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The Burden of Multiple Infections with *Plasmodium Falciparum*, *Schistosoma Mansoni* and Soil-transmitted Helminths among School Going Children in Kisumu, Kenya

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ABSTRACT

Background: Schistosomosis and soil-transmitted helminths are labelled neglected diseases and affect exclusively the poor in rural and urban areas of developing countries. In many cases, these infections occur where malaria is endemic and pose a major public health problem resulting in polyparasitism.
Objective: The present study was undertaken to investigate the prevalence, intensity and the distribution patterns of multiple infections with *Plasmodium sp*, soil-transmitted helminths and schistosomosis among schoolchildren in Kisumu Municipality, Western Kenya.
Methodology: Three hundred and fifty six (356) children were randomly selected from four primary schools. *Plasmodium* species identification and quantification was done using thin and thick blood smears while Kato Katz method (WHO kit) was used to quantify intestinal helminth egg/gram of stool. Nuclear Pore Filtration technique analysis of urine was used to diagnose *Schistosoma haematobium*. Additionally, questionnaires were administered to the participants to determine pre-disposing factors for parasite infections.
Results: Polyparasitism among the study population is common phenomenon with *Plasmodium falciparum* and *Schistosoma mansoni* as the main infections that occur in single or coinfection with other diagnosed parasites. Sixty two percent (62%) of the school age children harbour multiple parasites within them, infected with more than one parasite species and only 8.6% (N = 356) of the total children were negative to all parasites diagnosed.
Conclusion: The high prevalence of parasites among the children (91.4%) is important factor for instituting regular de-worming of schoolchildren and possible integration into the National Malaria Control programmes. There is need for policy change in malaria parasitaemia management to include treatment of asymptomatic individuals to reduce human reservoir and continuous transmission in the community and continuous public education to create awareness on dangers of infectious parasitic diseases..

KEYWORDS: *Plasmodium, Schistosoma*, Soil-transmitted helminths, schoolchildren, Kisumu, Kenya

INTRODUCTION

Malaria mainly caused by *Plasmodium falciparum* places a huge burden on human life and it is one of the major causes of morbidity and mortality in tropical countries especially in the Sub-Saharan Africa. Annually, an estimated 300 – 500 million clinical cases of malaria are reported while 1.5 – 2.7 million deaths occur worldwide mostly among children (Snow et al., 1999). In Kenya, malaria is a major cause of morbidity and mortality and the leading cause of outpatient and inpatient mortality (Ministry of Health, 20002).

Schistosomosis and soil-transmitted helminths (hookworms, *Ascaris lumbricoides* and *Trichuris trichiura*) on the other hand, are among the most neglected infections that affect mostly the poor in the rural and impoverished urban areas (Hotez et al., 2005). Cases of hookworm infection worldwide are estimated to be 740 million, with the highest prevalence occurring in sub-Saharan Africa and Eastern Asia (De Silva et al., 2003). It is also estimated that at least 200 million people are currently infected with schistosomosis, and its mortality is estimated to be 11,000 deaths per year, a burden that is responsible for about 1.7 million disability-adjusted life years (DALYs) lost per year (TDR/WHO 2002). The school going children are particularly vulnerable to helminth infections as a result of several factors including poor environmental sanitation, due to their high mobility and their incomplete physical development and immunological defence mechanisms (Montressor et al., 2002).

Polyparasitism affects a considerable proportion of the population especially in developing countries hence poses a great toll on public health (Keiser et al., 2002). Helminth infections trigger immune responses that may drain the body's ability to fight other infections hence make the infected individuals to be more susceptible to other co-infections which can be detrimental especially in HIV infected individual (Watkins and Pollitt, 1997). It has been found that helminth infections tend to exacerbate the effect of malaria parasites and increase the number of attack in an individual (Le Hesran et al., 2004). Hookworms and other soil-transmitted helminths (STHs) have been known to be responsible for extensive morbidity and mortality in sub-Saharan Africa (Handzel et al., 2003).

