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Human Giardiasis in Ghana – A Scoping Review of Studies From 2004 to 2024

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ABSTRACT

Background and Aim: Human giardiasis poses a significant public health challenge globally, particularly in resource-limited countries due to poor personal hygiene, environmental sanitation, and unsafe water. It affects approximately 300 million people globally every year, and children are the most at-risk population. This scoping review assesses the burden, transmission dynamics, and public health implications of human giardiasis in Ghana.

Methods: A comprehensive search strategy across PubMed, African Journals Online, Science Direct, Scopus and Web of Science databases using key terms "Giardia duodenalis," "Giardia intestinalis," and "Giardiasis." Published articles on Human giardiasis in Ghana between 2004 and 2024 on epidemiology, prevalence, diagnostic methods, and target populations were extracted.

Results: Seventeen studies conducted in Ghana met the inclusion criteria and were included in this review. The prevalence of *Giardia duodenalis* in Ghana varies significantly across studies and settings, with rates ranging from 0.7% to 59.6%, with children being the most affected. However, studies conducted in Ghana since 2020 indicate a lower prevalence, with rates between 0.7% and 13.0%. Regional studies indicate varied prevalence: 0.7%–13.0%, 2.3%–59.6%, and 5.9% in the Southern, Middle, and Northern belts, respectively.

Conclusion: The prevalence of human giardiasis in Ghana is relatively low. However, targeted public health interventions are necessary to maintain the progress achieved, in addition to improvements in sanitation and hygiene practices.

1 | Introduction

Human giardiasis is one of the most common gastrointestinal protozoan infections worldwide caused by *Giardia duodenalis* (also known as *Giardia lamblia*, *Giardia intestinalis*). It is a unicellular, flagellated, parasitic protozoan known for causing diarrheal diseases [1]. *G. duodenalis* exists in two morphological forms: the multi-flagellated trophozoite (four pairs of flagella) and the cyst [2]. Human giardiasis is globally distributed and considered one of the most prevalent parasitic infections in

Abbreviations: ELISA, Enzyme-linked Immunosorbent Assay; HIV, human immunodeficiency virus; PCR, polymerase chain reaction; SDGs, Sustainable Development Goals.

developed and resource-limited countries, especially countries in Asia, Africa, and Latin America [3]. The prevalence of human giardiasis varies widely depending on geographic region, socioeconomic status, and access to clean water and sanitation. About 300 million individuals are infected with *G. duodenalis* globally, resulting in an estimated 500,000 deaths reported annually [4, 5]. Human giardiasis is particularly prevalent in children living in resource-limited regions, hikers, and travelers to endemic regions. In regions lacking adequate sanitation, the incidence of human giardiasis is significantly elevated, ranging between 2% and 8% in developed countries, and 20% to 30% in resource-limited countries [5–7]. In sub-Saharan Africa and particularly, West Africa, prevalences are estimated to be between 7.4% and 8.9%, respectively [8].

1.1 | Assemblages of Giardia

G. duodenalis is environmentally ubiquitous and can persist for long periods in the environment in its cystic form [9, 10]. It can propagate through zoonotic reservoirs such as dogs, cats, sheep, and cattle, making it a significant public health concern [4]. Currently, eight different assemblages, A-H, have been identified. Assemblages A and B have been found to infect humans [11–13] and are known to also infect animals such as cattle [14–16], dog, monkeys, rabbit, African wild dog [10, 12, 13, 17], sheep, pig, goat, horse [15, 18, 19], cat, guinea pig, beaver, muskrat [10, 17, 20], moose, deer, water buffalo, ferret [10, 21], and seal, mako shark, gull [22]. Other assemblages identified in specific hosts include; C and D in dogs, wolves, African wild dog [12, 13, 23]; E, detected in cats, cattle, deer, pig, horse, sheep, yak [10, 15]; F, identified in cats and pigs [11, 24, 25]; G, in mice and rats [10]; and H, in gull and seals [22, 26]. Molecular evidence suggests that particular assemblages have the potential to infect new susceptible hosts, paving the way for new transmission pathways. Consequently, assemblage E was recently detected in nonhuman primates, rabbits, and humans [27, 28] while assemblage F was described in cattle [29, 30].

The difference in assemblages of the parasite has been linked to the varying symptoms identified in various individuals [31]. While a study conducted in sub-Saharan Africa has identified Assemblage A and B as the primary causes of giardiasis in humans [32], other studies in Nigeria, South Africa, Tanzania, and Kenya revealed mixed infections with assemblages A and B of *G. duodenalis*. Molecular study conducted in Nigeria revealed a remarkable diversity of Giardia assemblages, underscoring the prevalence of mixed infections among infected individuals [33]. Similarly, a study conducted in East Africa underscores the complexity of Giardia infections. Whereas in Kenya, polyparasitism, including Giardia co-infections with other parasites, was linked to diarrhea, a study in Tanzania revealed seasonal giardiasis prevalence patterns, influencing mixed infection dynamics and highlighting regional differences in parasitic disease ecology [34]. In Nigeria, whereas assemblage A is prevalent in children, assemblage B is more common in adults [33]. This notwithstanding, in Ghana, the predominant genotype causing giardiasis in children is assemblage B, even though both assemblage A and B are circulating in the country [35]. This variation could be attributed to differences in sampling techniques, host susceptibility, environmental factors, host exposure, immune response, or parasite virulence [36].

