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ORIGINAL ARTICLE

Evidence of reduced academic performance among schoolchildren with helminth infection

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Background: Soil-transmitted helminths (STHs) pose a formidable health risk to school-age children in resource-limited settings. Unfortunately, mass deworming campaigns have been derailed since the onset of the coronavirus disease 2019 pandemic. The present study assessed the cross-sectional associations between STHs, nutritional status and academic performance of schoolchildren in the Banda District of Ghana.

Methods: Schoolchildren (5–16 y of age; n=275) were recruited through both school and household visits by community health workers using a multistage cluster sampling technique. In addition to school microscopy, anthropometric records were also taken.

Results: The prevalence of geohelminthiasis was 40.4% (95% confidence interval 34.6 to 46.2). STHs targeted for elimination by the World Health Organization and national programmes were detected among schoolchildren. Children with intestinal parasite infection (53.7 [standard deviation {SD} 11.5]) had lower mean academic scores compared with uninfected children (59.6 [SD 16.9]) (p=0.034). In multiple regression analysis, intestinal parasite infection status and z-scores for weight-for-age showed a collective significant effect on the academic score (F_{1117}=8.169, p<0.001, R^2=0.125).

Conclusions: Schoolchildren with STHs had poorer academic performance compared with uninfected children, despite their nutritional status. In addition to school feeding programmes, school-based mass drug administration campaigns may be critical for improving learning outcomes in young schoolchildren.

Keywords: academic performance, COVID-19, malnutrition, school deworming, soil-transmitted helminths, sub-Saharan Africa.

Introduction

School-age children in developing countries are at risk of compromised health as a consequence of helminth infections.[1,2] Although helminth infections do not produce high mortality statistics, recent estimates suggest that morbidity due to helminth infections accounts for an estimated 20% of the disability-adjusted life years lost due to infectious diseases in children <14 y of age.[3] Among the well-described morbidities associated with helminth infection in children are undernutrition, anaemia and failure to achieve the genetic potential for growth.[3] Much like other diseases of poverty, the burden of STHs is disproportionately high in developing countries and affects children living in extreme poverty, particularly those living in rural communities or urban communities without adequate access to good water, sanitation and hygiene (WASH).[2] In sub-Saharan Africa, estimates of the prevalence of hookworm (*Ancylostoma duodenale* and *Necator americanus*) range from 30 to 50%.[4] Environmental factors present in tropical climates are known to be conducive to the life cycle of intestinal helminths that have been marked for eradication. Furthermore, STHs are thought to deepen inequality in society by widening the wealth gap and adversely affecting the future economic potential of children from poor socio-economic backgrounds.[5]

Current World Health Organization (WHO) guidelines for the management of STH infections focus on morbidity control through the use of mass drug administration (MDA) of anthelmintic drugs targeting preschool- and school-aged children as well as other at-risk groups.[6] In 2019, the School Health Education Programme (SHEP) Unit of the Ghana Education Service and the Neglected Tropical Disease (NTD) Programme of the Ghana Health Service, with the support of donor partners, undertook school-based deworming campaigns to control the burden of STHs. Under this initiative, schoolchildren ages 5–16 y were targeted for the administration of albendazole (400 mg by mouth) and praziquantel (20 mg/kg twice a day). The MDA was held in 32 371 basic schools in 178 districts across the country and covered approximately 6 million schoolchildren. Stakeholders were expected to build on the experiences of previous MDA campaigns conducted in November 2014, November 2015 and November 2019 to maximize the gains to be made in subsequent years.

