Original article

Prevalence of Giardiasis and Cryptosporidiosis among children in relation to water sources in Selected Village of Pawi Special District in Benishangul-Gumuz Region, Northwestern Ethiopia

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Abstract

Introduction: *Giardia lamblia* and *Cryptosporidium parvum* are implicated in many waterborne disease outbreaks in different parts of the world.

Objective: This study was conducted to assess the prevalence of these two parasites among children below 14 years old that drink water from different sources.

Methods: Single stool specimens were collected from a total of 384 children in Almu, K2V24, and K2V23/24 villages, Pawi Special District, northwestern Ethiopia, and microscopically examined for *Giardia* cyst/trophozoites and *Cryptosporidium* oocysts. For identification of *Cryptosporidium parvum* the modified Ziehl-Neelsen staining method was used. *Giardia lamblia* was detected using direct microscopy based on wet mount and formalin-ether concentration techniques.

Results: Out of the 384 children examined, 102 (26.6%) and 31 (8.1%) were found positive for *G. lamblia* and *C .parvum* infection, respectively. Prevalence of giardiasis in female children was significantly higher than in the males. However, no significant association was observed for infection of cryptosporidiosis between the two sexes. *G.lamblia* and *C. parvum* infection prevalence was not significantly different among the different age groups. On the other hand, the prevalence of *G. lamblia* and *C. parvum* was associated with the source of drinking water with more cases of giardiasis detected in study participants using water from unprotected water sources than those using the "protected" water. Contrary to this, more cases of cryptosporidiosis were detected in those using "protected" water sources.

Conclusion: From the findings of the study one can conclude that providing well protected and treated drinking water should be considered a priority for reducing the existing high prevalence of giardiasis and cryptosporidiosis in the study area. [*Ethiop. J. Health Dev.* 2010;24(3):205-213]

Introduction

Parasitic diseases are incriminated in causing more than 33% of global deaths of which intestinal parasitic infections are believed to take the major share (1,2). Lack of safe drinking water and environmental sanitation are largely responsible for more than 800 million expected cases of diarrheal diseases and 4.5 million associated deaths in many developing countries every year (3). Morbidity and mortality due to diarrheal diseases in developing countries remain to be the main public health problems that need due attention. Although there could be many other causes of diarrhea, the enteric protozoa *Cryptosporidium parvum* and *Giardia lamblia* have been recognized as important causes of both out break-related and sporadic diarrhea among human beings. Both immunocompetent and immunocompromised individuals could be the victims of diarrheal diseases caused by these parasites (3-6).

According to Abebe (9), over 60% of the communicable diseases occurring in Ethiopia are due to poor environmental health conditions as a result of unsafe and inadequate water supply and poor hygienic and sanitary practices. Approximately, 80% of the rural and 20% of urban population have no access to safe water. Three fourth of the health problems of children in Ethiopia are communicable diseases emanate from inadequacy of water and sanitation conditions. Surprisingly, enough 46% of the mortality of children less than five years is due to diarrhea in which water related diseases occupy a high proportion (10).

More than 80% of diseases in the world are attributed to unsafe drinking water or inadequate sanitation practices (19). In this respect in many villages of Ethiopia the community is forced to use unprotected water from rivers, streams, irrigation cannels, ponds, shallow wells, water harvesting ponds and the like. In such areas, where people use water from different sources, the possibility of infection with waterborne diseases such as cryptosporidiosis and giardiasis is expected to be extremely high.

A number of studies have been conducted on the distribution and prevalence of intestinal parasites in different parts of Ethiopia (11-15, 20), yet there are many

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localities where adequate, epidemiological information is not available. Hence, the present study was conducted to fill the existing gap and enable decision makers focus on improving water quality, sanitation and hygiene in Pawi Special District. Although water quality data was not available from the district, the clinical records in clinics have shown diarrhea to be dominant and on the whole its prevalence to be next to malaria (data not shown). Furthermore, water from the Diga dam and Ali spring (the two main drinking water sources), have not had proper treatment, neither chemically nor physically, for more than 10 years. As a result, the drinking water sources happened to be contaminated with *G.lamblia* and *C.parvum* contributing to the prevalence of high diarrheal infections in the population (21).

