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Human Strongyloidiasis in Ghana: A scoping review of prevalence and geographic distribution (2003–2023)

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Abstract

Background: Human strongyloidiasis is a neglected tropical disease with global public health concerns. Despite several interventions geared towards the prevention, control, and elimination of human strongyloidiasis in Ghana, infection and reinfection continue to occur, negatively impacting the health of affected populations. Lifelong autoinfection and fatal hyperinfection syndrome in immunocompromised individuals are often reported.

Objective: This scoping review aims to map and synthesise existing evidence on the prevalence and geographic distribution of human strongyloidiasis in Ghana between 2003 and 2023, identify research gaps and inform future priorities regarding control and elimination of the infection.

Methods: Original peer-reviewed studies published in English (2003 - 2023) that investigated human strongyloidiasis in Ghana were systematically searched and retrieved from six electronic databases and included in this review. Additional studies were identified from the reference lists of the reviewed articles. Relevant data were extracted from the included articles and presented in narrative and tabular formats.

Results: Twenty (20) articles that met the inclusion criteria were reviewed under broad subthemes: geographic distribution, prevalence, laboratory diagnostic methods, target population, and nature of public health intervention. Ten (50.0%) studies were conducted in the southern, six (30.0%) in the middle belt, and four (20.0%) in the northern sectors. Overall, 17 studies used cross-sectional designs, two retrospective, and one case-control method. The reported prevalence of human strongyloidiasis in Ghana ranged between 0.1% and 41.1%. However, a prevalence of 0.1% - 2.2% was reported in children, 0.5% - 41.1% in adults, 0.4% in HIV seropositive individuals, and 2.9% in food vendors. The geographical prevalence of human strongyloidiasis ranged between 0.1% - 21.2%, 0.4% - 2.9%, and 0.3% - 41.1% in the Northern, Middle belt, and Southern sectors, respectively. The direct wet mount and formal-ether concentration technique (70.0%), PCR (15.0%), and culture and other diagnostic techniques (5.0%) were used.

Conclusion: The national prevalence of strongyloidiasis in Ghana, based on this review, is low-to-moderate (median 1.45%), but extreme geographic heterogeneity exists, with localised hyperendemic regions (e.g., 21.2% and 41.1%) accounting for an increase in the mean to 4.5%. Population-weighted studies are essential for accurate national estimates, and targeted interventions are urgently needed to address high-transmission hotspots and underlying drivers of transmission. This review proposes further research and targeted interventions relevant to Ghana's efforts to meet the WHO's human strongyloidiasis elimination target by 2030.

Keywords: Strongyloidiasis, Ghana, *Strongyloides stercoralis*, Neglected tropical parasite, Scoping review

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INTRODUCTION

Human strongyloidiasis is a soil-transmitted helminthic infection of the gut, caused mainly by the rhabditid nematode, *Strongyloides stercoralis (S. stercoralis)*, which is globally distributed. It is predominantly found in tropical and subtropical countries in Sub-Saharan Africa, Central and South America, and Southeast Asia [1,2]. *Strongyloides stercoralis* is a neglected tropical parasite that infects human beings but occasionally parasitises primates and dogs [3]. Different species within the genus cause disease in amphibians, birds, primates, reptiles, and livestock. The rarer human-infecting species of Strongyloides comprises the zoonotic *S.*

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fuelleborni (fülleborni) subsp. *fuelleborni* and also *S. fuelleborni* subsp. *kellyi*, for which humans are the only known host currently [4], although they were initially thought to be a subspecies of *Strongyloides fuelleborni* [5]. Whereas Strongyloides *fuelleborni kellyi* is limited to Papua New Guinea in terms of distribution, animal reservoirs of the parasite are yet to be identified. Strongyloides *fuelleborni felleborni* is generally zoonotic with a wide geographical distribution [4].

Strongyloidiasis is endemic in tropical and subtropical regions of the world and has been reported to account for about 30-100 million infections annually [6, 7]. With the advent of highly sensitive diagnostic techniques, *S. stercoralis* infection is estimated to affect 613.9 million people worldwide, especially in Africa, Southeast Asia, and the Western Pacific regions [8]. Strongyloidiasis has been grossly underestimated and under-reported due to poor diagnosis [2]. The major public health challenge posed by human strongyloidiasis is, most often, its asymptomatic presentation that could last for years in immunocompetent individuals, thus making diagnosis and treatment difficult [9]. The life cycle of *S. stercoralis* is shown in Figure 1.

The most at-risk population of strongyloidiasis live in endemic areas with humid and warm climatic conditions, poor social infrastructure, and economic deprivation [11]. The presence of faecal contaminants in the environment may lead to its prevalence among farmers, migrants, mental health patients, prisoners, and people who live in areas with poor environmental sanitation [12]. Other at-risk persons include alcoholics, immigrants, travellers, malnourished individuals, people with malignancies, diabetic patients, chronic renal disease patients, and chronic obstructive pulmonary disease patients [13,14]. Individuals at increased risk of hyperinfection include those on immunosuppressants or corticosteroids, with immune deficiency disorders such as HTLV-1 or HIV/AIDS, and donors or recipients of organ transplantation [7,15]. Even though *Strongyloides stercoralis* infection is prevalent among HIV-AIDS patients who live in endemic communities, hyperinfection syndrome is seldom noticed [15].

