Giardia duodenalis in the Philippines: A review of prevalence, epidemiology, and diagnostic and treatment challenges

ABSTRACT

Giardia duodenalis, commonly referred to as *Giardia intestinalis* or *Giardia lamblia*, is a worldwide relevant protozoan parasite responsible for giardiasis, a gastrointestinal disorder. Giardiasis continues to pose a public health challenge in the Philippines, especially in areas with inadequate sanitation and hygiene. Prevalence rates differ nationwide, with elevated infection rates observed in children, institutionalized groups, and regions with restricted access to clean water. Assemblage B, the predominant genotype identified, underscores the danger of zoonotic transmission. Notwithstanding progress in molecular diagnoses, conventional microscopy continues to be the principal diagnostic instrument, limited by resource constraints. Chronic giardiasis leads to malnutrition, development retardation, and cognitive deficits, especially in children from disadvantaged backgrounds. Addressing these deficiencies requires enhanced diagnostic techniques, focused public health initiatives, and investments in water sanitation infrastructure. This review highlights significant research deficiencies and emphasizes the necessity for extensive initiatives to alleviate the impact of giardiasis in the Philippines.

Keywords: *Giardia duodenalis*, Giardiasis, Prevalence, Epidemiology, Philippines

I. INTRODUCTION

Giardia duodenalis, also known as *Giardia intestinalis* or *Giardia lamblia*, is a flagellated protozoan parasite responsible for causing giardiasis, a gastrointestinal illness. It is among the most widespread intestinal parasites worldwide, affecting millions annually, particularly in regions with inadequate sanitation and hygiene [1]. This protozoan poses a significant threat to both human and animal health. Within *Giardia*, eight genetic assemblages (A-H) have been identified, with

Assemblages A and B being the primary infective types in humans, although zoonotic transmission has also been documented [2,3].

The clinical manifestation of giardiasis varies from asymptomatic to severe gastrointestinal symptoms. Acute infections may result in extended diarrhea, stomach pain, bloating, malabsorption, and considerable weight loss [1,4]. Particularly in areas where giardiasis is prevalent, chronic infections in children have been associated to developmental stunting and cognitive problems. [5,6]. Asymptomatic carriers greatly contribute to *Giardia* transmission by cyst shedding [1,3].

Its prevalence ranges from 2–5% in industrialized nations to 20–30% in South Asia and sub-Saharan Africa with poor sanitation. Approximately 200 million people in Asia, Africa, and Latin America experience symptomatic giardiasis annually, highlighting its public health importance [7].

Giardiasis is a major health issue in the Philippines, especially in impoverished areas without clean water and sanitation. A study in a Manila slum found a prevalence rate of 22.05%, highlighting the significant infection rate gap between rural and urban areas [7]. In institutionalized populations, the disease is more common with a prevalence of 17.6% among inmates and 11.6% among children in residential institutions in Metro Manila [8].

Giardia is transmitted through the consumption of infective cysts, predominantly through contaminated water or food. Transmission between individuals, especially among children and institutionalized groups, is prevalent [5,7]. Environmental conditions, including inadequate waste disposal and insufficient access to potable water, aggravate the transmission of giardiasis. Inadequate handwashing and the use of untreated water are additional factors that contribute to its endemicity [1,7].

Recurrent infections cause developmental delays, stunted growth, and malnutrition in children. Chronic effects and high treatment costs strain families and the healthcare system [9]. The prevalence of *G. duodenalis* in untreated rural water sources emphasizes the need of improved water quality control and sanitation system.

Traditional stool microscopy diagnoses giardiasis by identifying cysts or trophozoites. This method, a gold standard for decades, is cheap and widely available, but intermittent cyst excretion, observer's expertise, and lack of sensitivity, especially in asymptomatic cases, can reduce its accuracy [10]. Ritchie's method or formalin-ether sedimentation are used to reduce false-negative results and increase sensitivity [11]. Microscopy is less sensitive and specific than enzyme-linked immunosorbent assay (ELISA) and immunochromatographic test (ICT). They detect stool *Giardia* antigen. Another sensitive immunological method is Direct Fluorescence Assay (DFA), which uses fluorescently labeled antibodies to identify *Giardia* cysts [12]. Molecular techniques such as polymerase chain reaction (PCR) and real-time PCR demonstrate superior sensitivity and specificity in the diagnosis of giardiasis, even in cases with low parasite loads in fecal samples. Symptomatic as well as those that are asymptomatic can be detected using real-time PCR [13]. As a result of their high cost and complexity, assays based on fluorescent microspheres and loop-mediated isothermal amplification (LAMP) are not typically utilized in countries with limited resources, such as the Philippines [14]. Innovative diagnostic methods like microRNA-based detection are being investigated. MiR5 and miR6 are promising biomarkers for giardiasis, especially in duodenal biopsy samples. PCR, histopathology, and imprint cytology on duodenal biopsies improve diagnostic accuracy, especially in chronic diarrhea patients [13,15].

