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Research article

Malaria coinfection with Neglected Tropical Diseases (NTDs) in children at Internally Displaced Persons (IDP) camp in Benin City, Nigeria

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ABSTRACT

Malaria and Neglected Tropical Diseases (NTDs) are highly endemic in poorer countries of the world. The research investigated the prevalence of parasitic infections among children in Internally Displaced Persons (IDP) camp in Benin City. Faecal, urine and blood specimen were collected from 184 children (100 males and 84 females) aged 6–15. Blood samples were prepared using thick film method and analyzed microscopically. Direct smear technique was employed for faecal sample and sedimentation method to concentrate ova from the urine sample. Ten species of parasites were identified in this study. The predominant species were *Plasmodium falciparum* (67.93%), *Entamoeba histolytica* (67.93%) and *Giardia duodenalis* (59.78%). *Plasmodium falciparum* and *E. histolytica* were most prevalent in both sexes, with *P. falciparum* infecting 68% males and 67.86% females while *E. histolytica* infected 66% males and 70.24% females ($P = 0.24$). Mixed infections with blood and intestinal parasites were recorded in 41.18% in age group 5–10 and 47.90% in age group 11–15 ($P < 0.5$). Also, mixed infections with blood and intestinal parasites were detected in 45% males and 50% females ($P = 0.51$). Urinary schistosomiasis was recorded in 28.80% of the participants. Parasitic infections especially *P. falciparum* malaria and amoebiasis were predominant among the children. Therefore, our findings call for specific intervention programmes to reduce parasite intensity and morbidity in the children. Environmental and personal hygiene should be implemented in order to curb parasitosis in the study area.

1. Introduction

Malaria and Neglected Tropical Diseases (NTDs), including intestinal parasitic infections (IPIs) and schistosomiasis, are highly endemic in developing nations of the world and remain a serious public health issue in sub-Saharan Africa, especially in impoverished and poor sanitary settings, with tremendous consequences for development (Yamey, 2002; Tchuenté et al., 2013; Kwenti et al., 2016). About 3.3 billion people worldwide are at risk of being infected with malaria and developing disease (Abossie et al., 2017). In 2018, about 228 million malaria cases and 405,000 deaths globally were recorded (WHO, 2019a). The burden is heaviest in the sub-Saharan African Region, with more than 80% of all malaria deaths, and children ages 1–4 years account for 78% of all deaths (Murray et al., 2012; WHO, 2019a; Naß and Efferth, 2019).

Plasmodium falciparum, out of the five human malaria parasites, is the most virulent and prevalent species in Africa where it was responsible for about 214 million clinical cases and 438,000 deaths recorded all over the world in the year 2015 (WHO, 2015; Bhatt et al., 2015). Primarily IPIs are caused by helminths (*Ascaris lumbricoides, Trichuris trichiura* and hookworm), protozoans (*Entamoeba histolytica*, *Giardia duodenalis* and *Balantidium coli*) or both (Harhay et al., 2010; Odo et al., 2016). The severity of intestinal parasitic infections (IPIs) is more pronounced in areas in Asian, Latin American and sub-Sahara African countries lacking potable water supply, good personal and environmental hygiene, and have rapid growth in human population (Mohammed et al., 2015). These infections predominate in children and 12% of the global disease burden is reported among children within 5–14 years of age in developing countries (Awasthi et al., 2003).

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Ascaris lumbricoides causes about 1.2 billion infections worldwide and *T. trichiura* and hookworm disease accounts for 795 million and 740 million (Alum et al., 2010). High prevalence of IPIs has been observed among school-going children in sub-Saharan African countries including: 84.6% in Nigeria (Awi-Waadu, 2008), 90% in Central Sudan (Ahmed et al., 2010), 50.0% in Rwanda (Emile et al., 2013), 48.7% in Tanzania (Speich et al., 2013) and 84.7% in Burkina Faso (Erismann et al., 2016). Malaria coinfection with IPIs predominates in sub-Saharan African countries due to their overlapping distribution (Hotez et al., 2009).