In Kenya, infections with *P. falciparum*, schistosomiasis and STHs are common in some areas hence leading to increase in chances of polyparasitism. Infections with intestinal

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parasites take long to show morbidity especially in young children and physical diagnosis is not readily established, thus making it difficult for patients to seek prompt treatment unlike malaria disease, which forces one to seek immediate medical attention upon infection. Furthermore, the lack of specificity of many signs and symptoms attributed to helminthic infections makes it difficult to measure the burden of morbidity attributed to a specific parasitic infection (Booth 1998). Therefore, in many countries a lot of effort in interventions and research are geared towards halting majorly malaria as public health problem. The impact of parasitic infections on children development, health and cognitive function will negatively impede the achievement of millennium development goal 6, target 8 that aims to halt and reverse the incidence of malaria and other major diseases by 2015. The study sought to investigate the prevalence and intensity of malaria parasites, *Schistosoma* species and soil-transmitted helminths among school-age children and investigate coinfections and factors that contribute to parasite burden.

METHODS AND MATERIALS

The Study Site

The study was carried out within Kisumu municipality do determine the burden of parasitic infections in school aged children. Geographical location of the Kisumu municipality is on the shores of Lake Victoria with warm climate and altitude of 1200m above sea level. It is an area with intense malaria transmission throughout the year mainly caused by *P. falciparum*. The proximity to the lake provides conducive breeding conditions and habitat for *Anopheles gambie* and fresh water snails the vectors for malaria and *Schistosoma* parasites respectively. The moist conditions coupled with poor sanitation provide ideal conditions for soil-transmitted helminths to thrive. The children in the area can access to the lake and ponds while carrying out their daily chores.

Study Population

Multi-stage sampling was used to select the schools located within Kisumu municipality and the participants were randomly selected from the schools. The study was explained to participants regarding the procedures and time commitment of the research. Those who consented in written were enrolled to participate in the study.

Selection Criteria

Only those willing to participate were included and that they were committed to avail themselves during the days of sample collections.

Benefits to the study participants

All children found infected with the parasites were treated with appropriate drugs for free.

Data Collection

Malaria parasites

Blood samples were used for examination of malaria parasites. Thick and thin blood smears were prepared from blood collected through finger prick to determine species and parasitaemia in accordance with established microscopy standard operating procedures. Asexual stages of malaria parasites were counted against 200 leucocytes where density was calculated, assuming that there are 8000 leucocytes/l of blood (Warhurst and Williams 1996). In cases where the slides were negative at 200 WBCs mark, the counting was increased to 500 WBCs before the slide was declared negative.

Helminths

Accurate diagnosis of helminths was determined by presence of egg counts of *S. mansoni* and soil transmitted helminthes (STHs) in defined quantities of stool using Kato Katz technique (Katz et al., 1972). Two Kato slides per stool sample were prepared using fixed quantity of sieved 41.7mg (WHO kit) of stool on a punched template. It was then mounted on slides and covered with malachite green impregnated cellophane and left to clear for 30 minutes before examining under a microscope. Examination of *S. haematobium* eggs in urine was done by Nuclear Pore Filtration technique as described by Kahama *et al.,* where three urine samples per study subject were collected between 10 a.m. and 2 p.m. on three consecutive days and examination done within six hours (Kahama et al., 1998). The parasite egg density was expressed as egg per gram of stool/ml of urine.

Pre-disposing factors to parasite infections

A questionnaire was administered in order to understand the type of behaviours/practices the participants engaged in that put them at risk to malaria, schistosomosis and soil-transmitted helminths.

Data Analysis

All data were managed by Standard Operating Procedures (SOPs). Data collected was analyzed using SPSS software for windows (version 11.5). Descriptive statistics was used to describe factors contributing to parasite burden among the study population. ANOVA was used for comparisons between means and to determine variation in infection intensities. The significance level throughout was regarded as $P<0.05$.

RESULTS

Parasite prevalence

Endemic malaria, mainly caused by *P. falciparum,* which accounts for 99% prevalence of all malaria-infected cases appeared to be the main cause of malaria cases in the study

population. *Plasmodium falciparum* was predominantly prevalent in Ogal and Gongo primary schools. Only two cases (1.0%) of *Plasmodium*-positive children had *P. malariae* whereas 5.6% *of the* samples were found with schizont and gametocyte stages of *P. falciparum*. Infection rate in the other schools was below 20% (Table 1).

