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Gastrointestinal Protozoa and Geohelminth Infections and their Associated Risk Factors Among Primary School Pupils in Bindawa Local Government Area of Katsina State, Nigeria

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ABSTRACT

Background and Objective: Gastrointestinal protozoans and geohelminths infections are among diseases that are grouped under Neglected Tropical Diseases (NTDs), most endemic among the poor and vulnerable populations in the tropics. This study was conducted to assess gastrointestinal protozoan and geohelminth infections and their associated risk factors among primary school pupils in Bindawa Local Government Area (LGA) of Katsina State, Nigeria. **Materials and Methods:** Stool samples were randomly collected from 440 pupils attending 11 selected primary schools within the LGA. Wet mount and concentration techniques were adopted for the analysis of the stool samples and examined using microscopy. Data were analysed using Chi-square analysis and odd ratio (OR) at 0.05 level of significance. **Results:** Among the 440 pupils sampled, 194 (44.09%) were infected with one parasite or the other. Males (45.5%) had more infections than their female counterparts (42.7%). The most commonly identified intestinal parasites were *Ascaris lumbricoides* (15.5%), *Entamoeba histolytica* (6.8%), hookworms (7.7%), *Trichuris trichiura* (3.4%) and *Giardia lamblia* (4.1%). **Conclusion:** This study concluded that there was a presence of intestinal parasitic infections among the primary school pupils in the study area with associated transmission risks.

KEYWORDS

Gastrointestinal parasite, neglected tropical diseases, infestation, prevalence, mass drug administration, hygiene, incidence

INTRODUCTION

Human gastrointestinal tract parasites are the main contributors to health problems in developed and underdeveloped countries alike. Protozoa and helminths are two categories into which they can be divided. *Ascaris lumbricoides*, *Ancylostoma duodenale* (hookworms), *Necator americanus*, *Trichuris trichiura*, *Strongyloides stercoralis* and *Enterobius vermicularis* are among the most prevalent soil-transmitted helminths (STH). The multicellular organisms known as helminths are known to rob their hosts of the nutrients they need for survival[1]. They are so named because humans contract them by coming into contact with soil that has picked up parasites due to improper human excrement disposal. Unicellular

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parasites known as protozoa can harm the intestinal mucosa, causing nutritional malabsorption that can cause diarrhoea and dysentery. *Giardia lamblia*, *Entamoeba histolytica*, *Balantidium coli* and *Cryptosporidium* are the most prevalent pathogenic protozoa[1].

According to estimates from the World Health Organization (WHO), intestinal parasites are present in 1.5 billion people or 24% of the world's population. Children are seen to suffer the highest burden of infection disproportionately, even while entire populations are geographically at risk[2]. More than 270 million pre-schoolers and more than 600 million school-age children need treatment and prevention measures[3]. Due to low social and economic conditions, inadequate sanitation and poor hygiene practices, parasitic diseases are a significant public health issue in underdeveloped nations. They lead to numerous issues with physical and mental development in children, including intestinal blockage, growth retardation and iron deficiency anaemia[4]. Their academic progress is hampered and economic growth is slowed down as a result[5]. School-aged children frequently engage in unclean behaviour and are engaged in such environments[6].

Even though there is a lack of awareness of gastrointestinal parasites, health status and poor hygiene among primary school children, limited studies have been made to ascertain the gastrointestinal protozoa and geohelminths infection and their associated risk factors among primary school children in Bindawa, Katsina State. This study aimed to determine the current status of gastrointestinal Protozoa and geohelminths infection and their associated risk factors among the primary school children in Bindawa Local Government Area, Katsina State.

MATERIALS AND METHODS

Study area: The study was conducted in Bindawa Local Government Area Katsina State Nigeria between May, 2022 and February, 2023. The land area of Bindawa is 398 km^2. It is situated at Longitude 12°40'1"N and Latitude 7°48'19"E, respectively. According to 2022 projection by city population, Bindawa LGA had a population of 269,900 individuals. The mean annual temperature around the LGA ranges from 35-39°C. Trees, shrubs and grasses are the primary plant species. The majority of natives work as farmers, government employees, fishermen, or perform other businesses.