Larger Philippine hospitals diagnose with stool microscopy and antigen detection. Giardiasis surveillance and management can be improved by molecular diagnostics, addressing

diagnostic challenges and improving public health [7]. This review addresses knowledge gaps and aligns Philippine public health efforts with global water quality and sanitation goals. To reduce the disease's impact, diagnostic capacity, especially molecular methods, must be increased and integrated into public health initiatives.

II. EPIDEMIOLOGY OF GIARDIASIS IN THE PHILIPPINES

Giardiasis is a global health concern, attributing to an estimated 28.2 million cases of diarrhea annually, predominantly in developing countries, particularly children and immunocompromised individuals, given the poor sanitation and socioeconomic conditions [9,16,17]. Several researchers in the Philippines conducted studies to determine the prevalence and distribution of giardiasis in the Philippines (Table 1). For instance, Natividad et al. [8] surveyed 3,456 diarrheic patients across the Philippines from 79 hospitals and healthcare centers. With the use of MeriFluor® *Cryptosporidium-Giardia* kit and fluorescence microscopy, it was shown that the prevalence of *Giardia* was at 2%, with Mindanao having the highest prevalence at 3.6%, compared to Luzon and Visayas having prevalence rates of 1.9% and 1.6%, respectively, so regional differences were evident. Notably, children 5–9 years old showed the highest prevalence at 6.7%, with no significant sex-specific trends. In a study by Rivera et al. [7], the prevalence of *G. duodenalis* in the BASECO compound was investigated using PCR-RFLP targeting the triose phosphate isomerase gene. Among 2,354 stool samples, 519 of the samples were positive for *Giardia* cysts. Assemblage B was also identified in the study as the most prevalent genotype with 86.47%, emphasizing the risk of zoonotic transmission. Children ages 6-15 years old exhibit a high prevalence of *Giardia* and also mixed assemblage A and B infections. Weerakoon et al. [9] investigated the prevalence of *G. duodenalis* infections among the residents from rural areas in

Northern Samar using multiplex qPCR. Among the 412 participants, the prevalence of *G. duodenalis* was reported at 19.2%. This implies the considerable burden of giardiasis in rural areas with limited access to clean water and sanitation. In 2017, Lirio et al. [18] conducted a study, carried out in Metro Manila, Philippines, targeting occupational groups; 41 were slaughterhouse workers, and 50 were vendors. The prevalence of *G. lamblia* was 7.69% among participants. Higher parasitic infections were observed among participants with lower educational attainment (elementary-level graduates or undergraduates).

Several studies on the role of animal reservoirs in giardiasis have provided valuable insights into the potential for zoonotic transmission of *Giardia* in the Philippines. A study of Velante et al. [19] on captive wildlife species in a facility in Manila, which includes the tigers, Palawan bearcats, and an Asian palm civet, found that there were no cysts or antigens of *G. duodenalis* detected in any of the samples, despite using multiple diagnostic methods such as the ImmunoRun® Antigen Detection Kit and modified flotation-sedimentation, showing a zero prevalence in these captive animals. This is in contrast with the studies related to livestock, which show a significant prevalence of *Giardia*. Afable et al. [20] studied livestock in Sariaya, Quezon; 103 fecal samples were collected. With the use of microscopy, 14 out of 103 samples (13.59%) were positive for *Giardia* cysts, while with PCR, 13 out of 103 samples (12.62%) were positive for *Giardia*, confirming assemblages A and B as zoonotic, alongside assemblage E, which is specific to livestock. Among the livestock, cattle have the highest mean cyst intensity at 14 cysts per gram (cpg), followed by pigs and carabaos. This study emphasizes the role of livestock as reservoirs of zoonotic *Giardia* strains. A study conducted by Adao et al. [21] on livestock, focusing primarily on porcine in animal farms in Bulacan Province, Philippines. He collected fecal samples from pigs and analyzed them using the polymerase chain reaction (PCR) for the presence of *G.*

lamblia. The results indicated that *G. lamblia* was present in 6% of the samples, and also assemblage B was the only assemblage detected, suggesting risk for zoonotic transmission of the disease for humans. Similarly, at the Puerto Princesa Subterranean River National Park in Palawan, Chavez et al. [22] examined fecal samples from long-tailed macaques (*Macaca fascicularis*) and compared them to other protozoans such as Entamoeba coli and Blastocystis sp.; the prevalence of *G. intestinalis* was lower at 8.57%, but it was nevertheless suggestive of possible zoonotic transmission in ecotourism destinations. In a more recent study, Paller et al. [23] collected fecal samples from 161 domesticated animals at a few farms in Laguna and Quezon provinces, Southern Luzon, Philippines, and used the immunofluorescence assay (IFA) to check for *Giardia*. *Giardia* was present in 73.9% of the animals, with ruminants having the highest rate of infection (89.47%).