Human schistosomiasis or bilharziasis is a freshwater snail-transmitted intravascular debilitating disease caused by blood-dwelling parasitic dimorphic *Schistosoma* trematode worms (Gryseels et al., 2006; Chen et al., 2020). Essentially, the disease is grouped into two: urogenital schistosomiasis and intestinal schistosomiasis based on the organs affected (Njunda et al., 2017). Basically, six major species infect man—*Schistosoma haematobium* (etiological agent of urogenital schistosomiasis), *S. intercalatum, S. mekongi*, *S. japonicum, S. mansoni* and *S. guineensis* (etiological agents of intestinal schistosomiasis)— however, *S. haematobium*, *S. japonicum* and *S. mansoni* are most pathogenic (Steinmann et al., 2006; Chuah et al., 2019). Not less than 240 million people are affected by schistosomiasis globally and about 200,000 deaths recorded yearly (Thétiot-Laurent et al., 2013; Hotez et al., 2014; WHO, 2019b). Approximately 90% of the cases occur in Africa of which nearly two-thirds are caused by *S. haematobium* (Hotez and Kamath, 2009; Vos et al., 2012). Nigeria has the highest prevalence among the 75 countries in which the disease is endemic (Uchendu et al., 2017; WHO, 2019b). In Nigeria, a prevalence of 9.5% was reported by the Federal Ministry of Health (2015). Other studies conducted in Maiduguri and Anambra, Nigeria, reported prevalence of 14.5% and 15.7% respectively (Joseph et al., 2010; Ugochukwu et al., 2013).

Evaluating the endemic level of parasitic infections in populations exposed to the disease is of utmost necessity in order to formulate specific and appropriate intervention programmes. There is dearth of empirical estimates of parasitic infections in the camp therefore; this research sought to determine the prevalence of malaria with NTD coinfection in children in IDP camp, Benin City, Nigeria. The outcome of this research will help the management of the camp in appropriate intervention programmes to tackle these diseases.

2. Materials and methods

2.1. Study location and population

The camp is located in a forested area in Ovia North-East Local Government Area of Edo State (06°38′41″ N and 05°34′48″ E) under the management of the International Christian Centre (ICC). Large part of the area has been converted to intensive agricultural system. Two distinct climatic conditions characterized the area-wet season (April–October) and dry season (November–March). Annual precipitation and temperature are relatively high averaging about 2000 mm and 22–36 °C respectively. The current vegetation cover of unplanted areas consists of a mosaic of abandoned farms, mainly grasslands, plantain and cassava.

Pupils from primary 1–5 in the camp were selected and participated in the survey. A total number of 250 pupils volunteered to take part in the study.

2.2. Ethical statement

The protocol for the current study was approved by the ethical review committee of the University of Benin Teaching Hospital, Benin City, Nigeria. The study was conducted with strict compliance to standard ethical guidelines. Approved consent was taken from the coordinator and other relevant authorities in the camp including the teachers and parents/guardians of the children before specimens were collected. Additionally, informed consent was sought and obtained from the children who were adequately informed of the importance of the study prior to the collection of specimen. Appropriate treatments were administered to infected children.

2.3. Sample collection

Faecal and urine samples were obtained from the children into labelled, sterile wide-mouthed screw-capped plastic bottles (supplied to them) with instructions on how each sample is to be taken. Blood sample was collected by finger pricking using sterile disposable lancets on the slides to screen for malaria. The method of stool and urine collection was explained to the children as well as their teachers and a single specimen was collected from each individual. The specimen bottles were labelled with the names, sexes and classes of the pupils. Specimens were stored in 10% formalin for parasitological analysis.

2.4. Questionnaire survey

Structured questionnaires were used to collect the clinical and socio-demographic information of the children on a standard form including age and gender and other anthropometric data.

2.5. Exclusion criteria

Children within 6–15 years were eventually selected for the exercise while those within 0–5 years were excluded because it will be difficult for them to submit samples (blood, faecal and urine).

2.6. Sample preparation and examination

2.6.1. Coproparasitological analysis

Direct smear method was used. A spatula was used to mix a small amount of the specimen with saline and iodine to make smooth thin preparations with each covered with a slip. Saline preparations were made for larvae, helminth eggs, ciliates, cysts and oocysts while iodine was used to examine the nuclei of cysts. Thereafter, they were observed using x10 and x40 magnifications of a compound light microscope.

