Effectiveness Of Albendazole On Soil Transmitted Nematodes Among School Children- *A Case Of Kakamega County, Kenya*

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Summary

BACKGROUND

Recent assessment by WHO on Soil Transmitted Nematodes (STN) point that their morbidity is still high in people mainly in children. *A. lumbricoides* **globally infects 1.2 billion people and** *T. trichiura* **795 million worldwide. Infections with** *Ancylostoma duodenale* **and** *Necator americanus* **740 million leading to 135,000 deaths per year. It became necessary to find out the effectiveness of** *Albendazole* **on soil transmitted** *Nematodes* **among school children- a case of kakamega county, kenya.**

METHODOLOGY

Study respondents were selected fom public primary school children in Kakamega County. A total of 731 and 665 (pre & post) children in 7 primary schools in three sub counties of Kakamega County were recruited in the study.

Pre-treatment survey was done in March, 2014 and follow up in September 2014. Fecal samples were examined for the presence of STN . 14 days after treatment using *Kato- Katz method.* The total number of eggs were expressed as *eggs/gm* of feaces (epg). Pretreatment prevalence was 43.5% for *Ascaris lumbricoides,* **1.8% for hookworm and 0.9% for** *Trichuris trichiura.*

RESULTS

Mean intensity of hookworm, *A. lumbricoides* **and** *T. trichiura* **infections in the pre-and post-surveys were reduced by 1.2%, 98.4% and 100% respectively. Prevalence decreased to 2.3% for** *Ascaris lumbricoides* **and 0 % for** *T. trichiura.* **Post treatment prevalence of** *A. lumbricoides* **and** *T. trichiura* **infections were significantly reduced by 94.8% and 100% respectively. A slight increase in hookworm prevalence was observed. However, this increase was not significant (p=0.993).**

CONCLUSION

The therapeutic efficacy of *Albendazol***e indicated a good reduction in parasite burden.** *Albendazole* **satisfactorily reduced STN infection while for hookworm there was a non-significant increase in prevalence.**

Key words: Cure rate, egg reduction rate, *albendazole*, Kenya

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Introduction

Recent assessment by WHO on Soil Transmitted Nematodes (STN) point that their morbidity is still high in people mainly in children (1).

It is estimated that *A. lumbricoides* globally infects 1.2 billion people, *T. trichiura* 795 million and infections with *Ancylostoma duodenale* and *Necator americanus* have reached 740 million people [1].

Mortality numbers due to STNs have almost reached 135,000 deaths per year, mainly due to infections with the hookworms, or the roundworm, *Ascaris lumbricoides* [2].

Preschool-ages account for about 270 million infections with ST*H*s and more than 600 million school-age children live in endemic areas of high transmission rate [3]. Soil transmitted *helminths* infections have enormous effect on cognitive ability and education of children. Poor countries have registered about 200 lost years related to absenteeism in school due to *helminths* infections [3].

Parasitic worm burden has caused intellectual deficits in low and middle income countries [3].

Soil Transmitted *Helminth* infections management and control is enhanced through mass treatment, health education and improved sanitation facilities and practices.

Due to the safety of *Anthelminthic,* the World Health Organization (WHO) allow regular (Mass Drug Administration) of single-dose of *Albendazole* 400mg (**ALB**) and *mebendazole* 500mg [7], prior to individual diagnosis in endemic regions in order to break transmission cycle and reduce morbidity [4,5, 6].

This has proved to be an inexpensive ` and appropriate approach to control and reduce the infection intensity levels.

Benzimidazole drugs (*albendazole* and *mebendazole)* have significant effectiven against *A. lumbricoides* (>98%) [12]. It is worth noting that *albendazole* has low efficacy against *T. trichiura*, while mebendazole (MBD) has been observed, in some cases, to be less efficacious against hookworms [12].

Besides, *albendazole* has been reported efficacious against T. trichiura in cases of low fecal egg counts [20].

However, where infection intensity is high, albendazole has not been effective on *Trichiuriasis* [20]. *Helminthiasis* is an outstanding neglected tropical disease and efforts of its control have recently been scaled up globally [8].

World Health Organization **(WHO)** laid foundation for the control soil transmitted *helminthiasis* [5]. This has led to the London Declaration [9] where powerful influential administrations, private organizations and Pharmaceutical companies pledged their support for the implementation of World Health Assembly ***(WHA) resolution 65.2.1***

Aim at creating avenues to source means for control of STNs both from international community and its member states [9].

Treatment based control programmes target school age children have been established. However, children under one year and pregnant women in their first trimester of pregnancy are not qualified for treatment under these programmes [10].

Both the scientific and political world has guaranteed support for control of Neglected Tropical Diseases [11].

Studies on possible resistance to major *Anthelminthic* drugs **(AR)** in livestock have raised concern that this could occur in human beings [11].

Observed drop in hookworm egg reduction rate in school children in Zanzibar after treatment with MBD suggest possible resistance [13]. Similar observations have been witnessed in Mali and in north-west Australia [11, 14].

