***Original Research Article***

# Epidemiology of Coccidian Parasites in HIV Patients of Northern Uganda


## ABSTRACT

**Aim:** The epidemiology of coccidian parasites in HIV patients of sub Saharan Uganda is poorly understood. This study aimed at determining the epidemiology of coccidian parasites and their associated risk factors. This was a cross sectional study carried out in Arua district in West Nile region of Northern Uganda for a period of five months.

**Materials and methods:** Participants in the study included HIV positive patients presenting with diarrhea. A total of 111 patients were included and classified into children, middle aged and adults. A structured questionnaire was administered and stool samples were obtained using sterile stool containers and laboratory analysis was carried out using modified Ziehl-Neelsen technique (ZN). Ethical clearance was acquired and the consent of the patients was sought.

**Results and discussion:** Coccidian prevalence was 5.4% in HIV patients with *Cryptosporidium species* being more prevalent (3.6%) than *Isospora belli* (1.8%) in females 2.7% compared to 0.9% in males. C*ryptosporidium* was more prevalent among 10-19 years (13.6%) with a significant relationship ($P = 0.021$) and less among 40-49 years (3.3%). The major risk factors associated were mainly consumption of contaminated tap and bore-hole water. Community lifestyle patterns are major contributing factors to the epidemiology of the condition. HIV patients on co-trimoxazole and drinking boiled water were shown to have a low prevalence of coccidian parasite diarrhea i.e. 1.9% and 2.6% respectively because co-trimoxazole is a prophylactic treatment and boiling drinking water kills these parasites. Patients taking co-trimoxazole and boiling water were shown to be associated with low infections ($P < 0.05$).

**Conclusion and recommendations:** The study highlighted the importance of screening for intestinal coccidian parasites among HIV patients as a way to control secondary infections in HIV patients regardless of age, sex and social status.



*Keywords: "Coccidia in Humans," "Coccidia in HIV patients," "Coccidia risk factors," "Cryptosporidium in Uganda," "Diarrhea in HIV patients."*


## 1. INTRODUCTION

Coccidian parasitic infections have altered the epidemiology and outcome of human immunodeficiency virus (HIV) patients in sub-Saharan Africa [1]. Diarrhea has been identified as a major presenting complaint in HIV-infected patients. It is estimated worldwide that about 3.5 billion people are infected, and that 450 million are ill as a result of intestinal parasites (coccidian parasites) and protozoan infections and that the majority are pre-school and school going children [2]. It is basically children from poor countries that are often more prone to these intestinal parasitic infections due to high poverty levels, poor sanitation and low literacy levels in the region [3].

A recent in Kenya has shown that *Entamoeba histolytica*, 225 (36.7%), *Cryptosporidium spp*. 187, (30.5%), *Giardia lamblia*, 98 (16%) were higher in children (<5 years) and that *Entamoeba histolytica,* and *Giardia. lamblia* were higher among outpatients than inpatients (13.8% vs 1.3% p < 0.001 and 5.8% vs 1.3% p < 0.049) respectively [4]. Intestinal parasitic infections have enormous effects on the general health of an HIV infected person [5] and Uganda being part of sub-Saharan Africa is already over burdened by HIV infection. These patients often suffer from frequent episodes of diarrhea that is accompanied with severe dehydration, loss of weight and muscle wasting which can be fatal [6]. Because of delayed diagnosis of these pathogens, patients usually take self-medication or local herbs without prescription from a qualified health worker which has resulted into improper management of the disease. Liberalization of the medical drug industry and poorly regulated herbal therapies by governments with in sub-saharan Africa is probably linked to un ending self medication in su-saharan Africa [1,7,8].

