

RESEARCH ARTICLE

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The Prevalence and burden of malaria, soil-transmitted helminths, Schistosomiasis and their co-occurrence among school children in Ogun State

Malaria, Soil-transmitted Helminths, and Schistosomiasis

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Abstract

Objectives: Untreated malaria presents severe complications. Soil-transmitted helminths (STHs) of the trio Hookworm, *Ascaris* and Whipworm account for a major disease burden worldwide. While the health of school-aged children is usually compromised by common diseases such as malaria, helminthiasis and Schistosomiasis, the co-infections are accountable for increased morbidities and associated consequences like anaemia and malnutrition in vulnerable populations. The study determined the prevalence and burden of polyparasitism with these 3 diseases among school children in the study areas.

Methods: Blood, urine and stool samples were collected from a total of 1103 primary school pupils with ages ranging from 4 to 15 years. Malaria parasite was detected using thick and thin blood films and mRDT. Stool samples of intestinal helminth infection were processed using formol-ether concentrations and Kato-Katz and Mac-Master Chamber techniques. Urine samples were analyzed using sedimentation by the centrifugation method for *Schistosoma haematobium*, and haemoglobin was determined using a haematology analyzer to establish anaemia.

Results: The overall mean age, haemoglobin, weight and height of the students' population was 9.97±2.637(years), 10.84±4.651(g/dl), 28.86±8.278(Kg) and 1.182(m)±1420, respectively. Age, height and weight showed no significant differences among pupils across the three senatorial zones.

Conclusion: The findings from this study showed that the co-endemicity of malaria and helminths infections is an important health problem in the study areas, among the subjects with concurrent *Plasmodium falciparum*, STH and *Schistosoma haematobium* infections resulting in increased the risk of lower haemoglobin levels and anaemia, which in turn calls for integrated disease control interventions.

Keywords: Malaria, Soil-transmitted helminths, Schistosomiasis, Co-occurrence, School children

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Plain English Summary

This study is about the investigation of polyparasitism with malaria, soil-transmitted helminths and schistosomiasis in school children in 3 Senatorial Zones of Ogun State (Ogun West, Ogun Central and Ogun East). Increased morbidities and related outcomes, such as anaemia and malnutrition, in vulnerable populations, including school-aged children, are caused by this co-occurrence and were all noted in this study. However, further investigation is still inevitable in the search for connections between the co-infections of helminths and malaria found in this investigation. More robust studies should focus on the immunological analysis of the interactions with consideration of different helminth species independently.

Background

Malaria, known for its global morbidity and mortality rates, especially among children under five and pregnant women (1, 2, 3), is a debilitating mosquito-borne parasitic disease caused by a protozoan of the genus *Plasmodium* with four distinct species (*Plasmodium falciparum*, *P. vivax*, *P. ovale*, and *Plasmodium malariae*) regularly infecting humans (4, 5). *Plasmodium falciparum*, the most virulent among the species is associated with the deadliest illness manifestations presentations and mortality rates (6, 7).

In 2022, there was a five million increase in cases. In addition, global malaria mortality increased in the year 2022 compared to 2019. Nevertheless, there was a decline in malaria deaths from 864,000 in 2000 to 576,000 in the year 2019 (8).

Malaria is treatable. Antimalarial medications tailored to the elimination of the parasite can be used during each symptomatic episode. The use of many intervention strategies is employed for the control of the disease. When treated appropriately, most people with uncomplicated malaria can effectively eradicate their illness. Over the years drug resistance has been the bane of the effective treatment and control of the disease. The development of *Plasmodium* drug resistance to nearly all known approved antimalarial medications added a level of difficulty to the management and eradication of malaria (9). However, because of the persistent issue of multi-drug resistance to existing medications, the effectiveness of antimalarial treatments has declined. Malaria prophylaxis has gradually decreased due to rising resistance to the current antimalarial drug artemisinin and its combination therapies (10).

Soil-transmitted helminths (STHs) are the intestinal worms infecting humans. As one of the most common infections in the world, soil-transmitted helminth (STH) infections primarily affect the poorest and most vulnerable groups. They are transmitted when human faeces contain eggs that can spread these illnesses and then contaminate the soil in areas with poor or deficient sanitation systems (11, 12, 13). The roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*), and hookworms (*Necator americanus* and

Ancylostoma duodenale) are the main species known as STHs (11, 13). Together they account for a major burden of disease worldwide. Preschoolers and school-age children had the highest frequency and severity of STH infections in endemic locations (11).

Schistosomiasis, a water-borne parasite infection causes a crippling chronic illness with significant morbidity and organ pathology. In Sub-Saharan Africa, schistosomiasis remains one of the most common neglected tropical diseases (NTDs) with a considerable amount of morbidity (11). African countries are home to the vast majority of schistosomiasis cases (88%). School-age children have the highest prevalence and intensity of schistosome infections but according to recent research, pre-school-aged children are also highly infected (11, 14).