Strongyloidiasis may present with acute, chronic, or hyperinfection syndrome, mostly characterised by low larval output. Although acute infections are rarely reported, individuals may experience local inflammation at the site of larval penetration, causing urticaria and itching around the feet, groin, buttocks, or trunk. Infected travellers may present with skin rashes and incessant diarrhoea [16]. Severe gastrointestinal infection can lead to anorexia, constipation, diarrhoea, abdominal pain, and occult intestinal bleeding. Clinical symptoms of pulmonary larval migration may also result in shortness of breath, cough, wheezing, or Loeffler's syndrome. Chronic cases of strongyloidiasis are common among people in endemic areas and are periodically detected in refugees and international travellers [17].

Hyperinfection of *Strongyloides stercoralis* is due to accelerated autoinfection (disseminated syndrome) when the larvae migrate to other internal organs of the host beyond the lung-autoinfective cycle [18]. Disseminated strongyloidiasis is common among individuals on immunosuppressants, alcoholics, HTLV-1 carriers,

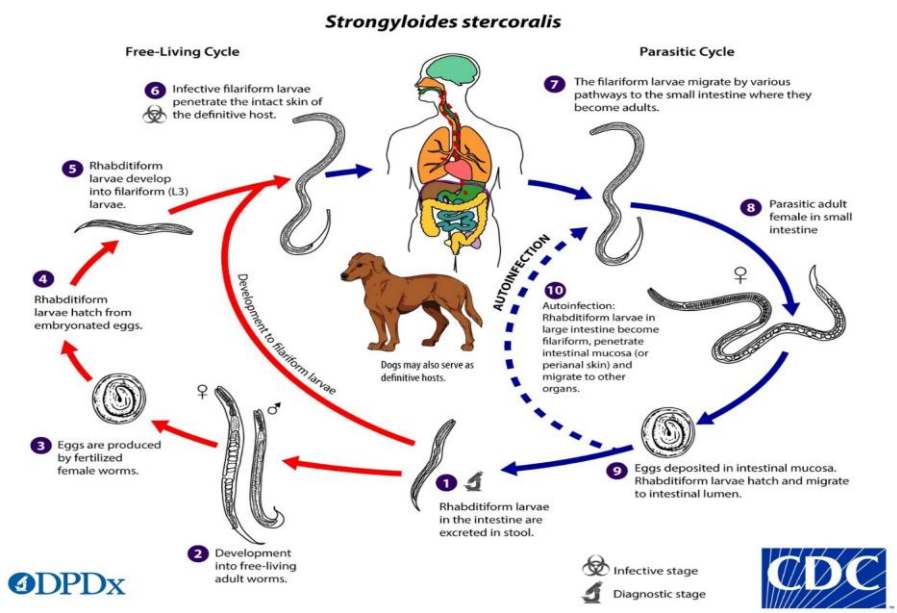

Figure 1. The life cycle of Strongyloides stercoralis.
Unique features include, irregular movement of autoinfective larvae, development of rhabditiform larvae from embryonated egg, and single generation of male and female free-living adults [10]

diabetic patients, organ transplant recipients, and those with haematological malignancies [15].

In Ghana, studies showed a varied prevalence of *Strongyloides stercoralis* infection: 4.8% (n = 26/538) and 39.5% among malnourished persons in Ga West Municipality in Accra [19], 0.45% (n = 3/861) in Berekum District [20], 43.0% of vegetables sold in open-air markets and a supermarket in Accra [21], 0.9% in the Middlebelt of Ghana (Kintampo South District and Kintampo North Municipality) [22], and 0.3% (n = 1/300) among school children within the Accra Metropolitan Area [23].

Disease diagnosis

Wet mount microscopy, nutrient agar plate culture (Koga agar plate), and the Baermann funnel techniques are common diagnostic tools to detect *Strongyloides stercoralis*. However, these tools demonstrate moderate sensitivity and poor diagnostic accuracy. Serious limitations of the Koga agar plate culture and Baermann's technique include their laborious and time-consuming nature and the inability to deploy them on a large scale [24, 25]. The polymerase chain reaction (PCR) is increasingly used as a routine diagnostic technique for *Strongyloides stercoralis* detection in stool samples, although there are concerns about sensitivity and limited data on its application to bodily fluids [26].

Stool samples from cases of *S. stercoralis* infection typically contain larvae rather than eggs, distinguishing them from other helminthic parasites. In chronic cases, the larvae are often present in limited numbers, which may result in counts falling below the detection threshold of available diagnostic tests [27,28]. Although it is common to find larvae in stool during heavy infections in endemic areas [14,29], intermittent and fewer larvae are produced in chronic situations [30]. Diagnosis of strongyloidiasis is fraught with challenges, such as low parasite load and low or irregular larval output, leading to underdiagnosis and underreporting of its prevalence [26].

Serological assays are comparatively more sensitive for detecting *Strongyloides stercoralis*; in developed countries, where they are available and used to determine therapeutic success [31]. Disadvantages of serological diagnosis include false-negative results in immunocompromised individuals and those with recent infections[32,33], false-positive results in persons with other parasitic infections, cross-reactivity with filarial worms [34,35] and the need for careful interpretation of results in Strongyloides-endemic areas [36]. Incidentally, real-time polymerase chain reaction remains the most sensitive diagnostic tool for the detection of *Strongyloides stercoralis* in stool samples [37].