Generally, the epidemiology of coccidian parasites in HIV patients of sub Saharan origin is still poorly understood. In a recent study in Ethiopia [9], prevalence of gastro intestinal coccidian parasites was shown to be 18% - 40% among patients that presented with diarrhea. A similar study in Uganda in HIV sero negative children 9-36 months revealed that out about 930 fecal samples that were examined, 116(12.5%) were *Cryptosporidium* positive [10]. Infection with *Cryptosporidium spp.* was found to be associated with lowered immunity and the major risk factors were absence of toilets, water source and poor standards of living [4]. In a previous study in Ethiopia also, the prevalence of *Cryptosporidium spp*. and *Isospora belli* (*I. belli*) were shown to be 20.8% and 7.9% respectively in HIV patients [11]. In a recent study in Kenya [12], it was shown that there was a prevalence of 50.9% of enteric parasites which were waterborne. The major risk factors identified in the study were; place of residence, agro-ecological, water source, family size, location, reliability to treatment and diarrheal status probably due to poor environmental sanitation and personal hygiene, food and individual contamination probably due to poor management and care of HIV patients [12]. Contamination of water with coccidian species has been reported at national water storage facilities [13]. Infection rates are highest in children living in sub-Saharan Africa and clinical cases are expected to be higher than reported due to limited infrastructure and research in the region [14,15]. The current control strategies are towards community drug delivery of anti-helminthic drugs against intestinal parasites but there is none against coccidian parasites [8]. Stimulating research and development in rural communities through support of clinical trials to improve treatment, in addition to securing and increasing drug availability, needs governmental funding and resources that do not presently exist in most sub Saharan health care facilities [15]. Coccidian parasites are well recognized and account for about 20% of diarrheal episodes in children in developing countries and up to 9% of episodes in developed settings and causes a considerable amount of diarrheal illness in young farm animals worldwide [7]. Sporadic outbreaks among children in developed countries have been reported due to fecal-oral transmission [1]. Epidemiological variations have been observed in the socioeconomic and geographical effects of the distribution of coccidian parasites in humans that may influence the sources and routes of transmission. The study was carried out to highlight the importance of screening for intestinal coccidian parasites among HIV patients and also to emphasize the necessity of increasing awareness among clinicians regarding the occurrence and management of these parasites in the region.

## 2. MATERIAL AND METHODS

This was a cross sectional study carried out in Arua regional referral hospital (ARRH) in Arua district of Northern Uganda for a period of five months (January to May 2013). Arua district is located in a corner of West Nile region of Uganda and it borders both South Sudan and the Democratic Republic of the Congo. Arua District has five counties which are all served by Arua regional referral hospital majorly. Being at the border of two countries, the major economic activity in the region is cross-border trade. There is also a high influx of refugees from South Sudan and now the natural environment in the district has been severely stressed in some areas and levels of hygiene have declined due to increase in population. Participants in the study included HIV positive patients both rural, urban or refugees who attended ARRH and presented with diarrhea. The exclution criteria included participants who did not present with diarrhea and were HIV sero negative. The entry point to the study was Arua hospital HIV clinic with in ARRH. The criteria for choosing participants in the study was based on hospital records for their HIV status and only those presenting with diarrhea were selected into the study after their consent. For children, consent was sought from their guardians/parents after explaining to them the aim of the study and stool collection procedure was explained to them. A total of 111 participants were included and classified as children (10-19 years), middle age (20-39 years) and adults (40-69 years). A control group of 31 participants (11 children, 10 adults and 10 elderly) who were HIV positive but had no diarrhea were randomly chosen for the study. Structured questions such as site for water collection, boiling drinking water, how oftened they cleaned water collection containers and if one was taking prophylactic treatment among others administered and stool samples were obtained using sterile stool containers and laboratory analysis was carried on fresh stool samples 2 hours after stool collection using formol ether concentration technique and modified Ziehl-Neelsen. Briefly; 10 ml of 10% formol-saline was added to approximately 2mg (matchstick head size) of semi formed/diarrheic faeces in a centrifuge tube, stirred using an applicator stick and filtered into another centrifuge tube. 3 ml of ether was added, mixed well and centrifuged at 3,000 rpm for 5 minutes. The sediment was then re-suspended after removing supernatant by tapping the bottom of the tube, mixed well and transferred to a slide for microscopic examination under a cover slip and viewed under microscope x10 objective and the findings were recorded. A small portion of the stool sediment that was concentrated was taken and a smear made on a clean slide. The smear was allowed to air dry then fixed with absolute methanol. The smear was stained with strong carbol fuchsin for 30 minutes, decolorised with 1% acid alcohol and rinsed with water and counter stained with 0.1% methylene blue (alkaline). The slides were viewed under x100 objective and recorded. Data obtained was recorded as frequency and expressed as percentages. Descriptive analysis using statistical Package for Social Scientists (SPSS) version 20 was carried out to determine associations and a p-value $< 0.05$ was considered statistically significant. All participants' results and details were confidentially kept by the researchers. A copy of this research report was submitted to the Department of Medical Laboratory Sciences and Mbarara University of science and technology research Ethical Committee for approval. Permission was sought from the hospital director, laboratory in-charge and head of HIV clinic Arua regional referral hospital. The purpose of this study including the procedure of specimen collection was explained to the participants. Consent of the patients was sought prior to recruitment for the study and the consent form was filled and signed by the patients. The consent form was translated into the local language and all participants/patients understood all the details of the study. Laboratory results of the patients were given to the clinicians concerned and all patients/participants were guided on how to get their results or any help from the hospital.