1.2 | Biology and Life Cycle

The cysts of *G. duodenalis* are instantly infectious and environmentally resistant, enabling the parasite to survive outside the host in harsh conditions for several months [37]. Individuals are infected through the fecal-oral route. The cysts are commonly found in non-diarrheal stool and are immediately infectious upon excretion. Once in the small intestine, exposure to gastric acid, proteases in the duodenum, and slightly alkaline pH in the small intestine triggers excystation of the excyzoite [38]. The excyzoite undergoes nuclear and cellular division, resulting in four binucleated trophozoites that colonize the intestine [38]. The trophozoite, the active replicative form of the parasite, multiplies by binary fission and can be free or attached to the intestinal wall, absorbing nutrients from the host via bulk endocytosis, utilizing peripheral vesicles, or receptor-mediated transport mechanisms [39, 40].

The trophozoites begin the process of encystation in the colon. This is due to changes in the intestinal environment, such as cholesterol deprivation and increased bile concentration [41]. The cysts are excreted in the feces, ready to infect a new host. The incubation period typically ranges from 1 to 3 weeks following exposure to the parasite, with symptoms persisting for 2 to 6 weeks [37].

1.3 | Mode of Transmission

The primary modes of transmission of human giardiasis include waterborne, foodborne, and person-to-person transmission. Waterborne transmission is the most common route, occurring through the ingestion of contaminated water, especially untreated or improperly treated water from lakes, rivers, streams, or wells [32, 42]. *G. duodenalis* cysts can survive for months in cold water, which is a significant risk factor in areas with poor sanitation [42]. Foodborne transmission is due to contaminated food, such as raw or undercooked fruits, and vegetables [32]. The use of contaminated water for washing or preparing food or poor hygiene practices among food handlers are significant risk factors [43]. Person-to-person transmission occurs particularly in settings with inadequate hygiene practices, such as indiscriminate defecation. Changing diapers, caring for infected individuals, or close contact in childcare centers, hospitals, or households are significant risk factors for the transmission of human giardiasis [32, 44].

Secondary modes of transmission include animal-to-person transmission, environmental contamination, and vector-borne transmission. Animals, particularly livestock, can serve as reservoirs for *G. duodenalis*, contaminating water sources and transmitting the parasite through zoonotic transmission [45]. Environmental contamination occurs when the cysts persist in soil and on surfaces contaminated with feces, contributing to indirect transmission through hand-to-mouth contact. The most at-risk populations for human giardiasis are children

under 5 years, immunocompromised individuals, travelers to endemic areas, people engaging in outdoor activities, low parental education, and individuals with poor hygiene or sanitation practices [46–48].

1.4 | Clinical Presentation

The clinical presentation of human giardiasis varies widely among individuals, ranging from asymptomatic cases to severe gastrointestinal disturbances. The primary clinical feature of giardiasis is watery, foul-smelling diarrhea, characterized by a greasy and floating appearance [49]. This symptom is frequently accompanied by abdominal cramps, bloating, and pain [50]. Additionally, nausea and vomiting are common, potentially leading to dehydration, particularly in pediatric patients and infants [33]. Fatigue, weight loss resulting from malabsorption of essential nutrients, and gastrointestinal distension are also reported [51].

In rare cases, giardiasis can progress to severe complications, including dehydration and electrolyte disturbances [33]. Prompt diagnosis and treatment are crucial to preventing complications, particularly in vulnerable populations such as children and immunocompromised individuals.

1.5 | Diagnosis and Treatment

The diagnosis of giardiasis relies on the detection of *G. duodenalis* cysts in stool samples, employing various diagnostic methods. Microscopy, the most common diagnostic method, involves examining fresh stool samples for cysts or trophozoites, necessitating multiple samples to enhance diagnostic accuracy [52]. Antigen detection tests, such as enzyme-linked immunosorbent assay (ELISA) and direct fluorescent antibody, offer higher sensitivity than microscopy [53]. Molecular methods, including polymerase chain reaction (PCR) assays, provide high sensitivity and specificity, yielding rapid results and proving particularly useful in complex cases [53].

Treatment typically involves the use of first-line options, including metronidazole (250–500 mg three times a day for 5–10 days), tinidazole (single dose), nitazoxanide, and paromomycin [49, 53]. While giardiasis generally resolves with appropriate treatment, complications such as dehydration, malnutrition, and lactose intolerance can occur, especially in children [49].