Then came the pandemic. The coronavirus disease 2019 (COVID-19) pandemic had wide-ranging disruptive effects on in-country programmes targeted at several NTDs, including school deworming campaigns. In the Bono Region, all deworming campaigns halted in the wake of the pandemic as a result of the strain placed on the health service by the pandemic. Indeed, the Ghana Health Service had to readjust programme goals to mobilize adequate resources to manage the public health threat caused by the pandemic. In addition, the government ordered the closure of all basic schools for an entire academic year, effectively bringing an end to all school health programs. Amid all the chaos, drugs intended for distribution in rural communities with the greatest burden of STHs expired as a result of these extended lockdowns. Meanwhile, children continued to be exposed to community factors that placed them at heightened risk of infection with STHs with no access to drugs.[7]

Several studies have highlighted a gap in knowledge and policy setting regarding the value of school deworming campaigns and children's academic performance or cognitive function.[8–10] However, data on helminth infection in Ghana has largely focused on prevalence estimates for health disability and not on children's academic performance. The present study aims to investigate the effect of STH infections on growth (nutritional status) and cognitive function in schoolchildren in the Bono Region of Ghana in light of demographic, socio-economic and epidemiologic contextual factors such as COVID-19-induced suspension of mass school-based deworming campaigns.

Methods

Study design and setting

A cross-sectional survey design was employed to determine the prevalence of intestinal helminths, anaemia and academic performance among schoolchildren in the Banda District of the Bono Region of Ghana (Figure 1). The Banda District is made up of several riparian communities covering a total land area of 2298.3 km^2 in the middle belt of Ghana. It is home to a population of approximately 25 000 people. The majority of the inhabitants (71.2%) find employment as skilled agricultural, forestry and fishery workers. The district is entirely rural, with a youthful population. The district has a household population of 20 171, with a total of 3685 households. The average household size in the district is about six persons per household. Children constitute the largest proportion of household members (41.7%). The three main sources of lighting in dwelling units in the district are electricity (46.3%), flashlight/torch (40.4%) and kerosene lamps (11.8%). The main source of fuel for cooking for most households in the district is wood (75.5%). The four main sources of water in the district are borehole, river/stream, public tap and pipe-borne water (96.4%). Almost 6% of the households drink water from a river or stream, while 0.4% drink water from a dugout, pond, lake, dam or canal. The most commonly used toilet facility in the district is open defaecation in the bush/field, accounting for 43.9%, followed by public toilets (34.2%). Only 3.4% of the households in the district have a modern toilet facility. Regarding school attendance, of the population $\geq$3 y of age, 62.5% are currently attending school and 37.5% have attended in the past.

Sampling technique and data collection

A total of 275 school-aged children (5–16 y of age) were recruited through school visits by community health workers using a multistage cluster sampling technique. The study was conducted in seven selected basic schools, three of which were under private ownership. The register of schools in the district was obtained from the SHEP office. Schools were clustered according to location and stratified according to educational level (basic grade 1–9). The allocation of students to schools and grade level was performed according to the number of students in each school and grade (Supplementary File 1). Study subjects were selected by systematic random sampling using the class roster as the sampling frame in each school. A validated and pretested questionnaire based on known risk factors was administered to each child–parent pair by trained field workers with translation to the local dialect where necessary. Data about sociodemographic characteristics and risk for intestinal helminthic infections were retrieved through face-to-face interviews with parent–child units. Afterwards, blood samples were collected into tripotassium ethylenediaminetetraacetic acid (EDTA) and gel tubes. Stool samples were collected into labelled, clean and dry stool containers and preserved with 10% formalin before they were transported to the Banda District hospital laboratory. Weight and height measurements were taken in duplicate with minimal clothing and without shoes and the mean values recorded. The anthropometric index of z-score for weight-for-age was computed as an indicator of growth status for schoolchildren using Anthroplus version 1.0.4 (WHO, Geneva, Switzerland). Schoolchildren were classified as underweight if they had z-score values less than two times the standard deviation (SD) for weight-for-age. The academic performance of the students was measured as the cumulative end-of-term examination results averaged over three consecutive school terms.