Methods

The study area

Pawi Special District is one of the 20 districts of the Benishangul-Gumuz Regional state. It is located at 11^{0}19’59.47”N latitude and 36^{0}25’00.66’’ E longitude with an altitude of 1500-1769 m a.s.l. located in western parts of Ethiopia some 556 km away from Addis Ababa (Figure 1). The district receives an average monthly rainfall of 107.1 mm with a uni-modal pattern, occurring from May to November. The monthly average maximum and minimum temperatures are 24.1^{o}c and 12.0 ^{o}c, respectively, and the mean annual relative humidity is 40.5% (source: the National Meteorological Service Agency). Pawi was established as a result of the famine integrated settlement program in 1985. More than 45,000 people are estimated to live in the district most of whom are poor farmers formerly dependent on food aid. The main crops that grow in the area are sorghum, sesame, groundnut and maize.

The district has 20 villages that get their water mainly from three sources, ‘*Ali-spring*’, ‘*Diga*’ dam and other sources like hand pumps and hand dug wells. The present study was conducted in December 2006 in three selected villages of the district (*Almu (V5), K*2V24 and K*2V23/45(V23)*). Almu is one of the villages of the district that gets its water from Diga dam, K2V24 gets its from Ali-spring and K2V23/45 from none of these two sources but they get their water from “protected” hand pumps and unprotected hand dug wells.