2.6.2. Examination of urine and blood specimens

The sedimentation technique (Cheesbrough, 2006) was adopted to concentrate ova from the urine samples. Two millilitres (2ml) of properly mixed urine was transferred into a tube and centrifuged at 2500 rpm for 5 min and left to settle. The supernatant was decanted and a minute amount of the pellet pipetted onto a microscopic slide, covered with a cover slip and observed microscopically for detection of *S. haematobium* ova. Blood examination was carried out by thick film preparations (Giemsa, 1902) and observed microscopically, using immersion oil.

2.7. Data analysis

Results were analyzed using Chi-square of SPSS v22. Chi-square test from the contingency tables was employed to analyze the differences in the prevalence of infection between ages and sex. The data were represented in tables, charts and percentage.

3. Results

3.1. Anthropometric characteristics of study population

Two hundred and fifty (250) children volunteered to take part in the study but 184 pupils submitted complete samples i.e., blood, faecal and urine samples and were finally used for the study.

The selected population was divided into two age groups: 6–10 years and 11–15 years. The ages range from 6 to 15 years with 17 (9.23%) of the children being 6–10 years old and 167 (90.76%) were 11–15 years old. The mean ages in the five classes were: Primary one 13.46 ± 1.426, Primary two 14.80 ± 1.166, Primary three 13.72 ± 1.176, Primary four

14.97 ± 1.217 and Primary five 14.63 ± 1.682. Overall, there were more males 100 (54.34%) than females 84 (45.65%).

3.2. Prevalence for the different parasitic infections

Ten (10) species of parasites were identified: *Plasmodium falciparum* was recorded in 125 pupils representing 67.93%, *Entamoeba histolytica* (67.93%), *Giardia duodenalis* (59.78%), *E. coli* (47.28%), *Ascaris lumbricoides* (34.24%), *Strongyloides stercoralis* (31.52%), Hookworms (32.07%), *Schistosoma haematobium* (28.80%), *Trichuris trichiura* (17.93%) and the least encountered parasite was *Isospora belli* (1.63%) (Table 1). This study showed that *P. falciparum* malaria (67.93%) and amoebiasis (67.93%) were most predominant in the study population. Furthermore, Table 2 shows that *P. falciparum* and *E. histolytica* were most prevalent in both sexes. A total of 100 males and 84 females participated in this study. Out of these, *P. falciparum* was reported in 68 (68%) males and 57 (67.86%) females and *E. histolytica* in 66 (66%) males and 59 (70.24%) females. The least prevalent parasite was *I. belli* which was reported in 2 (2%) males and 1 (1.19%) female ($P = 0.24$).

As presented in Table 2, *A. lumbricoides*, *P. falciparum*, *G. duodenalis*, *E. histolytica*, *E. coli*, *S. stercoralis*, *S. haematobium* and Hookworms were reported in male and females in the age groups but *I. belli* was only recorded in females 6–10 years age group while in males 11–15years age group ($P < 0.5$).

3.3. Mixed infections of malaria with NTDs co-infection

The prevalence of multi-parasitism in the different age groups (6–10 and 11–15 years) is presented in Figure 1. Of the 17 participants in age group 6–10 years; blood, urinary and intestinal parasites were recovered from 3 (17.65%) and 37 (22.16%) of 167 in age group 11–15 years. Intestinal and blood parasites were reported in 7 (41.18%) in age group 5–10 years and 80 (47.90) in age group 11–15 years. Besides, both intestinal and urinary parasites were reported in 2 (11.76%) in age group 5–10 years and 17 (10.18) in age group 11–15 years. Furthermore, only intestinal parasites were recovered from 5 (29.41) in age group 5–10 years and 33 (13.17) in age group 11–15 years ($P < 0.5$).