Study population: The study involved primary 1-6 pupils aged between 5-12 years from eleven randomly selected primary schools within Bindawa Local Government Area. These schools were; Bindawa Model Primary School, Bargai Primary School, Dageji Primary School, Makera Primary School, Rugarbade Primary School, Doro Model Primary School, Agalawa Primary School, Dakwale Primary School and Digga Primary School.

Data and sample collections: The sample of collected stools to gather information on the prevalence of intestinal parasite illnesses among students. Using pre-made questionnaires, information on social demographics, environmental factors and personal hygiene was gathered. On the day that stools were collected, students completed questionnaires and then they were given sterile specimen vials to bring stools in the morning. Class masters, who were instructors in the separate schools, completed a checklist about environmental sanitation in the classrooms. The procedures for collecting the stool samples are outlined below. Faecal samples were obtained using a sterile, leak-proof container that was dry, clean and contained an applicator stick. The faecal samples were taken at their school in the morning. The samples were examined for label and quantity errors before being delivered to the microbiology laboratory at Umaru Musa Yar'Adua University for additional research.

Gross examination of stool specimens: The stool samples were grossly examined for consistency, colour, presence of blood, mucus and adult worms or segments. They were then processed using direct wet mounts and concentration methods and thereafter observed under a microscope as described by Cheesbrough[7].

Sample preparations and microscopic examinations

Direct wet mounts: According to standard laboratory procedure, direct wet mounts were created to evaluate the presence or absence of adult worms, worm segments, eggs, protozoa cysts and/or trophozoites[7]. This was accomplished by taking about 2 g of stool specimen with an applicator stick, mixing it with a drop of ordinary saline placed in the middle of a microscope slide's left half and a drop of 0.9% Lugol's iodine solution placed in the middle of the slide's right half. To help identify motile protozoan trophozoites, the preparations were covered with coverslips and a drop of eosin was placed underneath the cover slip[8]. The slides were examined at 10X, 40X and 100X objective lenses.

According to Heckendorn *et al.*[9], the criteria for identifying protozoa trophozoites were motility structures, type of motility, number of nuclei, karyosomes and chromatid bars. While structural characteristics like sucking disks and spiral grooves or filaments were utilized to identify flagellate trophozoites, other structures like cytoplasmic inclusions like erythrocytes and yeast were used to identify amoebic trophozoites[10]. Each specimen's presence or absence of adult worms, eggs, larvae, protozoan trophozoites, or cysts was noted.

Formal-ether concentration technique:

- In order to analyze the feces samples, the concentration method was also used
- Approximately 1g (pea-size) of feces was emulsified in 4 mL of 10% formal saline using an applicator stick and a screw-cap bottle or tube
- After shaking the bottle, a further 3 mL of 10% v/v formal saline was added. The bottle was then sealed
- Sieved suspension from the emulsified waste was collected in a beaker
- Suspension was put into a conical, glass centrifuge tube, followed by the addition of 3-4 mL of diethyl ether
- Tube was sealed and mixing took place for a minute. The stopper was then loosened by wrapping a piece of tissue or fabric over the top of the tube
- Tube was immediately centrifuged for five minutes at 3000 rpm
- Layer of faeces waste was removed from the tube's wall using a stick and the tube was then turned upside down to remove the ether, faecal debris and formal water. The sand was still there
- After putting the tube back upright, the liquid from the side was allowed to drain to the bottom. The sediment was mixed and resuspended by tapping the tube's bottom
- After that, the sediment was put on a slide and covered with a cover glass
- Preparation was viewed under a 10X objective while the condenser iris was sufficiently closed to provide acceptable contrast. Examining tiny cysts and eggs with the 40X objective[7]

Each specimen's presence or lack of adult worms, eggs, larvae, protozoan trophozoites or cysts was noted. The eggs and larvae were identified using Atlas of Medical Parasitology and Medical Helminthology.