1.6 | Drug Resistance in Africa

The widespread use of metronidazole, the primary drug for the treatment of giardiasis, has precipitated the emergence of resistance [54, 55]. Elucidating the mechanisms underlying metronidazole resistance is essential for the development of efficacious treatment modalities. The principal mechanisms of metronidazole resistance in *G. duodenalis* include reduced drug uptake, diminished activation of the drug by downregulation of enzymes like pyruvate: ferredoxin oxidoreductase, increased futile cycling, upregulation of oxygen stress response, decreased electron flow, and accelerated deactivation of the metronidazole radical [54–56]. These mechanisms enable the parasite to survive and proliferate in the presence of the drug. Notwithstanding, metronidazole resistance often exacts a fitness cost from the parasite, manifesting as diminished growth rates and reduced infectivity in certain instances [56]. However, stable resistance can persist even after the removal of drug pressure, underscoring the necessity for alternative therapeutic approaches. This highlights the imperative for ongoing surveillance of drug resistance patterns and the development of innovative therapeutic strategies.

Human giardiasis poses a significant public health concern due to its high prevalence, environmental persistence, and ability to propagate through various reservoirs. Understanding the epidemiology and transmission dynamics of human giardiasis is crucial for the development of effective prevention and control strategies. This review aimed to provide a comprehensive overview of human giardiasis in Ghana between 2004 and 2024 and suggest ways to reduce the burden using targeted public health interventions.

2 | Methods

2.1 | Search Strategy

A comprehensive search was conducted on databases of African Journals Online, PubMed, Science Direct, Scopus, and Web of Science. The search strategy included only original studies and queries using a combination of keywords and terms such as “Giardia duodenalis,” “Giardia intestinalis,” “Giardia lamblia,” “Giardiasis,” “prevalence of giardiasis in Ghana,” “epidemiology of giardiasis in Ghana,” “gastrointestinal parasitic infections,” and “giardiasis in Ghana.”

2.2 | Review Framework

This scoping review adhered to the Condition-Context-Population (CocoPoP) framework recommended for review of prevalence and incidence data in the Joanna Briggs Institute (JBI) Reviewer Manual [57]. For this review, the term *Homo sapiens* refers to the species within the family Hominidae, characterized by complex cognitive abilities, upright posture, language use, and advanced social structures [58, 59]. Giardiasis is defined as an intestinal infection caused by the flagellated, binucleated, anaerobic protozoan parasite *G. duodenalis* (syn. *G. lamblia, G. intestinalis*), which affects several mammalian hosts, including humans [37, 60]. Viable cysts of *G. duodenalis* are transmitted through contaminated food or water, with humans, particularly children, considered the most significant reservoir host [8, 61]. Several clinical signs and symptoms characterize *G. duodenalis* infection, ranging from asymptomatic, acute or chronic diarrhea, vomiting, nausea, dehydration, abdominal cramps, weight loss, and malabsorption [3, 62]. The term *Ghana* designates a country in West Africa situated between latitudes 4.5° N and 11.5° N and longitudes 3.5° W and 1.5° E. Ghana is bordered to the east by west by Côte d'Ivoire, east by

Togo, to the north by Burkina Faso, and to the south by the Gulf of Guinea. The climate is predominantly tropical monsoon, and approximately 65% of the land is used for agriculture. This review included studies in which humans were clinically diagnosed based on medical laboratory investigations conducted during the study period.

2.3 | Eligibility Criteria

Included in this review were cross-sectional and case-control studies reporting the prevalence of *G. duodenalis* infections in Ghana, conducted in any population (e.g., children, adults, general population) using any diagnostic method (e.g., microscopy, antigen detection, molecular techniques). Studies on nonhuman giardiasis, conference abstracts, editorials, commentaries, case reports, case series, letters, protocols, theses, and narrative reviews were excluded. Studies conducted outside Ghana and studies with insufficient data to extract prevalence estimates were also excluded. No restrictions were placed on the age, sex, geographic location, or education level of the study population, provided the study was conducted in Ghana during the period considered in this review. All publications were imported into the Rayyan online platform (Rayyan-Intelligent Systematic Review) and were screened for potential eligibility. Full-text articles published in English between 2004 and 2024 were assessed for inclusion based on predefined criteria.

2.4 | Identification of Studies and Data Extraction

The screening was conducted in a stepwise process. The initial screening of studies was based on the title and abstract of retrieved articles by five authors (C. Y. D., I. N. A. A., P. N. A. B., J. J. A., and E. K. V.). The same authors conducted a full-text assessment of included studies when the abstracts were deemed insufficient to draw conclusions. Six independent senior authors (J.-P. K., N. T. K. D. D., G. B. K., P. B. T.-Q., I. A., and P. F. A.-K.) constituted the reviewer panel, assessed the quality of individual studies, and resolved by consensus any uncertainties or disagreements between the five full-text assessors on the inclusion of an article. The extraction of relevant data from each paper after full-text screening was summarized on data extraction forms. The full-text assessment evaluated and recorded the lead author's name, the study design, study settings, sample size, participant characteristics/recruitment, human giardiasis reported, data analysis, key findings, conclusions, and recommendations. For studies that were excluded, the reasons for the exclusion were recorded. For this review, data on prevalence, distribution, diagnostic method, demographics, year of the study, and study design were vital.