** K=Ketena , V=village*

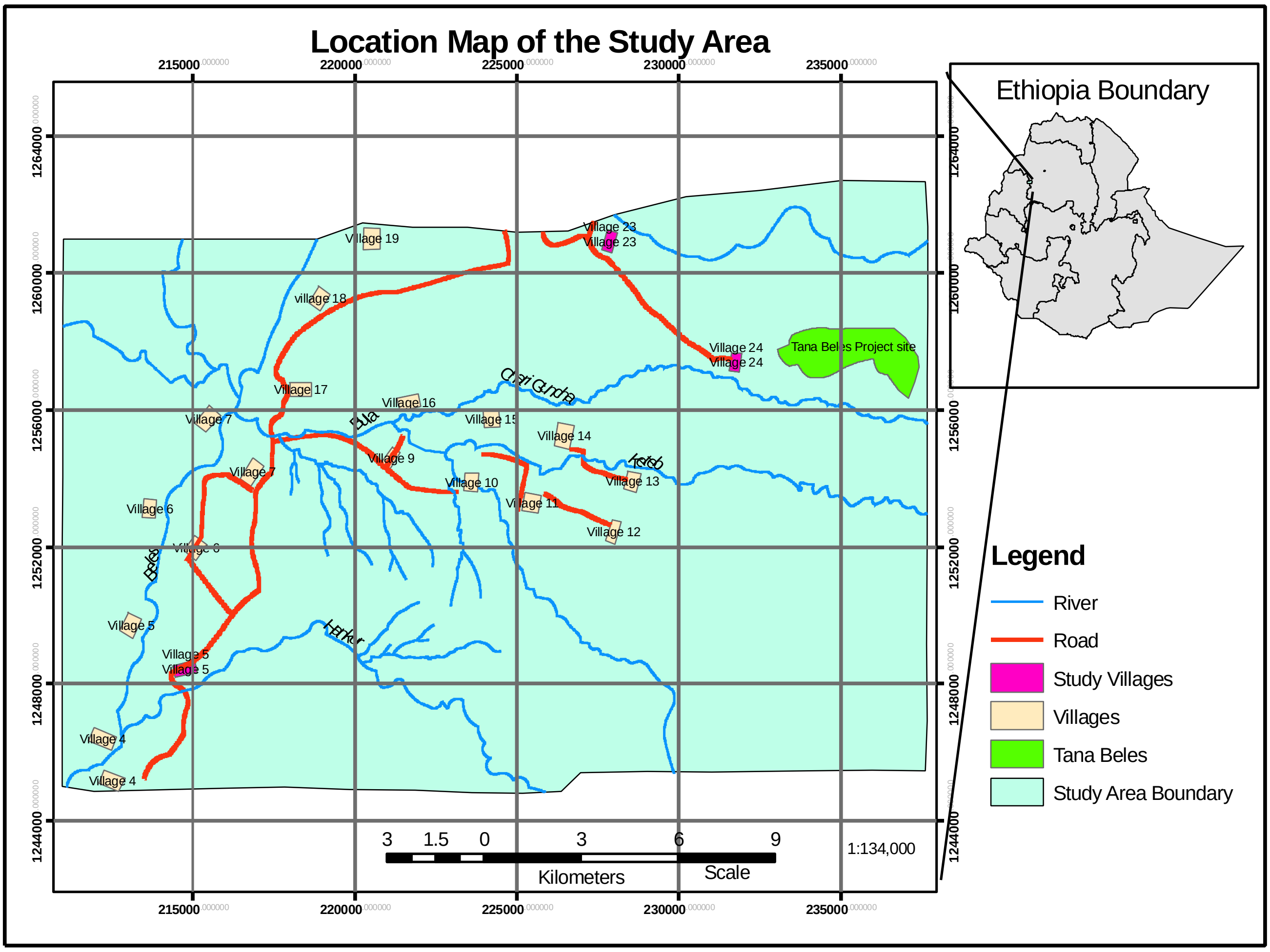

Figure1: **Location map of Pawi Special District, Benishangul-Gumuz Regional state (Source the Ethiopian Map Works Agency)**

The study population

A total of 384 children of age between 2 months and 14 years from the three selected villages were examined at the same time (December, 2006). "*Almu*", formerly known as village 5, was selected among all the villages that get water from *'Diga'* dam, *'K2V24' (Ketena two Village 24)* was selected as a representative of all the village that get water from *'Ali-spring'* and *'K2V23/45' (Ketena two Village 23/45)* was selected among those villages that could not get water from these two main sources getting it from "protected" hand pump and unprotected hand dug water. The study participants were randomly selected from each study site.

The sample size was calculated using the formula for cross-sectional surveys:

$n = Z^2 xpxq/d^2 = 1.96^2x0.50x0.50/.05^2 = 384$.

Z=1.96 at 95% confidence interval,

p is the proportion of positive individuals.

Since there were no studies conducted concerning the present topic in the area, p was taken as 50% to achieve the maximum sample size. d is the absolute precision and is taken as 0.05.

Stool collection and processing

A single fresh stool sample was collected with labeled stool cup from consulted study subjects (n=384) (December, 2006). For infants and young children, parents or guardians were made to collect stool samples. The questionnaires concerning socio-demographic characteristics of the study participants (age and sex), and drinking water source were filled by all the study participants' parents or guardians during the sample collection. A portion of the stool was preserved with SAF (15 g sodium acetate, 20 ml glacial acetic acid, 40 ml formalin and 925 ml distilled water) in a proportion of 1g of stool in 3 ml of SAF. The remaining part was processed using the following methods (22).

Direct wet mount method

A direct wet mount with normal saline (0.85% NaCl solution) was prepared at the field and observed for the presence of motile intestinal parasites and trophozoite under light microscope at 10X and 40X magnification. Lugol's iodine staining was used to observe cysts of intestinal parasites.

Formalin ether concentration

Using an applicator stick, about 1 g of preserved stool sample was placed in a clean 15 ml conical centrifuge tube containing 7 ml formalin. The sample was suspended and mixed thoroughly with applicator stick. The resulting suspension was filtered through a sieve (cotton gauze) into a beaker and the filtrate was poured back into the same tube. The debris trapped on the sieve was discarded. After adding 3 ml of diethyl ether to the mixture and hand shaken, the content was centrifuged at 2000 rpm for 3 minutes. The supernatant was poured way and the tube was replaced in its rack. Iodine stain preparation was made from the sediments. Finally, the entire area under the cover slip was systematically examined using ×10 and ×40 objective lenses and ova or cyst of different parasites were observed under the microscope (23).

Modified Zeihl-Neelsen Method

For detection of *Cryptosporidium* oocyst, direct and concentration smears were prepared. Fresh faecal samples were collected from children and thin smears were prepared, dried, fixed with methanol for 5 minutes in the field and stained by Zeihl-Neelsen techniques at the Ethiopian Health and Nutrition Research Institute (EHNRI) and the same procedure was used for smears prepared after concentration. In this technique, the slides were stained with carbol fuschine for 30 minutes and there after, they were washed with tap water. The slides were decolorized in acid alcohol for 1 minute and were counter stained with methlyene blue for another 1 minute. Finally, the stained smears were microscopically observed using 100x magnifications (24).