Schistosomosis due to *S. mansoni* was predominant among the parasites studied in all the schools. Ogal primary school had the highest infection rate of 75.9% followed by 55.7%, 48.9% and 45.6% in Nanga, Gongo and Kasagam primary schools respectively. Majority of the schistosomosis cases were caused by *S. mansoni* while only 0.4% were attributed to *S. haematobium* infection.

Soil transmitted helminthes (STHs) were common infections among children in all schools although hookworms was the least prevalent. Using morphological features, hookworm *filariform* larvae that were obtained after culturing hookworm positive stools for ten days revealed that *Necator americanus* was responsible for hookworm infection among the study population in Kisumu municipality. Soil transmitted helminths were more prevalent in Kasagam primary school than other parasites (Table 1).

Table 1: Overall parasite prevalence

	Gongo	Kasagam	Nanga	Ogal	Overall
P. Falciparum	48.9%	16.4%	18.2%	77.7%	49.2%
S. Mansoni	48.9%	43.8%	55.7%	75.9%	62.4%
N. Americanus	33.3%	56.4%	23.9%	11.4%	24.3%
A. Lumbricoides	35.6%	40.0%	23.9%	17.5%	24.3%
T. Trichiura	51.1%	40.0%	38.6%	26.5%	34.7%

Parasite infection by age and sex of the children

It was found out that girls were affected more with the parasites diagnosed than the boys as shown in Figure 1 particularly *Ascaris* and *Trichuris* infections in which girls had more than 55% and boys less than 40%. The children in ages between nine (9) and 14 years of age had high rates (above 14.5%) of parasite infections than those in 15- 16 age bracket (<10%) (Figure 2).

