

## NEGLECTED TROPICAL DISEASES (NTDs)

NTDs are found in several countries in Africa, Asia, and Latin America. NTDs are especially common in tropical areas where people do not have access to clean water or safe ways to dispose of human waste.

Information on diseases included in the WHO portfolio of NTDs is available at [https://www.who.int/neglected\\_diseases/diseases/en/external\\_icon](https://www.who.int/neglected_diseases/diseases/en/external_icon)

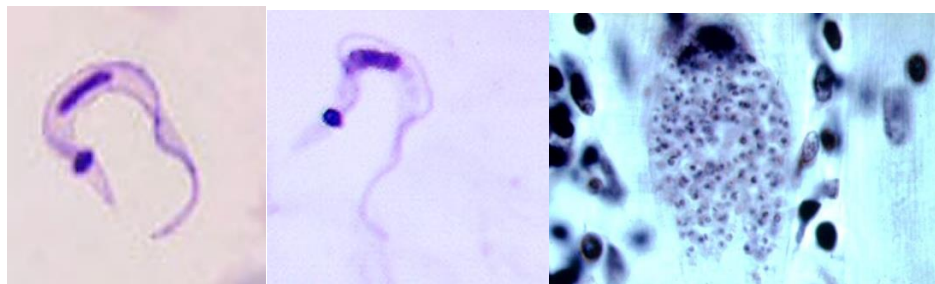
See below for more information on selected neglected tropical diseases:

**Buruli Ulcer:** **Buruli ulcer** is an infectious disease characterized by the development of painless open wounds. The disease is limited to certain areas of the world, most cases occurring in Sub-Saharan Africa and Australia. The first sign of infection is a small painless nodule or area of swelling, typically on the arms or legs. **Buruli ulcer** is caused by *Mycobacterium* and belongs to the family of bacteria that causes tuberculosis and leprosy. Buruli ulcer is presently the third most common mycobacterial disease of humans, after tuberculosis and leprosy, and the least understood of the three. Pathogenesis is related to a necrotizing and immunosuppressive toxin produced by *M. ulcerans*, called mycolactone. The incidence of this disease is highest in children up to 15 years old, and is a major public health problem in endemic countries due to disabling scarring and destruction of bone. Unlike leprosy and tuberculosis, Buruli ulcer is related to environmental factors and is thus considered non-communicable. The most plausible mode of transmission is by skin trauma at sites contaminated by *M. ulcerans*. Note the typical ulcers below.

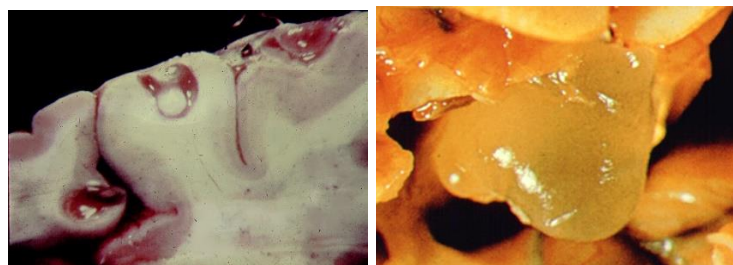


**Chagas' Disease:** American trypanosomiasis (Chagas' disease) is a zoonosis caused by *T. cruzi*, which was discovered in the intestine of a triatomid bug in Brazil in 1909 by Carlos Chagas, who described the entire life cycle in reservoir hosts. Trypanosomes are hemoflagellates, which cause serious medical problems for humans. Trypanosomes belong to the family Trypanosomatidae that live in the blood and tissues of their human hosts. The disease is transmitted to humans through the bite wound caused by reduviid bugs (triatomids, -kissing bugs, or conenose bugs). Humans are infected when metacyclic trypomastigotes are released with the feces while the insect is taking a blood meal and the feces are rubbed or scratched into the bite wound or onto mucosal surfaces such as eyes or mouth, an action stimulated by the allergic reaction to the insect's saliva. The organisms can also be transmitted as congenital

infections, by blood transfusion, or by organ transplantation. Sylvatic cycles of *T. cruzi* transmission extend from southern Argentina and Chile to northern California. In children younger than 5 years, the disease is seen in its severest form, whereas in older children and adults, the disease is milder and is commonly diagnosed in the subacute or chronic form rather than in the acute form. Acute systemic signs occur around week 2 to 3 of infection and are characterized by high fevers, which may be intermittent, remitting, or continuous; hepatosplenomegaly; myalgia; erythematous rash; acute myocarditis; lymphadenopathy; keratitis; and subcutaneous edema of the face, legs, and feet. There may be signs of CNS involvement including meningoencephalitis, which has a very poor prognosis. Myocarditis is manifested by electrocardiographic changes, tachycardia, chest pain, and weakness. The most frequent clinical sign of chronic Chagas' disease in 25 to 30% of patients is cardiomyopathy manifested by cardiomegaly and conduction changes. Note the trypomastigotes and amastigote forms in cardiac muscle (far right).