Several environmental studies conducted in the Philippines attribute the transmission of *Giardia* to water and environmental sources. In a study spanning the provinces of Batangas, Cavite, Manila, and Pampanga, Kumar et al. [24] found *G. lamblia* in both treated and untreated water samples. qPCR results showed that while treated water showed a lower prevalence (10%), untreated water had a far greater prevalence (69.6%) with concentrations as high as 8.90 cysts/L. This disparity highlights the problems in water treatment practices, as the Philippines has one of the highest prevalence rates of *Giardia* in Southeast Asia. Recreational water sources are also a major source of giardiasis. Lim et al. [25], for instance, found *Giardia* in water samples from lakes, ponds, and rivers, resulting in a prevalence rate of 45.5%, with the highest contamination rates found in recreational sources. Significantly, no *Giardia* was found in sources of treated drinking water, including tap water and wells, highlighting the significance of efficient water treatment in lowering environmental contamination. In 2017, Paller et al. [26] examined swimming pools in Calamba, Laguna, and found *Giardia* in 75% of samples, with private children's pools showing

the highest density (700 cysts/L). Factors such as infrequent cleaning and poor pool management practices were linked to increased contamination. Agricultural water sources are also critical points of concern. In another study by Paller et al. [27], *Giardia* cysts were detected in 100% of the water samples (from vegetable farms in Laguna) but were not explicitly reported in vegetable and soil samples, thereby pointing to irrigation water as the main cause of contamination. Contributing elements were found to be practices including poor farmer hygiene and using untreated animal feces as fertilizer. Rural and indigenous communities face distinct challenges. Labana et al. [28] detected *Giardia* in 4.2% of river water samples in Boliwong, Ifugao. Midstream cysts suggest zoonotic transmission risks, especially in areas where river water is used for household purposes. Conversely, Ramos et al. [29] found no *Giardia* spp. in the Taguibo Watershed in Butuan City. The fast-flowing nature of the river, together with limited agricultural and residential activity, was suggested as the primary factor for the absence of parasites. The role of biofilms in *Giardia* transmission has gained attention. Masangkay et al. [30,31] demonstrated that *Giardia* cysts were found exclusively in biofilms in Luzon reservoirs and Lake Buhi. While no cysts were detected in open water, biofilms act as reservoirs, trapping and preserving cysts, thereby posing localized transmission risks. In a study of Vejano et al. [32], *G. duodenalis* was detected in Laguna Lake with a prevalence rate of 16.7% and tributaries with a prevalence rate of 37.7%, using PCR methods. Animal fecal samples showed 4.2% prevalence with zoonotic assemblages. The contamination of the lake and rivers might be attributed to agricultural runoff and sewage disposal. Transmission of *Giardia* also extends to fresh produce. In a study of Tychuaco et al. [33] in four public markets in Manila, Philippines, 87 vegetable samples (64 leafy, 23 root) were analyzed for parasitic contamination. *Giardia* spp. was detected in 2.3% of the vegetable samples. Despite the low prevalence, it was present in leafy vegetables such as lettuce and cabbage, which are often

consumed raw. Contamination of the fresh produce is due to poor vendor hygiene and inadequate water sanitation during vegetable washing and storage.

To address these gaps, future epidemiological research should emphasize the use of molecular diagnostic tools and investigate the socioeconomic and environmental factors influencing giardiasis prevalence. Improvements in water sanitation infrastructure and targeted public health campaigns promoting hygienic practices are crucial to reducing the burden of giardiasis, particularly in vulnerable populations at heightened risk of infection.

Table 1 summarizes the research on the prevalence of giardiasis in the Philippines from 2007 to 2024 by various researchers, considering the human population, animal reservoir, and environment. These studies provide a comprehensive understanding of the epidemiology of giardiasis in the country. The findings from these studies contribute valuable information for public health interventions and policies related to giardiasis in the Philippines.

Table 1. Summary of studies on the prevalence of giardiasis in the Philippines.