Current treatment regimen and ivermectin resistance

The goals for therapy against *S. stercoralis* infections are to clear the parasite completely, thereby eliminating the risk of autoinfection, address symptomatic infection, and prevent complications associated with asymptomatic infections [38]. Evidence supports the efficacy of ivermectin and benzimidazoles (thiabendazole, mebendazole, and albendazole) for treating chronic strongyloidiasis [39]. The development of ivermectin from avermectin as a nematicide [40,41], has significantly contributed to the drastic reduction of onchocerciasis, lymphatic filariasis, soil-transmitted helminthiasis, scabies, and potentially malaria [16]. Although albendazole is recognised for its low efficacy and therapeutic effect on the parasite, mebendazole is not recommended for treating strongyloidiasis in the general population, particularly among pregnant women, due to its limited activity [39]. Thiabendazole is effective in the treatment of intestinal parasitic infections, but side effects such as malaise, nausea and or dizziness have been reported [42]. It is posited that an insufficient dosing regimen of ivermectin may result in incomplete parasite clearance, which could be misinterpreted as emerging resistance [43,44]. Ivermectin is effective against strongyloidiasis in immunosuppressed individuals; however, reinfection presents challenges to the elimination and eradication of the disease [45]. Poor diagnosis may not be easily differentiated from reinfection. A study has indicated potential ivermectin resistance in livestock, which could pose risks to humans [39,46]. To mitigate drug resistance, the combination of ivermectin and albendazole has been tested and shown to be effective in controlling other soil-transmitted helminths [47,48].

Study aim and research questions

Given the public health impact of strongyloidiasis on at-risk populations, it is important to understand the burden and associated factors driving transmission in Ghana. The knowledge of the prevalence and epidemiology of *S. stercoralis* infections would inform public health interventions aimed at improving health outcomes in strongyloidiasis-endemic areas. Therefore, this scoping review aimed to map and synthesise existing evidence on the prevalence and geographic distribution of human strongyloidiasis in Ghana between 2003 and 2023, identify research gaps and inform future priorities. To our knowledge, this is the first scoping review on the prevalence and epidemiology of human strongyloidiasis in Ghana. Consequently, this review was conducted based on the scoping review framework [49,50] by implementing a systematic methodology to provide a preliminary assessment of the quantity, quality, and key characteristics of the study design of available studies. Four primary research questions framed the review:

1. What are the reported prevalence, geographic distribution, and temporal trends of human strongyloidiasis in Ghana from 2003 to 2023?
2. What diagnostic methods have been used to detect *Strongyloides stercoralis* in Ghana, and how do they vary across regions or study populations?
3. What interventions (treatment, public health measures) have been implemented to control strongyloidiasis in Ghana between 2003 and 2023, and what is their reported impact on prevalence or geographic spread?

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4. What are the key methodological, geographic, or population-related gaps in the current literature on strongyloidiasis in Ghana from 2003 to 2023?

MATERIALS AND METHODS

Study design and sites

This study focused on reviewing existing literature on human strongyloidiasis in Ghana. Ghana is a tropical country in West Africa with a total land mass area of 239,000 km^2 and is located between latitudes 4.5 °N and 11.5 °N and longitudes 3.5 °W and 1.5 °E. Ghana is bounded to the west by the Republic of Côte d'Ivoire, to the east by the Republic of Togo, to the north by the Republic of Burkina Faso, and to the south by the Gulf of Guinea. Annually, the average temperature of Ghana is 26 °C (79 °F), with the tropical monsoon typically defining the climatic condition of the country [51,52]

Search strategy and selection process

A systematic search was conducted across multiple databases, including African Journals Online, Cochrane Library, Google Scholar, Web of Science, PubMed, and ScienceDirect, between January 2003 and December 2023. The search strategy was based on the PRESS 2015 Guideline Statement and ensured sensitivity, accuracy, and precision [53]. The search terms were combined using predetermined search terms, including Medical Subject Headings (MeSH) and relevant keywords. The strategy was validated by an information specialist and employed Boolean operators ("AND," "OR") to create relevant search queries and controlled vocabulary, such as "*Strongyloides stercoralis*" [MeSH] OR "strongyloidiasis" [MeSH] OR "Strongyloides" [tiab] OR "strongyloidiasis" [tiab], AND ("Ghana" [MeSH] OR Ghana[tiab]), AND ("humans" [MeSH] OR human*[tiab]), NOT (animal*[tiab] OR veterinary[tiab]). Truncation (*) was utilised to broaden search terms (e.g., human* to include humans), while field tags [tiab] and [MeSH] were used to target title/abstract and indexed terms, respectively.

Duplicate records were removed using Zotero, and screening was conducted with Rayyan QCRI [54]. Additionally, manual reference tracking was employed to identify further relevant studies. The methodological quality of the individual studies was assessed, and animal and human strongyloidiasis were differentiated. No restrictions were applied to the study design or region.

Eligibility criteria

Full-text peer-reviewed studies conducted in Ghana on human strongyloidiasis that reported primary data in English and were published between 2003 and 2023 were included. All studies reporting data on prevalence, diagnostics, control, treatment methods at local or regional levels, and intensity of infections in Ghana were included. No restrictions were placed on the geography, sex, age, or education level of the study population, provided the study was conducted in Ghana. Published articles that were not peer-reviewed (grey literature, book chapters), included secondary data, or were opinion pieces were excluded. Original studies or secondary data on animal strongyloidiasis were also excluded. All published articles were thoroughly screened and reviewed according to the eligibility criteria. Duplicates were removed, and published articles on any intervention for strongyloidiasis control in Ghana aimed at breaking the transmission were considered relevant and included in this study. The quality of the individual studies and the data underlying the publications was assessed prior to inclusion in this review (Figure 2).