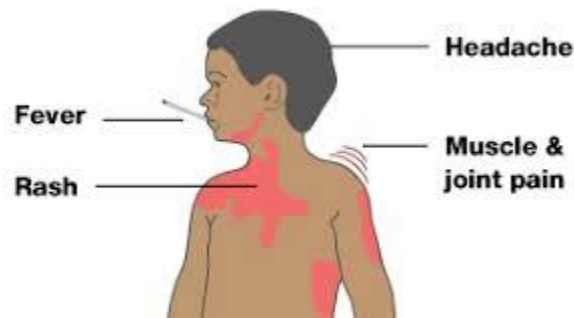


**Cysticercosis:** Infection with the tapeworm *Taenia solium* can result in two different conditions: taeniasis and cysticercosis. Taeniasis is the intestinal infection with the tapeworm and it occurs when a person eats raw or undercooked, infected pork. Taeniasis has no major impact on human health. However, tapeworm eggs passing in the stool of the tapeworm carrier and in the absence of a proper sanitation may contaminate the environment. While tapeworm eggs are infective for pigs, *T. solium* eggs may also infect humans if they are ingested via the fecal-oral route, or by ingesting contaminated food or water. Ingestion of tapeworm eggs causes infection with the larval parasite in the tissues such as muscles, skin, eyes and the central nervous system (human cysticercosis), with possible devastating effects on health. When cysts develop in the brain, the condition is referred to as neurocysticercosis. The presence of cysticerci in the brain represents the most frequent parasitic infection of the human nervous system and the most common cause of adult-onset epilepsy throughout the world. Note the cysticerci in brain tissue below.



**Dengue Fever:** Dengue is a mosquito-borne viral infection that is common in warm, tropical climates. Infection is caused by any one of four closely related dengue viral serotypes, and these can lead to a wide spectrum of symptoms (fever, headaches, pain behind the eyes, muscle and

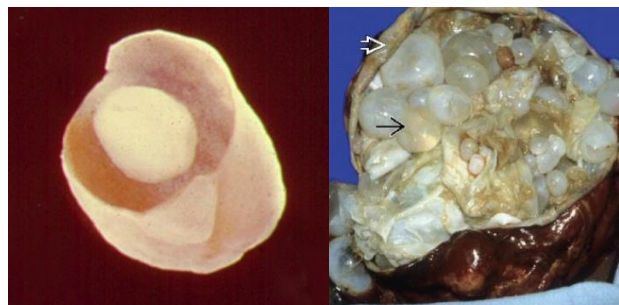
joint pain, nausea/vomiting, rash, and fatigue), including some which are extremely mild (unnoticeable) to those that may require medical intervention and hospitalization. In severe cases, fatalities can occur. There is no treatment for the infection itself but the symptoms that a patient experiences can be managed. WHO has listed dengue as a potential threat among ten diseases for 2019 and current outbreaks in many countries confirm this threat. Dengue epidemics tend to have seasonal patterns, peaking during and after rainy seasons. Factors that contribute to this increase include high mosquito population levels, susceptibility to circulating serotypes, favorable air temperatures, precipitation and humidity. All of these factors impact the reproduction and feeding patterns of mosquito populations, as well as the dengue virus incubation period. Lack of proactive control interventions and limited staff remain additional challenges. Dengue is increasing at a higher rate than any other communicable disease, with a 400% increase over 13 years (2000–2013). Annual dengue incidence is estimated to be 100 million symptomatic cases a year, with another ~300 million asymptomatic infections. The greatest burden is seen in Asia (75%) followed by Latin America and Africa. A technique that sterilizes male mosquitoes using radiation is now included as part of global health efforts to control diseases such as chikungunya, dengue, and Zika. Note the symptoms indicated below.



[Dracunculiasis \(Guinea Worm Disease\)](#): Guinea-worm disease is caused by the parasitic nematode *Dracunculus medinensis* or "Guinea-worm". This worm is the largest of the tissue parasite affecting humans. The adult female, which carries about 3 million embryos, can measure 600 to 800 mm in length and 2 mm in diameter. When a person ingests contaminated water from ponds or shallow open wells, the cyclops intermediate host is dissolved by the gastric acid of the stomach and the larvae are released and migrate through the intestinal wall. After approximately 3 months, the male and female meet and mate. The male becomes encapsulated and dies in the tissues while the female moves down the muscle planes. After about one year of the infection, the female worm emerges, usually from blisters on the feet, releasing thousands of larvae and thus repeating the life cycle. This infection has been targeted for total eradication. WHO works with Member States and in partnership with The Carter Center and the United Nations Children's Fund to support eradication of this disease. WHO provides technical guidance, works with national control programs to coordinate surveillance in dracunculiasis-free areas, and monitors and reports on the progress achieved. A total of 54 human cases of dracunculiasis (guinea-worm disease) were reported to the World Health Organization (WHO) in 2019, with Chad reporting 48 out of the 54 cases. Note the blister and worm removal below.



