Post-treatment Prevalence of Schistosomiasis and Geohelminthic Infections in Children and Adults Living along Lake Victoria, Kenya

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Abstract

Schistosomiasis and geohelminthic infections are major public health problems in developing countries and exert a heavy burden on morbidity when they occur singly or concurrently. Chemotherapeutic approach has been adopted in many endemic areas, using praziquantel and albendazole, based on World Health Organization (WHO) recommendations for control. The need for cost-effectiveness considerations in control strategies requires that greater emphasis be placed on further research to understand the factors that determine their occurrence and response to chemotherapy when they occur singly or concurrently. Towards this, a longitudinal survey in Kisumu and Siaya counties, Kenya, was conducted to assess the post-treatment prevalence of *Schistosoma mansoni*, *Trichuris trichiura, Ascaris lumbricoides* and hookworms in school children (9–12 years) and adults over a 9-month period (September 2008 – May 2009). Adults were followed up monthly, while children were followed up every two months. Baseline prevalence of schistosomiasis was 52.0% $\pm$ 2.5% in adults, and 38.5% $\pm$ 1.8% in children while that of geohelminthiasis was 22.5% $\pm$ 3.9% and 55.6% $\pm$ 4.1% in adults and school children respectively. The difference in prevalence between the adults and children for both schistosomiasis and geohelmithes was not significant (*P*=0.9302), After 9 and 5 treatments in adults and children respectively, there was reduction in prevalence of schistosomiasis to 28.9% $\pm$ 2.3% and 24.0% $\pm$ 3.1% in adults and children respectively, while in geohelminthiasis prevalence reduced to 4.3% $\pm$ 1.5% in adults and 27.0% $\pm$ 2.5% in school children. These difference in prevalence among adults and children was not significant (*P*=0.8717). This study shows the differential occurrence of schistosomiasis and geohelmiths in children and adults. It also shows that frequent and consistent treatment decreases the prevalence of helminths in endemic areas and is effective both in adults and children. There's however need for further studies to determine the most cost-effective strategies for mass drug administration, that will impact morbidity caused by helminths to sustainable levels in vulnerable groups.

Keywords: praziquantel, albendazole, prevalence, *Schistosomiasis*, geohelminthes.

Introduction

*Schistosomiasi*s and geohelminthiasis are major public health problems in developing countries (Mazigo *et al.,* 2010). The impact of the burden of these diseases is usually underestimated. About 200 million people are infected with schistosomes worldwide while about two billion people living near the lake regions globally are at high risk for infections with intestinal parasites (Gryseels *et al.,* 2006). In sub-Saharan Africa, *Schistosomiasis* is widespread with foci of high prevalence and high morbidity found adjacent to rivers, lakes and irrigation schemes. According to World Health Organization's (WHO), 2011), there is an estimated 9,152,972 people infected with schistosomiasis in Kenya, while an estimated 12 million people remain at risk of acquiring the infection (WHO, 2007).

Schistosomiasis rarely occurs singly in the lake region, and concurrent geohelminthic infections in this region have been largely unexplored. More epidemiological studies are necessary to understand the impact of any public health intervention, particularly the post-treatment prevalence among the high risk groups in endemic regions.

In 2001, the WHO urged member states to ensure access to essential drugs against helminthiasis for vulnerable groups in endemic areas (WHO, 2011). The best strategies for implementing this strategy have not been clearly defined. Approaches that could be taken could either target school-children or adults and non-school going children in the community. School aged-children are more accessible and present a more cost effective strategy for chemotherapy and health education given the already existing school infrastructure (Montresor *et al.*, 2002; Savioli *et al.,* 2002). In either situation, an assessment of post-treatment prevalence is important in order to establish if the control strategy being employed is effective. If not, new guidelines can be developed to be used by public health researchers as tools for intervention.

Previous studies on the prevalence of schistosomiasis and geohelminths along the shores of Lake Victoria have been done but the justification of the frequency and duration of mass drug administration are not well defined although they are dependent on the outcome of the treatment. The drugs praziquantel and albendazole have been used for the treatment of schistosomiasis and geohelminths in the lake region but the outcome and impact are not well documented. A study was undertaken to determine the pre and post treatment prevalence of schistosomiasis and concurrent geohelminth infections among school children, car washers and sand harvesters residing in close proximity to Lake Victoria in Western Kenya.