Laboratory procedures

Preserved stool samples were processed using the formalin–ether concentration method.[11] Briefly, a portion of stool weighing

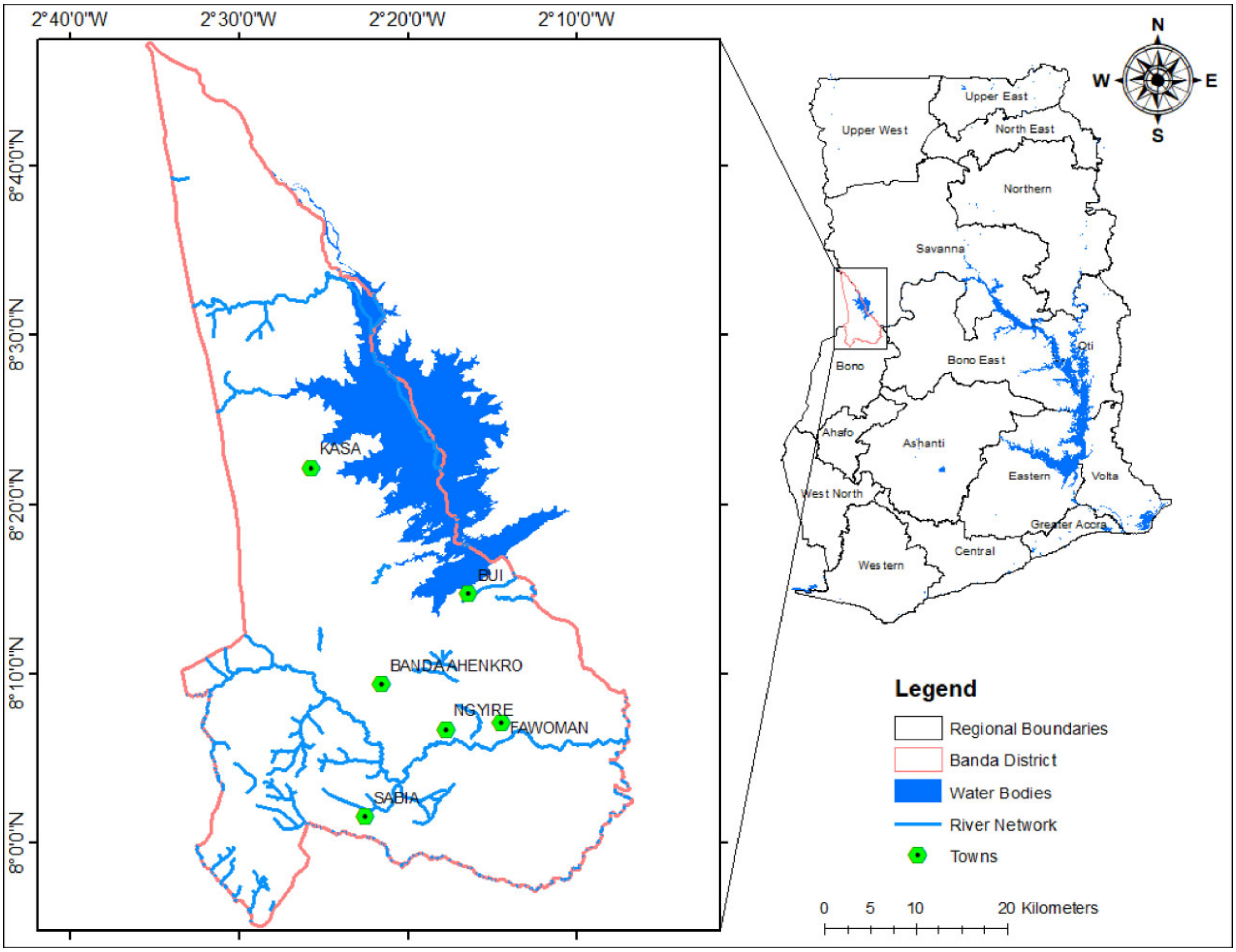

Figure 1. Map of Ghana showing the study area. Source: Earth Observation Research & Innovation Centre, University of Energy and Natural Resources.

approximately 2 g was placed in a separate stool container and mixed with 10 ml of 10% formalin, filtered through two layers of gauze into a 15-ml centrifuge tube and centrifuged at 2000 rpm for 2 min. The sample was stirred thoroughly and incubated for 5 min before the addition of 3 ml of diethyl ether and centrifugation at 2000 rpm for 2 min. The supernatant was discarded and the sediment was used to prepare a smear on a microscopic slide for observation of parasite ova. Blood films (thin and thick) were prepared and examined according to WHO guidelines to check for the presence of blood parasites (*Plasmodium*).[1] Haemoglobin (Hb) concentration levels were measured on an automated analyser (KX-21N, Sysmex, Kobe, Japan) using whole blood collected in EDTA tubes.