**Echinococcosis:** Currently, four species are recognized within the genus *Echinococcus*: *E. granulosus* (which causes cystic disease), *E. multilocularis* (which causes alveolar disease), *E. vogeli* (which causes polycystic disease), and *E. oligarthrus* (which causes polycystic disease). The areas of the world involved in sheep and cattle raising tend to be the areas where infections with *E. granulosus* are endemic; they even include the Basque sheep farmers in California. The number of infections in both animals and humans has decreased over the years as a result of education and various control measures. However, in some areas in Central Asia, figures suggest the surgical incidence is now greater than 10/100,000 (up to 27/100,000 in Tajikistan), and many of the cases are in children and the unemployed. The risk of infection depends on the association between humans and dogs. Those at high risk include populations where dogs are used to herd sheep and are also intimate members of the family, often having unrestricted access to the house and family members. Cystic echinococcosis has been recorded in 21 of China's 31 provinces, autonomous regions, and municipalities (approximately 87% of the territory). This infection constitutes one of the major health problems in this part of the world. Hydatid disease caused by *E. granulosus* is a zoonosis of major public health concern throughout Latin America, particularly in the Andean and South Cone regions. Cystic echinococcosis is also widely found throughout the region comprising Arab North Africa and the Middle East. After the gravid proglottids and eggs are passed in the feces from the canine host, they may be swallowed by an intermediate host, including humans. The released oncospheres will penetrate the intestine and be carried via the bloodstream, where they will be filtered out in the various organs. The most common site in humans is the liver (60 to 70% of cases). Hydatid disease in humans is potentially dangerous; however, cyst size and organ location will greatly influence the outcome. Clinical symptoms may appear after an incubation period of several months to years. Hydatid cysts should be considered in patients with abdominal masses with no clearly defined diagnostic findings. Note the hydatid cysts from liver, including daughter cysts.



**Fascioliasis:** Fascioliasis is a parasitic infection typically caused by *Fasciola hepatica*, which is also known as “the common liver fluke” or “the sheep liver fluke.” Fascioliasis is found in all



continents except Antarctica, in over 70 countries, especially where there are sheep or cattle. People usually become infected by eating raw watercress or other water plants contaminated with immature parasite larvae. The young worms move through the intestinal wall, the abdominal cavity, and the liver tissue, into the bile ducts, where they develop into mature adult flukes that produce eggs. The pathology typically is most pronounced in the bile ducts and liver. *Fasciola* infection is both treatable and preventable. Once the worms have established themselves in the bile ducts and matured, they cause considerable damage from mechanical obstruction and metabolic by-products. The degree of pathologic change depends on the number of flukes penetrating the liver. The infection produces hyperplasia of the biliary epithelium and fibrosis of the ducts, with portal or total biliary obstruction. The gallbladder undergoes similar pathologic changes and may even harbor adult worms. Note the egg and adult fluke below.

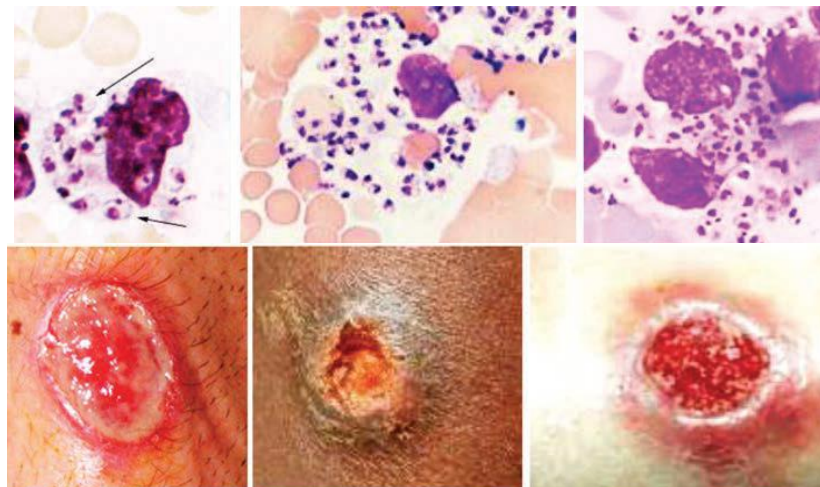


[Human African Trypanosomiasis \(African Sleeping Sickness\)](#) Trypanosomes are hemoflagellates, which are transmitted by tsetse flies (*Glossina* spp.) to a wide range of mammalian hosts. They cause serious medical problems for humans and livestock. Trypanosomes belong to the family Trypanosomatidae that live in the blood and tissues of their human hosts. The African trypanosomes belong to the subgenus Trypanozoon and as a group are referred to as the *Trypanosoma brucei* complex. *T. brucei brucei* strains are parasites of domestic and wild animals and are not known to be infectious for humans. Human infections are caused by *T. brucei gambiense* (West African trypanosomiasis) and *T. brucei rhodesiense* (East African trypanosomiasis). Infections caused by *T. brucei rhodesiense* are much more fulminant than those caused by *T. brucei gambiense*, the parasitemia is much higher, and the disease has a much faster progression. It is not possible to differentiate the three trypomastigotes of *T. brucei gambiense*, *T. brucei rhodesiense*, and *T. brucei brucei* on the basis of morphology, and all three organisms can be recovered in animal reservoir hosts. Differentiation is based on isoenzyme characteristics and DNA and RNA methods. It is estimated that 60 million people in 36 countries are at risk, and there are approximately 50,000 new cases per year of African trypanosomiasis. A unique feature of African trypanosomes is their ability to change the surface coat of the outer membrane of the trypomastigote, helping to evade the host immune response. The trypomastigote surface is covered with a dense coat of approximately 10<sup>7</sup> molecules of the membrane-form variant surface glycoprotein (VSG). There are approximately 100 to 1,000 genes in the genome, responsible for encoding as many as 1,000 different VSGs. More than 100 serotypes have been detected in a single infection. It is postulated that the trypomastigote changes its coat about every 5 to 7 days (antigenic variation). This change is responsible for successive waves of parasitemia every 7 to 14 days and allows the parasite to evade the host humoral immune response. In general, African trypanosomiasis caused by *T. brucei gambiense* (West African sleeping sickness) has a long, mild, chronic course that ends fatally with central nervous system (CNS) involvement after several years' duration. This is unlike the disease