Screening of studies and data extraction

The screening was conducted in a stepwise process. Initial screening of studies was done based on the title and abstract of retrieved articles; the same authors (CYD, JPK, PBT-Q, and IA) conducted a full-text assessment of included studies when the abstracts were deemed insufficient to conclude. A review panel assessed the quality of individual studies and resolved by consensus any uncertainties or disagreements between the two full-text assessors on the inclusion of an article.

The extraction of relevant data from each paper after the full-text screening was summarised on data extraction forms. The full-text assessment evaluated and recorded the lead author's name, country of origin, study design, study settings, sample size, participants' characteristics/recruitment, strongyloidiasis intervention reported data analysis, key findings, conclusions, and recommendations. For studies that were excluded, the reasons were recorded. Data on prevalence, distribution, treatment or control method, demographics, year of study, and study design were vital for this review. Studies on WASH intervention for *Strongyloides stercoralis* infection control were included. Strongyloidiasis control measures adopted by different countries in Africa were also critically examined for their effectiveness.

Data synthesis

As a result of heterogeneity in the study design, study settings, study population, and the nature of the intervention, a thorough synthesis was done to address the objective of this review. Findings of the studies were tabulated, highlighting the prevalence, target population, population size, nature of the intervention, study period, and year the study was published, among others. Data on the intensity and prevalence of human strongyloidiasis were extremely important for this review. Data on infected and non-infected humans was considered and included. Also, data on the geographic location, demographics, year of the study, and diagnostic technique used were all recorded where available. Most of the studies were cross-sectional.

Patient and Public Involvement

This was a scoping review, and no personal data from patients, clients, or members of the public was collected or generated.

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RESULTS

A total of 154 articles related to strongyloidiasis in Ghana were retrieved. Of these, 75 were duplicates and hence removed. After a thorough screening of the titles and abstracts, 79 articles remained for full-text assessment for eligibility. A further 55 were excluded, leaving 20 articles published between 2003 and 2023 across Ghana included in this review (Fig.2). Details of the coverage of this review include 10 (50.0%) studies conducted in the southern sector, 6 (30.0%) in the middle-belt and 4 (20.0%) in the northern sector. Of these, 17 studies used cross-sectional designs, 2 were retrospective studies, and 1 case-control study (Figure 3 and Table 1).

Most of the *Strongyloides stercoralis* infections reported in the studies included in this review were among children (5-16 years) with prevalence ranging from 0.1% to 2.2%. Pregnant women (15 - 49 years) had a prevalence range between 1.9% and 3.1% while food vendors (10 - 70 years) had 2.9% prevalence. For community-based studies involving children and adults, the age ranges from 5 to 100 years with a prevalence rate between 0.9% and 4.8%. The prevalence of strongyloidiasis infection in HIV seropositive

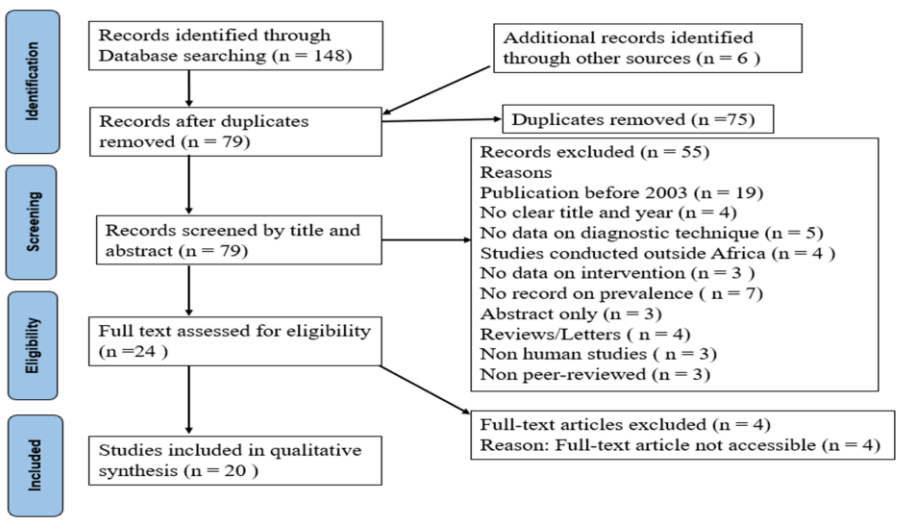

Figure 2. PRISMA Extension for Scoping Reviews (PRISMA-ScR)[55,56]

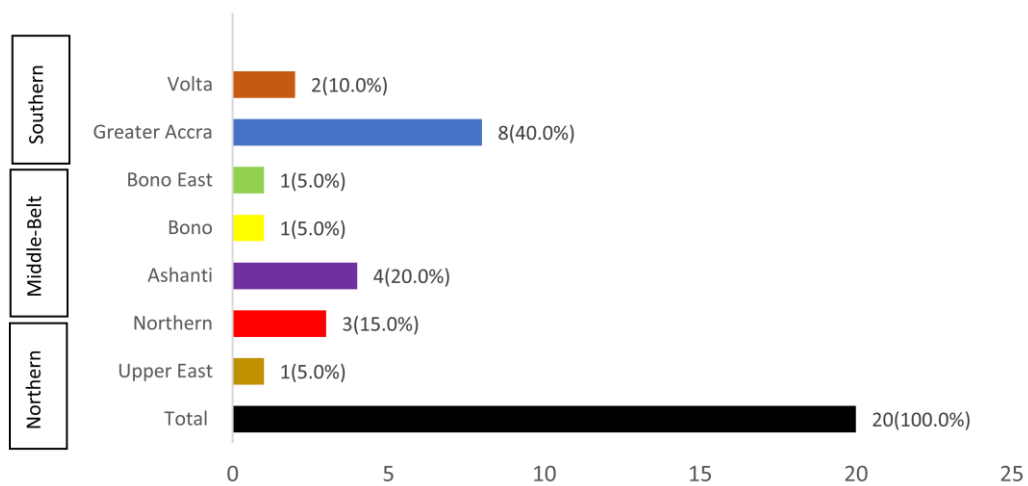

Figure 3. Regional distribution of studies on human strongyloidiasis in Ghana.