Questionnaires: In order to gather information on socio-demographic characteristics, personal hygiene habits and the risks of transmitting intestinal parasite illnesses in both the home and school settings, 440 copies of predesigned questionnaires were employed. The questionnaires were divided into three sections: The first dealt with socio-demographic factors like age, class and schools; the second deal with environmental factors like water source, toilet type and the presence of flies in latrines and/or toilets and the third section dealt with hygiene practices like washing hands before handling food.

Statistical analysis: Data were stored in an Excel spreadsheet 2013. Prevalence is expressed in a simple percentage of the positive sample over the total sample analysed in descriptive statistics. The distribution between the protozoan and geohelminths infections was presented in a bar chart. The risk factors associated with gastrointestinal protozoan and geohelmints infections among the children in the study area were analysed using an odds ratio (OR). Analysis was done at 95% confidence level (α = 0.05).

RESULTS

Prevalence of gastrointestinal protozoans and helminths, multiple infection status and identities of parasites isolated in relation to their sex and age group: A total of 440 children were included in the study, out of which 220 (50.0%) are males and 220 (50.0%) are females. Among age groups, 177 (40.2%) within 6-7 years, 144 (32.7%) within 8-9 years, 69 (15.7%) within 10-11 and 50 (11.4%) within 12 and above years.

All 440 children who enrolled in this study provided stool samples (100%). As presented in Table 1, out of the 440 stool samples examined for the presence of protozoan and helminths ova and cysts, 194 stool samples tested positive, giving a prevalence of 44.09%. Though the males had a higher prevalence of 45.5% than the females (42.7%), no significant association of infection with sex was established in this study (χ^2 = 0.332, df = 1, p = 0.565). Prevalence of protozoan and helminth infection among the age groups of the subjects indicated higher prevalence among children aged 8-9 years with 68 (47.5%) and lower prevalence among the 10-11 years with 28 (40.60%). Age group recorded their no significant association with the infection of protozoan and helminths (χ^2 =1.204, df = 3, p = 0.752).

Table 2 showed the prevalence of protozoan and helminths infection among the sex groups of the subjects with a higher prevalence of single infection among the males 91 (41.4%) than the prevalence in the females 74 (33.6%). Females had higher prevalence with 20 (9.1%) multiple infection than the males 9 (4.1%). Gender wise, there is a statistically significant association between the single and multiple infection status with protozoan and helminths (χ^2 = 6.070, df = 2, p = 0.048).

Prevalence of protozoan and helminths infection among the age groups based on the single and multiple infections of the subjects indicated higher prevalence among children aged 8-9 years in both single and multiple infections and 12 and above has the lower in single infection and 10-11 has the lower infection in multiple infections. The age group recorded a statistically insignificant association with the infection of protozoan and helminths (χ^2 = 5.604, df = 6, p = 0.469) (Table 2).

Table 2 showed the prevalence of protozoan and helminths infection among the gender groups based on the type of parasite among the type of parasite helminths had the higher percentage which is *Ascaris lumbricoides* with 68(15.5%) and among the protozoan *Entamoeba histolytica* has the higher percentage. Sex group recorded a statistically insignificant association with the infection of protozoan and helminths (χ^2 = 0.332, df = 1, p = 0.565).

Prevalence and identification of gastrointestinal protozoans and helminths parasite multiple infections among children in relation to primary schools: Prevalence and identification of protozoa and helminths infection among the different schools, based on a school visited a school that Bargai Primary School has the highest percentage of 21 (52.5%) while Bindawa Model Primary School and Doro Model Primary Schools had the lowest percentage of 15 (37.5). The school group recorded a statistically insignificant association with the infection of protozoa and helminths (χ^2 = 4.112, df = 10, p = 0.942) (Table 3).

Prevalence of protozoa and helminths infections among the different schools based on the single and multiple infection status shows that Bargai Primary School has the highest percentage of single infection of 18 (45.0%). While Bindawa Model Primary School has the lowest percentage of 11 (27.5%). similarly, for multiple infections, Agalawa Primary School had the highest percentage of 5 (12.5%) while Kangi Primary School had the lowest percentage of 1 (2.5%). The school group recorded a statistically insignificant association with the infection of protozoa and helminths (χ^2 = 9.905, df = 20, p = 0.970) (Table 4).