Schistosoma haematobium causes urogenital schistosomiasis, which is most common in Africa, and *S. intercalatum*, *S. mansoni*, *S. japonicum*, *S. guineensis*, or *S. mekongi* causes intestinal schistosomiasis, which varies depending on the tropical region of the world (*Schistosoma haematobium* and *S. mansoni* are the most common causes of sickness in Nigeria. In children in the high-risk age range of 5 to 15 years, it is linked to stunted growth, malnutrition, iron deficiency anaemia and impaired cognitive development leading to decreased academic performance (14).

The health of school-age children is usually compromised by common diseases such as malaria, helminthiasis and Schistosomiasis (15). In Lower Middle-Income Africa (LMI Africa) countries, the greatest burden is confirmed in children of school-going age, affecting their cognitive development and physical growth.

Malaria and soil-transmitted helminth infections are both widespread and are accountable for increased morbidities and associated consequences in vulnerable populations, including school-aged children (16, 17, 18, 19, 20, 21).

Co-infections with helminths and malaria parasites harm the host and synergism between multiple parasite species infecting and infection intensity are known to accelerate anaemia (22, 23, 24).

School-aged children are most at risk of plasmodium-helminth infection and thereby at greater of the consequences of co-infection (25). STH infection can accelerate or exacerbate malnutrition. Hence, infection with Malaria or STH could singly or combined be contributing factors to malnutrition and/or malaria (17, 26, 27). Polyparasitism with malaria, schistosomiasis and soil-transmitted helminths (STH) remains a major

public health in sub-Sahara Africa with devastating impacts on children's development (21, 28).

Materials and methods

Study Area and Sites

The study area was spread around the three senatorial zones namely Ogun- East, Ogun Central and Ogun West made up of 20 local governments in total (Figure.1) most especially their core rural areas where social amenities are lacking.



Figure 1. Map of Ogun State showing the three senatorial districts (Green- Ogun West; Red- Ogun Central; Blue- Ogun East) and the Local Government Areas (Ogun State biz, 2020). The state is bounded on the West by the Benin Republic; on the South by Lagos State and the Atlantic Ocean; on the East by Ondo State, and on the North by both Oyo and Osun States.

Study design

A community-based cross-sectional study design was employed for the study among primary school children between the ages of 4 - 15 whose parental consents were obtained from their guardians/parents to partake in the research without manifestations compatible with malaria in the past 14 days in senatorial zones of Ogun State.

Study Approach

The primary school was selected randomly, especially those that are based in the rural areas. The cross-sectional in primary school students was chosen.

Study Population

Children aged 4 - 15 years old with no history of sickness and not on anti-malaria, anti-helminthic drugs and not on iron supplementation for the past 6 weeks were included in the study.

Eligibility Criteria

Inclusion criteria: The participants should be enrolled in schools located in the rural area of the local government throughout the period. The participants must not have taken any anti-

helminths/anti-malaria drugs medication in past six weeks.

Exclusion Criteria: Students who are about to transfer to another school in less than six weeks. Participants who were on anti-helminths/anti-malaria drugs for less than three weeks. Menstruating girls at the point of urine collection. Refusal to give consent either by the parents or the pupils.

Data and sample collection

A structured questionnaire was administered to the participants and all the necessary information was well taken. Blood samples were collected to check for malaria, and anaemia in EDTA bottles; fresh stool samples were collected into sterile plastic universal bottles; mid-stream urine was collected in sterile plastic universal bottles for STH and *Schistosoma haematobium* and well-labelled for identification and processing.

Sample transport, storage, and processing

Blood, stool and urine samples were transported in a cold environment using ice packs inside transport boxes to the laboratory for processing. Blood and urine samples were stored at -4°C in the laboratory, while stool samples were aliquotly

divided into two, one was stored at 10% formol saline, while the other sample was frozen for other studies. Blood, urine and stool samples were collected from a total of 1,103 primary school pupils with ages ranging between 4 and 15 years.

Malaria parasite was detected using thick and thin blood film stained with Giemsa and Leishman stains and Rapid diagnostic tests for malaria (mRDT), following the World Health Organization guidelines. Stool samples were processed using formol-ether concentrations, Kato-Katz and Mac-Master Chamber techniques to confirm intestinal helminth infection as previously described (29). Urine samples were analyzed using sedimentation by centrifugation method for *Schistosoma haematobium* as previously described (30). Haemoglobin estimation was determined using an auto-haematology analyzer (SIEMENS 2800 BC) to establish anaemia with a value less than 11 g/dl or more, counting following the manufacturer's instructions. A complete blood count was obtained and anaemia was defined as $Hb < 11.0$ g/dL and further categorized as severe ($Hb < 7.0$ g/dL),

moderate (Hb between 7.0 and 10.0 g/dL), and mild (> 10 $Hb < 11$ g/dL) as reported by Cheesbrough (31).