caused by *T. brucei rhodesiense* (East African sleeping sickness), which has a short course, does not typically present as “sleeping sickness,” and ends fatally within a year. Note the trypomastigotes below.



**Leishmaniasis:** Leishmaniasis has been identified as high-priority disease by the World Health Organization. It is caused by protozoa belonging to the genus *Leishmania*, and it is transmitted by the bite of the phlebotomine sand fly, a vector found throughout the world's intertropical and temperate regions. The disease occurs in six clinical forms: self-healing or chronic cutaneous (CL), diffuse cutaneous leishmaniasis (DCL), mutilating mucosal or mucocutaneous leishmaniasis (ML MCL), life-threatening visceral leishmaniasis (VL), post-kala-azar dermal leishmaniasis (PKDL), and American tegumentary leishmaniasis (ATL) (some publications indicate that this is another designation for cutaneous leishmaniasis [ATL/CL]). These forms vary in degree of severity, with VL being by far the most devastating and having the highest mortality. Detection of parasites in aspirates, scrapings, or biopsy tissues depends on organism distribution, the host immune response, bacterial infections in the lesions, and whether the specimen is from an active or healing lesion. There are at present ~350 million people at risk and ~12 million cases, with an estimated worldwide annual incidence of 0.7 to 1.2 million cases of cutaneous leishmaniasis and 0.2 to 0.4 million cases of visceral leishmaniasis. Note the amastigote forms in cells and typical lesions below.



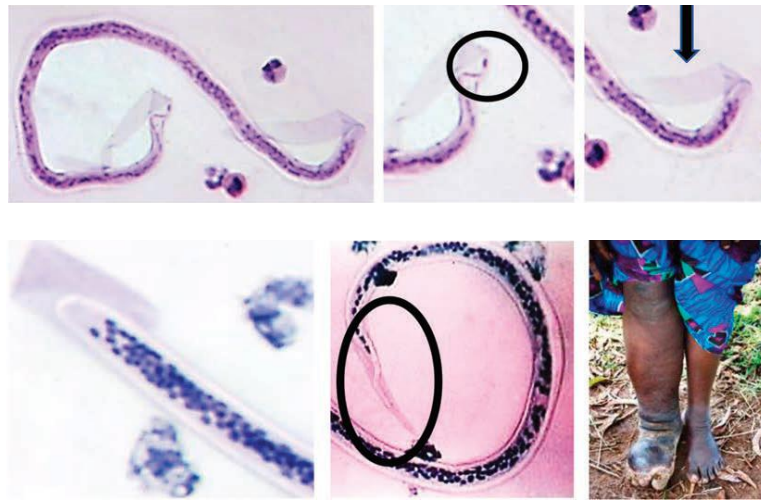
**Leprosy (Hansen's Disease):** Leprosy, also known as Hansen's disease, is a chronic infectious disease caused by *Mycobacterium leprae*. The disease mainly affects the skin, the peripheral

nerves, mucosal surfaces of the upper respiratory tract and the eyes. Leprosy is known to occur at all ages ranging from early infancy to very old age. Leprosy is likely transmitted via droplets, from the nose and mouth, during close and frequent contact with untreated cases. Symptoms may occur within 1 year but can also take as long as 20 years or even more to occur. Clinical signs are easy to observe. Skin lesion has usually a different pigmentation than the surrounding normal skin (less pigmented, reddish or copper-colored) and may have various aspects (flat, raised or nodules). Skin lesion can be single or multiple and may show a loss of sensation in the skin. Results comparing gene sequences of samples taken from human and infected wild armadillos showed that the two strains were related and that wild armadillos were a likely source of some human infections. But more importantly, it established leprosy as a zoonosis: an infectious disease that can be transmitted back and forth between animals and humans. Note the acid-fast bacilli in a bone marrow specimen and clinical manifestations of the disease.