Statistical analysis

SPSS for Windows version 25.0 (IBM, Armonk, NY, USA) was used to analyse collected data. Associations between variables were tested via bivariate analysis (χ^2 test). Bivariate correlations, independent t-tests and multiple regression analyses were performed to investigate associations between academic performance, helminth infection and nutritional status.

Ethical consideration

Ethical clearance was obtained from the Committee for Human Research and Ethics of the University of Energy and Natural Resources, School of Sciences (reference CHRE/AP/08/021) and the Committee on Human Research Publication and Ethics, School of Medical Sciences, Kwame Nkrumah University of Science and Technology Kumasi, Ghana (reference CHRPE/AP/140/21). Participants recruited for the study provided written informed consent (i.e. the participants gave assent and their parents gave consent).

All the individuals diagnosed to have intestinal protozoan infections were given metronidazole (Flagyl) orally as a standard adult dose (800 mg) or standard paediatric dose (200–400 mg) every 8 h for 5 d. Furthermore, those found to have schistosome infection received a standard oral dose of praziquantel (40 mg/kg body weight). Children infected with intestinal helminths received albendazole (400 mg) in a single dose as recommended by the NTD Programme and standard treatment guidelines of the Ghana Health Service.

Table 1. Demographic characteristics of schoolchildren

Parameter	n	%
Total	275	100
Gender		
Male	119	43.3
Female	156	56.7
Ethnic group		
Akan	86	31.3
Ga–Adangbe	8	2.9
Mole–Dagbani	181	65.8
Religion		
Christian	121	44.0
Islam	154	56.0
Class of participant		
Kindergarten and lower primary	105	38.2
Upper primary and junior high school	170	61.8
Coverage of school feeding programme		
Covered	201	73.1
Not covered	74	26.9
Parameters	Mean (SD)	Minimum–maximum
Age of respondent (n=275)	11.1 (2.4)	5–16
Hb concentration (g/dL) (n=275)	10.9 (1.7)	6.4–17.6
Academic score (%) (n=117)	56.4 (14.5)	20.1–99.2

Table 2. Infection status of schoolchildren

Parameter	n	%
Total	275	100
Infection status[a]		
Uninfected	121	44.0
Infected	154	56.0
Intestinal parasites[b]		
None	139	50.5
Intestinal parasite infection	136	49.5
Helminth infection		
None	164	59.6
Yes	111	40.4
Prevalence of helminth infection		
Strongyloides sp.(threadworm)	6	2.2
Ancylostoma sp.	11	4.0
Ascaris sp. (roundworm)	17	6.2
Taenia sp. (tapeworm)	68	24.7
Enterobius sp. (pinworm)	4	1.5
Trichuris trichiura	7	2.5
Trichostrongyloide sp.	1	0.4
Schistosoma sp.	20	7.3
Multiple helminth infections (n=111)		
No	82	73.9
Yes	29	26.1
Entamoeba sp.	54	19.6
Blood-borne protozoa		
None	260	94.5
Plasmodium sp.	15	5.5
Mixed infection[c]		
No	267	97.1
Yes	8	2.9

[a]Infection with either intestinal parasite and/or blood protozoa.
[b]Infection with either intestinal helminth and/or intestinal protozoa.
[c]A combination of blood-borne protozoa and intestinal parasites.

Results

A total of 275 schoolchildren ages 5–16 y were recruited for the study. All of them provided a blood sample and stool sample. The demographic characteristics of the participants are shown in Table 1. The mean age of the children was 11.1 y (SD 2.4 y). The majority of the participants were females, accounting for 156 (56.7%) of the total study population. Approximately two-thirds (65.8%) of study participants were descended from the Mole–Dagbani and the rest were mostly Akans (31.3%), with a minority of Ga-Adangbe descent. The major religious group was Islam (56%). The majority of the participants were attending public schools under the ministry-funded meal supplementation programme (73.1%). The mean blood Hb concentration was 10.9 g/dL (SD 1.7).