Table 1. Prevalence, diagnostic technique, and nature of intervention regarding strongyloidiasis in Ghana

Sector	Region	District	Study site	% Prevalence	Diagnostic technique	Study type	Target population (years)	Targeted population size	Nature of Intervention	Study period	Year Study published	Ref.
Northern	Northern	Not stated	Not stated	21.2 (45/212)	PCR, Culture /Baermann	Cross sectional	Mixed (adults and children)	212	Not stated	Not stated	2009	[57]
	Upper East	Kassena-Nankana	Navrongo War Memorial Hospital	2.3 (7/300)	FEC	Cross sectional	Pregnant women	300	Not stated	Aug - Nov 2005	2010	[58]
	Northen /North East/Savannah/ Upper West	Not stated	Nothern Ghana	0.1	Multiplex Bead Assay	Cross sectional /cluster	Children (1-9)	10840	Not stated	Nov 2015-April 2016	2022	[59]
Middle-belt	Ashanti	Kumasi Metropolis	KNUST food stalls/canteen,	2.9 (4/140)	DWT, FEC	Cross sectional	Food vendors (10-70)	140	Not stated	Feb-April 2011	2014	[60]
	Ashanti	Kumasi Metropolis	Kumasi	0.4 (3/800)	DWT, FEC	Cross sectional	HIV seropositive &negative adults (≤ 20 > 50)	800	Not stated	April - December 2008	2012	[61]
	Ashanti	Kumasi Metropolis	Komfo Anokye Teaching Hospital, Kumasi	0.5 (2/380)	DWT	Cross sectional	Women	760	Not stated	Not stated	2015	[62]
	Ashanti	Not stated	KNUST Hospital, Kumasi	2.0 (41/77)	PCR	Retrop ective	Children (≤13)	2046	Not stated	2007-2008	2022	[63]
	Ashanti	Asante Akim North municipal	Not stated	0.9 (4/548); 1.1(6/651)*	DWT, FEC, ELISA, PCR	Case-control	Children (≤13)	1234	Treatment (Albendazole (400 mg)	June 2007-October 2008	2015	[64]
	Bono	Banda	Asante Akim North municipal	2.2 (6/275)	FEC	Cross sectional	Children (5-16)	275	Treatment Albendazole (400 mg)	2021	2023	[65]
	Bono East	Kintampo North & Kintampo	7 basic schools	0.9 (14/1569)	DWT, KK, FEC	Cross sectional	Community based (<8-100)	1826	Not stated	Sep 2015 - August 2016	2018	[22]
Southern	Greater Accra	Dangme East	Kintampo North Municipality and Kintampo South District	1.9 (7/375)	FEC	Cross sectional	Pregnant women (15-49)	375	Not stated	April - July 2012	2017	[66]
	Greater Accra	Accra metropolis	Sege, Bonikope & Anyamam Health Centre	41.1 (37/90)	DWT, FEC	Cross sectional	Adult (≤18)	336	Not stated	Jan – Aug 2021	2023	[67]
	Greater Accra	Accra metropolis	Korle-Bu	0.3 (1/300)	DWT, FEC	Cross sectional	Children (2-9)	300	Not stated	Mar-July, 2016	2017	[23]
	Greater Accra	Accra metropolis	Odododiodio	2.0 (2/101)	DWT, FEC	Cross sectional	Mixed (5-22)	101	Not stated	April-June 2012	2015	[68]
	Greater Accra	Ga West Municipal	Osu Orphanage	4.8 (26/538)	FEC	Cross sectional	Mixed (6-≥40)	538	Treatment Albendazole (400 mg)	Sept 2019-Mar 2020	2020	[19]

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Table 1. Cont.

Sector	Region	District	Study site	% Prevalence	Diagnostic technique	Study type	Target population (years)	Targeted population size	Nature of Intervention	Study period	Year Study published	Ref.
	Greater Accra	Accra metropolis	Osu Orphanage	2.0 (2/101)	DWT, FEC	Cross sectional	Mixed (5-22)	101	Not stated	April-June 2012	2015	[68]
	Greater Accra	Ga West Municipal	Opah, Otuaplem, Dedeman, Onyansana, & Manchie	4.8 (26/538)	FEC	Cross sectional	Mixed (6-≥40)	538	Treatment Albendazole (400 mg)	Sept 2019-Mar 2020	2020	[19]
	Greater Accra	Accra metropolis	Accra Psychiatric hospital	0.9 (1/111)	DWT, FEC	Cross sectional	Psychiatric Patients (25–60)	111	Not stated	May-Aug 2012.	2015	[69]
	Greater Accra	Accra metropolis	Mamprobi Polyclinic, James Town Maternity Home &Achimota Hospital.	3.1	DWT, FEC	Cross sectional	Pregnant women (≤20 -≥40)	1000	Not stated	Jan-June 2007	2008	[70]
	Volta	Ho Municipal	Ho Teaching Hospital	0.6	DWT, FEC	Retrospective	Patients (<10 - >59)	7045	Not stated	Aug 2017-Jan 2018	2019	[71]
	Volta	Ho Municipal	Klave, Hoe, Freetown, Dave, Godokpe	0.7 (1/150)	DWT, FEC	Cross sectional	Asymptomatic Children (4-59 months)	150	Not stated	Not stated	2020	[72]
	Greater Accra	Accra metropolis	BA, WR, Ashanti, Central, GR, Volta, Eastern, UE, UW, Northern	1.0	PCR	Cross sectional	Ghanaian Global Polio Laboratory Network (GPLN) (0-17+)	448	Not stated	2016	2018	[73]