Table 1: General prevalence of protozoan and helminths infections by sex and age group among the school children in Bindawa Local Government Area, Katsina State, Nigeria

Variables	Category	Number examine	Number positive	Prevalence (%)	Statistical value (95% CI)
Sex	Male	220	100	45.5	χ^2 = 0.332, df = 1, p = 0.565
	Female	220	94	42.7	
	Total	440	194	44.09	
Age (years)	6-7	177	75	42.40	χ^2 = 1.204, df = 3, p = 0.752
	8-9	144	68	47.5	
	10-11	69	28	40.60	
	$\geq$12	50	23	46.00	
	Total	440	194	44.09	

Table 2: Prevalence of single and multiple protozoa and helminths infection stratified by sex and age group among the school children in Bindawa Local Government Area, Katsina State, Nigeria (n = 246)

Variables	Category	Uninfected (%)	Single infection (%)	Multiple infection (%)	Statistical value (95% CI)
Sex	Male	120 (54.5)	91 (41.4)	9 (4.1)	χ^2 = 6.070, df = 2, p = 0.048
	Female	126 (57.3)	74 (33.6)	20 (9.1)	
	Total	246	165	29	
Age (years)	6-7	102 (57.6)	67 (37.9)	8 (4.5)	χ^2 = 5.604, df = 6, p = 0.469
	8-9	76 (52.8)	59 (41.0)	9 (6.2)	
	10-11	41 (59.4)	22 (31.9)	6 (8.7)	
	$\geq$12	27 (54.0)	17 (34.0)	6 (12.0)	
	Total	246	165	29	

Table 3: Prevalence of protozoa and helminths infections stratified by selected primary schools in Bindawa Local Government Area, Katsina State, Nigeria

Variables	Category	Number examine	Number positive	Prevalence (%)	Statistical value (95% CI)
School	Bindawa Mod. PS	40	15	37.5	χ^2 = 4.112, df = 10, p = 0.942
	BR PS	40	21	52.5	
	MK PS	40	15	40.0	
	DG PS	40	16	40.0	
	FR PS	40	19	47.5	
	AG PS	40	19	47.5	
	DM PS	40	15	37.5	
	RB PS	40	20	50.0	
	KG PS	40	18	45.0	
	DK PS	40	18	45.0	
	DI PS	40	17	42.5	
	Total	440	194	44.09	

BR PS: Bargai Primary School, MK PS: Makera Primary School, DG PS: Dageji Primary School, FR PS: Faru Primary School, AG PS: Agalawa Primary School, DM PS: Doro Model Primary School, RB PS: Rugar Bade Primary School, KG PS: Kangi Primary School, DK PS: Dakwale Primary School and DI PS: Digga Primary School

Table 4: Prevalence of protozoan and helminths infection among the different schools based on the single and multiple infections

Variables	Category	Uninfected (%)	Single infection (%)	Multiple infection (%)	Statistical value (95% CI)
School	Bindawa Mod. PS	25 (62.5)	11 (27.5)	4 (10.0)	χ^2 = 9.905, df = 20, p = 0.970
	BR PS	19 (47.5)	18 (45.0)	3 (7.5)	
	MK PS	24 (60)	14 (35.0)	2 (5.0)	
	DG PS	24 (60.0)	13 (32.5)	3 (7.5)	
	FR PS	21 (52.5)	16 (40.0)	3 (7.5)	
	AG PS	21 (52.5)	14 (35.0)	5 (12.5)	
	DM PS	25 (62.5)	13 (32.5)	2 (5.0)	
	RB PS	20 (50)	18 (45.0)	2 (5.0)	
	KG PS	22 (55.0)	17 (42.5)	1 (2.5)	
	DK PS	22 (55.0)	16 (40.0)	2 (5.0)	
	DI PS	23 (57.5)	15 (37.5)	2 (5.0)	
	Total	246	165	29	

BR PS: Bargai Primary School, MK PS: Makera Primary School, DG PS: Dageji Primary School, FR PS: Faru Primary School, AG PS: Agalawa Primary School, DM PS: Doro Model Primary School, RB PS: Rugar Bade Primary School, KG PS: Kangi Primary School, DK PS: Dakwale Primary School and DI PS: Digga Primary School