For anthropometry indicators (Measurement of pupils' body weight and height); body weight was measured using a standardized weighing scale and recorded in kilograms; height was assessed using a well-calibrated wooden stadiometer and recorded in centimetres.

Statistical Analysis

Statistical Package for Social Sciences (SPSS) Version was used for analysis of the data.

Results

The total participants numbered 440, 309 and 354 students from Ogun East, Ogun Central and Ogun West respectively. According to Figure 2, the overall mean age, haemoglobin, weight and height of the students in the study population was 9.97 ± 2.637 (years), 10.84 ± 4.65 (g/dl), 28.86 ± 8.278 (Kg) and 1.182 (m) ± 1420 respectively.

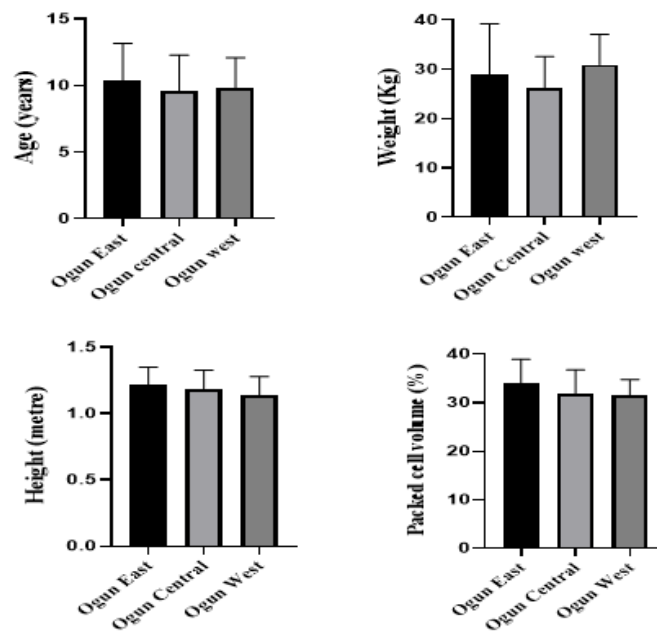


Figure 2: (a) Age (b) Weight (c) Height (d) Hemoglobin

Apart from *Ascaris lumbricoides* stated above, other helminths such as *Hookworm*, *Taenia spp*, and *Trichuris trichiura* were dominant parasites in the study population. However, according to each senatorial zone, these parameters age, haemoglobin, weight and height were respectively represented as follows: Ogun East 10.36 ± 2.796 (years), 11.84 ± 5.092 (g/dl), 29.06 ± 10.199 (Kg)

and $1.217 \pm .1310$ (M); Ogun Central 9.55 ± 2.744 (years), 10.62 ± 4.902 (g/dl), 26.20 ± 6.405 (Kg), and 1.187 ± 1399 (M): and Ogun West had 9.84 ± 2.249 (years), 10.49 ± 3.262 (g/dl), 30.95 ± 6.177 (Kg) and $1.133 \pm .1434$ (M) (Figure 2).

Malaria and *Ascaris lumbricoides* are very dominant in the study as revealed in the parasite count in Figure 3. Malaria and *Ascaris lumbricoides*

mean parasite counts were highest in Ogun Central when compared to the other zones. Apart from *Ascaris lumbricoides*, other helminths such as hookworms, *Taenia spp.*, and *Trichuris trichiura*

were also dominant parasites in the study population. However, *Taenia spp.* was more prevalent in the Ogun West zone (Figure 4).

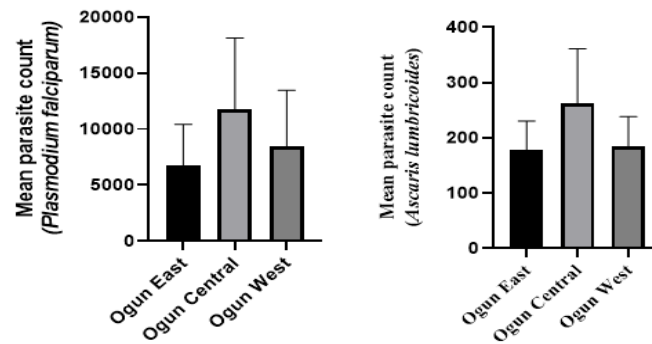


Figure 3: Mean parasite counts of *Plasmodium falciparum* respondents and helminths in 3 senatorial zones

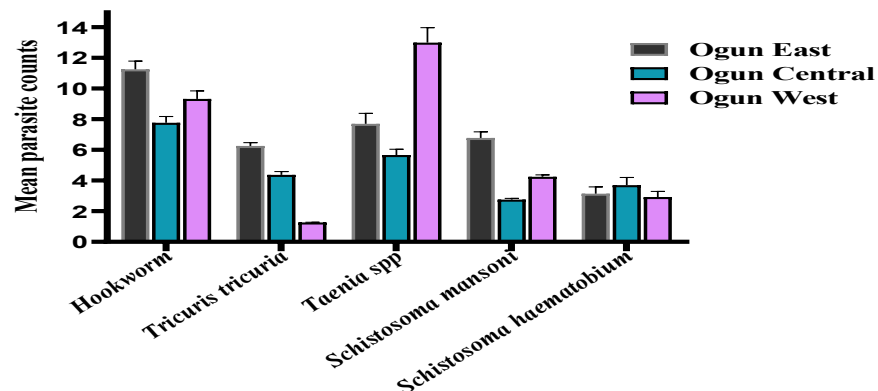


Figure 4: Mean parasite counts of *Plasmodium falciparum* in respondents and helminths in 3 senatorial zones and the distribution of *P. falciparum* in blood, STH in stool, and *S. haematobium* in urine.