Mixed infections of parasites (blood, urinary and intestinal parasites) were recorded in 16 (16%) males and 24 (28.57%) females (Figure 2). Blood and intestinal parasites were detected in 45 (45%) males and 42 (50%) females. Also, 11 (11%) of male and 8 (9.52%) of females were infected with intestinal and urinary parasites respectively. Lastly, 28 (28%) males and 10 (11.90%) females were infected with intestinal parasites only ($P = 0.51$).

4. Discussion

The current survey, to the best of our knowledge, is one of the few researches to be carried out in the IDP camp in Benin City, Nigeria, in the past years, with regards to epidemiological survey of parasitic diseases. Multiparasitism predominates in developing nations and the parasites involved may interact (Christensen et al., 1988; Cox, 2001), thus this research determined the rate of malaria coinfection with Neglected Tropical Diseases. The findings from this research showed high preponderance of parasitic infections including *Plasmodium falciparum* (67.93%), *Entamoeba histolytica* (67.93%) and *Giardia duodenalis* (59.78%) suggesting poor standard of living and low level of both personal and environmental hygiene in the camp (Ukoli, 1984; Smyth, 1996).

The high rate of *P. falciparum* malaria (67.93%) observed in this survey is similar to 61.1% observed among IDPs in Sudan by Eshag et al. (2020) but higher than 58% recorded by Brooks et al. (2017a) among children in IDP camp in the Democratic Republic of the Congo. It also markedly deviated from 17% documented by Charchuk et al. (2016) and 11.4% by Zhou et al. (2016) among displaced persons in the DRC and Myanmar respectively. Besides, in normal populations, the prevalence rate also corresponds with Getie et al. (2015) who recorded 71.7% in Ethiopia and Babamale et al. (2018) with 63.7% prevalence in Nigeria but higher than 41.7% reported by Teh et al. (2018) in Cameroon. The presence of female *Anopheles* mosquitoes and infected blood as well as bushes and small bodies of standing water are significant in the epidemiological study of malaria. The camp is surrounded by bushes and trees which serve as suitable habitat for vectors of malaria and these children relax and play in the open fields which results in multiple bites from mosquitoes. These predisposing factors probably led to the high rate of malaria documented in this research.

There was no variation in malaria prevalence according to sex (68% for male and 67.86% for females) corresponding with related surveys by Brooks et al. (2017a) and Ajakaye and Ibukunoluwa (2020) among displaced persons in the DRC and Nigeria respectively. This shows that gender is not a determinant of susceptibility to malaria infection (Nanvyat et al., 2017). This probably resulted because both sexes were exposed equally to predisposing factors to *P. falciparum* malaria. Contrastingly, Zhou et al. (2016) and Eshag et al. (2020) documented significantly higher prevalence in internally displaced male children in Myanmar and Sudan respectively whereas Brooks et al. (2017b) recorded slightly higher prevalence in females in IDP camp in the DRC. Additionally, no significant difference in the rate of malaria infection among the different age groups was documented in the current study agreeing with past studies (Sousa-Figueiredo et al., 2012; Okoli and Solomon, 2014). This was different from the survey carried out by Brooks et al. (2017b) who observed higher infection rate among younger displaced

Table 1. Prevalence of parasites and sex distributions among the children.

Parasites	Total (184)	Males (100)	Females (84)	*P* value
	% Positive	% Positive	% Positive	
Plasmodium falciparum	125 (67.93)	68 (68)	57 (67.86)	0.24
Entamoeba histolytica	125 (67.93)	66 (66)	59 (70.24)	
Giardia duodenalis	110 (59.78)	62 (62)	48 (57.14)	
E. coli	87 (47.28)	38 (38)	49 (58.33)	
Ascaris lumbricoides	63 (34.24)	34 (34)	29 (34.52)	
Hookworms	59 (32.07)	32 (32)	27 (32.14)	
Schistosoma haematobium	53 (28.80)	22 (22)	31 (36.90)	
Strongyloides stercoralis	58 (31.52)	33 (33)	25 (29.76)	
Trichuris trichiura	33 (17.93)	17 (17)	16 (19.05)	
Isospora belli	3 (1.63)	2 (2)	1 (1.19)	

Table 2. Distribution of parasites among the different age groups.

