes and poverty may influence in this growing problem.

The neglected status of the helminthiasis should be addressed on community levels and globally all over the world.

Author details

Mohamed S. Abdeltawabi, Nahla El Seddik and Hosni K. Salem*

*Address all correspondence to: Dr_hosni@kasralainy.edu.eg

Faculty of Medicine, Cairo University, Cairo, Egypt

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