Table 2 shows the infection status of the schoolchildren. Of the 275 stool samples examined, 154 (56.0%) were positive for one or more intestinal or blood parasite. The prevalence of intestinal parasite infections (helminth and intestinal protozoa) was 49.5% (95% confidence interval [CI] 43.5 to 55.4). Intestinal helminths targeted for elimination were detected in 40.4% (95% CI 34.6 to 46.2) of all cases. Commonly detected intestinal parasites were *Taenia* sp. (68/275 [24.7%]), *Schistosoma* sp. (20/275 [7.3%]), *Ascaris* sp. (17/275 [6.2%]), *Ancylostoma* sp. (11/275 [4.0%]) and *Trichuris trichiura* (7/275 [2.5%]). The prevalence of *Plasmodium* detection was 5.5% (n=15).

Of the 275 blood samples, 142 had low Hb levels, representing an anaemia prevalence of 51.64%. The mean Hb level of schoolchildren was 10.9 g/dL (SD 1.7; range 6.4–17.6) (Table 1). Table 3 shows results from the χ^2 test of association between the Hb level and intestinal parasite infection status (χ^2=9.163, df=1, p=0.002). Children with intestinal parasite infections were more likely to be classified as having low Hb (p=0.002). Of the 136 helminth-infected children, 83 (58.45%) had low Hb.

Academic performance scores averaged over three school terms were compared across categories of intestinal parasite infections (Table 4). Children without an intestinal parasite infection (59.6 [SD 16.9]) had higher mean academic scores compared with children with an intestinal parasite infection (53.7 [SD 11.5]) (t=2.148, df=91.277, p=0.034). Infected children (53.6 [SD 11.5]) performed poorly compared with uninfected children (59.9 [SD 16.9]). There was no difference in academic performance between underweight schoolchildren (61.5 [SD 18.5])

Table 3. The association of Hb and helminth status

Parameter	Hb status		Total	χ^2	df	p-Value
	Normal, n (%)	Anaemic[a], n (%)				
Total	133 (48.36)	142 (51.64)	275 (100.00)			
Intestinal parasites[b]						
No infection	80 (60.15)	59 (41.55)	139 (50.55)	9.163	1	0.002
Intestinal parasite infection	53 (39.85)	83 (58.45)	136 (49.45)			
Helminth infection						
No	95 (57.90)	69 (42.10)	164 (59.60)	14.879	1	0.000
Yes	38 (34.20)	73 (65.80)	111 (40.40)			

[a]Hb level <11.5 g/dL[31].
[b]Infection with either intestinal helminth and/or intestinal protozoa.

Table 4. Comparison of academic performance across health status of participants

Parameter	Academic performance, mean (SD)	t-Statistic	df	p-Value
Intestinal parasites[a]				
No infection (n=54)	59.6 (16.9)	2.148	91.277	0.034
Intestinal parasite infection (n=63)	53.7 (11.5)			
Helminth infection				
No infection (n=66)	58.2 (16.4)	1.539	115	0.127
Helminth infection (n=51)	54.1 (11.2)			
Blood parasites[b]				
No infection (n=114)	56.5 (14.6)	0.483	115	0.63
Plasmodium sp. (n=3)	52.4 (8.8)			
Mixed infection[c]				
No infection (n=115)	56.4 (14.6)	−0.003	115	0.998
Mixed infection (n=2)	56.5 (7.6)			
Infection status[d]				
Not infected (n=53)	59.9 (16.9)	2.296	88.618	0.024
Infected (n=64)	53.6 (11.5)			
Nutritional status				
Normal weight for age	55.6 (13.6)	−1.579	115	0.117
Low weight for age	61.5 (18.5)			

df: degrees of freedom.
p-Value <0.05 is considered statistically significant.
[a]Infection with intestinal parasites only.
[b]Infection with *Plasmodium* sp.
[c]A combination of blood-borne protozoa and intestinal parasites.
[d]Infection with intestinal parasite and/or blood protozoa.

and normal weight children (55.6 [SD 13.6]) (t=−1.579, df=115, p=0.117).