Ethical considerations

The study was reviewed and approved by the ethical committee of Biology Department, Addis Ababa University. Ethical considerations were addressed by treating positive intestinal parasites using the standard drugs. Individuals with positive results were treated with the appropriate treatment and the drugs were administered by clinicians working in the study areas. Written consent was sought from parents or guardians of the selected children. Besides, parents or care givers were asked to fill the questionnaire and assist during stool sample collection.

Data analysis

Statistical analysis was performed with SPSS software version 13. Chi square was used to verify possible association between infection and exposure to different factors. Values were considered to be statistically significant when the p-value obtained was less than 0.05.

Results

Giardiasis and Cryptosporidiosis among children of different sexes

Out of the 384 study subjects, 197 were males and 187 were females. Among the males 197(21.3%) were positive for giardiasis and among the females 187 (32.1%) were positive for giardiasis. The prevalence of cryptosporidiosis was 9.1% and 6.9% in the male and female children, respectively. The difference in the prevalence of giardiasis was significant ($p<0.05$) between males and females but the difference was not statistically significant ($p>0.05$) in the case of cryptosporidiosis (Table 1).

Table1: **Prevalence of Giardiasis and Cryptosporidiosis among children by sex in Pawi Special District, 2006/07**

Parasite identified	Sex	No. examined	No. Positive (%)	P-value
	Male	197	42 (21.3)	
Giardia lamblia	Female	187	60 (32.1)	0.017
	Male	197	18 (9.1)	
Cryptosporidium parvum	Female	187	13 (6.9)	0.432
Total		384	133 (34.6)	

Giardiasis and Cryptosporidiosis in the three study villages

In village K2V24, 140 stool samples were examined and out of these 32.1% and 5% were found positive for giardiasis and cryptosporidiosis, respectively. In Almu village, a total of 153 stool samples were examined and out of these 18.9% were found positive for giardiasis and 7.8% for cryptosporidiosis. In village K2V23/45, 91 stool samples were examined and out of these 30.8% and 13.2% were found positive for giardiasis and cryptosporidiosis, respectively. Infection prevalence of giardiasis and cryptosporidiosis should a significant difference among the three study sites (p<0.05) (Table-2). There were much lower infections for giardiasis in Almu while there were much higher infections at K2V23/45 for cryptosporidiosis.

Table 2: **Prevalence of Giardiasis and Cryptosporidiosis among children by study villages in Pawi Special District, 2006/07**

Study sites	Number of children examined	Parasite identified			
		G. lamblia		*C. parvum*	
		No. positive (%)	P-value	No. positive (%)	P-value
Almu	153	29 (18.9)		12 (7.8)	
K2V24	140	45 (32.1)	0.000	7 (5)	0.006
K2V24/45	91	28 (30.8)		12 (13.2)	
Total	384	102 (26.6)		31 (8.1)	

Giardiasis and Cryptosporidiosis among children of different age groups

Out of the 384 study subjects, 35 of them were between 2 and 12 months old, 116 were 1 to 5 years and 233 were 6 to 14 years. Among the 35 children aged 2-12 months, 11.4% and 11.4% were positive for giardiasis and cryptosporidiosis, respectively. Among the 116 children in the 1 to 5 years age category, 26.7% were found positive for giardiasis and 9.5% for cryptosporidiosis. Within the 233 children of age between 6 to 14 years, 28.8% and 6.9% were found positive for giardiasis and cryptosporidiosis, respectively. The difference in the prevalence of giardiasis and cryptosporidiosis among the different age groups was not significant (data not shown).

Giardiasis and Cryptosporidiosis among children that use different drinking water sources.

With regard to the source of drinking water, all of the community in K2V24 use Ali-spring water which is unprotected and with no proper treatment. The community of Almu use water from Diga dam which is also unprotected and with no treatment at all. The community of K2V23/45 use water from two main sources a "protected" hand pump and an unprotected hand-dug well.

Among the 140 stool samples collected from the children using water from Ali-spring, 32.1 % were positive for giardiasis and 5% were found positive for cryptosporidiosis. Among the 153 study subjects that use water from Diga dam, 18.9% were found positive for giardiasis and 7.84% for cryptosporidiosis. Among the 27 Study subjects that use "protected" water (hand pump), 3.7% were found positive for giardiasis and 25.9% for cryptosporidiosis. From the 64 study subjects that use unprotected hand-dug well, 42.2% were found positive for giardiasis and 7.8% for cryptosporidiosis. The analysis of the prevalence of giardiasis and cryptosporidiosis in relation to water source revealed that there was a statistically significant difference (p<0.05) among children that use different types of water sources (Table 3).