**Lymphatic Filariasis:** The filarial nematodes are a group of arthropod-borne worms that reside in the subcutaneous tissues, connective tissues, lymphatic system, or body cavities of humans. Some adult filarial worms can survive in the human host for many years, causing a number of chronic and debilitating symptoms, including inflammatory reactions. Most cases tend to be asymptomatic. Some people, however, develop a syndrome called elephantiasis, which is marked by severe swelling in the arms, legs, breasts, or genitals. The skin may become thicker as well, and the condition may become painful. The changes to the body have the potential to harm the person's social and economic situation. The worms are spread by the bites of infected mosquitoes. Three types of worms are known to cause the disease: *Wuchereria bancrofti*, *Brugia malayi*, and *Brugia timori*, with *Wuchereria bancrofti* being the most common. These worms damage the lymphatic system. The disease is diagnosed by microscopic examination of blood collected during the night when the microfilariae are in the blood (nocturnal periodicity). The blood is typically examined as a smear after being stained with Giemsa or other blood stains. Prevention can be achieved by treating entire groups in which the disease exists, known as mass deworming. This is done yearly for about six years, in an effort to rid a population of the disease entirely. Medications used include various antiparasitic drugs, including albendazole with ivermectin, or albendazole with diethylcarbamazine. The medications do not kill the adult worms but prevent further spread of the disease until the worms die on their own. Efforts to prevent mosquito bites are also recommended, including reducing the number of mosquitoes and promoting the use of bed nets. In 2015 about 38.5 million people were infected. About 950 million people are at risk of the disease in 54 countries. It is most common in tropical Africa and

Asia. Lymphatic filariasis is classified as a neglected tropical disease and one of the four main worm infections. The impact of the disease results in economic losses of billions of dollars a year. Note the microfilariae (sheath, tail, and head nuclei), and a case of elephantiasis.



**Onchocerciasis:** Adult *Onchocerca volvulus* worms (which cause a WHO neglected tropical disease) lie within fibrous tissue capsules in the dermis and subcutaneous tissues, and the microfilariae are usually nearby to be ingested by a species of *Simulium* (blackfly or buffalo gnat). Humans are infected when bitten by the infected fly, and larvae are deposited into the bite site. Microfilariae are normally found in the dermis. However, skin lesions must be differentiated from those caused by scabies, insect bites, streptocerciasis, contact dermatitis, hypersensitivity reactions, traumatic or inflammatory depigmentation, tuberculoid leprosy, dermatomycoses, and treponematoses. *O. volvulus* has infected 45 million to 50 million people in Africa and Central and South America, of whom approximately 1 million are blind. Symptoms of heavy *O. volvulus* infections include dermatitis, onchocercomas (subcutaneous nodules containing adult worms), lymphadenitis, and blindness. Individuals with onchocerciasis may have clinically normal skin, whereas others may have pruritus and disfiguring skin lesions. The pruritus may cause sleeplessness, fatigue, and weakness. The skin may be painful, hot, and edematous, eventually resulting in permanent thickening. Acute attacks of onchodermatitis have resulted in a purplish skin discoloration known as mal morado in Central America. Chronically infected skin loses its elasticity and becomes thickened. In Central America, these skin changes are frequently seen as noticeable thickening of the earlobes and thickening of facial skin to mimic leonine facies (seen in lepromatous leprosy). In Africa, the same skin changes occurring in the hip region produce a condition known as hanging groin, which may predispose infected individuals to inguinal and femoral hernias. Lymphadenopathy in the inguinal and femoral areas is common among Africans. Note the nodules on the scalp, a positive skin biopsy demonstrating organisms and a cross section of the nodule (row 1). In row 2, note the adult worms removed from a nodule, a case of river blindness, and the single nucleus at the tip of the microfilarial tail).