Figure 2 shows the prevalence of underweight (low weight-for-age) among schoolchildren. The general prevalence of underweight among the schoolchildren was 13.1% (36/275). Among the schoolchildren, 19.3% (23/119) of males were underweight and 8.3% (13/156) of females were underweight.

Academic performance scores averaged over three school terms were compared across categories of sociodemographic variables (Table 5). Children from low-income households (52.5 [SD 12.9]) performed poorly compared with children from households with higher incomes (59.6 [SD 15.0]).

In the multiple regression model, intestinal parasite infection status and z-scores for weight-for-age explained 12.5% of the

Table 5. Comparison of academic performance according to demographic characteristics of schoolchildren

Parameter	Academic performance, mean (SD)	t-Statistic	df	p-Value
Sex				
Male (n=54)	56.0 (13.8)	−0.315	115	0.753
Female (n=63)	56.8 (15.2)			
Household size				
≤7 (n=54)	57.3 (15.3)	0.607	115	0.545
>7 (n=63)	55.7 (13.9)			
Household income (cedi)				
≤150 (n=52)	52.5 (12.9)	−2.675	115	0.009
>150 (n=65)	59.6 (15.0)			
Household weekly expenditure (cedi)				
≤50 (n=76)	55.0 (13.8)	−1.444	115	0.151
>50 (n=41)	59.1 (15.5)			
Class of participants				
Kindergarten and lower primary (n=39)	55.1 (15.1)	−0.718	115	0.474
Upper primary and junior high school (n=78)	57.1 (14.2)			

df: degrees of freedom.
p-value <0.05 considered statistically significant.

Table 6. Determinants of schoolchildren’s academic performance over the past year (model 1)

Model		Unstandardized coefficients		Standardized coefficients	t-Statistic	p-Value
		β	SE	β		
1	(Constant)	59.912	1.862		32.177	0.000
	Intestinal parasite infection	−5.152	2.542	−0.178	−2.026	0.045
	z-score: weight for age	−3.577	1.077	−0.292	−3.321	0.001

SE: standard error.
Dependent variable: academic performance.
R^2=0.125, F=8.169, p<0.001.

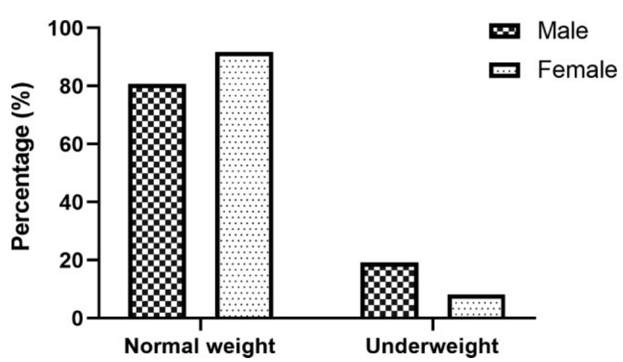

Figure 2. Nutritional status of schoolchildren. Source: fieldwork.

variability in academic scores (F_{1117}=8.169, p<0.001, R^2=0.125). As shown in Table 6, both intestinal parasite infection status (t=−2.026, p=0.045) and z-scores for weight-for-age (t=−3.321, p=0.001) were significant predictors of the academic score. However, the relationship between intestinal parasite infection status (t=−1.648, p=0.102) and academic scores was undermined when household income was added to the model ($F_{2,117}$=7.408, p<0.001, R^2=0.164) as shown in Table 7.

