Review Article

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Ascariasis: An Important Soil Transmitted Helminthiasis of Public Health Significance

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Abstract

Ascariasis, caused by the helminth *Ascaris lumbricoides*, remains one of the most widespread soil-transmitted helminth infections globally, predominantly affecting impoverished communities in tropical and subtropical regions. This review synthesizes current knowledge on the epidemiology, life cycle, environmental resilience, and public health implications of *Ascaris lumbricoides*. It highlights the critical role of inadequate sanitation, poor hygiene practices, and environmental contamination in sustaining transmission cycles. Advances in diagnostic tools, including molecular methods, have improved detection accuracy, yet challenges such as potential anthelmintic resistance underscore the need for integrated control strategies. Sustainable management requires a multifaceted approach combining with mass drug administration (MDA), improved water, sanitation and hygiene (WASH), health education, and environmental interventions, respectively. Cross-sectoral collaboration and innovative monitoring are vital for effective control, aiming toward the global goal of eliminating ascariasis as a public health problem by 2030. Addressing these challenges through coordinated efforts will significantly reduce disease burden and improve quality of life in vulnerable populations.

Keywords: Ascariasis, Control, Preventive chemotherapy, Public health, Sanitation, Soil-transmitted helminths

Introduction:

Soil-transmitted helminths (STHs) are a group of parasitic nematode worms that infect humans through contact with eggs or larvae in warm, moist soil, typically found in tropical and subtropical regions. Once inside the host, these parasites mature into adult worms and can persist for years in the human gastrointestinal tract. Globally, over one billion people are infected with at least one species of STH. Commonly referred to as intestinal worm infections, STHs are increasingly recognized as a major public health issue, particularly in low-resource and impoverished communities. They are also regarded as the most prevalent neglected tropical diseases (NTDs) in many developing regions (Mutombo et al., 2019). A significant portion of the global population is affected by one or more of the major STHs: an estimated 807–1,121 million people are infected with roundworms (*Ascaris lumbricoides*), 604-795 million with whipworms (*Trichuris trichiura*), and 576–740 million with hookworms (*Ancylostoma duodenale* and *Necator americanus*) (CDC, 2022).

Ascariasis is among the most widespread helminthic infections, and represents a significant public health challenge, particularly in low and middle-income countries (Hadush and Pal, 2016). It is especially prevalent in regions where sanitation is inadequate and hygiene practices are suboptimal, conditions commonly found in tropical and subtropical climates, notably in sub-Saharan Africa and Southeast Asia (WHO, 2023). The disease thrives in environments characterized by poor waste management, the application of untreated human faeces as fertilizer, and the use of insufficiently treated wastewater for crop irrigation. Transmission occurs primarily through the accidental ingestion of *Ascaris* eggs present in contaminated soil, water, or food. Globally, severe cases of ascariasis are responsible for approximately 60,000 deaths annually, with children being the most affected.

Two major Ascaris species are implicated in human and animal infections: *Ascaris lumbricoides*, which infects humans, and *Ascaris suum*, primarily found in pigs. Although morphologically similar, their close genetic relationship raises concerns regarding potential zoonotic transmission. The prevalence of ascariasis is strongly associated with low personal hygiene standards and inadequate sanitation infrastructure, especially in rural and agricultural settings (Hadush and Pal, 2016).

The use of water contaminated with faecal matter is a primary source of intestinal parasitic infections. Among these, ascariasis a chronic and potentially fatal disease caused mainly by *Ascaris lumbricoides* is of particular concern. This parasitic infection poses significant health and social challenges, especially for school-aged children in many developing countries across Africa, Asia, and Latin America. As a result, it is estimated that approximately one-quarter of the global population is infected with *Ascaris lumbricoides* (Hadush and Pal, 2016).

Ascaris lumbricoides and *Ascaris suum* are nematodes from the family Ascarididae, responsible for causing infections in humans and pigs, respectively. *Ascaris lumbricoides* is among the most prevalent human roundworms, infecting approximately 1.4 billion people worldwide. Infections are most frequently reported in sub-Saharan Africa, Latin America, China, and East Asia. The range of health issues caused by *Ascaris lumbricoides* infection is collectively referred to as ascariasis, which contributes significantly to the global disease burden, particularly in developing nations. The infection is estimated to result in a loss of 1.2 to 10.5 million disability-adjusted life years (DALYs). Furthermore, around 122 million cases annually are associated with substantial morbidity and serious health consequences. Despite its global impact, ascariasis remains a neglected tropical disease, receiving limited attention in public health programs and research efforts (Pal, 2014).