Age groups	6–10 years		Total	11–15 years		Total
	Males (% +ve)	Females (% +ve)		Males (% +ve)	Females (% +ve)	
Total no. examined	7	10	17	93	74	167
Plasmodium falciparum	7 (100)	5 (50)	12 (70.59)	61 (65.59)	50 (70.27)	113 (67.66)
Entamoeba histolytica	6 (85.71)	6 (60)	12 (70.59)	60 (64.52)	53 (71.62)	113 (67.66)
E. coli	4 (57.14)	7 (70)	11 (64.71)	34 (36.54)	42 (56.76)	76 (45.51)
Giardia duodenalis	3 (42.86)	5 (50)	8 (47.06)	59 (63.44)	43 (58.11)	102 (61.08)
Ascaris lumbricoides	2 (28.57)	5 (50)	7 (41.18)	32 (34.41)	24 (32.43)	56 (33.53)
Strongyloides stercoralis	3 (42.86)	2 (20)	5 (29.41)	30 (32.26)	23 (31.08)	53 (31.74)
Schistosoma haematobium	1 (14.29)	2 (20)	3 (17.65)	21 (22.58)	29 (39.19)	50 (29.94)
Hookworms	1 (14.29)	1 (10)	2 (11.76)	31 (33.33)	26 (35.26)	57 (34.13)
Trichuris trichiura	0 (0)	3 (30)	3 (17.65)	17 (18.28)	13 (17.57)	30 (17.96)
Isospora belli	0 (0)	1 (10)	1 (5.88)	2 (2.15)	0 (0)	2 (1.20)
***P* value**			0.11			0.10

children in the DRC; and Zhou et al. (2016) and Ajakaye and Ibukunoluwa (2020) who documented higher infections among older children in Myanmar and Nigeria respectively. In the current study, age had no influence on malaria prevalence. The high malaria prevalence reported in the different age groups suggests the absence of community acquired immunity among the children (Nanvyat et al., 2017). The different rate of malaria infection in the age groups and sexes as reported by these surveys could be attributed to different factors including the state of the camp, environmental/sanitary conditions which the children in the camps were exposed to and control schemes such as the use of insecticide treated nets.

E. histolytica was positive in the 67.93% of the participants in this survey similar to 69.87% reported by Hassan and Mero (2020) among displaced persons in Iraq but far higher than 6 and 23.5% recorded by Ahmed et al. (2015) and Ayuba et al. (2019) among IDPs in Pakistan and North-Central part of Nigeria respectively. It did agree with previous results of Alwabr and Al-Moayed (2016) in Yemen and Erismann et al. (2016) in Burkina Faso, who observed 64 and 66.5% prevalence, respectively. Lower prevalence 0.1 and 20.4% were documented by Kostopoulou et al. (2020) and Ngui et al. (2020) in Greece and Malaysia respectively in surveys conducted among normal populations. The high rate of amoebiasis reported in this research clearly indicates low level of personal and environmental hygiene of the children as well as the food handlers, since the widespread of intestinal parasitic infections is connected with unhygienic practices (Odo et al., 2016; Hailegebriel, 2017). The disparity in prevalence of this protozoan parasite among different authors might be associated with the degree of contaminants present in drinking water sources, environmental sanitation and personal hygiene of the children (Hailegebriel, 2017). Since the persons arrived at the camp at different times; this could have also contributed to the high rate of amoebiasis reported in this study noting that some of them could have brought their infections to the camp while the none infected ones could have been infected in the camp.

Furthermore, the rate of amoebiasis was marginally higher in females (70.24%) than in males (66%) affirming the reports of previous researches that both genders are evenly exposed to *E. histolytica* (Akingbade et al., 2013; Erismann et al., 2016) but disagreed with Ahmed (2013) who reported higher infection in males than females and Ajayi et al. (2017) who documented higher preponderance among females. This infection was also slightly recorded more in children less than 11 years of