2.5 | Data Synthesis

As a result of heterogeneity in the study design, study settings, and study population, a thorough narrative synthesis was done to address the objective of the review. Findings of the studies were tabulated highlighting the prevalence, target population, prevalence, and diagnostic technique, study period, year the study was published, among others.

2.6 | Patient and Public Involvement

Due to the study's scoping review nature, no patient or the public was directly or indirectly involved in its conceptualization or conduct.

3 | Results

3.1 | Study Selection and Criteria

A comprehensive search across multiple databases, including African Journals Online, PubMed, Science Direct, Scopus, and Web of Science, yielded 314 records. A total of 86 duplicates were removed, and a further 202 articles were excluded based on their titles and abstracts. The full-text assessment of the remaining 26 articles led to the exclusion of nine studies, citing reasons such as: studies conducted outside Ghana ($n = 1$), study conducted in 1995 but published in 2004 ($n = 1$), nonhuman studies ($n = 3$), no data on diagnostic technique ($n = 1$), no clear title and year ($n = 1$), and no data on prevalence ($n = 2$). Ultimately, 17 studies met the inclusion criteria and were included in the final synthesis (Figure 1).

3.2 | Studies on Human Giardiasis in Ghana

Studies conducted on human giardiasis in Ghana covered districts, communities, and target populations and largely categorized into Southern, Middle, and Northern belts of the country. The prevalence rates vary significantly across studies, ranging from 0.7% in the Ho Municipality of the Volta Region to 59.6% in the Kwabre East District of the Ashanti Region. The main diagnostic method used was microscopy (93.8%) (direct wet mount method and formol-ether concentration method).

Out of 17 of the studies, 12 (70.6%) were cross-sectional, providing a snapshot of infection rates at a specific point in time, 2 (11.8%) were retrospective studies, while 3 (17.6%) studies did not mention the type of study. The target populations studied include vulnerable groups such as pregnant women, children, human immunodeficiency virus (HIV)-positive patients, and household occupants (Table 1).

3.3 | An Overview of Study Sites and Target Populations

Broadly, 8 (47.1%) studies were conducted in both the Southern and Middle Belts, and 1 (5.9%) in the Northern Sector, respectively, which were included in this review. Ashanti Region, in the Middle belt had the highest studies, 7(41.2%) followed by the Greater Accra Region in the Southern belt with 4 (23.5%). Central and Volta Regions recorded two studies each (11.8%), while Oti and the Upper East Regions recorded the fewest studies of one (5.9%). Children under 5 years and school-aged children between 2 and 12 years were the primary focus, each accounting for 25% of the studies. Pregnant women were also a significant target population, featuring in 11.7% of the studies. Additionally, HIV-positive patients, diabetes patients, and general community members were also included in the study.

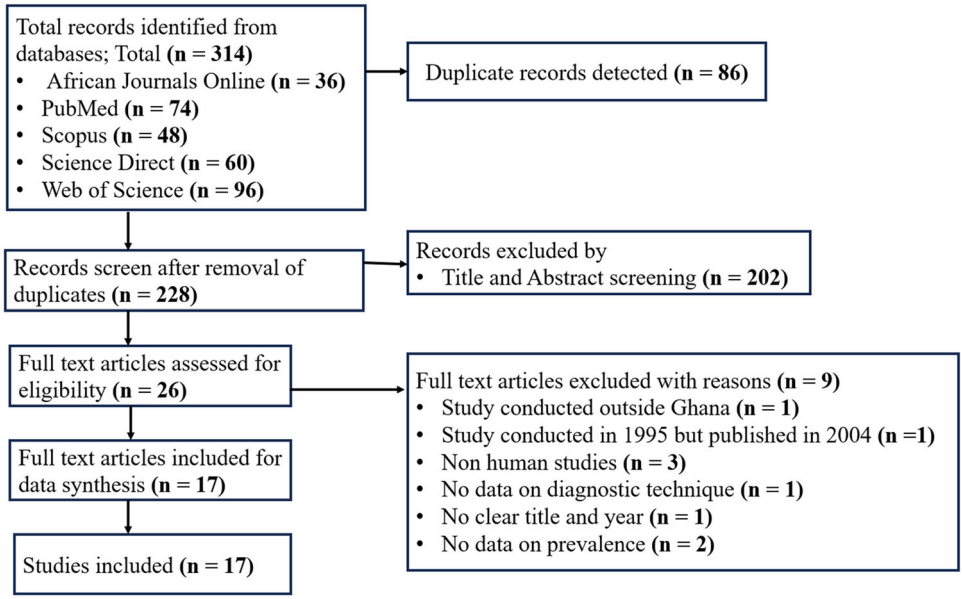

FIGURE 1 | A flow chart showing the criteria for the studies.