## 3. RESULTS

The study showed a Coccidian prevalence of 6 (5.4%) in HIV patients, no coccidian parasites were identified in the control group as shown in **Table 1.** The most prevalent coccidian species that were identified included *Cryptosporidium spp*. and *Isospora belli* i.e. (3.6%) and (1.8%) respectively. There was no *Cyclospora cayetensis* identified as shown in **Table 1**. From **Table 2**, out of the study group it was shown that the distribution of coccidian parasites was greater in females with an occurrence of 7.1% as compared to 2.4% among the male population. For both *Cryptosporidiosis* and *I. belli*, univariate analysis did not show any significant differences in infection between males and females, ($P$ = 0.19), however, HIV seropositive children (10-19) were three times more likely to be infected with coccidian parasites than the HIV seropositive middle aged (20-39) and adults (40-69) years i.e. 13.6%, 3.4% and 3.3% respectively. Further analysis showed that age was significantly associated with *Cryptosporidium spp.* infection, whereby the prevalence was tending to be highest in children aged 10-19 years being twice more than occurrence in participants of middle age (at 95% CI, $P$ = 0.021) as shown in **Table 3** that *Cryptosporidium spp*. was 3/3 (100%) in 10-19 age group and 1/2 (50%) among 20-39 years. As regards to *I. belli,* it was the least common species with 1/1 (100%) occurrence in adults (40-69), ½ (25%) in middle aged (20-39) and none in children 0/3 (10-19). there was no significant relationship between *I. belli* and age ($P$ = 0.15). From **Table 4,** the risk factors associated with diarrhea among those with coccidia were shown to be majorly in those who consumed raw drinking water from taps and bore holes i.e.12.9% and 2.7% respectively and further statistical analysis showed there existed no significant relationship ($P$ = 0.19). Most people collected their water from bore holes (74/111) and taps (31/111) compared to river (2/111) and community wells (4/111) as shown in **Table 4**. From the study group, HIV patients who drunk raw water and were not taking co-trimoxazole had a tendency towards higher prevalence of coccidian parasites of 6.9% and 8.5% respectively as compared to a low prevalence tendency towards those who took boiled water (2.6%) and were on co-trimoxazole (1.9%) as shown in **Table 4.** Further analysis showed there exists a strong relationships ($P < 0.05$) in HIV patients who take boiled water as well as prophylactic treatment. There were different causes of diarrhea in the study however emphasis of the researchers focused on coccidian parasites study. Some of the incidental findings included; *Entamoeba hystolytica (E. histolytica), Giardia lamblia (G.lamblia), Ascaris lumbricoides (A.lumbricoides), Escherichia coli (E. coli), Trichuris trichiura (T. tricura)* and *Hook* worms. Some of the patients presented with mixed infections and commonest parasite found was Giardia lambria and Entamoeba histolytica. Tendency to higher prevalence was shown to be among children (10-19) as shown in **Table 5**. Further analysis showed that there existed a significant relationship between the *G. lambria*, *E. histolytica* with age and water quality i.e. ($P$ = 0.015, $P$ = 0.021 respectively) and no significant relationship with sex.

**Table 1. Prevalence of coccidian parasites in the study population**

| Species | Coccidian | No coccidian | Total |
|---|---|---|---|
| | Frequency (%) | | |
| Study group | 6 (5.4) | 105 (94.6) | 111 (100) |
| Control group | 0 (0) | 32 (100) | 32 (100) |
| | | | |
| *Cryptosporidium spp* | 4 (3.6) | 107 (96.4) | 111 (100) |
| *I. belli* | 2 (1.8) | 109 (98.2) | 111 (100) |
| *C. cayatenensis* | 0 (0) | 111 (100) | 111 (100) |
| Total | 6 (5.4) | 105 (94.6) | 111 (100) |