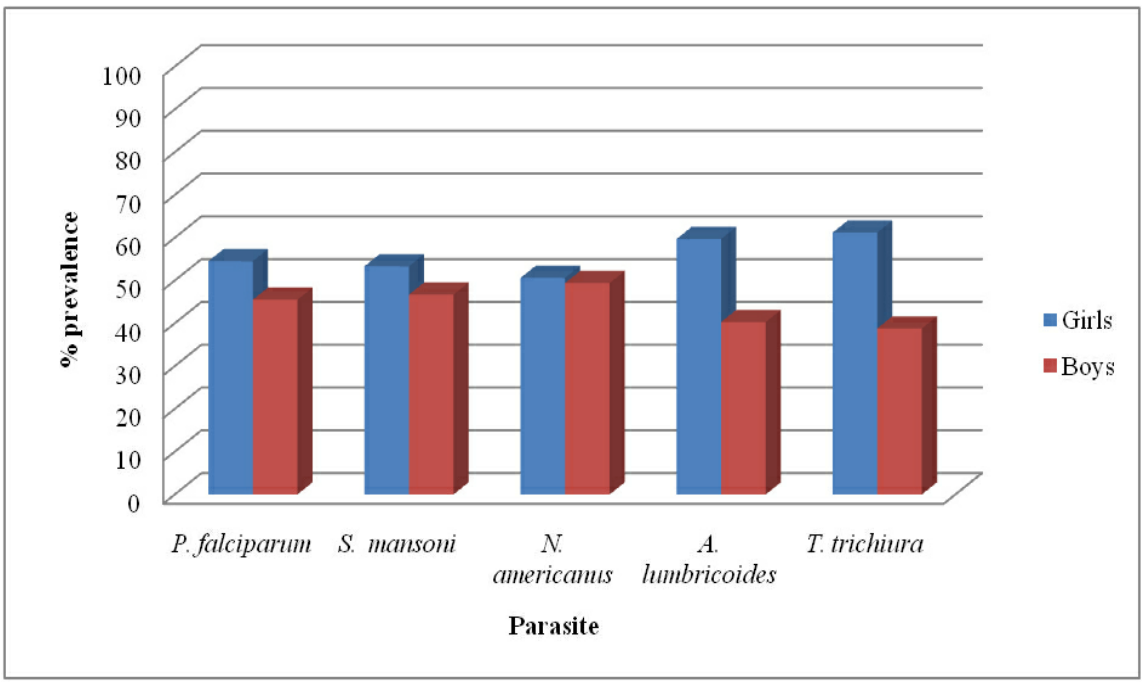

Figure 1: Parasite infection by sex of the children

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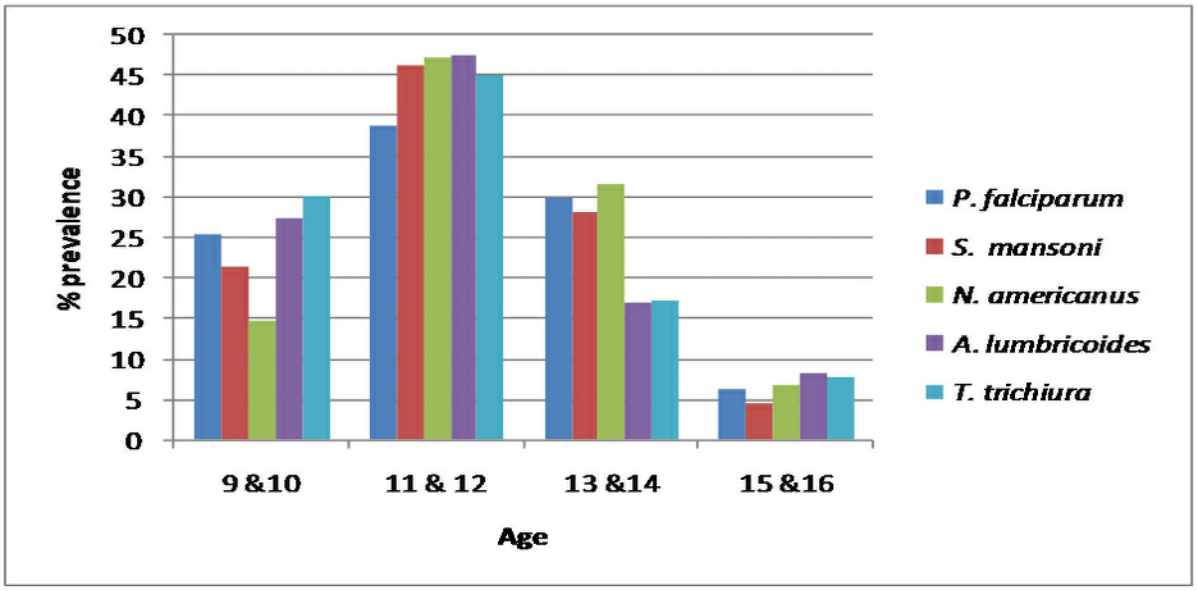

Figure 2: Parasite infection by age of children

Parasite intensity

Most of the infected children (34.7%, 25.8% 26.8% and 37.4%) had light intensity to *P. falciparum, S. mansoni, Necator americanus* and *T. trichiura* infections respectively compared to light and heavy infections (Table 2). Generally, high/heavy parasite densities were only observed in *P. falciparum* and *S. mansoni* infections particularly in Gongo

Infections	Kasagam	Nanga	Gongo	Ogal	Hospital	Overall
Light						
P. Falciparum	16.4	13.6	44.4	59	50	34.7
S. Mansoni	18.2	26.1	33.3	41.6	10	25.8
N. Americanus	21.8	23.9	33	10.8	10	26.8
A. Lumbricoides	21.8	12.5	8.9	6.6	13.3	12.6
T. Trichiura	38.2	38.6	46.7	25.9	0	37.4
Moderate						
S. Mansoni	12.7	11.4	13.3	22.3	0	11.9
N. Americanus	18.2	0	0	0	0	0
A. Lumbricoides	18.2	11.4	26.7	9.6	3.3	13.8
T. Trichiura	1.8	0	4.4	0.6	0	1.7
Heavy						
P. Falciparum	0	2.3	4.4	18.9	23.3	9.7
S. Mansoni	12.7	18.2	2.2	12	3.3	9.7
N. Americanus	0	0	0	0.6	0	0.6
A. Lumbricoides	0	0	0	1.2	0	1.2
T. Trichiura	0	0	0	0	0	0

Multiple parasite infections

Many children (84.8%) in the study harboured more than one parasite in them as shown in Figure 3. Some children (2.3 %) examined were infected with all the five parasites diagnosed. Majority of the children were co-infected with *P. falciparum,* and *S. mansoni* accounting for 19.3% (data not shown) and coinfection between *P. falciparum* and any helminth was equally high (40.5%).

Only 8.6% had none of the parasites diagnosed, which implied that the highest number of the children (91.4%) were infected with one or more different types of parasites (Figure 4).