Table 3: **Prevalence of Giardiasis and Cryptosporidiosis among children using different water sources in Pawi Special District, 2006/07**

Water source	Number of children examined	Parasite identified			
		G. lamblia		*C. parvum*	
		No. positive (%)	P-value	No. positive (%)	P-value
Ali-spring (un protected)	140	45 (32.1)		7 (5)	
Diga dam (un protected)	153	29 (18.9)		12 (7.8)	
Hand pump ("protected")	27	1 (3.7)	0.000	7 (25.9)	0.006
Manually dug well (un protected)	64	27 (42.2)		5 (7.8)	
Total	384	102 (26.6)		31 (8.1)	

Intestinal parasites other than G. lamblia and C. parvum.

Based on parasitological examination of stool specimens by direct and formalin-ether concentration techniques, different types of intestinal parasites (both pathogenic and non-pathogenic) other than *Cryptosporidium parvum* and *Giardia lamblia* were identified (Table 4). The study has shown that the prevalence of hookworm spp. was 18.3%, *Ascraris lumbricoides* 8.3%, *S.mansoni* 6.3%, *Entameba histolytica/dispar* 6.3%, *Blastocystis hominis* 3.4% and that of *Hymenolepies nana* was 1%. Other non-pathogenic intestinal parasites like *Entameoba coli* and *Iodoamoeba butschilii* were also encountered in the study. Single parasite infection had the highest prevalence followed by double and triple. Overall co-infection was detected in 4.4% of the study subjects. Among the double parasitic infection, *G. lamblia* and *C. parvum* comprised the highest proportion.

Table 4: **Pathogenic and non pathogenic intestinal parasites other than *G.lamblia* and *C.parvum* in Pawi Special District, 2006/07**

Intestinal parasites	No observed (%)			Total (n=384)
	K2V24 (n=140)	Almu (n=153)	K2V23/45 (n=91)	
Protozoa				
Entameoba histolytica/dispar	14 (10)	8 (5.2)	2 (2.3)	24 (6.3)
Entameoba coli	2 (1.4)	0 (0)	1 (1.1)	3 (0.8)
Iodoamoeba butschilii	0 (0)	1 (0.7)	0 (0)	1 (0.3)
Blastocytis hominis	7 (5)	1 (0.7)	5 (5.5)	13 (3.4)
Helminths				
Hymenolepis nana	1 (0.7)	2 (1.3)	1 (1.1)	4 (1.0)
Hymenolopis diminuta	2 (1.4)	1 (0.7)	0 (0)	3 (0.8)
Enterobious vermicularis	3 (2.1)	2 (1.3)	0 (0)	5 (1.3)
Hookworm spp	34 (24.2)	15 (9.8)	21 (23.1)	70 (18.3)
Ascaris lumbricoides	13 (9.3)	13 (8.5)	6 (6.6)	32 (8.3)
Schistosoma mansoni	1 (0.7)	18 (11.8)	5 (5.5)	24 (6.3)
Taenia spp.	3 (2.1)	4 (2.6)	1 (1.1)	8 (2.1)

Discussion

In the present study many of the children in the three villages, participating in the study, were found harboring many intestinal parasites. Although the study subjects were living in different villages of the district, the infection prevalence of *G. lamblia* and *C. parvum* on average was similar to what was reported by Iqbal *et al.* (25) in which the prevalence of *C. parvum* infection among children in developing countries was shown to range between 5% and 10%. This is also in agreement with the report of Gebru and Girma (14) in which the prevalence of *C. parvum* in diarrheal children in Jimma was found to be 3.3% and Assefa *et al.* (13) in which the prevalence of *C.parvum* in diarrhoeal children in Addis Ababa was reported to be 5.3%. The higher prevalence of *Cryptosporidium parvum* infection observed in children would not only be the result of contaminated water and food but their contact with domestic animals contact with animals could also contribute to the high prevalence as the community is involved in rearing cattle (26).