**Table 2. Distribution of coccidian parasites by sex and age**

| | | Frequency (%) | | |
|---|---|---|---|---|
| | | Coccidia | No coccidia | Total |
| Sex | Female | 5 (7.1) | 65 (92.9) | 70 (100) |
| | Male | 1 (2.4) | 40 (95.6) | 41 (100) |
| | Total | 6 (5.4) | 105 (94.6) | 111 (100) |
| Age | 10-19 | 3 (13.6) | 19 (86.4) | 22 (100) |
| | 20-39 | 2 (3.4) | 57 (96.6) | 59 (100) |
| | 40-69 | 1 (3.3) | 29 (96.7) | 30 (100) |
| | Total | 6 (5.4) | 105 (94.6) | 111 (100) |

**Table 3. Distribution of coccidian species by sex and age**

| | | *Cryptosporidium spp* | *I. belli* | Total |
|---|---|---|---|---|
| | Female | 3 (60) | 2 (40) | 5 (100) |
| Sex | Male | 1 (100) | 0 (0) | 1 (100) |
| | Total | 4 (66.7) | 2 (33.3) | 6 (100) |
| Age | 10-19 | 3 (100) | 0 (0) | 3 (100) |
| | 20-39 | 1 (50) | 1 (50) | 2 (100) |
| | 40-69 | 0 (0) | 1 (100) | 1 (100) |
| | Total | 4 (66.7) | 2 (33.3) | 6 (100) |

**Table 4.** Risk factors associated with coccidian parasite infection

| | | **Frequency (%)** | | |
|---|---|---|---|---|
| | | **Coccidia** | **No coccidia** | **Total** |
| Water source | Bore hole | 2 (2.7) | 72 (97.3) | 74 (100) |
| | Tap | 4 (12.9) | 27 (87.1) | 31 (100) |
| | River | 0 (0) | 2 (100) | 2 (100) |
| | Community well | 0 (0) | 4 (100) | 4 (100) |
| | Total | 6 (5.4) | 105 (94.6) | 111 (100) |
| Water quality | Drink boiled water | 1 (2.6) | 38 (97.4) | 39 (100) |
| | Drink raw water | 5 (6.9) | 67 (93.1) | 72 (100) |
| | Total | 6 (5.4) | 106 (94.6) | 111 (100) |
| Prophylaxis treatment | Taking co-trimoxazole | 1 (1.9) | 51 (98.1) | 52 (100) |
| | Not taking co-trimoxazole | 5 (8.5) | 54 (91.5) | 59 (100) |
| | Total | 6 (5.4) | 106 (94.6) | 111 (100) |

**Table 5. Incidental findings in the study**

| | | Parasite | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *E. hystolytica* | *G. lamblia* | *A. lumbricoides* | *E. coli* | *T.trichiura* | *Hook worms* | **TOTAL** |
| | | Frequency (%) | | | | | | |
| Sex | Male | 2 (25) | 3 (37.5) | 0 (0) | 1 (12.5) | 0 (0) | 2 (25) | 8 (100) |
| | Female | 3 (30) | 4 (40) | 1 (10) | 0 (0) | 1 (10) | 1 (10) | 10 (100) |
| | Total | 5 (27.7) | 7 (38.9) | 1 (5.6) | 1 (5.6) | 1 (5.6) | 3 (16.7) | 18 (100) |
| Age | 10-19 | 4 (36.4) | 3 (27.3) | 1 (9.1) | 0 (0) | 1 (9.1) | 2 (18.2) | 11 (100) |
| | 20-39 | 1 (25) | 2 (50) | 0 (0) | 1 (25) | 0 (0) | 0 (0) | 4 (100) |
| | 40-69 | 0 (0) | 2 (66.7) | 0 (0) | 0 (0) | 0 (0) | 1 (33.3) | 3 (100) |
| | Total | 5 (27.7) | 7 38.9) | 1 (5.6) | 1 (5.6) | 1 (5.6) | 3 (16.7) | 18 (100) |
| Water quality | Boil water | 2 (33.3) | 2 (33.3) | 0 (0) | 1 (16.7) | 1 (16.7) | 0 (0) | 6 (100) |
| | Do not boil water | 3 (25) | 5 (41.7) | 1 (8.3) | 0 (0) | 0 (0) | 3 (25) | 12 (100) |
| | Total | 5 27.7) | 7 (38.9) | 1 (5.6) | 1 (5.6) | 1 (5.6) | 3 (16.7) | 18 (100) |