However, according to Figure 5, out of 1103 students that participated, 446 (40.4%) were positive for malaria, 528 (47.9%) for helminths, 139 (12.6%) for *Schistosoma haematobium*, while

those that were co-infected such as malaria/helminths 247 (22.7%), malaria/*Schistosoma haematobium* 60 (5.4%), malaria/helminths/SH 29 (2.6%).

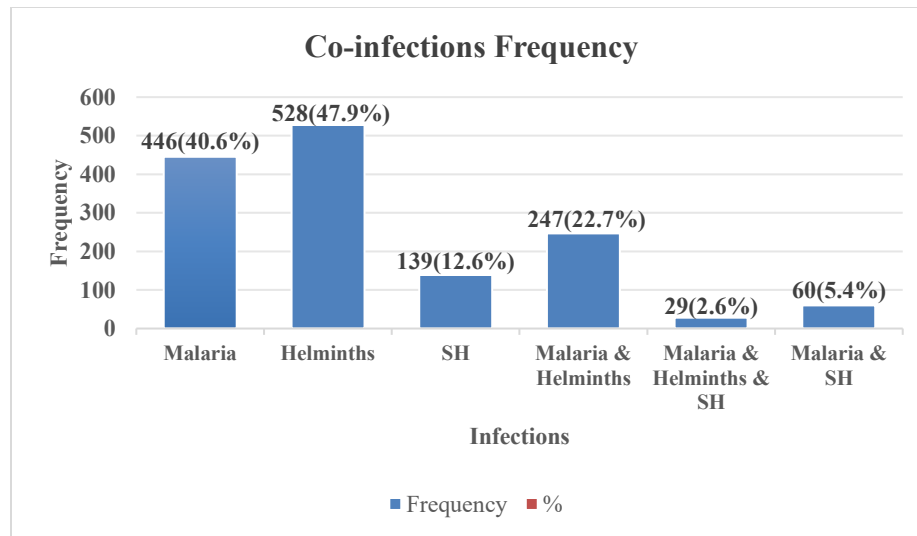


Figure 5: Frequency distribution of parasites and co-occurrence indicates the polyparasitism distribution of malaria, helminths, *Schistosoma haematobium*, and Malaria/helminth, malaria/SH, malaria/helminths/SH co-infections frequency in the study area. SH: *Schistosoma haematobium*

The general characteristics of the results shown in all the 3 senatorial zones which comprise 1103 students made up of Males 526 (47.7%), Female 577 (52.3%), Age group (4-9) years 444 (40.3%), and 10-15 years 659 (59.7%) respectively. Malnourished students were categorized into underweight 545 (49.4%), Stunted 444 (40.3%),

Wasted 564 (59.3%) according to WHO measurements, and generally malnourished students were 99 (8.9%). Malaria-infected pupils were 446 (40.6%), Soil-transmitted Helminths-infected students were 528 (47.9%), *Schistosoma haematobium* 139 (12.6%) and 462 (41.9%) were anaemic as shown in Table 1.

Table 1: Distribution of general characteristics variables of the 3 senatorial zones

Variables	Frequency	Percentage
Manifestation of Malnutrition		
Underweight	545	49.4
Stunted	444	40.3
Wasted	564	59.3
Malaria infection		
Positive	446	40.6
Negative	657	59.4
STH		
Positive	528	47.9
Negative	575	52.1
SH		
Positive	139	12.6
Negative	964	87.4
Age Range (Years)		
4-9	444	40.3
10-15	659	59.7
Gender		
Male	526	47.7
Female	577	52.3
Occurrence of Anaemia		
Yes	462	41.9
No	641	58.1

The proportion of anaemia cases attributable to malnutrition or specific parasitic infections was estimated as population-attributable risk percentages. The result of this study shows that 146 (33.2%), 147 (47.6%) and 169 (47.7%) for Ogun East, Central and West of the School children had anaemia which was mild or moderate and no severe anaemia was recorded. The prevalence of anaemia was significantly higher ($P < 0.001$) in the youngest age group (4-9) than those older (10-15) and in children who were malaria parasite positive than those negative as shown in Table 2.