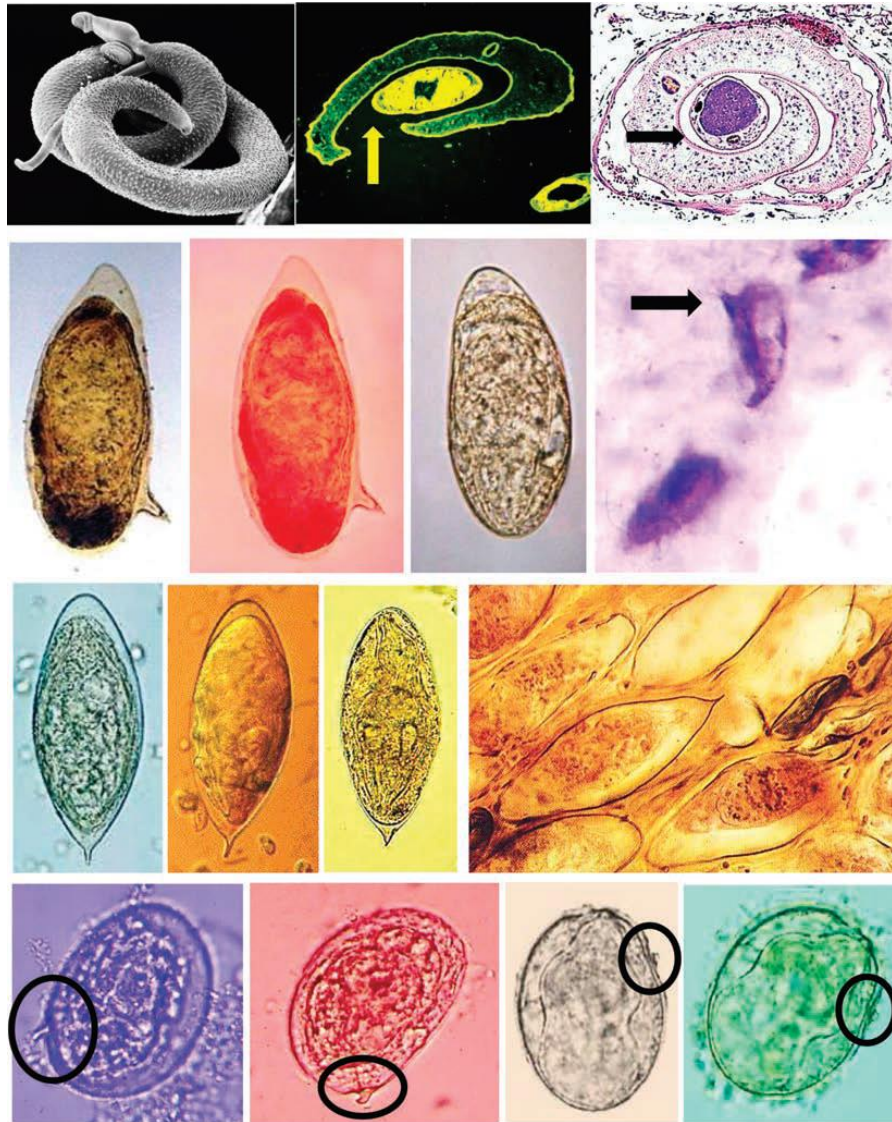


**Rabies:** Rabies is a fatal but preventable viral disease. It can spread to people and pets if they are bitten or scratched by a rabid animal. In the United States, rabies is mostly found in wild animals like bats, raccoons, skunks, and foxes. However, in many other countries dogs still carry rabies, and most rabies deaths in people worldwide are caused by dog bites. The rabies virus infects the central nervous system. If a person does not receive the appropriate medical care after a potential rabies exposure, the virus can cause disease in the brain, ultimately resulting in death. Rabies can be prevented by vaccinating pets, staying away from wildlife, and seeking medical care after potential exposures before symptoms start. Postmortem testing for rabies in animals may be necessary to determine the rabies exposure risk to humans. Samples requiring confirmation, variant typing, or formalin-fixed tissues may be sent to CDC for additional diagnostic testing. After a bite or other rabies exposure, the rabies virus has to travel through the body to the brain before it can cause symptoms. This time between the exposure and the appearance of symptoms is called the incubation period, which may last for weeks to months. The incubation period may vary based on the location of the bite (how far away it is from the brain), the type of rabies virus, and any existing immunity. The first symptoms of rabies may be very similar to those of the flu including general weakness or discomfort, fever, or headache. These symptoms may last for days. There may be also discomfort or a prickling or itching sensation at the site of the bite, progressing within days to acute symptoms of cerebral dysfunction, anxiety, confusion, and agitation. As the disease progresses, the person may experience delirium, abnormal behavior, hallucinations, hydrophobia (fear of water), and insomnia. The acute period of disease typically ends after 2 to 10 days. Once clinical signs of rabies appear, the disease is nearly always fatal, and treatment is typically supportive. To date less than 20 cases of human survival from clinical rabies have been documented, and only a few survivors had no history of pre- or postexposure prophylaxis. Approximately 5,000 animal rabies cases are reported annually to CDC, and more than 90% of those cases occur in wildlife. The number of rabies-related human deaths in the United States declined during the twentieth century, from more than 100 annually in the early 1900's to just one or two per year since 1960. Note the animals in which rabies can be found below (foxes, bats, skunks, and raccoons).



**Schistosomiasis:** Schistosomes belong to the phylum Platyhelminthes, family Schistosomatidae, and are a group of digenetic, dioecious trematodes requiring definitive and intermediate hosts to complete their life cycles. Four species are important agents of human disease: *Schistosoma mansoni*, *S. japonicum*, *S. mekongi*, and *S. haematobium*. Schistosomiasis affects between 200 million and 300 million people in 77 countries throughout the world. The parasites that cause schistosomiasis live in certain types of freshwater snails. The infectious form of the parasite, known as cercariae, emerge from the snail into the water. Humans become infected when the skin comes in contact with contaminated freshwater. Over several weeks, the parasites migrate through host tissue and develop into adult worms inside the blood vessels of the body. Once mature, the worms mate and females produce eggs. Some of these eggs travel to the bladder or intestine and are passed into the urine or stool. Most human infections are caused by *Schistosoma mansoni*, *S. haematobium*, or *S. japonicum*. Stool or urine samples can be examined microscopically for parasite eggs (stool for *S. mansoni* or *S. japonicum* eggs and urine for *S. haematobium* eggs). The eggs tend to be passed intermittently and in small amounts and may not be detected, so it may be necessary to perform a blood (serologic) test. Note: The adult worms may be found in blood vessels where they don't normally reside: it is recommended that BOTH stool and urine be examined if schistosomiasis is suspected. Symptoms of schistosomiasis are caused not by the worms themselves but by the body's reaction to the eggs. Eggs shed by the adult worms that do not pass out of the body can become lodged in the intestine or bladder, causing inflammation or scarring. Children who are repeatedly infected can develop anemia, malnutrition, and learning difficulties. After years of infection, the parasite can also damage the liver, intestine, spleen, lungs, and bladder. Without treatment, schistosomiasis can persist for years. Signs and symptoms of chronic schistosomiasis include: abdominal pain, enlarged liver, blood in the stool or blood in the urine, and problems passing urine. Chronic infection can also lead to increased risk of liver fibrosis or bladder cancer. Row 1, note the adult worms that lie in copula within the blood vessels (the small one is the female lying within the gynecophoral canal