Materials and Methods

This study was conducted between September 2008 to May 2009 in Kisumu county (0^{0}6S; 34^{0}45E) and Asembo Bay (0^{0}18S, 34^{0}38E), located within 3 km of Lake Victoria in Nyanza region, Kenya. The climate of these areas is hot all year (28^{0}C). Rainy seasons are experienced between March and June and in November. The study was reviewed and approved by the Scientific and Ethical Review Committees of the Kenya Medical Research Institute, and study participants were recruited into the study following written informed consent by the adults, and parental informed consent and children's assent in the case of the school children.

Study participants were sampled purposively and the sample size determined as described by Handzel *et al.,* 2003. The adult study participants comprised of 157 individuals, aged over 18 years old and engaged in economic activities which exposed them to lake water; specifically washing cars (68 adults) and harvesting sand from the lake (89 adults). One hundred and four (104) school children aged 9-12 years, and attending school in close proximity to the lake were included in the study.

Each study participant submitted 10ml of urine and 200 mg of stool in the morning for schistosome and geohelminths testing. All specimens were processed within six hours of collection. Each stool specimen was analyzed in duplicate by the Kato-Katz method for eggs of *S. mansoni, A. lumbricoides, T. trichiura,* and hookworms. Urine specimens were tested for the presence of haematuria as a proxy indicator for *S. haematobium* infection using Ames Hemastix strips (Miles Inc.).

Individuals testing positive for schistosomiasis were treated with praziquantel (40 mg/kg) and those testing positive for geohelminths were treated with albendazole (400 mg). Both drugs were used in concurrent infections. For adults, follow-up stool samples were taken every four weeks post-treatment, and those who were still excreting eggs were treated again. Follow-ups and retreatments continued every 4 weeks upto the end of the study period. Due to logistical complexity of following up children in school, and taking up school time, the same procedure of sample collection, examination and treatment for positive cases was followed for children every 8 weeks for 9 months. Cure rate was defined as the children and adults who were positive for helminthic infection before treatment and negative during follow ups. There was a total of 9 follow ups for adults and 5 for school children including the initial sampling at the beginning of the study.

Results and Discussions

The 68 male car washers, 89 male sand harvesters and 104 school children (both male and female, 9-12years old) experienced a total of 111, 194 and 112 infection episodes respectively over the course of 9 months (September 2008 to May 2009). Mean number (mean $\pm$ standard error of the mean (SEM) of infection episodes within this period for schistosomiasis per individual was 4.9 $\pm$ 1.7 in car washers, 3.5 $\pm$ 2.2 in sand harvesters and 1.5 $\pm$ 1.1 in school children.

The baseline prevalence of schistosomiasis among car washers, sand harvesters and school children was 63.0%, 41.0% and 38.5% respectively, while that of individuals harbouring at least one type of helminthic infections was 17.8%, 27.2% and 55.6% respectively. Multiple infections of schistosomiasis and geohelminths occurred equally among car washers and sand harvesters but were higher in children. In case of single infections, *S. mansoni* was the most prevalent as indicated above followed by hookworm at 1.5%, 2.3% and 12.5% in car washers, sand harvesters and children respectively. There were no cases of *S. haematobium* among adults but only 2.9% among children. The prevalence of geohelminths was 55.6%, 17.8% in car washers (17.8%) (P>0.05) and 27.2% in sand harvesters (27.2%) (P>0.05).

After treatment, there was decreased prevalence over time (Fig. 1). This was most evident among car washers where the overall helminth prevalence dropped by 47.0% (t=0.6760, P=0.0119) as compared to that in sand harvesters which dropped by 35.6% (t=0.7443, P=0.1455) and in school children by 43.1% (t=0.9606, P=0.1652). Cases of single *S. mansoni* infection persisted in all groups although there was considerable decrease in prevalence ($p<0.05$). *S. mansoni* prevalence dropped by 32.2% in car washers, 14.0% in sand harvesters and 14.5% in school children. There were no cases of *S. haematobium* infections in children during the first follow-up.