The anaemia prevalence in the study area was 41.9% while anaemic prevalence distributed in different senatorial districts were expressed as follows: Ogun West and Ogun Central were almost the same (47.7%) and (46%) while that of Ogun East was (33.2%). The *Schistosoma haematobium*

was also harboured by the school children as follows 63 (14.3%), 42 (13.6%) and 43 (12.1%) by Ogun East, Central and West respectively with low ova counts for *S. haematobium*. However, intestinal helminths prevalence such as *Ascaris lumbricoides* in each senatorial district were 133 (30.2%), 117 (37.9%), and 104 (29.4%), while that of Hookworm 21 (4.8%), 16 (5.2%) and 20 (5.6%) and *Trichuris trichiura* 16 (3.6%) all for Ogun East, Ogun Central and Ogun West respectively and all the 3 STHs were statistically significant according to Table 2. Also, some children suffered from co-occurrences with multiple species or different parasites such as *Ascaris lumbricoides* and Hookworm 16 (3.6%), 6 (1.9%) and 16 (4.5%) in different senatorial districts. *Ascaris lumbricoides* and *Taenia spp* co-occurrences in each senatorial 11(2.5%), 12 (3.9%) and 2 (0.6%).

Table 2: Description of the baseline and demographic characteristics of the studied population by senatorial zones

Characteristics	Senatorial districts			P-value
	Ogun East	Ogun Central	Ogun West	
Sex				
Boys (n, %)	196 (44.5)	157 (50.8)	173 (48.9)	0.207
Girls (n, %)	244 (55.5)	152 (49.2)	181 (51.1)	
Age group (years)				
4-9 (n, %)	158 (35.9)	143 (40.4)	143 (40.4)	0.017*
10-15 (n, %)	282 (64.1)	166 (53.7)	211 (59.6)	
Ascaris prevalence (%)	133 (30.2)	117 (37.9)	104 (29.4)	0.063
Ascaris intensity (epg)	5.198(6.663 – 4.055)	13.758(23.904 – 7.919)	11.640(18.033 – 7.513)	< 0.001
Hookworm prevalence (%)	21 (4.8)	16 (5.2)	20 (5.6)	0.011
Hookworm intensity (epg)	4.091(5.654 – 4.091)	8.711(13.420-5.613)	6.924(9.735 – 4.925)	< 0.001
TT prevalence (%)	16 (3.6)	15 (4.9)	4 (1.1)	0.030
TT intensity (epg)	21.985(51.073-9.464)	63.214(208.123-19.200)	35(129.794-9.438)	< 0.001
Taenia prevalence (%)	34 (7.7)	21 (6.8)	27 (7.6)	0.739
Taenia intensity (epg)	28.659(76.577-10.726)	10.971(37.833-3.182)	9.000(27.759-2.918)	< 0.001
SM (%)	26 (5.9)	9 (2.9)	11 (3.1)	0.062
SM intensity (epg)	28.659(76.577-10.726)			
SH (%)	63 (14.3)	42 (13.6)	43 (12.1)	0.668
Malaria prevalence (%)	242(55.0)	166 (53.7)	209 (59.0)	0.341
Malaria density (mps/ μ L)	72.195(27.459-10.444)	21.269(12.233-7.036)	0.076(.120-.048)	0.881
Prevalence of coinfection (%)				
Ascaris + Hookworm	16(3.6)	6(1.9)	16(4.5)	0.185
Ascaris + Taenia	11(2.5)	12(3.9)	2(0.6)	0.015
Hookworm + Taenia	2(0.5)	1(0.3)	1(0.3)	0.914
Ascaris +` Hookworm + Taenia	1(0.2)	0(0.0)	0(0.0)	0.470
Anaemia prevalence (%)	146(33.2)	147(47.6)	169(47.7)	< 0.001
Pf + Ascar +` Hookworm + Tae	1(0.2)	0(0.0)	0(0.0)	0.470
Mean Hb (g/dL)	3.557(4.153-3.046)	2.522(2.154 - 2.954)	2.141(2.489 – 1.842)	< 0.001
Prevalence of stunting (%)	146(33.2)	112(36.2)	186(52.5)	< 0.001
Prevalence of wasted or thinness (%)	334(75.9)	249(80.6)	71(20.1)	< 0.001
Prevalence of underweight (%)	234(53.2)	197(63.8)	175(49.4)	< 0.001

Table 2 summarizes the baseline characteristics of our study population of a total of 1103 school children, including the socio-demographic and clinical characteristics of the study participants and the age of the participants were in the age of (4-9) and (10-15). The mean standard of age, haemoglobin, weight, Height of the participants were represented as follows: Ogun East 10.36 ± 2.796 (years), 11.28 ± 5.092 (g/dl%), 29.06 ± 10.199 (Kg) and $1.217 \pm .1310$ (M); Ogun Central 9.55 ± 2.744 (years), 10.61 ± 4.902 (g/dl), 26.20 ± 6.405 (Kg), and 1.187 ± 1399 (M); and Ogun West had 9.84 ± 2.249 (years), 10.49 ± 3.262 (g/dl), 30.95 ± 6.177 (Kg) and $1.133 \pm .1434$ (M).