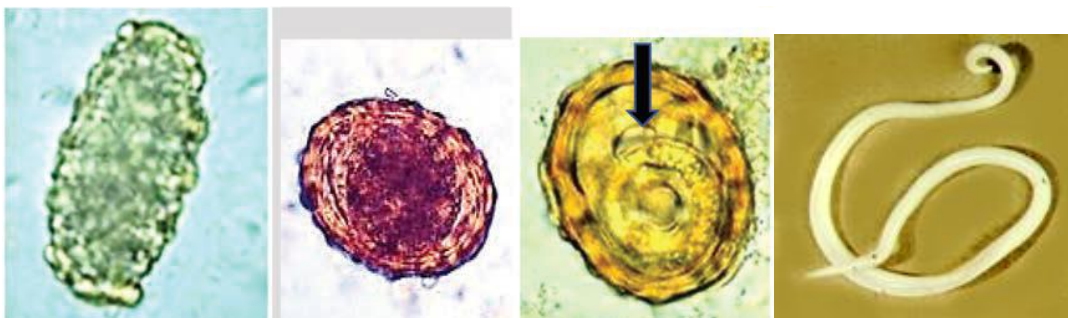
of the male worm.). Row 2 shows *S. mansoni* eggs (large lateral spine) and eggs in a rectal biopsy. Row 3 shows *S. haematobium* eggs (large terminal spine) and eggs in a bladder biopsy. Row 4 shows *S. japonicum* eggs with the small lateral spine.



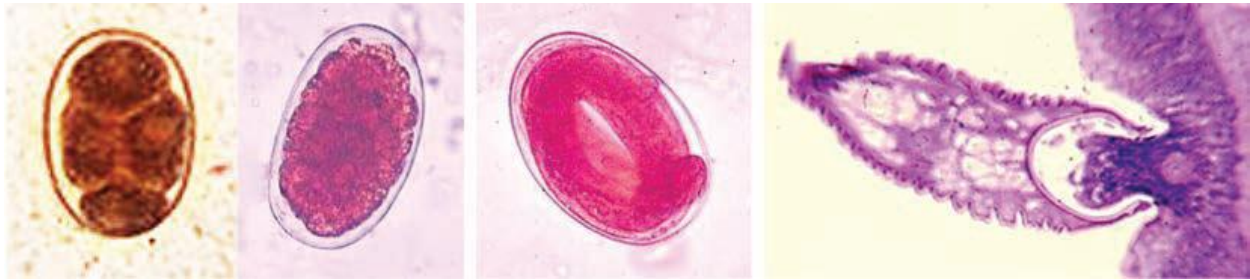
[Soil-transmitted Helminths \(STH\) \(Ascaris, Hookworm, and Whipworm\)](#) Soil-transmitted helminths refer to the intestinal nematodes infecting humans that are transmitted through contaminated soil: *Ascaris lumbricoides*, *Trichuris trichiura* (whipworm), and *Ancylostoma duodenale* and *Necator americanus* (hookworms). A large part of the world's population is infected with one or more of these soil-transmitted helminths. Soil-transmitted helminths live in the intestine and their eggs are passed in the feces of infected persons. If an infected person defecates outside or if the feces of an infected person are used as fertilizer, eggs are deposited on soil. *Ascaris* and hookworm eggs become infective as they mature in soil. People are infected with *Ascaris* and whipworm when eggs are ingested. This can happen when hands or fingers that