Predisposing factors to parasite infection

The study sought to find out the factors that predispose children to parasite infection and it was found out that over 60% of the children from Nanga, and Kasagam primary schools had access to good sources of water (tap water or borehole), a toilet at home and wore shoes to school. On the other hand, children attending Gongo, Nanga and Ogal primary schools were at high risk of schistosomosis as over 40% swim, wash, and bath or assist the adults in fishing at Lake Victoria. Many households did not have toilet facilities as shown in Figure 5.

It was also noted that children from Kasagam primary school use water collected from runoff from the neighbouring Nyalenda slum at times when there was shortage of water for cleaning toilets at the school, exposing them to parasite infections particularly the soil-transmitted helminths (Figure 6). As many children as 63.2% (N = 266) were at risk of being bitten by malaria infected *Anopheles* mosquitoes because of lack of bed net use or mosquito repellents (Figure 7).

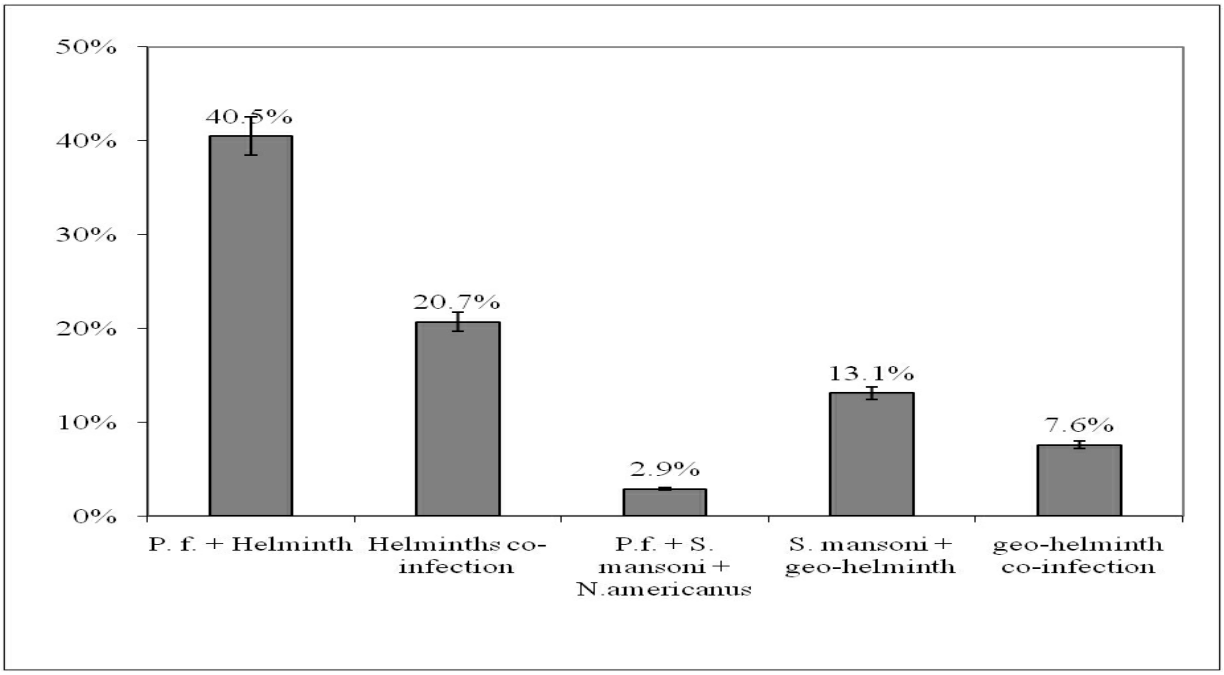

Figure 3: Prevalence of different parasite co-infections

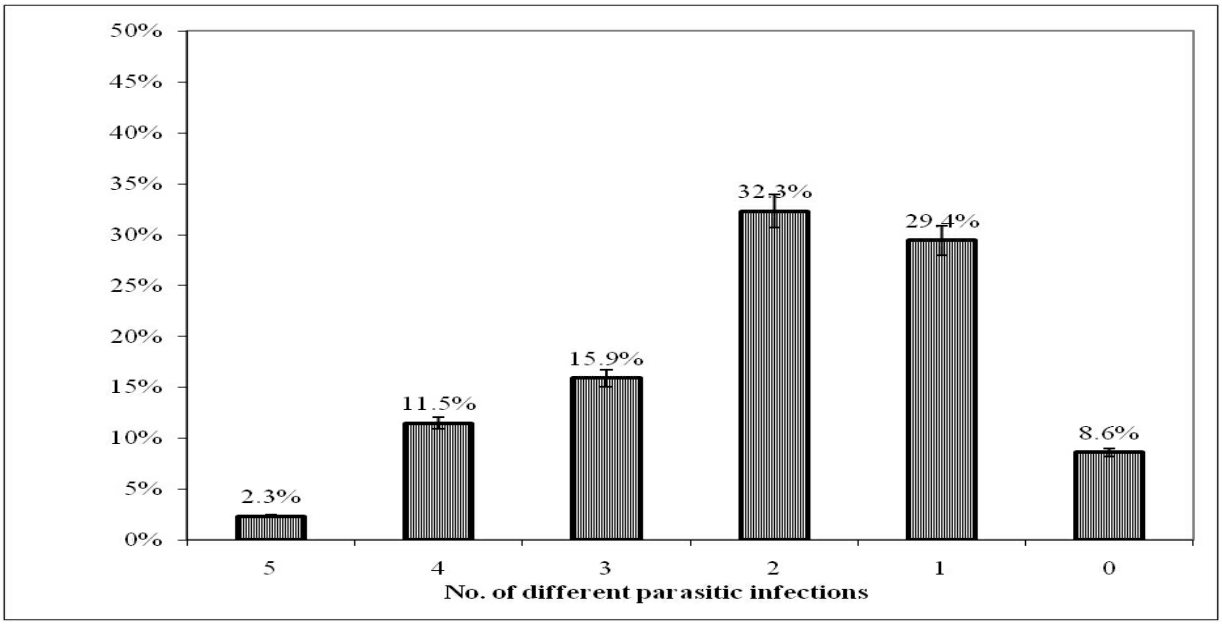

Figure 4: No of different parasite coinfections

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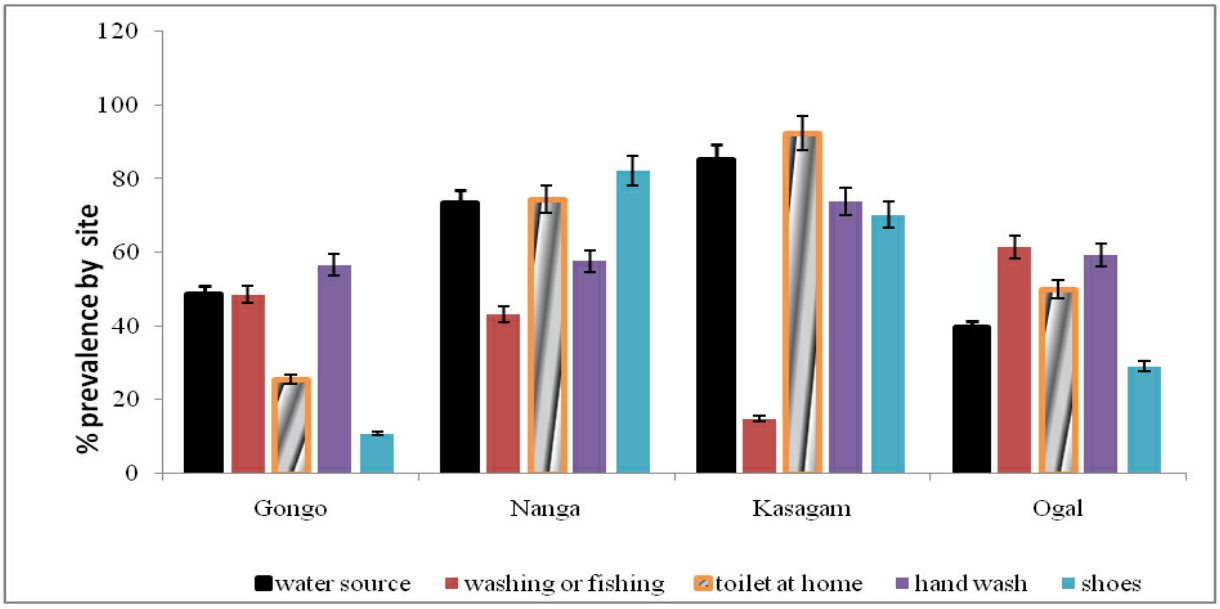