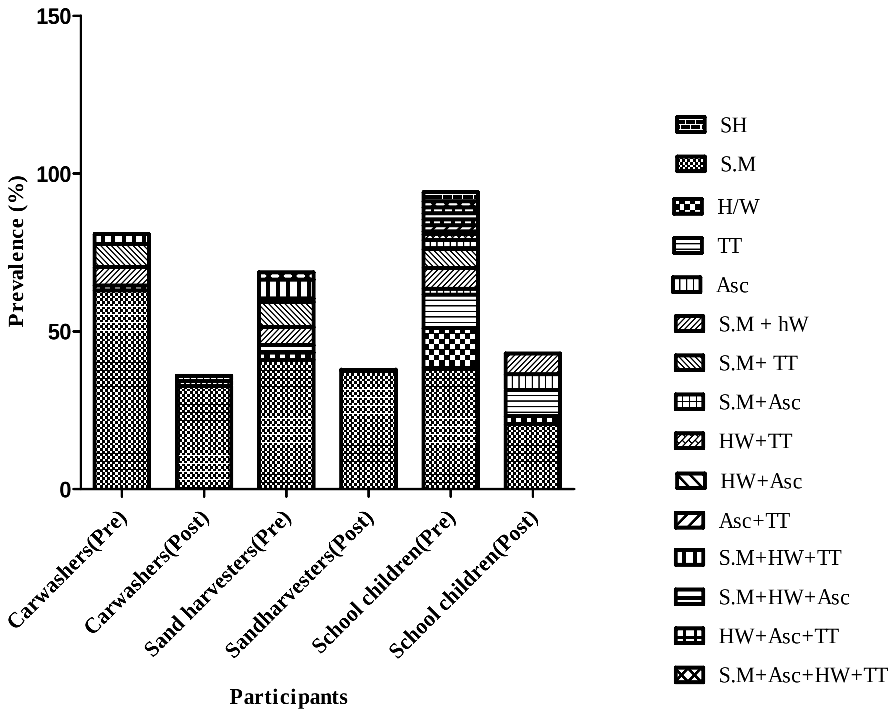

Figure 1: Prevalence of schistosomiasis and geohelminths
(S.M - *S. mansoni*, H/W – Hookworm, TT – *T. trichiura*, Asc - *A. lumbricoides*)

All age groups had a moderate intensity of infection at baseline. During the first follow-up in car washers there was an increase in *S. mansoni* epg but during the subsequent follow-ups, there was considerable reduction in the epg (*P*=0.0033). The baseline epg for car washers was 208 $\pm$ 56 before treatment. After the first treatment, it increased to 294 $\pm$ 57 though the increase was not significant (*P*>0.05) and by the ninth follow-up the epg had dropped significantly to 4 $\pm$1 (Fig. 2). The baseline *S. mansoni* epg among sand harvesters was 256 $\pm$ 56 and decreased to 7 $\pm$ 2 epg after treatment. However during the first follow-up, there was a slight increase in epg to 299 $\pm$ 48 and from the second to the ninth follow-up the epg reduced considerably (*P*=0.0002) (Fig. 2). In school children, there was a significant reduction in *S. mansoni* epg over time (*P*<0.0001). During the third follow-up, there was an increase in *S. mansoni* epg but this increase was not significant (*P*>0.05) (Fig. 2). The baseline epg of children was 347 $\pm$ 72. This reduced to 97 $\pm$ 19 during the first follow-up and this trend was observed to the end of the study except during the third follow-up where the epg slightly increased from 45.8 ± 2.1 to 62.5 ± 2.9 (Fig. 2). At the end of the study period the epg had reduced significantly to 19 ± 11 (P<0.0001). This reduction in epg was lower than that in adults though it was not significant. Generally, there was significant reduction in *S. mansoni* epg over the 9 months period among car washers (F=2.821, P=0.0033), school children (F=18.04, P<0.0001) and sand harvesters (F=3.751, P=0.0002) with the overall reduction in epg after the last treatment being 98.2%, 97.3% and 94.5% among car washers, sand harvesters and school children respectively.