The inclusion of both healthcare facilities and community settings, provided valuable insights into the burden of the infection on different populations and settings. Overall, the study provides a robust background for understanding the dynamics of *G. duodenalis* transmission in Ghana and informing public health interventions.

Disparities in prevalence across the three belts have been identified in this review. This visual representation is helpful for identifying areas that may require more attention or resources related to the measured variable (Figure 2).

4 | Discussion

The prevalence of *G. duodenalis* in Ghana exhibits significant variability across studies and settings, with prevalence rates ranging from 0.7% to 59.6%. It is worth noting that, but for the prevalence of 28.1% reported in 2022, the prevalence of 59.6% and 39.0% were reported almost a decade ago. Otherwise, based on the current study, the prevalence of human giardiasis in Ghana is generally low. Comparatively, studies conducted in Algeria, Libya, and Madagascar reported moderate prevalence of 14.6%, 26.3%, and 12.6%, respectively [8]. Furthermore, the findings of the present study agree with studies that reported low prevalence in Côte d'Ivoire (13.9%) and Equatorial Guinea (14.2%), respectively [79]. These regional figures are consistent with the findings in Ghana, highlighting the disproportionate burden of giardiasis in resource-limited settings. This notable disparity underscores the significant role of environmental and socioeconomic factors in transmitting *G. duodenalis*, emphasizing the need for targeted interventions to address these underlying factors. In the case of the 59.6%, 39.0%, and 28.1% prevalence rates reported in the Ashanti region, it is unclear if there was any public health intervention to reduce the burden in the Kwabre East District, Akim North Municipality, and Manhyia North Sub Metro, respectively, since no current follow-up study was conducted to assess the current level of giardiasis in those localities [74]. The post-2020 studies on human giardiasis conducted in Ghana reported a relatively low prevalence of between 0.7% and 28.1% in the Ho Municipality of the Volta Region and Manhyia North Sub Metro of the Ashanti Region, respectively. While the lowest prevalence of 0.7% was reported in the Ho Municipality of the Volta Region [68], the Municipality recorded 7.0% prevalence in less than 7 years. This fluctuation emphasizes the fact that giardiasis prevalence is affected by various factors, including environmental conditions, public health interventions, population behaviors, and safe water. The decrease in *G. duodenalis* prevalence observed in 2020 could be correlated with the COVID-19 pandemic and its associated lockdown measures enforced in the country. These restrictions potentially led to diminished human interaction, increased adherence to hygiene protocols, and enhanced environmental sanitation, ultimately contributing to reduced *G. duodenalis* transmission.

The geographical distribution of *G. duodenalis* prevalence is particularly striking. The Southern and Middle belts of Ghana, especially the Greater Accra and Ashanti Regions, reported higher prevalence rates compared to the Northern belt. This disparity may be attributed to differences in sanitation infrastructure, healthcare access, and population density. The disparity could also be due to the number of studies conducted in the Southern and Middle belts compared to the Northern Sector. For instance, urban areas such as Cape Coast Metropolis with higher population densities may experience increased transmission rates due to crowded living conditions and inadequate waste management systems compared to the Kadjebi District of the Oti Region. Furthermore, the prevalence of giardiasis is notably higher in specific vulnerable groups, particularly children under 5 years of age. Studies indicate that children are at a greater risk of infection due to factors such as poor hygiene practices, close contact in communal settings, and immature immune systems [80, 81]. Consequently, many studies focused on this demographic, which may contribute to the observed higher prevalence rates in some regions.

TABLE 1 | Studies on Human Giardiasis in Ghana.

Sector	Region	District	Study site	Population size	% Prevalence	Diagnostic techniques	Study type	Target population	Study period	References
Southern	Central	Cape Coast Metropolis	Ekon M/A primary A, Ekon M/A primary B, Archbishop Amissah Attah primary, Wilson-Sey primary, and Philip Quaicoo Boy's Primary	230	13.0 (30/230)	Wet mount and formol-ether concentration techniques	Not stated	Clinically healthy basic school children	February–March 2014	[63]
		Awutu Senya East municipality	Kasoa Polyclinic	300	2.3 (7/300)	Direct wet mount method and formol-ether concentration method	Cross-sectional	Pregnant women	2018	[64]
	Greater Accra	Accra Metropolitan	Princess Marie Louise Children's Hospital	485	5.6 (27/485)	Direct smear method, formal-ether concentration method, and Enzyme immunoassay test	Cross-sectional	Children ≤ 5 years	March 2010 and June 2013	[35]
		Ga West Municipality	Opah, Otuaplem, Dedeman, Onyansana, Manchie	538	5.0 (27/538)	Formol-ether concentration method	Cross-sectional	Household occupants over 5 years old and those who have stayed in the community for at least a year	September 2019–March 2020	[65]
		Ashiedu Keteke sub-metropolitan district, Ablekuma Central Municipality,	Princess Marie Louise Children Hospital, Shukura Hospital, and Mamprobi Hospital	315	5.4 (17/315)	Formol-ether concentration method	Cross-sectional	Febrile children with diarrhea aged 6 months to 5 years	May–October 2022	[66]