Key: DWT-Direct Wet mount, KK – Kato-Katz, FEC -Formal-ether Concentration, PCR-Polymerase chain reaction; Case-Control*

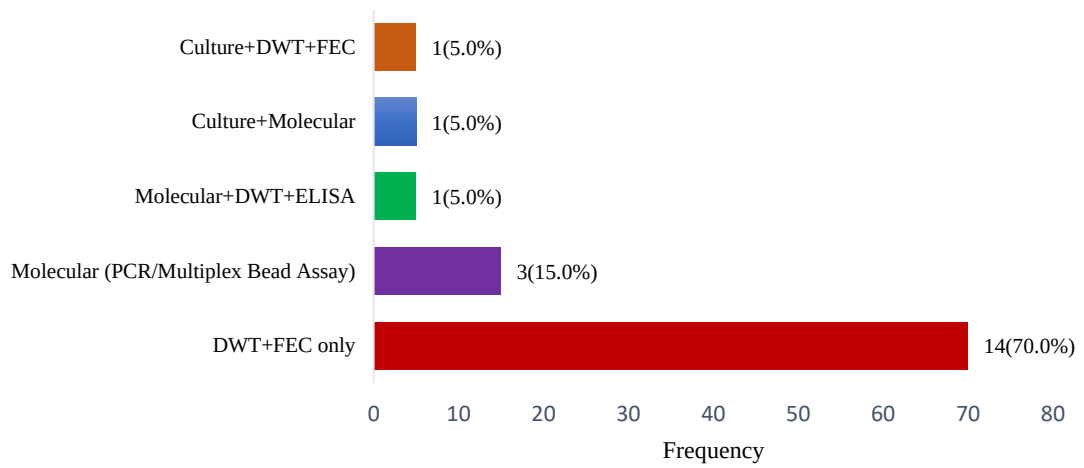

Figure 4. Diagnostic techniques used to detect *S. stercoralis*

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individuals (between 20 and 50 years) was 0.4%. The distribution of strongyloidiasis prevalence revealed 0.1% - 21.2%, 0.9% -2.9%, and 0.3% - 41.1% for northern, middle-belt, and southern sectors, respectively. Various techniques have been utilised to detect S. stercoralis in stool specimens during the period of this review. The direct wet mount and formal-ether concentration techniques were the most common, accounting for 70.0% of the cases, molecular methods, including PCR and Multiplex Bead Assay, represented 15.0%, and the combination of different techniques accounted for only 5.0%, as illustrated in Figure 4. The national prevalence of human strongyloidiasis in Ghana is low to moderate (median 1.45%), but extreme geographic heterogeneity exists, with localised hyperendemic regions (21.2% and 41.1%) inflating the mean to 4.5%. Different prevalence rates are reported across the regions, which is graphically represented to