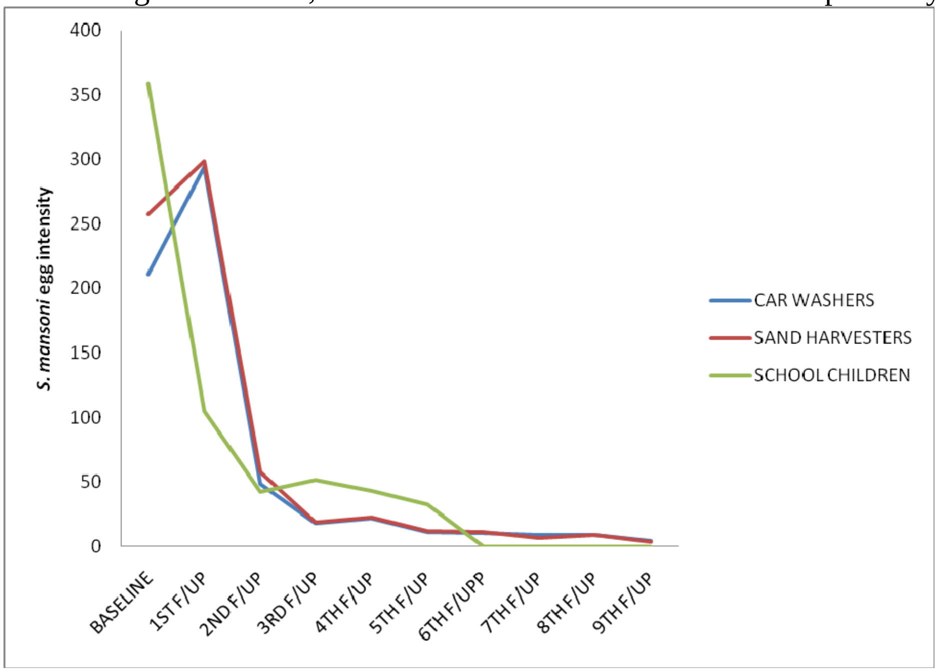

Figure 2: *Schistosoma mansoni* egg intensity in multiple follow-ups among study participants

After 9 follow-ups in adults and 5 follow-ups in children, the overall reduction in schistosomiasis was 87.0% in sand harvesters, 82.0% in car washers 70.0% in school children while the overall reduction in geohelminthiasis was 79.0% in sand harvesters, 83.0% in car washers and 86.0% in school children. The overall reduction in *S. mansoni* epg after the last treatment was 98.2%, 97.3% and 94.5% among car washers, sand harvesters and school children respectively (Fig. 2) (P<0.05). The *S. mansoni* epg reduction in children was lower than that in car washers and sand harvesters but this difference was not significant. Similar trends were observed in the prevalence of geohelminths which reduced considerably faster than the prevalence of schistosomiasis (P=0.0033).

Regardless of the presence of many geohelminthic species, the prevalence of schistosomiasis varied significantly (F=25.43, P<0.0001) among the different groups of participants. Children had the highest prevalence of geohelminthic infections (55.6% ± 4.1% pre-treatment and 27.0% ± 2.5% post-treatment) and the lowest prevalence of *S. mansoni* infection (38.5% ±1.8% pre-treatment and 24.0% ± 3.1% post-treatment). Car washers on the other hand had the highest prevalence of *S. mansoni* infection (63.0% ± 1.3% pre-treatment and 30.8% + 1.1% post treatment) and the least prevalence of geohelminthic infections (17.8% ± 2.0% pre-treatment and 3.0% ± 0.8% post treatment). Although the prevalence of *S. mansoni* infection before treatment was higher in individuals who had geohelminths than those without, after treatment, it decreased concomitantly with decrease in the number of geohelminths (P>0.05) (Fig. 3).

Discussions

Concurrent infections with *S. mansoni* and geohelminths even in low-moderate intensities have impacts on the health of individuals. Studies have indicated that the odds ratio for having anaemia increase when children are infected with *S. mansoni* and two to three intestinal helminths compared with children with a single parasite species (Brito *et al.,* 2006). This study of co-infections of *S. mansoni* and geohelminths showed that, baseline infection of *S. mansoni* and geohelminths was moderate. Prevalences of over 20% for schistosomiasis and the geohelminths was highest among all study participants. Schistosomiasis is a water-borne disease and the study participants spent most of their time in infested waters at specific times when cercariae found suitable hosts to infect.

Presence of geohelminths was mainly due to lack of sanitary facilities. Only 2.9% of *S. haematobium* cases were observed among school children. These students could have been exposed to the causative agents elsewhere and moved to the study sites after being infected. Studies have shown that prevalence of *S. haematobium* increased with distance from the lake (Lwambo *et al.,* 1999) yet this study was carried out within 3 km of the lake.

After treatment of participants over the 9-months period, there was significant reduction in prevalence (P<0.05) but *S. mansoni* infection persisted. This can be due to increased exposure of participants to the sources of infection and increased transmission in the infested waters. Persisting geohelminth infections can be explained by poor sanitary facilities, unsanitary practices and poor personal hygiene. Variation in seasons could also favour the free-living helminthic stages to transform to parasitic stages

(Nguhiu *et al.,* 2009) which will infect participants and lead to increased prevalence rates. A similar study carried out in Nigeria (Olsen *et al.,* 2009) had comparable results where multiple infections were attributed to poor personal hygiene, poor environmental sanitation leading to contamination of soil and water sources.