Figure 5: Risk factors to helminth infections

Figure 6: Dirty water running from neighbouring slums predisposes children to parasitic infection

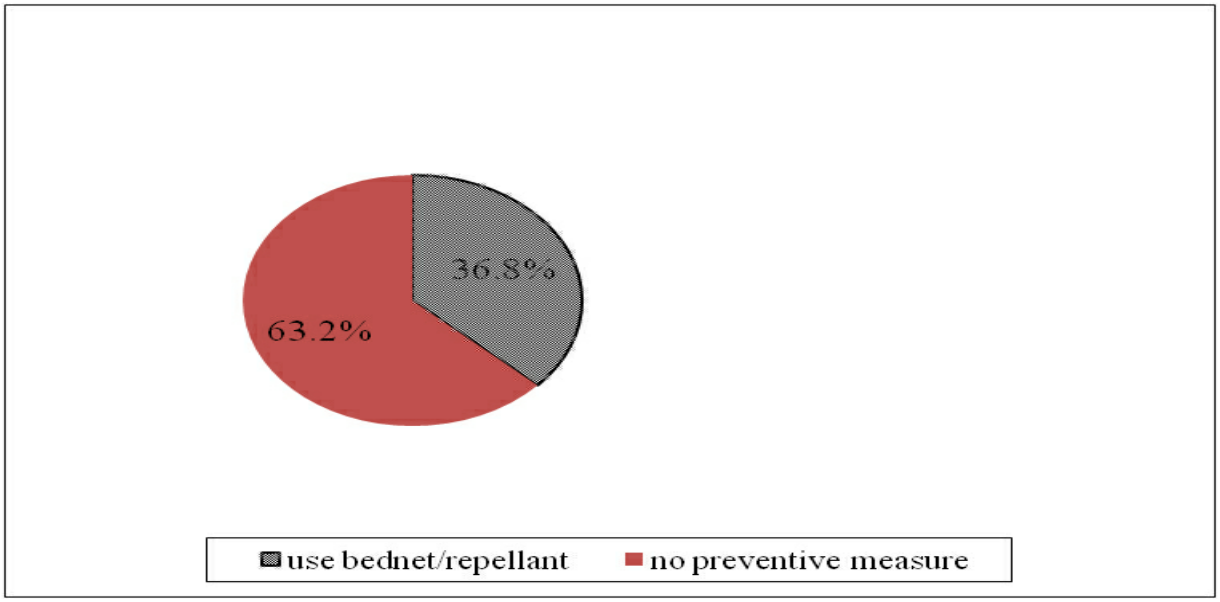

Figure 7: Insecticide Treated Net Use

DISCUSSION

The study confirmed the existence of polyparasitism among school going children in the study area. This case is likely to reflect infections in the general population in the regions surrounding Lake Victoria. In spite of the majority of the children having remarkably light infections to all the parasites diagnosed, a number of children had heavy parasite densities especially malaria parasitaemia and *A. lumbricoides*. There is increase evidence that even low or moderate intensity infection significantly retards childhood growth and development and on cognitive function of the children (Montressor et al., 2002 and Stephenson et al., 1989). Therefore, the impact of multiple parasitic infections particularly *P. falciparum* with schistosomosis and soil-transmitted helminths on cognitive function and child development cannot be underestimated in this population. The proximity to the Lake Victoria plays a role in transmission and sustenance of malaria and schistosomosis in this region by providing a habitat and breeding sites of *A. gambiae* and fresh water snails (*Biomphalari*a species) respectively. Children in this area have easy access to the lake and river water as they go about their daily chores. There was scanty presence of *S. haematobium* and it was not clear whether its infection was acquired elsewhere or there was focal point in which the parasite occurs.

Majority of the children (63.2%) do not use preventive measures against malaria such as using insecticide treated nets or repellents to reduce the chances of infection despite the government of Kenya's effort in providing free ILLN to communities living in malaria endemic areas, thus exposing them to infection. The presence of gametocytes in the blood of some children in this region is suggestive of high infectivity thus, implying that children play a role in *P. falciparum* transmission in this particular community an indication shown in previous studies (Gilles, 1993).