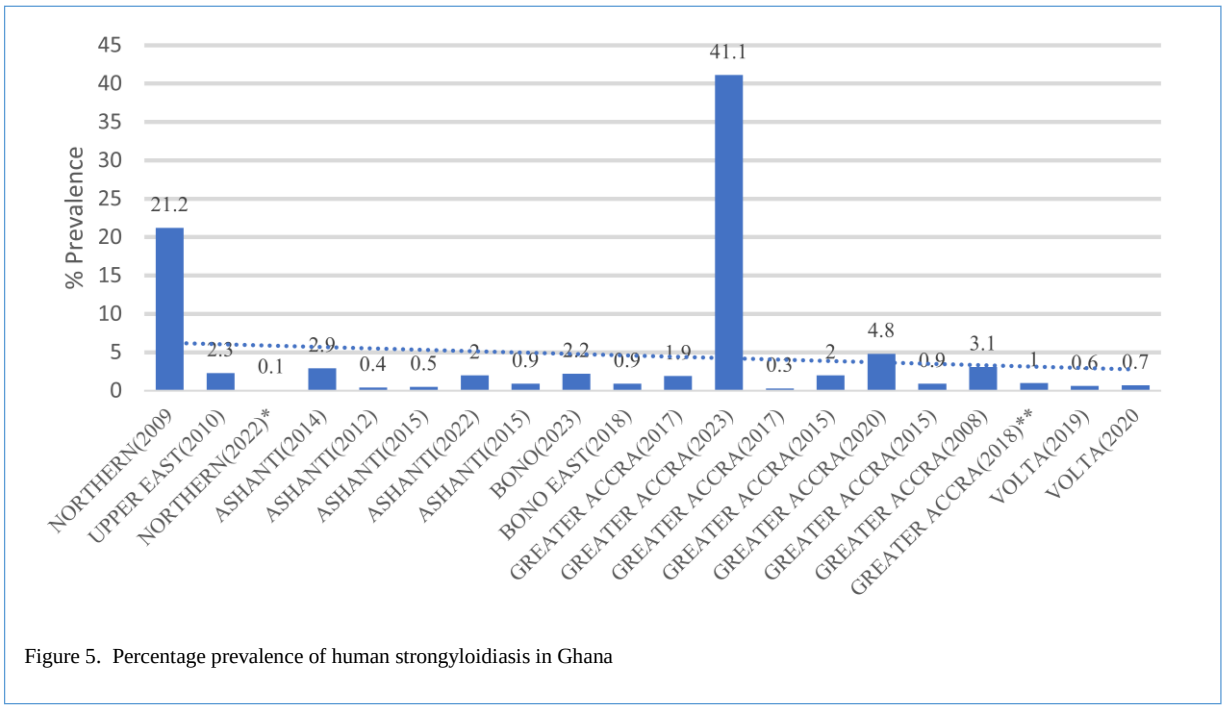

Figure 5. Percentage prevalence of human strongyloidiasis in Ghana

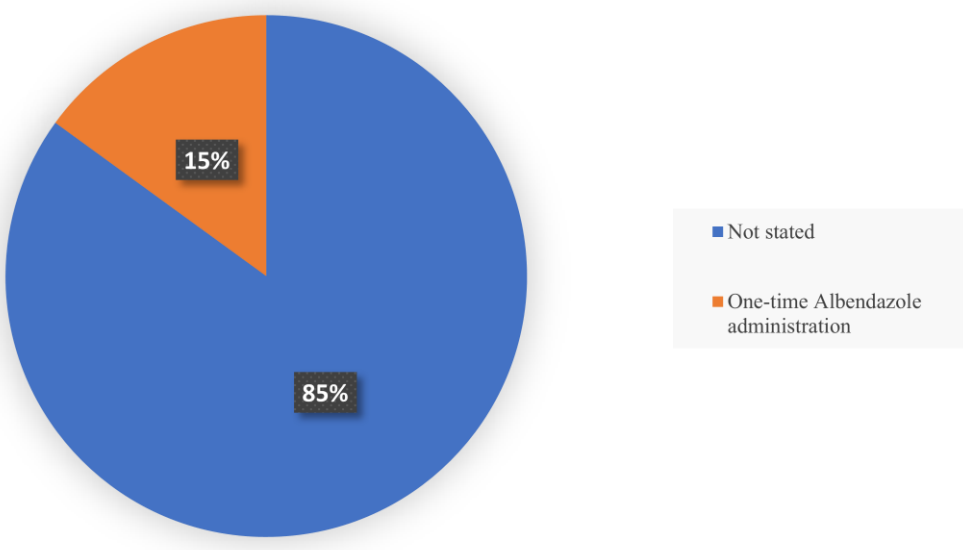

Figure 6. Proportion of studies that reported strongyloidiasis control intervention in Ghana

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enhance identifying areas that may require public health interventions (Figure 5).

Albendazole and mebendazole administration for preventive and curative purposes remain the single most implemented control measure reported in three (3) studies, while seventeen (17) studies did not state the nature of the intervention (Figure 6).

DISCUSSION

Human *Strongyloides stercoralis* infection remains endemic and under-reported in many resource-limited settings, including Ghana, with the most at-risk population being children. This review assesses the prevalence and epidemiological data of human strongyloidiasis across Ghana to estimate the approximately twenty-year period prevalence of infection, suggests a need for further primary research, informs public health intervention, and the possibility of its elimination by 2030 as projected by the WHO.

Diagnostic technique, prevalence, and demographic characteristics

The prevalence of *Strongyloides stercoralis* infection in Ghana is low to moderate. Geographically, Ghana's southern, northern, and middle belts have the highest, moderate and least prevalence in that order. Unsafe water, poor personal and environmental sanitation, and poverty were factors that accounted for the transmission in resource-limited settings. The findings of this study are consistent with other similar studies in Ethiopia [74], Cambodia [75] and Brazil [76]. The sensitivity of the diagnostic technique used is vital to detecting *S. stercolaris* infection. In the present study, only five out of the 20 studies reported the use of molecular techniques for parasite detection. Such observation in a resource-poor setting demonstrates that the true prevalence of *Strongyloides stercoralis* infection is globally underestimated and under-reported due to the use of diagnostic techniques with poor sensitivity [26]. Stool microscopy and Kato-Katz techniques, which are commonly used for *Strongyloides stercoralis* detection, have poor diagnostic sensitivity and, hence, account for the underestimation of the global prevalence of the infection.

The concentration methods, such as the formol-ether concentration technique, Kogar agar plate culture and Baermann techniques, although quite better, have unsatisfactory sensitivity. Serological techniques provide a better alternative albeit with concerns regarding their specificity. Molecular techniques, such as polymerase chain reaction (PCR), albeit with a high parasite detection rate, are expensive and require technical expertise in their application. This challenge is further compounded by the delayed diagnosis of infection as a result of the non-presentation of specific gastrointestinal signs and symptoms, irregular larval output and low parasite load [77].

A study conducted in Kuwait [78] showed the prevalence of 7% and 1.45% out of 384 stool specimens examined for *S. stercoralis* using stool examination and ELISA-based serology techniques for individuals from endemic and non-endemic areas, respectively. A study conducted [79] in the Amhara region of Ethiopia revealed varied prevalence rates of strongyloidiasis based on the sensitivity of the diagnostic technique used. The prevalence based on the comparison of five diagnostic techniques reported 39.0%, 28.8%, 10.9%, 10.3%, 4.0% and 2.0% by real-time polymerase chain reaction (RT-PCR), agar plate culture (APC), Baermann concentration technique (BCT), spontaneous tube sedimentation technique (STST), and formol-ether concentration technique (FECT) respectively. Prevalence rates of 48.2%, 45.0%, and 41.1% were reported in children between 12-14 years, males and rural dwellers, respectively. A similar investigation conducted by Amor et al. [80] in north-western Ethiopia among school-aged children showed 3.5%, 12.1% and 13.4% by conventional stool concentration (formol-ether), Baermann and PCR, respectively. These comparable study outcomes further indicate that S. Stercoralis is under-reported and under-reported due to reliance on conventional diagnostic methods.