Discussion

The study showed the occurrence of polyparasitism infection with malaria, Soil-

transmitted helminths and Schistosomiasis among school children in primary schools in Ogun State, Nigeria. This is regarded as of public health importance. The prevalence of malaria in the study area was 40.6 per cent. However, when the senatorial zones were considered, no statistically significant difference was observed in the rate of *P. falciparum* infection: Ogun East - 242 (55.0%), Ogun Central - 166 (53.7%), and Ogun West - 209 (59.0%) respectively, as shown in Table 3. While *P. falciparum* accounted for all infections but as asymptomatic infections with largely low to moderate-level parasitaemia. Approximately half of the affected school children suffered from stunted growth due to malnutrition, with low to moderate anaemia; no cases of severe anaemia were recorded.

Table 3: Distribution of Mean parasite of *P. falciparum* and STH in senatorial zone of Ogun State

Senatorial Districts	<i>P. F</i> (%)	<i>Ascaris</i> (%)	HW (%)	<i>Taenia</i> (%)	TT (%)	SM (%)	SH (%)
Ogun East n=440							
No. infected (%)	242 (55.0)	133 (30.2)	21 (4.8)	16 (3.6)	34 (7.7)	26 (5.9)	63 (14.3)
mean parasite	6730.52	177.05	11.25	6.25	8.77	6.78	3.14
Ogun Central n=309							
No. infected (%)	166 (53.7)	117 (37.9)	16 (5.2)	15 (4.9)	21 (6.8)	9 (2.9)	42 (13.6)
mean parasite	11792.77	261.91	7.77	4.37	5.66	2.75	3.70
Ogun West n=354							
No. infected (%)	209 (59.0)	104 (29.4)	20 (5.6)	4 (1.1)	27 (7.6)	11 (3.1)	43 (12.1)
mean parasite	8479.93	184.32	9.32	1.27	12.99	4.24	2.93
p-value	.263	.000	.030	.075	.059	.442	.614
**p-value	.341	.036*	.858	.019*	.800	.062	.669

* Significant value of comparison of number infected; *Ascaris lumbricoides* showed significant value when compared with other helminths. ** Significant value of comparison mean parasite count; Both *Ascaris lumbricoides* and *Taenia sp* showed significant value when parasite count was done. P. F: *Plasmodium falciparum*, HW: Hookworm, TT: *Trichuris trichiura*, SM: *Schistosoma mansoni*, SH: *Schistosoma haematobium*

The prevalence of 40.6% recorded in the study area contradicts previous reports (23, 32, 33, 34, 35) that had a higher prevalence and those with a lower prevalence (20). However, it confirms previous reports (16, 36) that malaria is hyperendemic in Ogun State, Nigeria. Compared to other African countries, the prevalence of malaria parasite infection is lower than the 59.0%, 69.9%, and 46% recorded in malaria-affected schoolchildren in Ghana, Tanzania, and Cameroon, respectively (37, 38, 39). The prevalence of helminths was higher in a study by Oluwole et al in 2018, but it was also decreased in comparison to other earlier studies (33, 40, 41). *Ascaris lumbricoides*, however, was more prevalent in Ogun Central than in the other senatorial districts (Figure 3). The results indicate

that both malaria and soil-transmitted helminths thrive in similar environmental conditions. This study is the first in the area to encompass all three senatorial zones, with no previous reports for comparison.

Figure 1 indicates that age and height did not show significant differences among pupils across the three senatorial zones. Ogun East was slightly taller than Ogun Central and Ogun West. However, pupils from Ogun East had a slight relative weight advantage over the others, though no significant differences were observed, with Ogun Central having the least weight.

Ogun East had the greatest haemoglobin content when compared to Ogun Central and Ogun West, in that order. Comparing Ogun Central to the other

zones, the mean parasite levels for *Ascaris lumbricoides* and malaria were higher there. The explanation for this is that both diseases (*Ascaris lumbricoides* and malaria) co-infections flourish and thrive in environments with similar geography, water, and lifestyles that allow and facilitate the coexistence of the parasites (21).

The study showed a reduced prevalence of anaemia compared to a previous report (42). The impact of malaria on anaemia was evident in the younger age group within the study area, consistent with earlier reports from Nigeria (16, 18, 43, 44, 45). The incidence of anaemia in this study was lower compared to that of Cameroon and Ghana (37, 46). Several studies have reported high prevalence rates of anaemia, including 71.5% in children aged 6 months to 10 years living in Mutengene, South West Region of Cameroon; 44.8% in children aged 10 years and below in Muyuka, Cameroon; 19.8% in primary school children in the Mount Cameroon area; and 44.2%, 11%, and 19% in Cameroon, Ethiopia, and Tanzania, respectively (47, 48, 49, 50). The relatively high prevalence of anaemia observed in this study could result from the high incidence of malaria transmission due to children's limited proximity to health centres and the unavailability of bed nets. Additionally, for those with access to bed nets, there is often improper guidance on their regular use. Furthermore, effective treatment with Artemisinin-based Combination Therapy (ACTs) should be made available in rural areas and enforced by healthcare providers, as malaria is one

of the major causes of anaemia. Mass drug administration is key for controlling or fighting helminth infections, which is not regular, as observed in this study. However, there was no significant difference in prevalence, especially in rural areas, which can contribute to a high prevalence of anaemia.