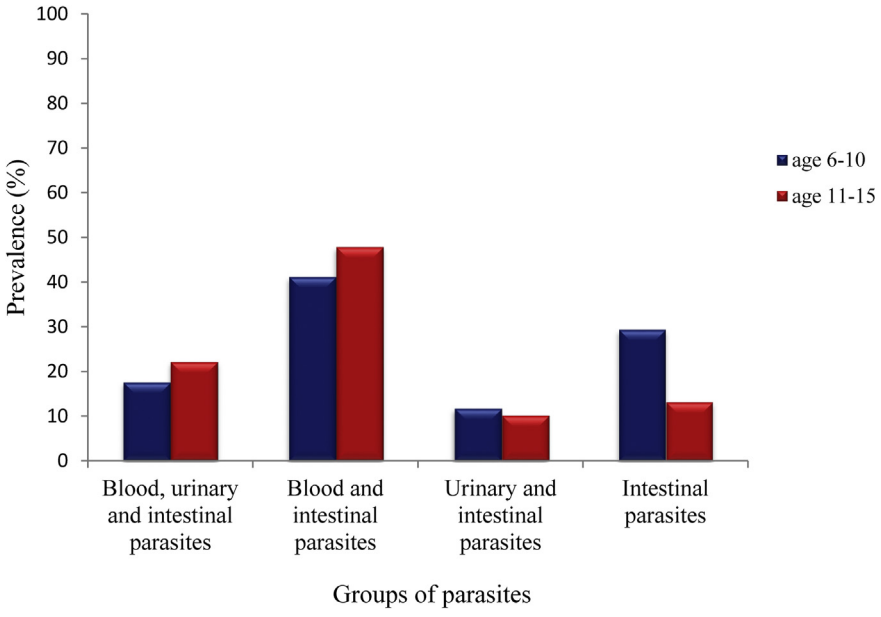

Figure 1. Prevalence of multi-parasitism according to age groups.

age laying credence to the fact that children in this age group (6–10years) spend much of their leisure time outdoors, play on the ground and make contact with contaminated soil, bite their nails and eat indiscriminately with unwashed hands (Ahmed, 2013; Ajayi et al., 2017). This report is in consonance with those of Odo et al. (2016) and Ahmed (2013) but differs from that of Houmsou et al. (2009) and Hailegebriel (2017) who recorded more infections in older children (age group 12–14years).

Schistosomiasis haematobia was observed in 28.80% of the participants in this study. It was at variance with 51% observed in a survey carried out by Beltrame et al. (2017) in African refugees arriving Italy, and 8 and 9% respectively reported by Quandelacy et al. (2010) and Posey et al. (2007) among Sudanese refugees in the United States of America. It agreed with 26.09% observed by Kabiru et al. (2013) and 27.27% by Bello et al. (2014) among normal populations in Nigeria. The children in the camp are not allowed to go to the streams, rivers, nearby ponds and wells to draw water; this probably led to the low rate of urinary schistosomiasis observed in this survey. The camp gets its water from a borehole that is constructed within its premises. This prevents the children from coming into contact with the snail intermediate host that could be in abundance in these water bodies. Females (36.90%) were more infected with schistosomiasis haematobia than males (22%). This could have been related to females having more contacts with water that could possibly be contaminated back in their respective states when they engage in activities such as washing, cooking and drawing water from wells and other sources of water. This deviated from the studies of Liao et al. (2011) and Otuneme et al. (2014), who recorded higher prevalence in males. It was also observed to be more prevalent in older children supporting the reports of Federal Ministry of Health (2015) and Uchendu et al. (2017) in Nigeria; and Ntonifor et al. (2015) in Cameroon. A contradictory report was recorded by Njunda et al. (2017) who documented higher prevalence in children below 10 years.

Multiple infections were observed in both sexes and in the different age groups. Mixed infection with blood and intestinal parasites were recorded in both sexes (45% males and 50% females) and in the age groups (41.18% in age group 5–10 and 47.90% in age group 11–15) probably heightened by the presence of the aetiological agents of these infections in the camp. A similar occurrence was recorded by previous studies (Midzi et al., 2008; Degarege et al., 2012). The findings of positive association between intestinal parasites and *P. falciparum* infections among the children might be related to the presence of socio-economic, environmental and behavioral factors that can increase the risk of concurrent infection with both intestinal parasites and *Plasmodium* spp. (Brooker et al., 2007). Additionally, the high prevalence of *P. falciparum* malaria among children co-infected with intestinal parasites could be linked to down regulation of their immune system (Salazar-Castañon et al., 2014), paving way for *P. falciparum* to enter into the host and multiply at a faster rate (Degarege et al., 2016).