Study Overview and Sample Collection Details	**Diagnostic Method**	**Purpose**	**Prevalence of *Giardia***	**Reference**
Human Population				
Stool samples were collected from 3,456 patients with diarrhea, including 63.4% children and 36.6% adults, across 79 health facilities in Luzon, Visayas, and Mindanao.	Direct Fluorescence Detection	MeriFluor® *Cryptosporidium-Giardia* kit was utilized to identify *Giardia* cysts	Overall Prevalence: • 9 out of 3,456 stool samples, yielding an overall prevalence of 2.0%. Geographic Prevalence: • Luzon: 1.9% (32/1,667 samples). • Visayas: 1.6% (23/1,399 samples). • Mindanao: 3.6% (14/390 samples) (highest prevalence). Age Distribution: • Pediatric patients: 2.0% prevalence (43/2,160 samples). • Adults: 1.9% prevalence (24/1,245 samples). • Highest prevalence among children aged 5-9 years (6.7%). Sex-Specific Prevalence: • Male: 2.2% (42/1,934 samples). • Female: 1.8% (27/1,520 samples)	[8]
	Fluorescence microscopy	Identified *Giardia* cysts based on their characteristic apple-green fluorescence		
A total of 2,354 stool samples were collected from Baseco Compound, Metro Manila, including	Microscopy	Used to detect *Giardia* cysts morphologically	Overall prevalence: • 519 samples (22.05%) Block 17 (35.40%)	[7]

79 from children aged 0–5, 48 from those aged 6–15, and 6 from people over 15 years old.	Polymerase Chain Reaction-Restriction Fragment Length Polymorphism (PCR-RFLP)	Targeted the triose phosphate isomerase (tpi) gene to genotype *G. duodenalis*.	Block 10 (12.20%) Assemblage A: Found in 37.59% of samples. • Subtypes: Assemblage A-I (2.26%) and Assemblage A-II (35.34%). Assemblage B: Detected in 86.47% of samples. Mixed Assemblages (A + B): Found in 24.06% of samples	
Fecal samples were collected from 412 participants (218 males, 194 females; average age 40.3) across 18 barangays in Northern Samar, Philippines.	Multiplex Quantitative PCR (qPCR)	Applied for the detection of *G. duodenalis* and simultaneous screening of multiple parasites from stool samples	Overall prevalence: 19.2% (95% CI: 15.4–23.0)	[9]
Stool samples were collected from 91 participants in Metro Manila between January and February 2017, including 41 slaughterhouse workers and 50 food vendors.	Direct Wet Mount	Performed for the initial detection.	Overall prevalence: 7.69% (7/91)	[18]
	Formalin-Ether Sedimentation	Utilized for parasite concentration.		
	Microscopy	Detection of parasite		
Animal Reservoir				
Fecal samples from 11 captive animals (8 tigers, 2 Palawan bearcats, and 1 Asian palm civet) were collected twice, with a two-month gap, at a wildlife facility in Manila.	Modified Flotation-Sedimentation Method	Detection of the presence of *G. duodenalis* cysts and trophozoites	Overall prevalence: 0%	[19]

	ImmunoRun® Antigen Detection Kit	Confirmation of results from the flotation-sedimentation method		
A total of 103 fecal samples were collected from livestock farms in Sariaya, Quezon, including 47 from cattle, 44 from pigs, and 12 from carabaos.	Microscopy with Lugol's Iodine Stain	Initial detection and morphological identification of cysts/oocysts under 400× and 1000× magnifications.	14 out of 103 samples (13.59%)	[20]
	Polymerase Chain Reaction (PCR)	Confirmation and characterization of *Giardia* assemblages	13 out of 103 samples (12.62%)	
Fecal samples from pigs were gathered from animal farms in Bulacan Province, Philippines.	PCR (Polymerase Chain Reaction)	Detection and molecular characterization of *G. duodenalis*	6% of the porcine samples were positive for *G. duodenalis*.	[21]
In Puerto Princesa Subterranean River National Park, Palawan, 35 fecal samples from long-tailed macaques were collected, including 16 fresh and 19 dry samples.	Formalin-Ethyl Acetate Concentration Technique (FEACT)	For initial detection and identification of enteroparasites.	*G. intestinalis* was detected in 3 out of 35 samples, resulting in a prevalence of 8.57%	[22]
	Microscopy	To morphologically identify and document the presence of enteroparasites.		
Fecal samples from 44 pigs were collected in Sariaya, Quezon.	Polymerase Chain Reaction (PCR)	Used for the detection and genotyping of *Giardia duodenalis* targeting the tpi gene	molecular prevalence of *G. duodenalis* in pigs from the Philippines was reported as 15.9%.	[34]
Fecal samples from 161 domesticated animals were collected from farms in Laguna and Quezon, Southern Luzon.	Immunofluorescence Assay (IFA)	Used to identify the presence and incidence of *Giardia* in farm animals	Overall prevalence was 73.9% and ruminants show the highest prevalence at 89.47%	[23]
Environment				