The objective of this article aims to provide an in-depth understanding of the epidemiology, transmission dynamics, clinical features, diagnostic approaches, treatment options, and current control strategies for ascariasis, emphasizing recent advances and ongoing challenges in global efforts to combat this persistent helminthic infection.

Etiology:

Ascariasis is caused by two closely related nematode species: *Ascaris lumbricoides* and *Ascaris suum*, both of which are of significant public health relevance (Pal, 2007). *Ascaris suum* is especially important from a zoonotic perspective, as pigs act as a reservoir host for this parasite. Although the *Ascaris* species in human and pig are morphologically indistinguishable, molecular analyses have demonstrated small but notable genetic differences. These include approximately six nucleotide variations (1.3%) in the first internal transcribed spacer (ITS-1) and 3–4% variation in mitochondrial DNA (mtDNA), highlighting a close evolutionary relationship between the two species (Soulsby, 2005; Pal, 2007; Dutto and Petrosillo, 2013).

Experimental cross-transmission studies have demonstrated that *Ascaris lumbricoides* is capable of infecting pigs, while *Ascaris suum* can also infect humans. However, both species tend to exhibit a strong host-specific preference, typically infecting their conventional hosts. In non-endemic regions such as North America and Denmark, human cases of ascariasis have been attributed to *Ascaris suum*, suggesting that pigs may serve as a reservoir for human infection in these areas. Conversely, molecular epidemiological investigations in endemic regions, such as Guatemala and China have revealed little to no evidence of cross-infection between species, indicating limited gene flow among *Ascaris* genotypes in such settings (Dold and Holland, 2011; Zhou et al., 2012; Pal, 2014).

Epidemiology:

Soil-transmitted helminth (STH) infections are prevalent across tropical and subtropical regions, where environmental conditions are highly conducive to their transmission. Climate factors, particularly sufficient soil moisture and warm temperatures are crucial for the development and survival of infective larvae in the environment (Brooker and Michael, 2000; Brooker et al., 2006). Among these infections, ascariasis, caused by *Ascaris lumbricoides*, is one of the most widespread globally. The disease disproportionately affects populations in low and middle-income countries, especially in areas with inadequate sanitation and poor hygiene practices. According to the World Health Organization (2023), over 800 million people are currently infected with *Ascaris lumbricoides*, with the highest burdens reported in sub-Saharan Africa, Southeast Asia and Latin America.

The transmission dynamics of *Ascaris lumbricoides* are significantly influenced by a combination of environmental, socioeconomic and behavioral factors. Warm and humid climates create optimal conditions for the survival and development of *Ascaris* eggs in the soil, resulting in higher transmission rates in these environments (Weatherhead et al., 2017). Children, particularly those aged 5–14 years, are the most vulnerable group due to their frequent exposure to contaminated soil, poor hygiene practices, and under developed immune systems (Gyorkos et al., 2021).

Recent geospatial analyses and molecular epidemiology studies have enhanced our understanding of the global distribution of ascariasis. According to Pullan et al. (2022), despite ongoing mass drug administration (MDA) campaigns, transmission continues in certain hotspots, particularly in parts of East Africa and Southeast Asia, where reinfection rates remain high. Additionally, one study by Mekonnen and co-workers (2022) highlighted that conventional microscopic techniques may underestimate the true prevalence of infections, especially in regions with low-intensity transmission, underscoring the importance of more sensitive molecular diagnostic tools, such as quantitative PCR (qPCR).

Urbanization and improvements in water, sanitation, and hygiene (WASH) infrastructure have contributed to a decline in ascariasis prevalence in some regions. However, in many rural areas, particularly those with pig farming and poor sanitation, *Ascaris suum* may contribute to zoonotic infections, which complicate control efforts (Nejsum et al., 2012). In non-endemic regions, such as parts of Europe and North America, imported cases and

occasional zoonotic transmission from pigs have also been documented (Zhou et al., 2012).

Transmission and Life cycle:

Human and animal transmission primarily ensues through the fecal-oral route when embryonated eggs are ingested from contaminated soil or feces. Larvae then hatch and migrate through the intestinal tract to the lungs, where maturation and dissemination occur through the bronchial tree. Mature larvae then migrate back to the intestine to develop into adults (CDC, 2019). Adult female worms in the intestines produce approximately 200,000 eggs per day (Kanneganti et al., 2013), and adult worms can survive in human host systems up to 2 years. In soils, fertilized eggs can persist up to 10 years (Kanneganti et al., 2013; Woodhall et al., 2014; Miller et al., 2015). Manifestations of ascariasis include impaired cognition, vitamin A deficiency, stunting, and asthma (Weatherhead et al., 2017). Complications can occur in those infected with intestinal obstruction or when rogue worms invade other host systems, including the liver, pancreas, or lungs (Woodhall et al., 2014).