5. Conclusion

The results observed in this study are of great significance with regards to controlling malaria and NTDs in children in the camp on the rationale that school-aged children in this camp are at considerable risk especially with intestinal parasites. Therefore, measures to prevent children from infection with intestinal parasites, such as improved personal and environmental sanitation, adequate disposal of excrement, hygiene education and access to clean drinkable water, should be promoted, as school-aged children represent the main reservoirs for intestinal parasites transmission (Kenny and Kelly, 2009; Speich et al., 2016). Nevertheless, *E. histolytica* and *E. coli* may not be completely eradicated from the camp as their cysts are able to withstand adverse environmental conditions for long period of time. Therefore, we recommend integration of different WASH (Water, Sanitation and Hygiene) intervention programmes to reduce parasite intensity and manage potential risks from parasitic infections thus reducing morbidity in the children (Kenny and Kelly, 2009; Speich et al., 2016). Implementation of WASH intervention programmes and appropriate health-seeking activities are highly important if sustained control and elimination of parasitic infections are to be achieved (Hopkins, 2016).

Parasitic coinfection and interaction need further studies in order to understand their mechanisms and public health importance. Since the same individual may be coinfected with different species of parasite with

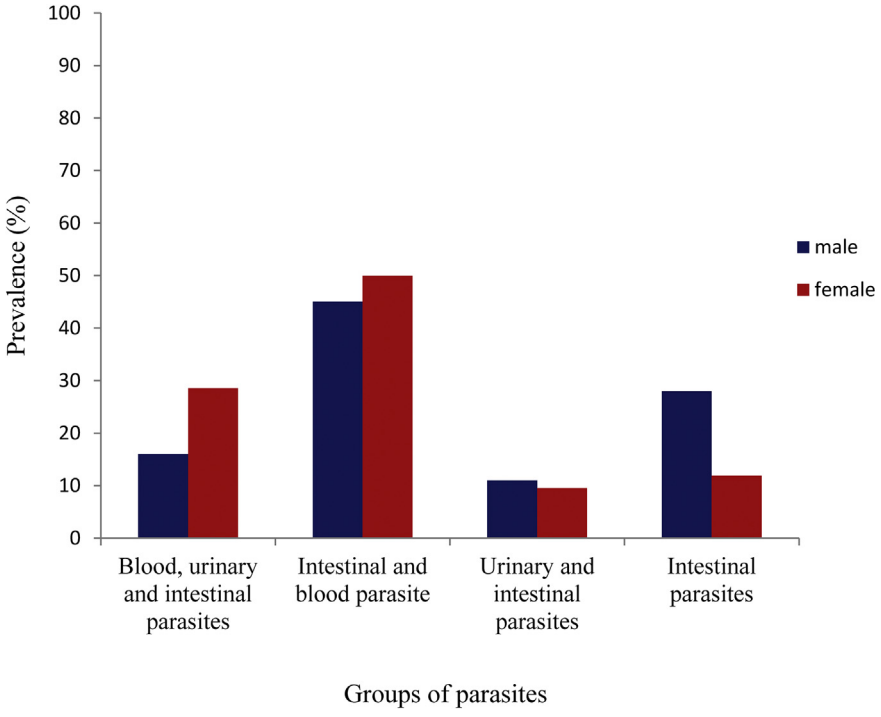

Figure 2. Prevalence of sex-linked multiparasitism.

one affecting the severity of the other, it would be of great significance to implement integrated control programmes that render multiple treatments against several parasitic infections at the same time and also reduce poverty (Briand et al., 2005).

Declarations

Author contribution statement

E. Edosomwan: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

I. Evbuomwan: Analyzed and interpreted the data; Wrote the paper.

C. Agbalalah: Performed the experiments.

S.Dahunsi: Analyzed and interpreted the data.

B. Abhulimhen-Iyoha: Contributed reagents, materials, analysis tools or data.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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