Discussion

In the wake of the first cases of severe acute respiratory syndrome coronavirus 2 infections in Ghana, the government took several precautionary measures to avoid community spread and contain the virus. As part of these measures, school activities were suspended and schoolchildren had to stay at home for >1 y. By compelling national authorities to lock down schools, the COVID-19 pandemic completely disrupted MDA campaigns previously held in schools. Furthermore, children staying at home

Table 7. Determinants of schoolchildren's academic performance over the past year (model 2)

Model		Unstandardized coefficients		Standardized coefficients	t-Statistic	p-Value
		β	SE	β		
1	(Constant)	50.309	4.567		11.017	0.000
	Intestinal parasite infection	−4.172	2.532	−0.144	−1.648	0.102
	z-score: weight for age	−3.467	1.059	−0.283	−3.275	0.001
	Household income	5.820	2.536	.201	2.295	0.024

SE: standard error.
Dependent variable: academic performance.
R^2=0.164, F=7.408, p<0.001.

faced a greater risk of reinfection from community-acquired helminths.[7] Once restrictions were eased and schools allowed to reopen, the present study investigated the burden of helminth infections in an endemic community and the cross-sectional relationship with nutritional status and school performance.

A high burden (40.4 [95% CI 34.6 to 46.2]) of STHs was detected among schoolchildren. Several classes of intestinal parasites were present in stool samples collected from school-age children: these included *Taenia*, *Schistosoma*, *Strongyloides*, *Ascaris* and *Entamoeba*. Estimates of the prevalence of STHs among schoolchildren in Ghana range from 6 to 45%[4,12,13] under varying contexts. Abera et al.[14] recorded a prevalence of 41.46% in an area in northern Ethiopia, while Davis et al.[15] recorded a frequency of 40.5% and 40.7% among preschool and school-aged children, respectively. However, the prevalence of hookworms (*Ancylostoma duodenale* and *Necator americanus*) was much lower in the present study than what had been previously known (30–50%) before the onset of MDA in schools.[16,17]

In Ghana, sporadic community-based administration of antihelminth agents to schoolchildren in targeted communities as part of eradication efforts has been reported to lower the burden of helminths reported in communities with such a history.[17] The low prevalence of hookworm may reflect the impact of previous deworming campaigns in the region.[4] However, this may be difficult to prove in the absence of pre-MDA campaign data for the Banda District where the present study was conducted.

Nevertheless, the burden of intestinal parasites and helminths is higher than other estimates in school-age children from the region.[4,18–20] In addition, they remain far above elimination targets set by the WHO. The variation in prevalence might be due to research scheduling, participant sampling, seasonal changes in survey conduct, environmental circumstances or other geographical characteristics in these study locations.

The higher-than-expected burden of STHs discovered among school-age children several months after a mass deworming exercise in the region might be indicative of persistent reinfection patterns[7] and reflect the impact of the pandemic in reducing control efforts implemented through the school system. In the absence of control measures aimed at reducing exposure, treatment of STH infections will naturally be followed by avoidable reinfection, necessitating repeated treatments.[21,22] As such, to sustain the benefits of treatment well beyond campaign periods and to pre-empt the adverse effects of future public health shocks such as the COVID-19 pandemic on gains made through MDA programmes, efforts to reduce environmental exposure to infection through improved sanitation and hygiene behaviours must be prioritized.[23–25] Transmission of protozoa that live in a human's intestine to another human typically occurs through the faecal–oral route (e.g. contaminated food or water or person-to-person contact). Thus the high prevalence of *Entamoeba* sp. in the community would suggest that unsanitary conditions exist that need to be improved.

Inhabitants living close to water bodies have been reported to maintain significantly elevated relative risks for helminth infections and might also be a reason for the burden of helminths observed in the Banda District of the Bono Region, where contact with stagnant water bodies is an important part of daily life, especially for children who are continuously exposed to contaminated soil and water and often lack the awareness of good personal hygiene. Gyasi et al.[26] investigated the incidence and prevalence of *Schistosoma haematobium* infection in riparian communities of the Bui Dam. The study revealed that *S. haematobium* was more prevalent among inhabitants living closer to the Bui Dam, with children <14 y of age being the worst affected. As a result, control efforts must factor in the contextual requirements within such geographic locations to achieve and sustain programme targets.