Mersha and Tiruneh (12) reported higher rates of *C. parvum* detected in north western Ethiopia than the present study. In addition, *C.parvum* infection prevalence found in the present study was much lower than what was reported from adult diarrhoeal AIDS patients (25.9%) from Addis Ababa hospitals (27). Since the study participants included children below the age of 14 years, which is not a high risk group for HIV infection, it can be assumed that the cryptosporidiosis detected in the present study, by and large, is not opportunistic. Thus, the lower prevalence of *C.parvum* is to be expected (28).

Prevalence of giardiasis in the present study (26.6%) was higher than what was reported by Seyoum *et al.* (16), who reported a much lower prevalence in preschool children (9.3%). In the Central and northern highlands of Ethiopia, a 3 to 23% prevalence was reported by McConnel and Armstrong (11) and Endeshaw *et al.* (18) reported a prevalence of 20.8% among diarrheal patients referred to the Ethiopian Health and Nutrition Research Institute (EHNRI). However, Ayalew (15) reported a prevalence of 38% among children from eastern Ethiopia (Dire Dawa), which is higher than the present study. According to Gilman *et al.* (29) unless prior infections were protective for giardiasis, one would expect to see a higher rate of giardiasis in developing countries where the living standard of the society is very low. However, usually there are asymptomatic *Giardia* infections serving as unidentified carriers and may be responsible for transmission of infection (30).

An overall difference in the prevalence of giardiasis and cryptosporidiosis has been shown in many studies during the dry and wet season samplings. In this study, it was not possible to investigate seasonality in the prevalence of giardiasis and cryptosporidiosis because of financial constraints. The prevalence of intestinal protozoan parasites has been reported to be associated with the amount of rainfall (31, 32). Studies in central America, South Africa, Kuwait and India have also revealed a high peak incidence of these parasites in the rainy seasons (33-35). The same trend was observed in eastern Ethiopia (15). With regard to this phenomenon, the two water sources, Ali-spring and Diga dam, are highly exposed to runoff in the rainy season. Diga dam, especially, is totally changed into runoff water as a result of which the district Water Resource Office is forced to close the dam and stops providing water to the community during the rainy season. This shows that contamination of drinking water sources by runoff containing feces of infected humans and animals is an inevitable phenomenon (7, 8).

In the present study the prevalence of *G. lamblia* infection was significantly different between males and females ($p<0.05$), females were more infected than males. This is the opposite of the report by Mahmud *et al.* (36) where a higher prevalence of *G. lamblia* infection among males than females was recorded in Egypt finding. Similar finding to that of Egypt also came from northern Jordan (37). The possible explanation for our findings could be the increased chance of exposure of females to contaminated waters as they are usually engaged in fetching water for the family in Ethiopia.

C. parvum infection was not significantly associated, in the present study, with sex which may indicate that both sexes have equal chance of being infected. This finding is in agreement with a study conducted in Mexico City where gender of children did not influence the rate at which *C. parvum* infections was detected (31). Similarly male and female individuals tested for cryptosporidiosis among the Kwa-Zulu-Natal population were found to have similar prevalence (38). However, an opposite observation was reported from Guinea Bissau by Molbak *et al.* (39) and by Frasere *et al.* (40) among Bedouin infants in Israel where the prevalence of *C. parvum* infection in males was higher than in females. In their study, they suggested that there might have been an unmeasured intra-familial factor functioning to expose infant boys or to protect infant girls in their study population. In Ethiopia, Adamu (27) reported that the prevalence of *C. parvum* in males was detected to be higher than in females. This necessitates the need for further investigation as to why there is such inconsistency regarding infection among male and female children.

Although the difference in prevalence between the age groups was not statistically significant, there was higher prevalence of *Giardia lamblia* infection among the 6 to 14 and 1 to 5 years old but less prevalent in the <1 year groups. The lower prevalence observed in the < 1 year group may be explained by the fact that the community has a culture of prolonged breast feeding of children. The established trend of giardiasis is that its prevalence increases with age and with development of immunity in older individuals, prevalence of giardiasis becomes reduced. The report of Lindo *et al.* (23), which states that giardiasis increases with the age of children and is not clustered in a particular age group, strengthens the above explanation. The overall non-significant difference among different age groups in our case may indicate that giardiasis is not limited to some age groups but can infect individuals of any age group.