After treatment of participants, there was a consistent downward trend towards decreased prevalence over time. Initially, there were low cure rates among all subjects and at times there was re-infection. These variations could be due to four factors; high intensity in infection, high transmission of infection, lack of previous immunologic response to schistosomes and geohelminths and underdeveloped immune system. However, after three doses of praziquantel and one dose of albendazole, cure rates were well above the generally accepted efficacies of 80 – 90% for praziquantel and 83% for albendazole. (Li *et al.,* 2000a; Li *et al.,* 2000b; Katz *et al.,* 2006).

A similar study carried out in Senegal, yielded cure rates between 18-39%; the lowest cure rate reported at the time and way below the expected cure rate of 70-90% (Gryseels *et al.,* 2006). Underdeveloped immune system and high intensity due to high parasite load were used to explain the trends observed in this newly exposed Senegalese population. As seen by others (Kabatereine *et al.,* 2003: Stothard et al. 2009), it was found that higher intensities of infection were significantly associated with the inability to complete cure.

The highest cure rates were observed in car washers while the lowest was in children. Children could be more vulnerable to parasitic infections and get re-infected faster than adults. Children immune systems are also naive or underdeveloped compared to that of adults thus their ability to complete cure takes a longer rime and they may not easily fight infections as readily as adults (Naus *et al.,* 1999). Children also received fewer treatments than adults but the end result was not statistically significant. This could be used in other studies to determine cost effective frequencies for mass drug administration strategies.

The data presented here provides evidence that treatment of schistosomiasis and geohelminthiasis reduces the number of eggs released into the environment and the number of infected snails in the water. Contamination of the soil in the surrounding environment is also reduced thus reducing transmission of geohelminths and reducing the risk of getting re-infection among the study participants. In this study the reduction in helminthic prevalence over the 9-month period was significant in all study participants

(*P*<0.05) i.e. in car washers (*P*=0.0033), sand harvesters (*P*=0.0002) and school children (*P*<0.0001). Some individuals who were highly susceptible continued to acquire infection at the same high frequency throughout the study. Since everyone is not treated simultaneously, the remaining subjects can serve as human reservoirs and eliminate eggs thus continue transmission of infection. Other people apart from the study subjects may also contribute to the transmission and there may be need to treat the whole community to ensure that transmission is totally interrupted. This will be cost effective in the long run since the sources for re-infection will have been reduced

Clustering of *S. mansoni* infections near Lake Victoria and the epidemiological data associating frequency of water contact with *S. mansoni* infection indicates that the lake is the sole or primary source of infection (Handzel *et al.,* 2003). The prevalence of *S. mansoni* has been associated with proximity to Lake Victoria while the prevalence of *S. haematobium* increases with distance from the lake (Lwambo *et al.,* 1999). While schistosomiasis tends to share a focal distribution, little is known regarding the spatial distribution of hookworm, roundworm and whipworm infections (Guararie *et al.,* 2005).

Low cure rates of geohelminths could be attributed to high transmission of infection due to unhygienic and unsanitary practices by most of the subjects, and climatic conditions that favour distribution of infective parasitic stages of the geohelminths. Children had the highest numbers of geohelminths before and after treatment because children practice many unhygienic practices than adults making them susceptible to various geohelminthic infections and would also increase their chances of getting re-infection. In a different study in Uganda, low efficacies were reported for albendazole against *T. trichiura* which were not cleared over a 6-month period of treating infected respondents (Olsen *et al.,* 2009). This was not the case in this study since the geohelminth that recurred to the end of the study (and probably did not respond to albendazole well) was *A. lumbricoides*

Before treatment, *S. mansoni* epg was generally higher in individuals with other helminths than those without. This decreased concomitantly with a decrease in the number of geohelminthic species. Before treatment, the presence of one parasite could increase a person's susceptibility to another parasite due to a compromised immune system or impaired nutritional status. Most helminth infections have an impact on the nutritional status of an individual increasing their susceptibility. When an individual is treated, of both infections, the nutritional status usually improves thus improved immune responses if there is no re-infection. This means that combined treatment is the best way forward for these coexisting infections to reduce their prevalence. The cost of combined control is usually lower since schistosome and geohelminthic infections are highly prevalent in the same communities (Koukourani, 2006) as seen in this study population.