Thirty-three water samples (10 treated and 23 untreated) were collected from Batangas, Cavite, Manila, and Pampanga, Philippines.	Immunomagnetic Separation (IMS)	Used to isolate and purify Giardia cysts	Treated Water Samples: • 1 out of 10 samples (10%), with an average concentration of 0.02 ± 0.06 cysts/L. Untreated Water Samples: • 16 out of 23 samples (69.6%), with an average concentration of 8.90 ± 19.65 cysts/L.	[24]
	Microscopy	Utilized to morphologically identify Giardia cysts		
	Real-Time PCR (qPCR)	Targeted small subunit RNA (SSU rRNA) gene for *G. lamblia* for comfirmation		
Thirty-three water samples were collected from urban and rural sources (rivers, lakes, ponds, wells, swimming pools, and rainwater tanks) in the Philippines.	Microscopy	Used for morphological identification of Giardia cysts	Overall Prevalence: • 45.5% of water samples. Prevalence by Source: • Rivers: 90% (9 out of 10 samples). • Lakes: 66.7% (4 out of 6 samples). • Ponds: 50% (2 out of 4 samples). • Swimming Pools: 33.3% (1 out of 3 samples). • Rainwater Tanks: 100% (1 out of 1 sample). 0% prevalence in drinking water sources	[25]
	Polymerase Chain Reaction (PCR)	Targeted specific genetic sequences for confirmation		
Water samples were collected from 12 swimming pools (6 private, 6 public) in Brgy. Pansol, Laguna, from April to July (100L from adult pools, 50L from children's pools).	Immunofluorescence Assay (IFA)	Determined the prevalence and density of *Giardia* in recreational pools.	Overall: 75% of the swimming pools (9 out of 12 pools) 83.33% of private pools. 66.67% of public pools. More prevalent in children pools (83.33%) compared to adult pools (66.67%).	[26]
Twenty-four surface water samples (9 from rivers, 9 from creeks, and 9 from water pumps) were collected in Boliwong, Ifugao, Philippines.	Direct Fluorescent Antibody (DFA) Test	Utilized for the detection and confirmation of *Giardia cysts*	Out of 24 water samples, 1 sample (4.2%) was positive for Giardia spp. midstream river sample, with a low concentration of 0.1 cyst/L	[28]
	Immunomagnetic Separation (IMS)	Enhanced the sensitivity of detection for low-concentration samples		
Sixty-nine environmental water samples (23 surface water, 23 bottom water,	Immunofluorescence Testing (IFT	Utilized Aqua-Glo™ G/C Direct Kit for specific detection of *Giardia* cysts	4% (1/23) of Substrate-Associated Biofilms (SAB)	[30]

and 23 biofilms) were collected from major reservoirs in Luzon, including Laguna de Bay and Taal Lake.	Scanning Electron Microscopy (SEM)	Used to assess the structure and presence of *Giardia* within biofilms.	No *Giardia* cysts were detected in Surface Water (SW) or Bottom Water (BW) samples.	
Three water samples (upstream, midstream, and downstream) were collected from Taguibo Watershed in Butuan City, Philippines.	Microscopy	Used for direct microscopic smear examination	No *Giardia spp.* cysts were detected in any of the three water samples (upstream, midstream, and downstream)	[29]
A total of 168 vegetable samples (including lettuce), 55 soil samples, and 15 water samples were collected from four vegetable farms and a reference farm.	Standard parasitological techniques	Used to detect and identify parasite eggs and cysts.	*Giardia* cysts were observed in all water samples (100%), however not explicitly reported in vegetable and soil samples.	[27]
A total of 36 water samples from Laguna Lake, 69 from tributaries, and 48 from agricultural animals in Rizal and Laguna were collected.	Nested PCR	Targeted the small subunit ribosomal RNA (SSU rRNA) gene of *G. duodenalis* for primary detection	Laguna Lake Water Samples: • Overall prevalence: 16.7% (6/36 samples). • Aseemblage A: 100% Tributary River Water Samples: • Overall prevalence: 37.7% (26/69 samples). • High prevalence in: o Bagumbayan River: 66.7% (6/9 samples). o Santa Rosa River: 55.6% (5/9 samples). o San Cristobal River: 44.4% (4/9 samples). • Assemblage A: 88.5%. • Assemblage B: 7.7% • Mixed assemblages: 3.8% Animal samples: Overall prevalence: 4.2% (2/48 samples).	[32]
	Semi-Nested PCR	Used the glutamate dehydrogenase (gdh) gene for further genotyping and sub-genotyping		
Fifteen aquatic samples (5 surface water, 5 well	Immunofluorescence Testing (IFT)	Confirmatory method for detecting *Giardia* cysts	Aquatic Matrices:	[31]