Pathogenesis and Clinical Manifestations:

Infections caused by soil-transmitted helminths (STHs) are often asymptomatic, with many individuals showing no consistent signs or symptoms. However, these infections can lead to nutritional deficiencies, as the worms consume the host's tissues and blood, resulting in a loss of protein and iron. Although many cases remain asymptomatic, heavy worm infestations can cause significant morbidity. In children, ascariasis is frequently associated with malnutrition, growth retardation, and impaired cognitive development (Gyorkos et al., 2021). In severe cases, ascariasis may lead to complications such as intestinal obstruction, volvulus, or biliary ascariasis. Pulmonary symptoms during larval migration, such as cough, wheezing, and eosinophilia, are characteristic of Löffler's syndrome (Bethony et al., 2006). The clinical spectrum of the disease can range from asymptomatic cases to more severe symptoms, including nausea, vomiting, abdominal pain, pneumonia, and intestinal obstruction (Hadush and Pal, 2016).

Diagnosis of Ascariasis:

The diagnosis of ascariasis typically involves detecting *Ascaris lumbricoides* eggs in stool samples through light microscopy, which is widely used in endemic regions due to its cost-effectiveness and ease of use. However, traditional methods, such as direct smears and the Kato-Katz technique, often suffer from low sensitivity, especially in cases of mild infections or following mass drug administration (MDA) campaigns that reduce the worm load within the population (Gyorkos et al., 2021; WHO, 2023). To enhance diagnostic accuracy, concentration techniques like formalin-ether sedimentation and flotation methods are frequently used. Although these techniques improve egg detection, they still depend on the skill of the technician and the timing of sample collection relative to the parasite's life cycle (Bogoch et al., 2020).

Molecular diagnostic techniques have become more accurate than traditional diagnostic approaches in recent years. Even in situations when the parasite burden is low, techniques such as loop-mediated isothermal amplification (LAMP) and quantitative polymerase chain reaction (qPCR) provide good sensitivity and specificity for identifying *Ascaris* DNA in stool samples (Easton et al., 2021; Mekonnen et al., 2022). Serological assays have also been investigated for the detection of antibodies against *Ascaris lumbricoides*, especially in cases of infections beyond the intestines or ectopic ascariasis. However, due to their incapacity to distinguish between previous and current infections and their cross-reactivity with other helminth species, the practical application of these tests is restricted in endemic areas (Tefera et al., 2019).

Imaging tests such as abdominal X-rays, CT scans, and MRIs can help identify complications like intestinal blockage, biliary ascariasis, and pancreatitis, which are associated with severe Ascaris infections. In these cases, live worms may be observed in the bile ducts or intestines (Udayakumar and Jayakumar, 2020). Additionally, there have been significant advancements in the development of point-of-care diagnostic tools. Lateral flow tests and antigen detection assays are being explored as promising solutions for rapid, field-based diagnosis (Silva et al., 2023).

Treatment and Drug Resistance of Ascariasis:

Albendazole and Mebendazole are the primary treatments recommended by the World Health Organization (WHO) for ascariasis. These medications effectively reduce worm loads, although multiple doses may be necessary for complete elimination (WHO, 2023). For severe cases where heavy worm infestations lead to complications such as intestinal obstruction, a combination of anthelmintics, supportive care (e.g. nasogastric decompression and fluid therapy), and surgery may be required (Udayakumar and Jayakumar, 2020). The global strategy to control soil-transmitted helminthiasis (STHs) relies heavily on preventive chemotherapy, particularly targeting school-aged children, achieving over 60% coverage in targeted countries by 2022.

Despite the efficacy of these drugs, there is growing concern about the emergence of drug resistance, particularly in areas where MDA campaigns have been in place for several years. Although confirmed cases of Ascaris resistance are still rare, genetic markers

associated with Benzimidazole resistance, specifically mutations in the β-tubulin gene at codons 167, 198, and 200, have been identified in Ascaris populations, raising alarms for potential resistance development (Diawara et al., 2013; Zuccherato et al., 2021).

In veterinary nematodes, such as *Haemonchus contortus*, these mutations are well-documented and confer resistance to Benzimidazoles. Recent genomic studies in human Ascaris have detected low-frequency resistance alleles, indicating the early stages of selection pressure due to widespread use of Albendazole and Mebendazole.