(Continues)

TABLE 1 | (Continued)

Sector	Region	District	Study site	Population size	% Prevalence	Diagnostic techniques	Study type	Target population	Study period	References
		Ablekuma South District								
		Accra Metropolitan Area	Primary schools in the metropolitan area	300	9.3 (28/300)	Formol-ether concentration method and Direct mount method	Cross-sectional	School children aged 2–9 years	May–July 2016	[67]
	Volta	Ho Municipality	Klave, Hoe, Freetown, Dave, and Godokpe	150	0.7 (1/150)	Formol-ether concentration method and Direct mount method	Cross-sectional	Asymptomatic children under 5 years	2012 and 2016	[68]
		Ho Municipality	Klefe Achatime, Klefe Demete, Sokode Gbogame, Ho Bankoe, Ho SSNIT Flats	302	7.0 (21/302)	Formol-ether concentration method and Direct mount method	Cross-sectional	Asymptomatic children under 5 years	October 2016–March 2017	[69]
Middle-Belt	Ashanti	Kwabre East District	Aboaso, Ahwiaa, Adanwomase, Antoa, Mamponteng, and Ntonso circuits	884	59.6 (293/884)	Iodine and saline mounts (direct technique) and the formol-ether concentration method	Not stated	Pupils below the age of 6	May 2012–April 2013	[70]
		Manhyia North Sub-Metropolis	Tafo Government Hospital	150	28.1 (42/150)	Direct wet mount	Cross-sectional	Pregnant women	November 2016–January 2017	[71]
		Suame District	Komfo Anokye Teaching Hospital	500	19.0 (95/500)	Direct wet mount, formol-ether concentration method	Cross-sectional	HIV seropositive and negative adults	April and December 2008	[72]
	Ashanti	Kumasi Metropolitan	St Michael's Catholic Hospital	107	2.3 (2/107)	PCR	Not stated	Infants between 1 and 12 months	August 2014–July 2015	[73]

(Continues)

TABLE 1 | (Continued)

Sector	Region	District	Study site	Population size	% Prevalence	Diagnostic techniques	Study type	Target population	Study period	References
		Ashanti Akim North Municipality	Agogo Presbyterian Hospital	1234	39.0 (470/1,234)	Stool microscopy, polymerase chain reaction (PCR), and ELISA tests	Retrospective study	Children 13 years and below	June 2007 and October 2008	[74]
		Ashanti Akim North Municipality	Agogo Presbyterian Hospital	1080	9.7 (105/1080)	Direct wet mount method	Retrospective study	Children under 18 years	January 2006–May 2009	[75]
		Kumasi Metropolitan	Kentinkrono, Gyinyase, Kyirapatre, Ayigya, Aboabo, Manhyia	2400	12.2 (292/2400)	Direct wet mount method	Cross-sectional	Primary school children aged 5–12 years	January–September 2011	[76]
	Oti	Kadjebi District	St. Mary Theresa Hospital	335	3.0 (10/335)	Direct wet mount, formol-ether concentration method	Cross-sectional	HIV-positive patients	June–September 2021.	[77]
Northern	Upper East	Bolgatanga Municipality	Bolgatanga Regional Hospital, Afrikids Health Care Center, Epsona Health Care Center	152	5.9 (9/152)	Direct wet mount, formol-ether concentration method	Cross-sectional	Diabetes mellitus patients	2019	[78]

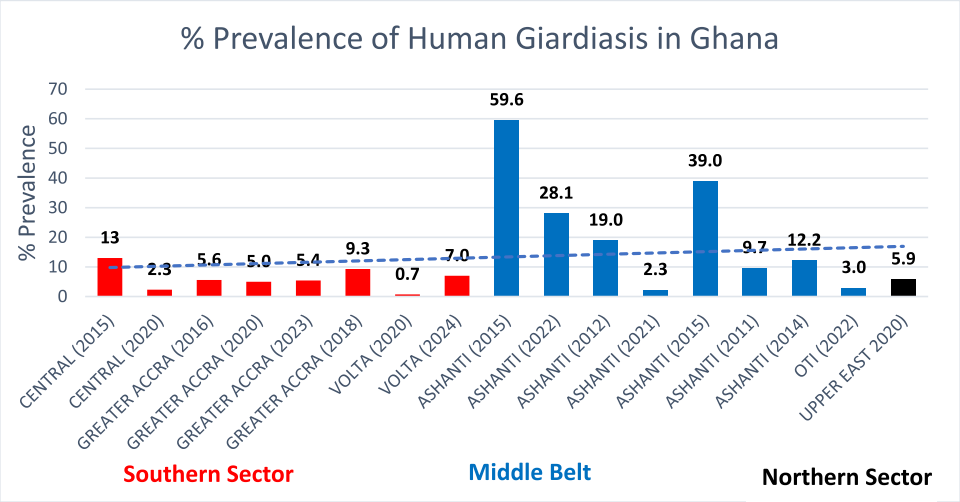

FIGURE 2 | Percentage prevalence of human giardiasis in Ghana.