## 4. DISCUSSION

The study showed prevalence of coccidian parasites of 5.4% with *cryptosporidium spp*. being twice more prevalent (66.7%) than *I. belli* (33.3%) and that *cryptosporidium spp*. were more in age group 10-19 years i.e 3/3 (100%). A study in central Uganda revealed a prevalence of 25% in a population of over 1000 children suffering from diarrhea due to *Cryptosporidium spp*. [16]. There were incidental findings in the study which included protozoan parasites such as *E. hystolytica (27.7%), G. lamblia* (38.9%) and hook worms (16.7%) which were more common in children and were as well potential causes of diarrhea among the participants. Their mode of transmission is faeco-oral route just like coccidia but much emphasis was put on coccidian parasites because of their ability to cause chronic diarrhea.Intestinal parasitic infections are classified today as the leading causes of mortality and morbidity among patients infected with HIV and specifically, gastrointestinal protozoa which cause significant morbidity in children and are opportunistic infections in patients living with HIV/ AIDS [6]. Children being major suffers is linked to the mode of transmission of these intestinal parasites (feaco-oral) in relation to personal and community hygiene, because of inadequate knowledge in this group, they tend to suffer the consequences of intestinal parasites.

The major risk factor associated with coccidian parasites in the study was consumption of raw drinking water from the bore hole and the taps**.** Community lifestyle patterns such as poor health hygiene and poor nutritional standards and low education levels have contributed to increased disease burden in rural communities and also the fact that there was scarcity of fire wood, firewood collection sites were far have also promoted challenges in preparation of safe drinking water which is in agreement with a recent study [8]. Poor sanitation habits such as failure to clean water collecting jerricans and water collection areas over long periods of time were some of the factors observed that lead to contamination of water collected from taps and bore holes in the communities [9]. Due to challenges of financing, which is characteristic of sub-Saharan African local government, servicing of water pipes is hardily carried out thus leading to sporadic leakages and contamination of the water [15]. This has subsequently led to increased episodes of infections in rural communities that are often forced to share the limited water sources especially in the dry seasons. Patients actively on co-trimoxazole treatment were found to have a low prevalence of coccidian parasites because it is a prophylactic treatment in HIV infection [8]. Due to reduced immunity in acquired immune deficiency syndrome (AIDS) disease, prophylactic treatment was given to HIV clients to prevent opportunistic infections such as chronic diarrhea due to gastro-intestinal parasites however, abuse of this drug causes resistance to bacteria and coccidia parasites which could have been the reason as to why there were some coccidian parasites dtected in a patient on prophylactic treatment. It is there fore recommended to take co-trimoxazole in its full dosesge as a prophylactic treatment in management of diarrhea in immune suppressed patients [17].

The major risk factors attributed to diarrheal diseases are place of residence, agro-ecological, water source, family size, location, reliability, treatment and diarrheal status probably due to poor environmental sanitation and personal hygiene [12]. Arua being at the boarder of Uganda with Sudan and Congo has contributed to likelihood of poor sanitation due to an increasing population and the area also having few hospitals which cannot handle these growing numbers of population effectively. A recent census in Uganda has shown than the population of Arua district alone has increased from 559,075 persons in 2002 to 785,189 persons in 2014 census [18]. Adult females of reproductive age and children in developing countries are more likely to suffer from poor nutrition habits due to shortage of enough food as a result of population raise hence leading to low immunity and being susceptible to secondary infections [19,20,21]. Children are associated with a weak immunity and coupled with poor nutritional habits. Inferential analysis showed there existed a stronger relationship in drinking boiled water and co-trimoxazole. This would be due to the added advantage of boiled water where by the eggs and parasites are killed thus breaking the lifecycle. Research has shown that consumption of unboiled water is a likely risk factor to water borne diseases [22]. The consequencies associated with coccidian parasite infection is the ability to cause chronic diarhea which leads to severe muscle wasting, dehydration and even death. There is need for the government to strengthen the health system in management and creation of awareness of this disease to all clinicians and immune suppressed persons.

Major constraints to the study included; small sample size and limited number of diagnostic tools used due to severe financial constraints.