Table 5: Prevalence of protozoan and helminths infection stratified by school classes among the children in Bindawa Local Government Area, Katsina State, Nigeria

Variables	Category	Number examine	Number positive	Prevalence (%)	Statistical values (95% CI)
Class	Primary 1	95	44	46.3	χ^2 = 2.259, df = 5, p = 0.812
	Primary 2	87	33	37.9	
	Primary 3	78	36	46.2	
	Primary 4	69	33	47.8	
	Primary 5	58	24	41.4	
	Primary 6	53	24	45.3	
	Total	440	194	44.09	

Table 6: Prevalence of single and multiple protozoa and helminths infection among the children by class (n = 246)

Variables	Category	Uninfected (%)	Single infection (%)	Multiple infection (%)	Statistical analysis (95% CI)
Class	Primary 1	51 (53.7)	40 (42.1)	4 (4.2)	χ^2 = 7.737, df = 10, p = 0.655
	Primary 2	54 (62.1)	28 (32.2)	5 (5.7)	
	Primary 3	42 (53.8)	31 (39.7)	5 (6.4)	
	Primary 4	36 (52.2)	29 (42.0)	4 (5.8)	
	Primary 5	34 (58.6)	20 (34.5)	4 (6.9)	
	Primary 6	29 (54.7)	17 (32.1)	7 (13.2)	
	Total	246 (55.9)	165 (37.5)	29 (6.6)	

Prevalence and identification of gastrointestinal protozoan and helminths parasite in single and multiple infection status and among the school children by class: Table 5 showed the prevalence and identification of protozoa and helminth parasites in multiple infections among the different classes. Primary one has the highest percentage of 44 (46.3%) while primary two has the lowest percentage of 33 (37.9%). The class group recorded a statistically insignificant association with the infection of protozoa and helminths (χ^2 = 2.259, df = 5, p = 0.812).

Prevalence of protozoa and helminths infection among the different classes based on the single and multiple infections showed that primary one has the highest percentage of 40 (42.1%) while primary six has the lowest percentage of 17 (32.1%). And for multiple infections, primary six has the highest percentage of 7 (13.2%) while primary one, four and five had the lowest percentage of 4 (4.2%). The class group recorded a statistically insignificant association with the infection of protozoa and helminths (χ^2 = 7.737, df = 10, p = 0.655) (Table 6).

Risk factors that are associated with the protozoan and goehelminths: Table 7 showed that only about 50% of the student usually take their drugs after 3 months and there is no significant association with the intestinal parasite (OR = 1.487 with p-value 0.1920).

A total of 17.7% of the students opted for boiling drinking water and this choice demonstrated a significant association with a reduced likelihood of infection with intestinal parasites (OR = 0.230 with a p-value of 0.008). Notably, a considerable number of students neglected handwashing after using toilets or before meals and among them, 54.9% were found to be infected with intestinal parasites. Conversely, those students who adhered to proper hand hygiene by using soap after toilet visits and before meals showed a lower likelihood of infection with intestinal parasites (OR = 0.333, with a p-value of 0.005). However, washing hands with water alone, without soap, did not exhibit a significant reduction in infections with intestinal parasites (OR = 0.733, p-value 1.0199).

Approximately 50.3% of students washed fruits before consumption, significantly decreasing their chances of infection with intestinal parasites (OR = 0.880, with a p-value of 5.0428). On the other hand, around 50.8% of students consumed food from open places, a practice that was associated with an increased risk of intestinal parasite infection (OR = 2.273, with a p-value of 0.0034). Notably, 67.4% of students habitually wore shoes when working on farms or walking on wet grounds, leading to a substantial reduction in their chances of intestinal parasitic infections, particularly hookworms (OR = 0.095, p-value 0.003).