In this context, Krücken and others (2021) emphasized that the extensive and repeated use of single-drug regimens without rotation or combination therapy could accelerate the spread of resistance alleles in endemic populations. Current recommendations from the WHO stress the importance of integrated control strategies, combining drug administration with improvements in water, sanitation, hygiene (WASH), and health education to reduce reinfection and delay resistance development (Campbell et al., 2022).

Control and Prevention of Ascariasis:

The control and prevention of ascariasis, a significant soil-transmitted helminth (STH) infection, depend on an integrated strategy that incorporates preventive chemotherapy, health education, and improvements in water, sanitation, and hygiene (WASH). Implementing effective control measures is crucial to reducing the prevalence and intensity of infections, as well as minimizing the risk of reinfection in endemic communities.

Preventive Chemotherapy

Preventive chemotherapy with Albendazole (400 mg) or Mebendazole (500 mg) is the primary method for controlling ascariasis in endemic areas. The World Health Organization advises mass drug administration (MDA) for at-risk populations, particularly preschool and school-aged children, once or twice a year to disrupt transmission. In 2022, over 676 million children worldwide received treatment through school-based deworming initiatives (WHO, 2023). These MDA programs have demonstrated significant success in reducing worm loads and improving the health of children. However, they must be consistently maintained and regularly assessed to ensure ongoing effectiveness and prevent the disease from resurfacing (Moser et al., 2021).

Water, Sanitation and Hygiene (WASH)

Sustainable control of ascariasis requires addressing the environmental and behavioral factors that facilitate transmission. Since *Ascaris lumbricoides* eggs are transmitted via the fecal-oral route, poor sanitation and unsafe water contribute significantly to the burden of disease. Key WASH interventions include: construction and use of latrines, proper disposal of human feces, access to clean and safe drinking water, hand washing with soap, especially after defecation and before eating. It is mentioned that improved sanitation is associated with a 50% reduction in STH infections, including ascariasis (Strunz et al., 2014; Ziegelbauer et al., 2022).

Health Education and Behavior Change

Health education campaigns that focus on promoting proper hand hygiene, encouraging the use of latrines, and preventing open defecation play a crucial role in ascariasis control (Pal, 2007). School-based programs are particularly impactful, as they can foster long-lasting hygienic habits in children (Freeman et al., 2021). It is important to teach the children not to eat any food fallen on the floor (Pal, 2007). Engaging communities and using culturally relevant messages enhances the effectiveness and sustainability of these health interventions. A combination of education and deworming has proven to be more effective than relying on either approach individually (Campbell et al., 2018).

Environmental Management and Surveillance

Environmental control measures, including the safe disposal of sludge and night soil, as well as discouraging the use of untreated human feces as fertilizer, are essential to prevent soil contamination with *Ascaris* eggs (Pal, 2007; Jourdan et al., 2018). Additionally, surveillance systems that track infection trends, monitor treatment coverage, and assess potential anthelmintic resistance are crucial for guiding control efforts and adapting strategies as needed (Krücken et al., 2021).

Toward Elimination: An Integrated Strategy

The WHO's 2021–2030 roadmaps for neglected tropical diseases set ambitious targets for eliminating STHs as a public health problem. Achieving this goal requires:

- Scaling up MDA coverage to >75% of at-risk populations,
- Integrating WASH infrastructure improvements,
- Strengthening monitoring and evaluation frameworks,
- Ensuring cross-sectoral collaboration between the health education, and sanitation sectors.

Conclusions:

Ascariasis remains a significant public health concern, especially in impoverished regions with inadequate sanitation and hygiene infrastructure. Despite the success of mass deworming programs and environmental interventions, persistent challenges such as transmission hotspots and potential drug resistance hinder progress

toward eradication. The integration of preventive chemotherapy, health education, improved WASH infrastructure, and cross-sectoral collaboration is essential for sustainable control and eventual elimination of ascariasis.

Based on the above conclusions, the following recommendations are recorded:

- Enhancing water, sanitation, and hygiene (WASH) infrastructure to reduce environmental contamination with *Ascaris* eggs.
- Promoting health education campaigns that foster hygienic behaviors, such as regular hand washing and proper sanitation practices.
- Implementing environmental management strategies, including safe disposal of human feces and managing sludge and fertilizer use.
- Strengthening surveillance systems to monitor infection trends, assess treatment efficacy, and detect potential drug resistance.
- Promoting cross-sectoral collaboration among health, education, and sanitation sectors to ensure comprehensive intervention strategies.

Conflict of Interest:

There were no conflicts of interest.

Author's Contribution:

All authors contributed equally. They read the final manuscript before submission.

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