water, 5 biofilms) and 5 freshwater sponge samples were collected from Lake Buhi, Camarines Sur.			• *Giardia spp.* was not detected in any of the aquatic matrices (SW, WS, or SAB). Freshwater Sponges: • *Giardia spp.* cysts were detected in 20% (1/5) of sponge samples via IFT.	
A total of 87 vegetable samples (64 leafy and 23 root) were collected from four public markets in Manila, Philippines.	Microscopic examination with Lugol's Iodine staining	Used for detecting protozoan cysts	Overall Prevalence: 2.3% (2/87) Vegetable-Specific Prevalence: Lettuce (*Lactuca sativa*): 10.0% (1/10 samples). Cabbage (*Brassica oleracea*): 11.1% (1/9 samples) Quiapo Public Market: 55.6% overall contamination rate. Talipapa in Barangay 407: 55.0% overall contamination rate. Divisoria Market: 50.0% overall contamination rate. Altura Marketplace: 15.6% overall contamination rate.	[33]

III. DIAGNOSTIC METHODS FOR GIARDIASIS

Considering its diverse clinical manifestations and significant public health implications in the Philippines, precise diagnosis of giardiasis is essential [10]. A variety of diagnostic techniques are available, including microscopy, molecular methods, antigen detection, and innovative approaches such as microRNA-based detection [10,20] (Table 1). Employing a combination of these methods can improve diagnostic accuracy, especially in cases with low parasite loads or sporadic cyst shedding [10,20].

Traditionally, stool microscopy has been the cornerstone of giardiasis diagnosis in the Philippines. Microscopic identification of *Giardia* spp. in fecal specimens is regarded as the definitive method for diagnosing giardiasis. This technique is employed to identify cysts and trophozoites. To increase diagnostic yield, though, its sensitivity varies from 50% to 70% depending on the parasite load and the observer's expertise; it also usually requires the analysis of several stool samples taken on several days. Notwithstanding these constraints, microscopy is still extensively used in fields with limited resources since it is cheap and can simultaneously detect co-infections with other intestinal parasites, so acting as a valuable tool [10,35].

Molecular diagnostics, particularly polymerase chain reaction (PCR), have emerged as the gold standard for giardiasis diagnosis [11]. With the added benefit of genotyping *Giardia* into Assemblages A and B, which are absolutely vital for knowledge of zoonotic transmission, PCR-based methods including real-time PCR exhibit high sensitivity and specificity [14]. Duodenal biopsy together with PCR or histopathological analysis is utilized in chronic cases where fecal samples do not yield positive results to enhance detection [13]. Although PCR is the recommended approach for giardiasis diagnosis, its great cost causes practical difficulties. Offering PCR

diagnostic treatments is difficult, particularly in underdeveloped nations with limited tools and infrastructure [11].

Antigen detection methods, including immunoassay techniques such as enzyme-linked immunosorbent assays (ELISAs) and rapid antigen detection tests (RDTs), like non-enzymatic immunochromatographic assays, are used to identify *G. intestinalis* antigens in human fecal samples [12,14]. These tests, which target specific *Giardia* antigens in stool specimens, offer sensitivity and specificity rates exceeding 90% [12]. While they are highly effective in high-throughput diagnostic environments, their widespread use in the Philippines is hindered by the high cost of test kits and limitations in supply chain logistics [11]. Fluorescence microscopy, which detects cysts stained with fluorochrome-labeled anti-cyst antibodies, is another option but is subjective and relies heavily on the training and expertise of the observer, limiting its accessibility. Emerging technologies, such as fluorescent microsphere-based assays (Luminex) and loop-mediated isothermal amplification (LAMP), show promise as advanced diagnostic tools [14].

Emerging tools including microRNA-based diagnostics and loop-mediated isothermal amplification (LAMP) have great potential to detect giardiasis. LAMP is best for field use in areas with limited resources since it runs at a constant temperature, so removing the need for thermal cycling [14]. *Giardia*-specific microRNAs (e.g., miR5 and miR6) have shown great sensitivity and specificity in recent studies, so providing a non-invasive substitute that might enhance current approaches. Although these technologies are still in experimental phases, in the Philippines they are a vital area for next investment and study [15].