Table 7: Risk factors associated with the protozoan and geohelminths infections among the pupils in primary school in Bindaw LGA

Risk factors	Positive	Negative	Odd ration (OR)	p-value
Age	194	246	1.257	0.462
Sex	194	246	1.005	1.000
History of taking drugs	200	240	1.487	0.1920
Boiling drinking water	278	162	0.230	0.008
Washing hand after visiting toilet	240	200	0.733	1.0199
Washing hand with soap	190	250	0.333	0.005
Sources of fruit and vegetable	204	236	0.804	0.3040
Washing of fruit before eating	150	290	0.880	5.0428
Eating food sold in open place	220	220	2.273	0.0034
Wearing of shoes frequently	210	230	0.095	0.003
Swimming in stream/river	197	243	0.841	4.052
Handwashing facilities at school	274	166	0.030	0.005
Types of toilet	330	90	1.0418	0.8677
Flies and cockroaches in sanitary facilities	350	90	1.1107	0.5935
Involving in farming activities	150	290	0.900	6.066

A significant observation was that a majority of students (76%) used pit latrines at home rather than flush toilets. The study highlighted that 54.7% of students were infested with flies and/or cockroaches, both of which significantly influenced the incidence of intestinal parasite infections (OR = 1.0418, p = 0.8677) and (OR = 1.1107, p-value 0.5935), respectively.

A relatively small proportion of students (37%) engaged in frequent bathing or swimming in rivers, streams, or pools and this practice did not have a significant influence on the likelihood of infection with intestinal parasites among the students (OR = 0.841, p-value 4.052) Top of Form and also a few numbers (30%) of students are involved in farming activities and this may reduce the chances of being infected with especially Hookworm and there is no significant association between the parasite (OR = 0.900, p-value 6.066).

DISCUSSION

In this study, the relationship between intestinal parasitic infections and sex was not statistically significant (χ^2 = 0.332, p = 0.565, df = 1), although male students had a slightly higher infection rate (45.5%) than females (42.7%). Other studies done in Katsina showed that the males had a higher prevalence of infections with 34.4% of them being infected as compared to females with a prevalence of 24.4%[11]. Other studies, such as the one conducted in Bondo District, Kenya among students aged 5 to 20, found that males had a higher infection rate than females, with 39.0% compared to 34.5%, however, the difference was not statistically significant[12]. In China, male students were infected at a greater rate (53%), compared to 39% among female students aged 10-23 years[13]. This disparity with the current study could be attributed to the existing meteorological and sociological conditions in the study sites.

Children belonging to the age group 8-9 years were the most infected (47.20%) while the age group 10-11 years were least affected (40.6%) and there was no statistically significant association between the age and infection in this study (χ^2 = 1.204, p = 0.752, df = 3). This was similar to the work of Odiere *et al.*[14], who reported that intestinal parasites were not age-dependent. However, this was in contrast with Tegen *et al.*[15], who reported that infection was significantly associated with the age group 4-5 years.

The study showed that the infection rate of protozoa and helminths was moderately higher in the study population whose history of drug administration lasted two months (52.7%) than last three months respectively but the difference was not significant.

Pupils who consumed untreated water (not boiled or treated), were 0.230 times more likely to become infected with intestinal parasites compared to those who did not. According to Omarova *et al.*[16], the boiling of water is generally considered safe as it eliminates protozoan cysts, helminth larvae and eggs.

However, in developing countries, the scarcity of fuel, particularly firewood[3], can pose challenges to the boiling process. Chlorine treatment is effective in purifying drinking water but is more commonly applied in piped water systems. In this study, most schools had borehole water, but it was not subjected to treatment. The effectiveness of water treatment systems may be compromised if chlorine levels are insufficient to eradicate pathogenic cysts. Some of such cysts, such as those of *Giardia lamblia* are known to resist standard chlorine levels in water[17]. In some instances, higher chlorine levels are considered effective, which implies the need for de-chlorination before such water is used[18].

The study found that washing hands with water alone, without soap, significantly reduced the risk of acquiring intestinal parasitic infections. This observation might be attributed to the potential contamination of the water used. Studies conducted in Ethiopia[19] supported these findings, indicating that individuals who infrequently washed their hands with soap and water after fieldwork faced an elevated risk of intestinal parasitic infection compared to those who did so frequently. Neglecting hand washing after toilet visits and before meals increases the likelihood of contaminating food and water with protozoan and helminth cysts, leading to ingestion[13].