## 5. CONCLUSION AND RECOMMENDATION

From the study, it was shown that there was generally a reduced prevalence of coccidian parasites as compared to previous studies in Uganda, Kenya and Ethiopia which can be assumed that perhaps most HIV patients in West Nile region of Uganda do take prophylactic treatment for gastro-intestinal diseases.

Routine diagnosis of intestinal coccidia will obviate unnecessary treatment especially in the children who are more likely to suffer from side-effects of anti-parasitic drug therapy well as erroneous treatment with the antibiotics might augment antibiotic resistance amongst the bacterial population as well as altering the normal flora that is usually present in the human gastro intestinal tract thereby rendering it pathogenic.
Patients with HIV living in rural communities where it is difficult to access safe drinking water should be encouraged to take prophylactic treatments seriously. A further study should be

conducted in the region using a wider array of laboratory diagnostic tools like polymerase chain reaction (PCR) and larger sample size in order to determine the scale of diarrheal diseases in HIV patients in the region.

## REFERENCES


[1]. Agholi, M., Hatam, G. R., & Motazedian, M. H. HIV/AIDS-Associated Opportunistic Protozoal Diarrhea. *AIDS Research and Human Retroviruses*. 2012:2*9*(1), 120911064948006. doi:10.1089/AID.2012.0119

[2]. Montresor A, Crompton DWT, Bundy DAP, Hall A, Savioli L:Guidelines for the evaluation of soil- ransmitted helminthiasis and schistosomiasis at community level: A guide for managers of control programmes.Trans R Soc Trop Med Hyg. 1998: 92(4):470–471.

[3]. Albonico M, Montresor A, Crompton DW, Savioli L:Intervention for the control of soil-transmitted helminthiasis in the community.Adv Parasitol. 2006: 61:311–48

[4]. Mbae, C. K., Nokes, D. J., Mulinge, E., Nyambura, J., Waruru, A., & Kariuki, S.. Intestinal parasitic infections in children presenting with diarrhoea in outpatient and inpatient settings in an informal settlement of Nairobi , Kenya. *BMC Infectious Diseases*. (2013): *13*(1), 1. doi:10.1186/1471-2334-13-243

[5]. Nissapatorn V:Lessons learned about opportunistic infections in southeast Asia.Southeast Asian J Trop Med Public Health. 2008: 39(4):625–641.

[6]. KurniawanA,KaryadiT,DwintasariSW,SariIP,YunihastutiE,DjauziS Smith HV:Intestinal parasitic infections in HIV/ AIDS patients presenting with diarrhoea in Jakarta, Indonesia.Trans R Soc Trop Med Hyg.2009: 103(9):892–898

[7]. Cook, G. C. Tropical medicine. *Postgrad Med J*. 1991:*67*, 798–822.

[8]. Fletcher, S. M., Stark, D., Harkness, J., & Ellis, J. Enteric protozoa in the developed world: A public health perspective. *Clinical Microbiology Reviews*. 2012:*25*(3), 420–449. doi:10.1128/CMR.05038-11

[9]. Missaye, A., Dagnew, M., Alemu, A., & Alemu, A. Prevalence of intestinal parasites and associated risk factors among HIV/AIDS patients with pre-ART and on-ART attending dessie hospital ART clinic, Northeast Ethiopia. *AIDS Research and Therapy*. 2013:*10*(1), 7. doi:10.1186/1742-6405-10-7

[10]. Mor, S. M., Tumwine, J. K., Ndeezi, G., Srinivasan, M. G., Kaddu-mulindwa, D. H., Tzipori, S., & Griffiths, J. K.. Respiratory cryptosporidiosis in HIV-seronegative children, Uganda: potential for respiratory transmission. *NIH Public Access*. 2011:*50*(10), 1366–1372. doi:10.1086/652140.Respiratory

[11]. Endeshaw, T., Mohammed, H., & Woldemichael, T. Cryptosporidium parvum and other instestinal parasites among diarrhoeal patients referred to EHNRI in Ethiopia. *Ethiopian Medical Journal*. 2004:*42*(3), 195–8. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16895037

[12]. Kipyegen, C. K., Shivairo, R. S., & Odhiambo, R. O. Prevalence of intestinal parasites among HIV patients in Baringo, Kenya. *The Pan African Medical Journal*. 2012:*13*, 37.