An earlier study has shown that nutritional status improves after treatment of *Schistosoma japonicum* infected children. (Coutinho *et al.,* 2006). It is therefore possible that when the nutritional status improves, immune responses will improve and a person's resistance to water- and soil- borne infections will also increase. A similar study showed that infection intensities of different species were positively correlated, and individuals with single-species infections had lower species-specific egg counts than individuals with multiple-species infections**.**

In conclusion, this study has shown that frequent and consistent treatment of water- and soil- borne infections reduces prevalence and epg of parasites among participants in highly endemic areas. This reduction was more evident in adults who were treated monthly compared to children who were treated on alternate months. Despite the fewer treatments of skipping a month in between, the end result was not statistically different, and therefore this could be an argument for studies to determine cost effective frequencies for mass drug administration strategies.

These findings highlight the need for further studies to determine the safest and most cost-effective frequency for mass drug administration that would impact morbidity caused by schistosomiasis and geohelminths. Treatment programs should also include socio-economic development and efforts to improve sanitation as an approach to improve health and poverty reduction.

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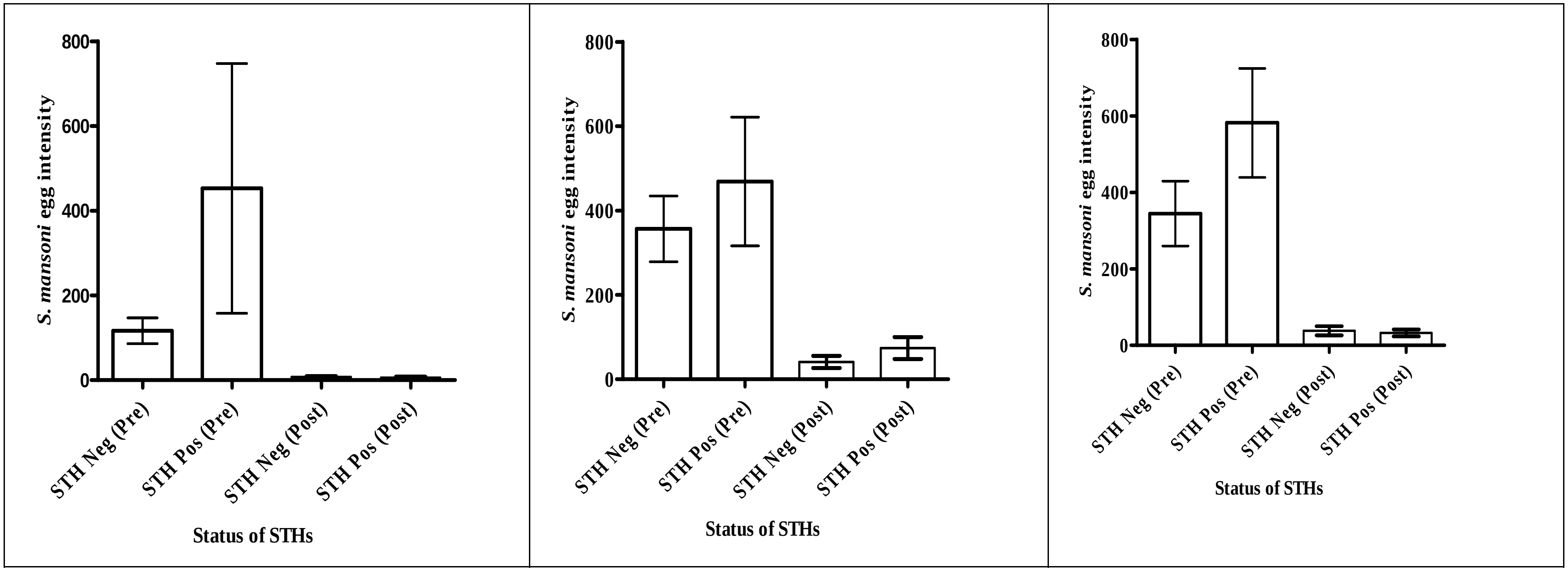

Figure 3: Effect of geohelminths on *S. mansoni* epg among study participants

STH Neg (Pre) – Negative for soil-transmitted helminths (Pre-treatment), STH Pos (Pre) – Positive for soil-transmitted helminths (Pre-treatment), STH Neg (Post) -Negative for soil-transmitted helminths (Post-treatment), STH Pos (Post)- Positive for soil-transmitted helminths (Post-treatment).