In general, a high burden of intestinal parasites and helminths, in particular, have been strongly linked with poor nutritional status and anaemia.[3] The high prevalence of anaemia among schoolchildren in the study area and the significant cross-sectional association between intestinal parasite infection and suboptimal Hb concentration confirm this assertion (Table 3). When unchecked, poor nutritional status and anaemia may undermine academic performance in schoolchildren. However, the present data did not reveal an association between poor nutritional status and academic performance. Several reasons may be ascribed to this, including the broad age range[5–16] and the sensitivity of markers of nutrition across the age spectrum.[1,27] A more comprehensive nutritional assessment based on anthropometric, biochemical and clinical data is required to confirm this finding.

Rather, academic performance averaged from scores over three school terms was significantly associated with intestinal parasite status (Tables 5–7). Some similar studies have reported concordant findings.[8,28] This adds to the growing body of data in support of an association between the academic performance of schoolchildren and helminthiasis (Supplementary file 2: Determinants of schoolchildren's academic performance over the past year). Several mechanisms have been put forward to explain this association, including an improvement in school attendance following mass deworming of schoolchildren during the academic year.[13] Not all studies report a significant relationship between children's cognitive performance and their anthropometric and helminthiasis data.[29] In addition to intestinal parasite status, low household income level was associated with poor academic performance. Children from low-income households performed poorly compared with children from households with higher income (Table 5–7). In previous studies, indicators of household income or socio-economic status have been reported to have a strong impact on both helminth infection and academic performance.[12,25,30] Poor households are subjected to risk factors for recurrent helminth infection such as household rearing of livestock and a lack of basic amenities such as treated drinking water and toilet facilities.[25] This may explain why household income interferes with the relationship between parasite infection and academic performance. Academic performance is an important socio-economic objective for every society. In the broadest sense, it provides an indication of the fortunes of society in the future. However, this finding suggests that significant investment may be needed to offset household poverty and guarantee quality educational outcomes. Recognizing this, the government has introduced a policy to provide free school meals to schoolchildren. However, aside from meal supplementation, mass deworming campaigns may be crucial for attaining expected educational targets.

Limitations

Cross-sectional studies provide a snapshot of associations between variables within the population under study at a particular time, unlike cohort studies that follow subjects across time and can provide data on cause and effect. This means that there is a potential for bias since the temporality of helminth infections cannot be accounted for. It is plausible to consider that persistent helminth infections within the population can have more deleterious effects on children than one-off infections. Thus the pattern and severity of infections across time could introduce bias that the study was not designed to overcome. The study also did not investigate the helminth status of household members. Therefore any interpretation of our findings must consider these limitations.

Conclusions

Data collected immediately after the easing of COVID-19 restrictions among schoolchildren in the Banda District of Ghana show that the prevalence of STHs is 40.4% and higher than programme targets. Commonly detected intestinal parasites were *Taenia* sp., *Schistosoma* sp., *Ascaris* sp., *Ancylostoma* sp. and *Trichuris trichiura*. Helminth infection, either independently or together with *Entamoeba* sp., household income and z-scores for weight-for-age may be important predictors of academic performance for schoolchildren. Schoolchildren with intestinal parasite infection had poorer academic performance compared with uninfected children, despite their nutritional status. In addition to school feeding programmes, consistent MDA campaigns may be critical for improving learning outcomes in young schoolchildren.

Supplementary data

Supplementary data are available at *International Health* online.

Authors' contributions: ETD, DB, SFG and MTY conceived the study. KBO, WIOB and JEO designed the study protocol and trained field and laboratory staff. JEO, BAA and SKA carried out the clinical assessment. OD, SA and ASR carried out the laboratory and data analysis and interpretation. ETD, AGAA and OD drafted the manuscript. BAA, SFG and WIOB critically revised the manuscript for intellectual content. All authors read and approved the final manuscript. ETD and DB are guarantors of the paper.

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Data availability: The data underlying this article will be shared on reasonable request to the corresponding author or ethics review board.

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