In the Philippines, comparative research has highlighted the shortcomings of relying solely on conventional microscopy for diagnosing giardiasis. A study by Yason and Rivera [7] in a

Manila slum area revealed a higher prevalence of *Giardia* infections than previously reported, demonstrating the improved diagnostic sensitivity achieved by combining PCR with microscopy. Their findings showed that both assemblages A and B affect human and animal hosts, suggesting a potential zoonotic risk. This underscores the need to improve diagnostic methods to inform targeted health policies [7].

To address the challenges of diagnosing giardiasis in the Philippines, it is essential to adopt molecular, antigen-based, and emerging diagnostic tools. The goal is to advance research into the latest diagnostic technologies and ensure these tools are both affordable and accessible, facilitating their integration into regional healthcare systems, particularly in developing countries where giardiasis is widespread but resource limitations hinder accurate diagnosis.

A summary table of various diagnostic methods for giardiasis is presented below, highlighting the importance of assessing the strengths, limitations, and suitability of each method based on the available resources and healthcare infrastructure in different areas. This will help guide the selection of the most appropriate diagnostic approach to enhance accuracy and treatment efficacy.

Table 2. A comparative analysis of the currently available diagnostic methods used in studies for detecting giardiasis.

Diagnostic Method	Purpose and Findings	Reference
Enzyme-linked immunosorbent assay (ELISA)	Tests stool samples with great sensitivity (up to 95%) and specificity (100%) for *Giardia*-specific antigens including GSA-65. Especially in low-intensity infections, ELISA detects more cases than microscopy.	[12]
Rapid immunochromatographic tests (RDTs)	Uses visual indicators to detect *Giardia* antigens in stool samples, so generating quick, point-of-care diagnosis. Results are available in 10–15 minutes, making this method suitable for field and resource-limited settings.	[14]
Polymerase Chain Reaction (PCR)	Detects *Giardia* DNA in stool samples with high sensitivity and specificity. Multiplex PCR enables many protozoan parasites be simultaneously detected, while nested PCR increases the detection of low parasite loads.	[14]
Real-time PCR	Amplifies and quantifies *Giardia* DNA in stool samples to provide high sensitivity for low parasite loads moderate or asymptomatic infections detection.	[35]
Duodenal biopsy with PCR/Histopathology	An advanced method used in persistent or chronic cases. Histopathology and imprint cytology can identify trophozoites, while PCR on biopsy samples improves diagnostic yield, detecting cases missed by stool-based methods.	[13]
MicroRNA-based detection	Identifies *Giardia*-specific miRNAs (e.g., miR5, miR6) in duodenal biopsy and stool samples. This emerging method demonstrates high sensitivity and could outperform traditional DNA-based diagnostics for biopsy samples.	[15]
Loop-mediated isothermal amplification (LAMP)	A rapid and cost-effective molecular method that amplifies *Giardia* DNA at a constant temperature without requiring thermal cycling. LAMP is ideal for resource-limited settings due to its simplicity and efficiency.	[14]
Fluorescent microsphere-based assays	Uses tools like Luminex to combine immunological and molecular detection. Large-scale epidemiological investigations can benefit from the simultaneous identification of *Giardia* and other diseases made possible by these high-throughput tests.	[14]

IV. PATHOGENESIS AND TRANSMISSION

G. duodenalis causes giardiasis through two life stages: the trophozoite and the cyst. The infection occurs when individuals ingest cysts, which are environmentally resistant, from contaminated food, water, or infected persons [1,4]. The trophozoites use ventral disks to attach to the intestinal epithelium, resulting in mechanical damage to the brush border, shortening of microvilli, and increased intestinal permeability, which leads to nutrient malabsorption [4,7]. The parasite's proteases further disrupt the intestinal barrier, contributing to diarrhea and malabsorption, particularly during acute infections [4]. In the Philippines, chronic cases of malnutrition, stunted growth, and cognitive impairments present serious public health issues, particularly among children [3,7].

Multiple routes spread giardiasis in the Philippines. The most common route of transmission is waterborne, with *Giardia* cysts found in rivers, recreational pools, and Laguna Lake, the country's largest inland lake. The most common zoonotic genotype in environmental samples is Assemblage A, indicating widespread water contamination [7,32]. In densely populated urban slums and institutional settings such as daycare centers, person-to-person transmission is also prevalent, facilitated by asymptomatic carriers who shed infective cysts [3,7]. Giardiasis persists due to livestock and domestic animal zoonotic transmission, as Assemblages A and B have been found in the Philippines [7,32]. Although understudied, foodborne transmission can occur through cyst contamination during irrigation or food handling [3,6].