[13]. Puleston, R. L., Mallaghan, C. M., Modha, D. E., Hunter, P. R., Nguyen-Van-Tam, J. S., Regan, C. M., Chalmers, R. M. The first recorded outbreak of cryptosporidiosis due to Cryptosporidium cuniculus (formerly rabbit genotype), following a water quality incident. *Journal of Water and Health*. 2014:*12*(1), 41–50. doi:10.2166/wh.2013.097

[14]. Raccurt, C. P., Fouché, B., Agnamey, P., Menotti, J., Chouaki, T., Totet, A., & Pape, J. W. Short report: Presence of Enterocytozoon bieneusi associated with intestinal coccidia in patients with chronic diarrhea visiting an HIV center in Haiti. *American Journal of Tropical Medicine and Hygiene*. 2008:*79*(4), 579–580.

[15]. Michael, H. O., Horton, J., & Piero, O. L. Epidemiology and control of human gastrointestinal parasites in children. *Expert Rev Anti Infect Ther*. 2010:*8*(2), 219–234. doi:10.1586/eri.09.119.Epidemiology

[16]. Tumwine, J. K., Kekitiinwa, A., Nabukeera, N., Akiyoshi, D. E., Rich, S. M., Widmer, G., Tzipori, S. Cryptosporidium parvum in children with diarrhea in Mulago Hospital, Kampala, Uganda. *The American Journal of Tropical Medicine and Hygiene*. 2003:*68*(6), 710–5. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12887032

[17]. Abecasis, A. B., Wensing, A. M. J., Paraskevis, D., Vercauteren, J., Theys, K., Van de Vijver, D. a M. C., Vandamme, A.-M. HIV-1 subtype distribution and its demographic determinants in newly diagnosed patients in Europe suggest highly compartmentalized epidemics. *Retrovirology*. 2013:*10*,7. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3564855&tool=pmcentrez&rendertype=abstract

[18]. http://www.citypopulation.de/php/uganda-admin.php?adm2id=002

[19]. Schürmann, D., Bergmann, F., Albrecht, H., Padberg, J., Wünsche, T., Grünewald, T., Suttorp, N. Effectiveness of twice-weekly pyrimethamine-sulfadoxine as primary prophylaxis of Pneumocystis carinii pneumonia and toxoplasmic encephalitis in patients with advanced HIV infection. *European Journal of Clinical Microbiology & Infectious Diseases : Official Publication of the European Society of Clinical Microbiology*. 2002:*21*(5), 353–61. doi:10.1007/s10096-002-0723-3

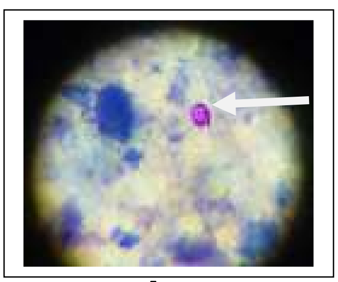
[20]. Rogerson, S. R., Gladstone, M., Callaghan, M., Erhart, L., Rogerson, S. J., Borgstein, E., & Broadhead, R. L. HIV infection among paediatric in-patients in Blantyre, Malawi. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 2004:*98*(9), 544–552.

[21]. Behera, B., Mirdha, B. R., Makharia, G. K., Bhatnagar, S., Dattagupta, S., & Samantaray, J. C. Parasites in patients with malabsorption syndrome: A clinical study in children and adults. *Digestive Diseases and Sciences*. 2008. *53*(3), 672–679.

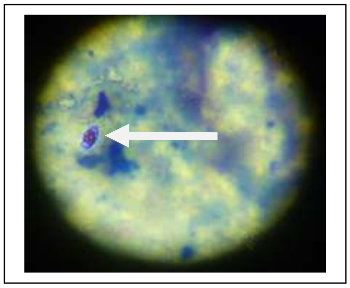
[22]. Agustina, R., Sari, T. P., Satroamidjojo, S., Bovee-oudenhoven, I. M. J., Feskens, E. J. M., & Kok, F. J. Association of food-hygiene practices and diarrhea prevalence among Indonesian young children from low socioeconomic urban areas. *BMC Public Health*. 2013:*13*(1), 1. doi:10.1186/1471-2458-13-977

## APPENDIX

**Fig. 1. Photomicrographs showing coccidian parasites**



**A**



**B**

**Fig. 1.** Modified Ziehl-Neelsen stain of *Cryptosporidium species* (A) and *Isospora belli* (B) under x100 objective lens