4.1 | Determinants of *G. duodenalis* Prevalence

Access to clean water, proper sanitation facilities, socioeconomic conditions, and cultural practices significantly influence the prevalence of *G. duodenalis*. In developing countries like Ghana, where inadequate sanitation and contaminated water sources facilitate transmission of diarrheal diseases, including giardiasis, access to potable water and handwashing facilities is associated with lower prevalence rates [82]. Additionally, socioeconomic status impacts health outcomes, with wealthier nations benefiting from public health measures, education, and healthcare access, leading to lower infection rates [83]. Conversely, resource-limited settings struggle with high rates of gastrointestinal infections due to poverty, lack of education, and inadequate healthcare systems. Cultural practices related to hygiene, food handling, and water consumption also contribute to prevalence rates, with traditional practices in some countries increasing exposure to contaminated water or food.

4.2 | Environmental Influences on Prevalence

The environment plays a crucial role in the transmission dynamics of *G. duodenalis*. In regions where water sources are contaminated, through agricultural runoff, poor sanitation practices, or inadequate waste disposal, the prevalence of giardiasis tends to be significantly higher. Studies indicate that areas without access to clean drinking water and proper sewage systems report elevated rates of infection [84–86]. The resilience of *G. duodenalis* cysts in various environmental conditions further complicates the transmission dynamics. The cysts can survive outside the host for extended periods, making them a persistent threat in contaminated water sources. The transmission routes, primarily through the fecal-oral pathway, highlight the need for improved sanitation and hygiene practices to mitigate the risk of infection [87].

In Ghana, factors such as indiscriminate defecation, improper food handling, and crowded living conditions exacerbate the transmission of giardiasis. The cysts of *G. duodenalis* are immediately infectious and can remain viable in harsh environmental conditions for several months. Individuals become infected through contaminated water, food, or direct contact with fecal matter. Once ingested, the cysts undergo excystation in the small intestine, leading to the release of trophozoites that can colonize the intestinal lining and cause gastrointestinal symptoms.

4.3 | Population Demographics and Impact

The demographic characteristics of the populations studied significantly influence the reported prevalence rates of *G. duodenalis*. Children under 5 years, immunocompromised individuals, and specific vulnerable groups, such as pregnant women and HIV-positive patients, are at a higher risk of giardiasis [88]. Consequently, many studies focus on these populations, which may skew prevalence rates higher in these groups compared to the general population.

Children, particularly those in school settings, are frequently targeted due to their susceptibility to infections and the potential for rapid transmission within communal environments. A study done in Pakistan [81] discovered that children were at risk of giardiasis due to unpiped water, poor storage, proximity to rubbish, unpaved pathways, and inadequate latrines. Additionally, the focus on pregnant women, children, and individuals with compromised immune systems highlights the need for tailored public health interventions aimed at these high-risk groups [81]

Moreover, the diversity of study settings—from healthcare facilities to community environments, and the diagnostic technique used—provides a comprehensive understanding of the burden of giardiasis in Ghana.

4.4 | Regional Disparities in Prevalence

The geographical distribution of human giardiasis in Ghana reveals significant regional disparities. The Middle belt,

particularly the Ashanti region, had the highest number of studies and reports with elevated prevalence rates. In contrast, the Northern sector has fewer studies and generally lower prevalence rates. This discrepancy may be linked to differences in socioeconomic conditions, healthcare access, and environmental sanitation [89]. The studies conducted in the Ashanti region also highlight the importance of regional factors in determining giardiasis prevalence. The Ashanti region, with its mix of urban and rural communities, presents a unique context for understanding how socioeconomic conditions and environmental factors interact to influence infection rates. In the Greater Accra region, urbanization has led to increased population density and, consequently, greater challenges in waste management and sanitation. These factors contribute to the higher prevalence of giardiasis in urban areas compared to rural settings. Conversely, the Northern sector, which is less densely populated and may have better access to clean water sources, tends to report lower prevalence rates.