Environmental and socioeconomic factors significantly influence the transmission dynamics of giardiasis in the Philippines. The country's growing population, inadequate sanitation infrastructure, and high poverty rates contribute to the persistence of the disease [7,17]. Rural communities reliant on untreated water sources and urban slums with insufficient waste disposal

systems are particularly vulnerable to giardiasis [3,7]. Giardiasis is common in rural and urban slums with poor waste disposal and untreated water. A Manila slum study found 22.05% prevalence, mostly associated with Assemblage B. *Giardia* cysts were found in 37.7% of tributary river samples in Laguna Lake, indicating widespread environmental contamination of water sources [32].

Giardiasis affects public health as well as individual health. Children and immunocompromised people are most at risk of malnutrition, stunted growth, and chronic gastrointestinal issues [3,4,7]. Seasonal transmission peaks during the rainy season complicate control [3,32]. Due to the high cost of treatment, it put a strain financially on the community, and loss of productivity also affects the economy. So, to address the issue on giardiasis it is needed to improve water monitoring, health education, and invest more in diagnostic tools. For targeted interventions, molecular epidemiology and environmental surveillance should be given more importance.

V. TREATMENT AND VACCINE

Currently, no commercial vaccine is available to prevent giardiasis, although ongoing global research and experimental animal studies have shown promising potential. The parasite's ability to alter its surface antigens poses significant challenges to vaccine development. To date, no vaccination campaigns specific to the Philippines have been conducted [1,4,36]. Collaborative efforts between local and international research institutions could play a crucial role in advancing vaccine development for giardiasis [36].

Nitroimidazoles, such as metronidazole and tinidazole, are used for treatment, with the latter preferred because of its single-dose regimen and less side effects [1,6]. For circumstances where nitroimidazoles are not effective, other drugs such as albendazole and nitazoxanide are used. Nitroimidazoles are becoming less used; treatment failures in some areas are recorded at 20%. [37–39]. Reduced drug activation pathways in *Giardia*, such as pyruvate ferredoxin oxidoreductase activity or nitroreductase enzyme changes, affect the parasite's susceptibility to nitroimidazoles [37,40]. Access to alternative treatments is particularly limited in rural areas [39]. Due to its limitations, searching for alternative treatments is important to address issues of drug resistance and for effective treatment. Plant-based phytochemicals, Lactobacillus probiotics, and nanotechnology may treat *Giardia* infections by targeting the parasite's adhesion mechanisms and boosting the host immune response [4,6].

Without vaccines, sanitation, hygiene, and water safety take front stage in prevention. Essential practices are hand washing, safe food management, boiling or filtering of drinking water [4,5]. Environmental factors like warm, humid climates and widespread water pollution aggravate the higher transmission risks even more [1,37]. Public education and infrastructure improvements are essential to reducing giardiasis. [5,36].

In the Philippines and neighboring countries, poverty and insufficient sanitation infrastructure contribute significantly to the high burden of diseases. The limited documentation of resistance trends in the Philippines underscores the urgent need for localized research to guide public health policies effectively. Priorities should include the development of region-specific vaccines for *Giardia*, improved access to second-line treatments, and initiatives to enhance sanitation infrastructure and public health education [5,37,38].

VI. CONCLUSION AND FUTURE DIRECTIONS

Giardiasis remains a significant public health challenge in the Philippines, particularly in underserved regions with inadequate water and sanitation infrastructure. The disease contributes to malnutrition, developmental stunting, and cognitive impairments, especially in children and impoverished communities. Despite being both preventable and treatable, the persistent high prevalence, environmental contamination, and zoonotic transmission emphasize the urgent need to address gaps in water sanitation and public health infrastructure.

While advancements in molecular diagnostics for giardiasis could enhance disease detection, the high costs and limited availability of resources in the country hinder the widespread use of these technologies. Furthermore, current epidemiological data is outdated, necessitating renewed efforts to accurately assess the burden of giardiasis and understand its transmission dynamics in the Philippines.

To effectively combat giardiasis, the Philippines must invest in public health campaigns and Water, Sanitation, and Hygiene (WASH) programs that emphasize hygiene, safe water handling, and early diagnosis. Public healthcare systems should prioritize the adoption of molecular diagnostic tools to improve detection and facilitate access to alternative treatments, addressing the challenge of drug resistance. Policymakers should focus on enhancing water treatment and waste management systems to mitigate environmental risks. Additionally, collaborative research between local and international institutions is essential for developing vaccines and supporting resource-limited disease control campaigns. By prioritizing these critical areas, the Philippines can significantly reduce giardiasis prevalence and its associated health impacts, ultimately improving the quality of life in affected communities.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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