Table 4 shows the distribution of parasites according to the age group in the senatorial zones. The *Ascaris lumbricoides*, 354 (32.1%), Hookworm 57(5.2%), *Schistosoma haematobium* 148 (13.4%), *Taenia spp* 82 (7.4%), *Schistosoma mansoni* 46 (4.2%), *Trichuris trichiura* 35 (3.2%). However, the age (10-15) group had the highest prevalence in which Ogun West, East and Central had (63.8%), (57.8%) and (57.7%) respectively but the difference was not statistically significant ($p = 0.14$) when compared with age group (4-9). This is contrary to the study done in Cameroon in which the younger age group had the highest infection rate (37). The distribution of *S. haematobium* by age was statistically significant in the age group (10-15) most especially in Ogun Central and Ogun West ($p=0.007$ and $p=0.000$) when compared with other studies (51, 52) because the higher the age, the more active the pupils to the social devices such as occupational activities such as farming, fishing, swimming and other sporting activities. The other helminths had the highest prevalence in the age group (10-15) also but all were not statistically significant except *Ascaris lumbricoides* in Ogun West which is statistically significant 75 (35.2%) ($p= 0.003$).

Table 4: Distribution of parasites according to age in the senatorial zones

Senatorial District	Age group	No. Exam	PF (%)	AS (%)	HW (%)	TT (%)	Taenia (%)	SM (%)	SH (%)
Ogun East	4-9	158	79 (50.0)	45 (28.5)	5 (3.2)	4 (2.5)	13 (8.2)	10 (6.3)	18(28.6
	10-15	282	163 (57.8)	88 (31.2)	16 (5.7)	12 (4.3)	21 (7.4)	16 (5.7)	45(71.4%)
	p-value		.849	.550	.236	.354	.768	.780	.190
Ogun Central	4-9	146	72 (49.3)	47 (32.2)	5 (3.4)	6 (4.1)	12 (8.2)	5 (3.4)	12(28.6%)
	10-15	163	94 (57.7)	70 (42.9)	11 (6.7)	9 (5.5)	9 (5.5)	4 (2.5)	30 (71.4%)
	p-value		.131	.052	.188	.584	.347	.612	.007*
Ogun West	4-9	141	73 (51.8)	29 (20.6)	6 (4.3)	1 (0.7)	11 (7.8)	4 (2.8)	5 (11.6%)
	10-15	213	136 (63.8)	75 (35.2)	14 (6.6)	3 (1.4)	16 (7.5)	7(3.3)	38(88.4%)
	p-value		.244	.003*	.355	.542	.920	.811	.000*
Total		1103	617 (40.6)	354 (32.1)	57 (5.2)	35 (3.2)	82 (7.4)	46 (4.2)	148 (13.4)

* Significant value of comparison of the number infected. P.F: *Plasmodium falciparum*, HW: Hookworm, TT: *Trichuris trichiura*, SM: *Schistosoma mansoni*, SH: *Schistosoma haematobium*

Considering the gender of the participants as shown in Table 5, parasites were not sensitive to gender. The infections with *P. falciparum* and other soil helminths showed no statistically significant differences between males and females, except for *Schistosoma haematobium*, which was statistically significant for males in Ogun West, with 30 (69.8%)

compared to females at 13 (30.2%) ($p = .005^*$). The reason may be due to socio-cultural factors: males are more frequently engaged in water-contact activities such as swimming, bathing, fishing, farming, and watering than their female counterparts. This is in agreement with studies by (51) but not similar to some others (36).

Table 5: Distribution of parasites according to gender in the senatorial zones

Senatorial District	Sex	No. Exam	PF (%)	AS (%)	HW (%)	TT (%)	Taenia (%)	SM (%)	SH (%)
Ogun East	Male	196	102(52.0)	67(50.4)	12(57.1)	8(50.0)	19(55.9)	14(53.8)	26(41.3)
	Female	244	140(57.4)	66(49.6)	9(42.9)	8(50.0)	15(44.1)	14(6.2)	37(58.7)
	p-value		.725	.105	.234	.655	.166	.325	.572
Ogun Central	Male	157	74(47.1)	56(47.9)	9(52.6)	8(53.3)	12(57.1)	5(55.6)	24(57.1)
	Female	152	92(60.5)	61(52.1)	7(43.8)	7(46.7)	9(42.9)	4(44.4)	18(42.9)
	p-value		.483	.419	.655	.841	.548	.773	.377
Ogun West	Male	173	109(63.0)	54(51.9)	13(65.0)	1(25.0)	10(37.0)	5(45.5)	30(69.8)
	Female	181	100(55.2)	50(48.1)	7(35.0)	3(75.0)	17(63.0)	6(54.5)	13(30.2)
	p-value		.822	.459	.137	.337	.201	.818	.005*
Total		1103	617(55.9)	354(32.1)	57(5.2)	35(3.2)	82(7.4)	46(4.1)	148(13.4)