The occurrence of high rates of helminthic infections (schistosomosis, *N. americanus, A. lumbricoides* and *T. trichiura*), may perhaps be indicative of faecal contamination of the water sources and soils, which are important in completion of their life cycles. For instance, many children from Nyalenda slums are continuously being exposed to parasites due to lack of good sewage disposal and inadequate water supply in school as well as at residential areas that force them to use polluted run-off water. This also explains why the children had high prevalence of STHs. The high prevalence of schistosomosis among the children was not surprising as previous studies showed it as common especially among fishing communities (Smith et al., 1979). This is because majority of the children either wash, bath, swim or help their fishing parents, processes that expose them to *S. mansoni* infection. Most of the children residing near the lake were likely to be affected by *S. mansoni* possibly through higher cumulative exposure than their counterparts residing further away from the lake. This also demonstrates the role that the lake plays in the transmission of *S. Mansoni.*

The incidence rates of STHs particularly *A. lumbricoides* and *T. trichiura* were most pronounced among the younger children (9-14 years), revealing their vulnerability probably due to their young age whose immunity has not developed well. This age group are also likely not to observe proper hygiene, and are therefore more exposed to parasite infection than the older children are. The decline of parasite incidence rates with increasing age may be attributed to acquisition of immunity to parasites particularly to *P. falciparum* with continuous exposure (Montressor et al., 2002 and Hommel & Gilles 1998). There is no clear explanation as to why the results indicated high prevalence of *P. falciparum, A. lumbricoides* and *T. trichiura* among the girls than in the boys. The probable conclusion might be linked to the nature of girls' activities and duties like fetching water and cleaning are more exposed to parasite infections than the boys are or may be due to factors related to host susceptibility and immunological variability among different genders. High prevalence of *S. mansoni* and *N. americanus* among the boys is consistent with other previous studies (Kabatereine et al., 1999). The high prevalence of schistosomosis among the boys is not surprising since they spend more time in the lake either swimming or helping their parents who thrive their livelihood in fishing. The parasites intensity however, was statistically independent of sex of the children as was observed in previous studies (Brooker et al., 2000).

Previous studies on predisposing factors to STHs found lack of toilet facilities as a risk factor for intestinal helminths infection (Olsen, 2001). Therefore lack of good faecal disposal and lack of portable drinking water, could have contributed to high infection rates of STHs among the children. The children in the slum for instance wade through dirty water daily either going to school or while playing or going about their lives at home, a factor that exposes them to parasite infections. The study has demonstrated that the schoolchildren especially from the rural poor and impoverished urban areas are faced with wide infestation of parasitic infection, more commonly multiple parasite infection that impedes the health and development of the children.

CONCLUSIONS

The favourable environmental conditions coupled with poor lifestyles and sanitation plays a vital role in parasitic burden among inhabiting populations in these areas. The high prevalence of parasite infections among children (91.2% infection rate) is an important indication for the need to introduce three-month intervals of regular de-worming of the children. In addition, scaling up coverage of preventive measures to *P. falciparum* transmission by using insecticide treated mosquito nets (ITNs) in communities living in the study area is necessary in order to meet the "Roll Back Malaria" campaign control strategic framework. Measures that reduce *P. falciparum* and helminths infections and this will greatly reduced the prevalence and intensity of infection and debilitating consequences related to these parasitic infections.

RECOMMENDATION

There is need to provide appropriate preventive measures and mechanisms to ensure that these vulnerable groups get access to health services, safe water and good sanitation. In line with the findings, there is need to embark on control of helminth infections among school going children and be integrated in National malaria control program. More specifically is the need to treat regularly the infected

individuals to reduce morbidity, contamination of the environment and provision of sanitation facilities in schools and poor urban setting especially in endemic areas. Changing of policy in treatment of only malaria symptomatic individuals needs to be changed so as to include also those with asymptomatic parasitaemia so as to reduce human reservoir as stated previously (Geiger et al., 2013).

COMPETING INTERESTS

All authors declare they have no competing interest in the study

AUTHORS' CONTRIBUTIONS

EM conceived, developed concept, collected data, participated in data entry and analysis. RO, JK and CM supervised the entire work, edited the final manuscript. SP administered questionnaire, and participated in data analysis.

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