Non-molecular methods do not discriminate between the genetically diverse human pathogenic species: *Strongyloides stercoralis*, S. fuelleborni fuelleborni, and *S. fuelleborni kellyi* and other non-human species. Additionally, *S. fuelleborni* eggs in the stools of infected individuals may be misidentified as hookworm eggs since they have similar morphology. This poses another layer of challenge for accurate diagnosis and treatment in resource-limited areas. This speciation and identification were necessary for the detection of the pathogenic *S. fuelleborni* in a Belgian student returning from the Democratic Republic of Congo [81]. Precise knowledge of the biology of *S. fuelleborni* is required to aid the diagnosis. The ova of *S. fuelleborni* only hatch in the external environment, and the infective larvae are not detected in stool specimens, hence making autoinfection impossible [78].

The treatment of strongyloidiasis is oral ivermectin or benzimidazoles (thiabendazole, mebendazole, and albendazole). Although albendazole and thiabendazole are only considered alternatives to ivermectin, albendazole, and thiabendazole combination therapy is highly recommended in *Strongyloides stercoralis* endemic areas [39,47]. Mebendazole is contraindicated in pregnant women, while albendazole or ivermectin are better tolerated than thiabendazole, in humans [33,85]. As part of the global elimination strategy of strongyloidiasis and other soil-transmitted helminths, the World Health Organization (WHO) recommended the use of mass drug administration (MDA) to disrupt transmission and the disease burden in endemic areas. To this end, ivermectin is part of a triple-drug regimen (ivermectin, diethylcarbamazine and albendazole) instead of the two-drug regimen (diethylcarbamazine and albendazole or ivermectin and

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albendazole) currently being practised [82]. The direct target of this treatment regimen is the control of Lymphatic filariasis albeit providing ancillary benefit towards reducing the burden of strongyloidiasis [83]. There is a dearth of information regarding the resistance of *Strongyloides stercoralis* to ivermectin or benzimidazoles globally. Although an insufficient dosing regimen resulting in incomplete parasite clearing, low sensitive diagnostic technique, and reinfection could be misinterpreted as emerging resistance [46], non-human *Strongyloides stercoralis* resistance has been reported [39, 46]. Nonetheless, none of the studies included in this review reported treatment failure, emerging resistance, or poor tolerance of any of the recommended drugs for the treatment of strongyloidiasis. It is unclear if the drugs of choice remain efficacious in treating the parasite in Ghana.

Strongyloidiasis has a negative impact on the health and wellness of individuals, particularly children and pregnant women, in resource-limited settings, including Ghana [31, 84]. The lack of safe water, adequate sanitation, and proper personal and environmental hygiene practices are significant risk factor associated with the transmission of Strongyloides ster*coralis* and other soil-transmitted helminth infections [71]. While these factors are prevalent in both urban and rural areas of Ghana, a disproportionate number of studies have been conducted in southern Ghana, resulting in a critical research gap regarding the actual epidemiology of human strongyloidiasis.

Strengths and weaknesses of this review

This review is the result of a comprehensive search using general and inclusive terms with a well-structured synthesis of available data. Data on the control, prevention, and elimination of strongyloidiasis as a neglected tropical disease in Ghana were included. The limitation of this study is the exclusion of studies not carried out in Ghana and articles published earlier than 2003 and after December 2023, leading to the omission of potentially valuable research articles for this review. Furthermore, the exclusion of non-English studies may have led to language bias.

Knowledge and research gaps identified

1. Effective control and elimination of strongyloidiasis as a neglected tropical disease can only be achieved based on the evidence of current national epidemiological data. This will guide the planning, implementation, monitoring, and evaluation of any preventive chemotherapeutic measures such as mass drug administration.

2. Animal strongyloidiasis reported elsewhere in cattle, dogs, and cats is an evolving phenomenon that must engage the attention of researchers. Studies on this will provide the needed information on the detection, population structure, genetics, interrelatedness of human and animal strongyloidiasis, and zoonotic potential.

3. Molecular study of *S. stercoralis* and genomic analysis of *S. stercoralis* isolates is currently lacking in Ghana. Molecular data will provide information on the susceptibility or resistance of Ghanaian *S. stercoralis* isolates to ivermectin and benzimidazoles (albendazole and thiabendazole).

Conclusion

The national prevalence of strongyloidiasis in Ghana is low to moderate (median 1.45%), but there are areas with extreme geographic heterogeneity, including hyperendemic regions (21.2% and 41.1%), thus increasing the mean to 4.5%. Population-weighted studies are essential for accurate national estimates, and targeted interventions are urgently needed to address high-transmission hotspots and underlying drivers of transmission. With further research and targeted interventions, Ghana is likely to meet the WHO's elimination target by 2030.

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Ethical consideration

Not Applicable

Consent to publish

All authors agreed on the content of the final paper.

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Competing Interest

The authors declare no conflict of interest

Author contribution

GBK, PBT-Q, PFA-K, and CYD conceived the study. CYD, PBT-Q, JPK and IA reviewed relevant literature. CYD drafted the manuscript which was critically reviewed by JPK, IA, GBK, PBT-Q, and PFA-K. All authors read, edited, and approved the manuscript.

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Availability of data

Data is available upon request to the corresponding author

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