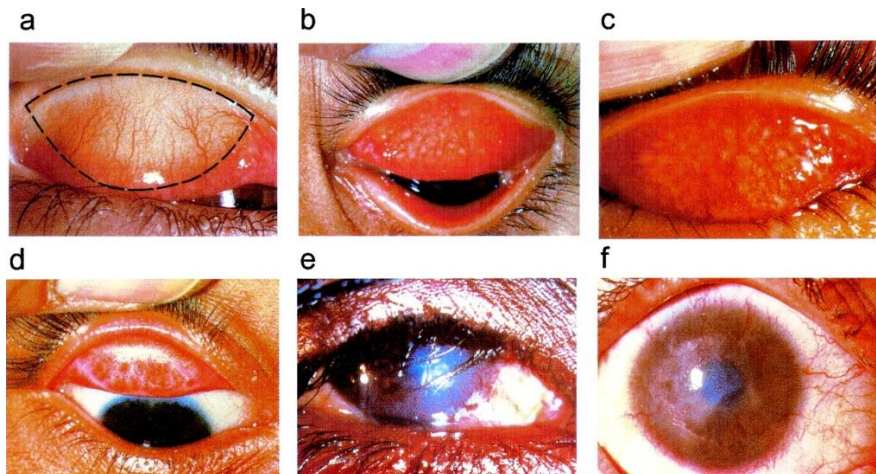
have contaminated dirt on them are put in the mouth or by consuming vegetables and fruits that have not been carefully cooked, washed or peeled. Hookworm eggs are not infective. They hatch in soil, releasing larvae (immature worms) that mature into a form that can penetrate the skin of humans. Hookworm infection is transmitted primarily by walking barefoot on contaminated soil. One kind of hookworm (*Ancylostoma duodenale*) can also be transmitted through the ingestion of larvae. Eggs are difficult to kill while they are in the soil, especially clay soil under favorable environmental conditions. In some countries where infections are common, mass population treatment plans have been used with great success, even in areas with high reinfection rates. People with ascariasis are often asymptomatic, or symptoms may be minimal. Symptoms include abdominal discomfort or pain. Heavy infections can block the intestines and slow growth in children. Other symptoms such as cough are due to migration of the larvae through the lungs (part of the life cycle). People infected with whipworm can range from being asymptomatic to having frequent, painful bowel movements that contain a mixture of mucus, water, and blood. Rectal prolapse (when the rectum sags and comes out of the anus) can also occur, primarily in heavy infections in children. Hookworm infection used to be widespread in the United States, particularly in the southeastern region, but improvements in living conditions have greatly reduced hookworm infections. Hookworms live in the small intestine, and the eggs are passed in the feces. These eggs in the soil can then mature and hatch, releasing larvae. The larvae mature into an infective form that can penetrate the skin of humans. Hookworm infection is mainly acquired by walking barefoot on contaminated soil. Most people infected with hookworms are asymptomatic, while others have gastrointestinal symptoms. The most serious effects of hookworm infection are blood loss leading to anemia, a serious problem with heavy infections in children. The standard O&P exam is recommended for recovery and identification of the eggs of these soil-transmitted nematodes in stool specimens, primarily from the wet preparation examination of the concentration sediment. In the larval migration phase of *Ascaris* and hookworm infections, diagnosis can occasionally be made by finding the larvae in sputum or in gastric washings (part of the indirect life cycle – not relevant for *Trichuris* infections that have no larval migration pathway in their life cycles (direct cycle)). Note the *Ascaris* eggs and adult male worm (row 1). In row 2, notice the *Trichuris* eggs and the adult male worm. In row 3, note the hookworm eggs and tissue section of worm attached to the intestinal mucosa.







**Trachoma:** Trachoma is an eye infection affecting both eyes. It is the world's leading cause of infectious blindness. A bacterium called *Chlamydia trachomatis* causes trachoma. According to the World Health Organization (WHO), trachoma has caused the visual impairment of 1.8 million people. Of those people, 450 thousand are irreversibly blind. In its early stages, trachoma causes conjunctivitis (pink eye). Early symptoms begin to appear within five to 12 days of exposure to the organism. These symptoms can include: mild itching and irritation of the eyes and eyelids, and a discharge from the eyes. As the infection progresses, symptoms include eye pain and blurred vision. If the infection is untreated, scarring occurs inside the eyelid. This leads to the eyelashes turning inward toward the eye. This condition is called trichiasis. The eyelashes brush and scratch against the cornea, the clear, dome-shaped window at the front of the eye. This continual irritation turns the cornea cloudy. It can lead to the development of corneal ulcers and vision loss. Trachoma is rare in the United States and Europe, but is commonly found in developing nations. Poverty, crowded living conditions, and poor sanitation help spread the disease. Most of the people infected are women and children. Trachoma is very contagious. It is spread by direct contact with an infected person, insects, especially flies, or contaminated objects, such as towels. Treatment may include surgery, antibiotics, facial cleanliness, and environmental improvements.



WHO simplified system. (a) Normal conjunctiva, showing area to be examined. (b) Follicular trachomatous inflammation (TF). (c) Intense trachomatous inflammation (TI) (and follicular trachomatous inflammation). (d) Conjunctival scarring (TS). (e) Trichiasis (TT). (f) Corneal opacity (CO). Reproduced with the permission of the World Health Organization.

The following six NTDs can be controlled or even eliminated through mass administration of safe and effective medicines or other, effective interventions:

- Dracunculiasis (Guinea Worm Disease)
- Lymphatic Filariasis
- Onchocerciasis
- Schistosomiasis
- Soil-transmitted Helminths (STH) (i.e., *Ascaris*, Hookworm, and Whipworm)
- Trachoma

Controlling the vectors (e.g., mosquitoes, black flies) that transmit these diseases and improving basic water, sanitation, and hygiene are highly effective strategies against these NTDs.

## REFERENCES

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