The pattern of age difference in infection with *C. parvum* appears not significant in the present study ($p>0.05$) showing that there was no variation in *Cryptosporidium parvum* infection between infants < 1 year, whose immune status is not well established and in older children. This finding is in agreement with what was reported by Ayalew (15). The non-significant variation among the three age groups may be attributed to the poor personal and environmental hygiene, poor water quality and the close contact of all age groups to domestic animals. On the contrary the difference in infection prevalence of *C. parvum* between age groups was reported by Lindo *et al.* (23) in Jamaica, Adegbola *et al.* (30) and Tumwine *et al.* (41) in Sub-Saharan African countries including Uganda and Gambia and Assefa *et al.* (13) in Ethiopia.

Prevalence of *C. parvum* and *G. lamblia* infection has shown to have a significant difference between the three villages. As the living standard of the communities in the three villages is more or less comparable, the existing difference in the prevalence of both parasites in the three villages seems to be associated with the type of water source each village uses. More than 50% of the demand for water supply in Pawi is met from the two water sources (Ali-spring and Diga dam). The prevalence of giardiasis and cryptosporidiosis in other villages, which were not included in this study, is expected to be as high as that was observed in the selected villages because they use the same water source for domestic purposes and also have more or less the same socioeconomic status.

In village K2V23/45, children who use water from "protected" a hand pump have shown significantly reduced infection prevalence of giardiasis when compared with those who use water from unprotected hand dug wells ($p<0.05$), which implies the need for strengthening water development to intervene in the transmission of giardiasis. However, children that use the "protected" hand pump water source have shown significantly increased prevalence of *C. parvum* infection when compared with those who use unprotected water source. Isaac-Renton *et al.* (42) had reported that there was lower risk of exposure to *Cryptosporidium* infection in people that use protected water sources as they were not able to detect oocyst in protected deep wells. The possible explanation for the observed increased prevalence of *Cryptosporidium parvum*, among the study participants that drink water from "protected" hand pumps, could be due to seepage from latrines because these hand pumps are mostly constructed near houses so these water sources might have been inadequately protected. This is in agreement with the report of Craun *et al.* (43) in USA where they explain that inadequately protected ground water sources cause twice as many waterborne parasite outbreaks than would un-protected surface water. The other possible explanation could be due to the unhygienic practice of children immersing their contaminated hands into stored water in the house (44). Another key issue that is worth noticing is that neither this study nor others have done any water quality test in the study area which is the main shortcoming in our study.

The level of prevalence of intestinal helminths and protozoa other than *G. lamblia* and *C. parvum* in the present study is more or less in agreement with what was reported by others (11, 16, 20, 45) for other parts of Ethiopia. However, the prevalence of hookworm spp. infection was almost equivalent (18.3%) to the national average (22%) (46). This high prevalence of Hookworm spp. together with the existing high malarial disease situation in the district would undoubtedly exacerbate the public health situation in the area, especially in association with anemia. The relatively high prevalence of *Ascaris lumbricoides* and *Entamoeba histolytica/dispar* would reflect the unhygienic situation of the study area.

The prevalence of *S.mansoni* was found to be high (6.3%), compared to what was reported (0.7%) by the Aklilu Lemma Institute of Pathobiology (47) for the Pawi area. Schistosomiasis in the study area is underestimated by clinicians, and besides, there is little awareness about the disease by most of the population in the area. The possible reason for this could be the inadequate reliability of the routinely used diagnostic technique (simple wet mount). Moreover, in our study, we were only able to get a single case of schistosomiasis in the field study using wet mount method. However, in the laboratory using formalin ether concentration techniques, we were able to observe 23 additional cases, which implies that it will not be a surprise if schistosomiasis is overlooked by the local clinicians, partly, owing to the routinely used diagnostic technique (wet mount) which is not sensitive enough.

Conclusions and recommendations

Higher prevalence rates of *Giardia lamblia* (26.6%) and *Cryptosporidium parvum* (8.1%) infection is detected in the present study. The higher prevalence of these parasites was associated with the type of water source that the study participants were using. The finding of the study provides partial explanation to the etiology of the highly prevalent diarrhea, gastritis and abdominal diseases that are frequently reported as among the ten top diseases by health institutions in the district. The fact that we observed more cases of cryptosporidiosis among the study participants using "protected water" would signify the importance of personal and communal hygiene in the study area. Providing of well protected and treated drinking water and proper education on hygienic practice to the community would help in reducing the prevalence of these parasites; moreover, further analysis of the drinking water sources for the presence of cysts and oocysts should be done.

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