4.5 | Human Giardiasis and the One Health Approach

Giardiasis is transmitted to humans from various domestic and wild animals through fecal contamination. This is because *Giardia* assemblages A and B can infect humans, and their pets as well as rodents [90, 91], while other assemblages are known to be host-specific [92]. A study conducted in Cambodia by Inpankaew et al. [13] found only 2% of dogs had *G. duodenalis* assemblages that were potentially zoonotic. Another study conducted [93] in Norway also discovered a predominant number of sub-assemblage A-I strains instead of A-III in wild reindeer. Several studies have focused on the possibility of zoonotic transmission of giardiasis from cattle, dogs, and cats, but there remains relatively little direct evidence to support its significance in human infections [94, 95].

The implementation of the One Health approach in Ghana can effectively prevent and control human giardiasis by integrating human, animal, and environmental health strategies. Public health education campaigns can promote hygiene practices, while regular water quality testing can reduce environmental contamination. Collaborating with veterinarians to manage domestic animals and implementing comprehensive sanitation measures can decrease human giardiasis outbreaks. A holistic One Health framework, fostering collaboration among healthcare providers, environmental scientists, and agricultural experts, can enhance Ghana's efforts in controlling giardiasis.

4.6 | Public Health Interventions for Human Giardiasis Control in Ghana

Addressing human giardiasis in Ghana requires a multifaceted approach that integrates public health interventions that emphasizes improving water quality, sanitation, community health education, and policy-driven solutions.

1. Enhancement of water quality and sanitation infrastructure: Ensuring access to safe drinking water and improving sanitation facilities, particularly in rural and underserved urban areas, is fundamental to reducing giardiasis transmission. Investments in infrastructure and waste management systems are necessary to minimize water source contamination and promote environmental hygiene.
2. Community health education and promotion: Targeted health education campaigns are vital to raising awareness about giardiasis prevention. Emphasizing proper hygiene practices, such as handwashing and safe food handling, can empower communities to adopt behaviors that reduce disease transmission and improve public health outcomes.
3. Strengthened surveillance and targeted healthcare services: Establishing robust surveillance systems enables timely detection and response to giardiasis cases. Regular screenings for high-risk populations, including young children and pregnant women, alongside improved access to accurate diagnosis and treatment, are critical for early intervention and reducing the disease burden.
4. Policy advocacy and research for sustainable solutions: Advocacy for national policies prioritizing water safety, sanitation, and health education is essential to secure funding and support for giardiasis control programs. Concurrently, investing in research, such as molecular epidemiology studies, can provide insights into Giardia strains and inform evidence-based, long-term interventions.

By implementing these targeted public health interventions, Ghana can significantly reduce the burden of human giardiasis, particularly among vulnerable groups like children and pregnant women. These strategies will address immediate health concerns and contribute to long-term improvements in public health infrastructure and outcomes. Efforts aimed at reducing the burden of human giardiasis in Ghana align with the Sustainable Development Goals (SDGs) by improving water quality and sanitation (SDG 6) [96, 97], reducing disease burden (SDG 3) [98, 99], and promoting health education. Consequently, these initiatives would reduce poverty (SDG 1) [96] by minimizing healthcare costs and improving productivity, while fostering sustainable communities (SDG 11) [100] through better waste management and environmental hygiene.

5 | Conclusion

This review on *G. duodenalis* infections in Ghana reveals a significant public health concern, with prevalence rates ranging from 0.7% to 59.6%. The disease affects vulnerable populations, particularly children and pregnant women. The diagnostic method used is microscopy, highlighting the need for improved techniques. Environmental factors and zoonotic transmission pathways contribute to the epidemiology of the disease. Improving public health education, regular surveillance, improving sanitation infrastructure, and exploring genetic diversity for targeted treatment strategies are recommended.

Author Contributions

Christopher Yaw Dumevi: conceptualization, data curation, investigation, formal analysis, methodology, project administration,

validation, visualization, writing – original draft, writing – review and editing. **Isabella Naa Ayeley Aryee:** writing – original draft, data curation. **Peter Nii Apai Baddoo:** data curation, writing – original draft. **Joyce Junior Asiamah:** writing – original draft, writing – review and editing. **Ezekiel Kofi Vicar:** writing – original draft, writing – review and editing. **James-Paul Kretchy:** writing – original draft, writing – review and editing, formal analysis, supervision, validation, project administration. **Nicholas T. K. D. Dayie:** writing – review and editing, supervision, validation, formal analysis. **George Boateng Kyei:** validation, writing – review and editing, supervision, formal analysis. **Patience B. Tetteh-Quarcoo:** writing – review and editing, validation, supervision, formal analysis. **Irene Ayi:** formal analysis, writing – review and editing, supervision. **Patrick F. Ayeh-Kumi:** conceptualization, writing – review and editing, formal analysis, project administration, supervision, validation.

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Ethics Statement

The authors have nothing to report.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The authors confirm that all data supporting the findings of the study are available in the article. Data sharing is not applicable as no new data was created or analyzed.

Transparency Statement

The lead author, Patrick F. Ayeh-Kumi, affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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