The current study revealed significantly lower infection rates among students who washed their hands with soap and water after using toilets. Soap's abrasive properties contribute to the removal of parasite eggs and/or cysts that may have adhered to the hands, preventing ingestion[5].

Failure to wash fruits before consumption increased the chances of infections with intestinal parasites but did not show a significant association. Common fruits in the area, such as mangoes, are often collected from the ground surface, making them susceptible to contamination with human feces containing helminth eggs, particularly those of *Ascaris lumbricoides*. The ingestion of these eggs may occur if the fruits are not adequately washed or peeled[20].

This study showed the infection rate of protozoa and helminths was higher in those who use drinking water from boreholes than well and tap respectively but the difference was significant. The results of another study also showed a significant positive association between the source of drinking water and Protozoa and helminths[21]. These factors could have led to an increase in transmission of intestinal parasites especially *Entamoeba histolytica* and *Giardia lamblia* that are commonly transmitted through faecal contamination of drinking water[22].

The study indicated that students involved in farming activities were more likely to get infected with intestinal parasites compared to those who were not involved and the study did not show a significant association. This is because the helminth eggs adhere to hands, especially on the fingernails thus can be transferred to other surfaces or may be ingested leading to infection. Other studies done in Argentina recorded higher intestinal parasitic infections among farming communities due to ingestion of eggs and penetration of the larvae through the skin[23]. The study showed that all the eleven schools sampled had pit latrines higher than the water closet and also show a significant association between the parasites. The establishment and proper utilization of toilets have been proposed as an effective strategy for controlling intestinal parasites. In situations where toilets are challenging to maintain cleanliness and the water table is high, helminth infections may not be adequately managed[24]. The study revealed the presence of flies and/or cockroaches in pit latrines both at home and in school, demonstrating a significant association with the parasite. This suggests that these facilities were not well-maintained from a hygiene perspective. These vectors have the potential to mechanically carry helminth cysts and deposit them on food, leading to infections[6]. Moreover, they could serve as a source of infection for latrine users, particularly if proper hand hygiene practices are not followed after latrine use. Studies done in part of Nigeria indicated that filthy houseflies and cockroaches mechanically carry parasites cysts and eggs into food; hence increasing chances of infection[25].

Wearing protective clothing such as gloves and gum boots while working on farms prevents the penetration of *Ancylostoma duodenale*, *Necator americanus* and *Strongyloides stercoralis* larvae through the skin[26]. In addition, farm workers are advised to wash their hands thoroughly with soap after work and before eating to avoid ingestion of the helminth eggs[22].

There is a need for further study on the parasites among these children employing molecular techniques to ensure accurate identification of the parasites and enhance drug efficacy.

CONCLUSION

This study identifies the prevalence of gastrointestinal protozoan and geohelminths among school-age children in Bindawa LGA. This study demonstrated that there is poor knowledge, attitude and practices among the children sampled for stool which leads to the continued occurrence of the infection in the communities. However, these findings revealed, that the infection is endemic in the study area. These findings suggest the need for further surveys using molecular diagnostic techniques for genomic identification of the parasite at the species level. There is a need for the provision of modern toilets and other sanitation facilities to reduce the presence of flies and cockroaches in school toilets. More frequent deworming programs are required in these schools, once every three months. The public health sector should provide health education and promote environmental sanitation in schools and communities.

SIGNIFICANCE STATEMENT

In various regions, including Nigeria and neighbouring areas like Kano and Zamfara, reports on the prevalence of intestinal protozoan and geohelminth infections among pupils have been documented. The distribution and occurrence of these intestinal parasites vary due to diverse environmental and social factors. Therefore, assessing the prevalence of different intestinal protozoa and geohelminths becomes essential for formulating appropriate management strategies and predicting infection-related risk factors, particularly in Bindawa Local Government Area of Katsina State. This study aims to offer insights into the prevalence of gastrointestinal protozoa and helminths among primary school students in Bindawa, reflecting the broader scenario in rural schools. It also identifies risk factors associated with intestinal parasite transmission among students, proposing intervention measures to enhance student health in schools.

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