*Significant value of comparison of the number infected. P.F: *Plasmodium falciparum*, HW: Hookworm, TT: *Trichuris trichiura*, SM: *Schistosoma mansoni*, SH: *Schistosoma haematobium*

This study recorded a 47.9% prevalence of helminth infections, similar to previous studies in Nigeria (43, 53, 54), but lower than that recorded in Indonesia (55). Co-infection rates were comparable to the work referenced in (53) but slightly higher than certain previous reports (18, 23, 36). However, co-infection of malaria and helminths was similar to cases reported in Cameroon and Ghana (40, 47). Therefore, the control of malaria and helminths should be concurrently addressed, especially in highly endemic areas, to reduce the burden of infections. Ogun State previously recorded the highest prevalence of schistosomiasis infections in Nigeria, but interventions by the Federal Ministry of Health have led to a reduction. The prevalence of *Schistosoma haematobium* in the study area is now lower compared with previous studies in Kano, Ogun, and Oyo States (41, 56, 57, 58).

This study observed co-infection of both *P. falciparum* and intestinal helminths among school children in Ogun State, Nigeria. Given the plausible hypothesis of a biological interaction between helminths and *P. falciparum*, and increasing advocacy for deworming, there is a need for prospective studies to investigate the effects of helminths and the treatment of helminth infection on *P. falciparum* in this area. This work is the first study to document the prevalence of malaria co-infected with helminths among primary school children in this area. The success of malaria/helminth control will depend on a systematic understanding of the micro-geographic risk of malaria transmission, enabling the identification of high-risk spots.

Malaria, soil-transmitted helminths, and *Schistosoma haematobium* remain infectious diseases that threaten nearly half of the world's population. The most affected are African children, as these diseases are major multifactorial agents of anaemia and malnutrition. These infections,

coupled with other social factors, are predictive of undernourishment in these school children.

Conclusion

The findings of this study indicate that the co-occurrence of multiple parasite infections (polyparasitism) is common among children attending schools in the three senatorial zones of Ogun State. Concurrent *P. falciparum*, STH, and *S. haematobium* infections increase the risk of lower haemoglobin (Hb) levels and anaemia, which necessitates integrated disease control interventions. Nevertheless, further investigation is essential to explore the associations between malaria and helminth co-infections detected in this study. In light of this development, gathering trustworthy data on the prevalence of co-infection with soil-transmitted helminths (STH), schistosomiasis, and malaria in endemic areas has become a crucial first step toward creating locally relevant control measures to stop the spread of these illnesses.

To develop an integrated control approach, we planned the investigations described in this work to assess the co-prevalence and burden of malaria, helminths, and schistosomiasis among school children.

The co-endemicity of malaria and helminth infections is an important health issue in the study area, particularly affecting highly vulnerable groups, especially school children. The study provides evidence of the negative effects on these children, suggesting that control measures should address both malaria and helminth co-infections by combining vector control with anthelmintic drugs for the worms. However, to strengthen the conclusions, further studies should focus on immunological analyses of the interactions, considering different helminth species independently. The findings of the present study suggest that there are variabilities in the

prevalence of malaria/STH and SCH co-infections, as well as in the effects of co-occurrence on anaemia/malnutrition.

List of Abbreviations

STH: Soil-transmitted helminths
P.F: *Plasmodium falciparum*
HW: Hookworm
TT: *Trichuris trichiura*
SM: *Schistosoma mansoni*
SH: *Schistosoma haematobium*

Declarations

Ethical approval and consent to participate

Ethical approvals were obtained from the Committees of the following institutions and establishments: Olabisi Onabanjo University teaching Hospital Health Research Ethics Committee (OOUTH/DA/326/494); Universal Basic Education Board, Abeokuta (SUBEB/SS/1102/22); and Ministry of Education, Science and Technology, Abeokuta (ESS.1/406/94).

Consent for publication

All the authors gave consent for the publication of the work under the Creative Commons Attribution-Non-Commercial 4.0 license.

Availability of data and materials

The data and materials associated with this research will be made available by the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Nil.

Author contributions

JKA, AOJA and AAO conceived and designed the work. All authors participated in the collection and analysis of samples. JKA, AOJA and AAO did the analysis and interpretation of data. JKA, AOJA and AAO drafted the work and wrote the main manuscript text. All authors reviewed the manuscript and approved the submitted version.

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