Drug resistance in human *helminthiasis* has so far not been conclusively documented unlike in livestock, however there is need to closely monitor extensive use of *antiheminthic* in terms of dosage, target populations and treatment frequency that may influence efficacy [14]. These factors may contribute to advancement of *Anthelminthic* Resistance in STN.

It is possible that current control strategies may affect drug effectiveness due to exerted drug pressure that may evolve *Antihelminthic* drug resistance. The recommended method for monitoring the efficacy of *Anthelmintic* drugs against STHs is egg reduction rate [16].

In livestock, effectiveness of *Anthelminthic* is established through dosage determination and consistent experimental situations such diagnostic methods [17].

Egg reduction rate has been preferred to cure rate as the best indicator in determination of *Anthelminthic* effectiveness in human *helminthiasis.*

Furthermore, in an effort towards elimination of all parasites, cure rate is may not suitable indicator in high intensity infections unlike in low intensity infections especially when the same drug is used [8].

This study aimed at assessing the effectiveness of albendazole currently in use in the control of soil transmitted *helminths* in Kakamega county, Kenya.

Materials And Methods

Study Site

The study site was Kakamega county Western, Kenya. This region is characterized with varied physical geographical features. This extends from the hills of northern Bungoma County to Busia County that borders Lake Victoria.

The highest physical feature is Mount Elgon whose peak is at an altitude of 4,302 metres (14,114 ft), while the lowest point is the town of Busia at an altitude of 1, 200 metres. Subsistence and large-scale sugar cane farming are practiced in this area. It has a population of 1,660,651 people [20].

Tropical climate is predominant in the county despite variations due to with different altitude. It is located at 00°20'N 34°46'E with an area of 3,033.8 km.

Study Design

This was cross-sectional study involving public primary school children in Kakamega County. The schools were from three different districts, Kakamega South, Kakamega Central, and Kakamega East. The schools were selected randomly.

Samples were collected and examined for STN from infected naturally school-age children. If one parasites was present at a low prevalence (e.g. less than 10%) it is not considered to be of public health importance, and assessment of *anthelminthic* drug effectiveness against this parasite is not considered necessary [21].

Study Population

A total of 1,396 children in 7 primary schools in three sub counties of Kakamega County were recruited in pre and post treatment study.

Pupils in Early Childhood (ECD) class two, to class six from Kakamega South, East and central sub county formed the study group
.

Pupils from public primary schools and not under any treatment were included in the study. Those who had been dewormed within the last three months and on some treatment were excluded from the study.

Children below 4 years and above 16 years were also excluded. The head teacher from each school provided pupils' registered list and parents confirmed the age of their children when obtaining the informed consent. Parents and guardians for the lower primary provided information. Incase any pupil was on any treatment.

In total of 731 Pre-survey and 665 Post – survey children in 7 schools were included in this study.

Parasitological Examination

Children were given a single dose of *albendazole* 400 mg. Fourteen days after the drug intervention, fresh stool samples were examined for *helminths* based on double 47.1mg ***Katz*** smear [22].

Fibrous material were removed using 250µm metal sieve. Sieved stool collected was scooped to fill a template. A piece of cellophane soaked in glycerine malachite green was pressed and spread uniformly.

The slides were observed under the microscope before duration of one hour was over for hookworms to avoid clearing of eggs. For the eggs of other helminths, examination was done later. Overall numbers of eggs were expressed as eggs/gm of feaces ***(epg).*** Random examination of 10% of the daily examined ***Kato- Katz*** slides was performed by the team leader.

Statistical analysis

Prevalence of each STN species was calculated at school, and sub county levels. Confidence intervals (95% CI) were obtained by binomial logistic regression, considering clustering by schools. To test the significance, Wald test was used to compare prevalence by location, age group and sex [23].

In this study, age groups were used for the purpose of analysis were, 4–5, 6–7, 8–9, 10–11, 12–13, 14-16 year-olds [23].

Determined mean egg counts were expressed as arithmetic mean eggs per gram. Infection intensities were categorized based on WHO guidelines, into light, moderate-heavy infections [14].

Prevalences of infections were calculated by binomial logistic regression [24, 25].

Results

Overall, 1,396 children were examined in 7 public primary schools for pre and post treatment survey across 3 sub-counties in Kakamega County, Western Kenya.

Different schools and children per sub-county are recorded (***Table 1***). Information on age of children was obtained for all the participants in the study and ranged between 4 to 16 years with a mean age of 10 years (*Std = 2.6* years).

Gender information was also collected for all the participants. 700 children were of male gender (50.2%) and 695 were females (49.8%) ***(Table 1).***

Stool samples were collected and processed by Kato- Katz technique method. In total, 731 children and 665 provided stool samples both at baseline and at follow-up surveys respectively and were included in the analysis.

Table 1: *Children and Schools Surveyed in each Sub-County: Pre and Post Treatment*

Sub County	Pre-treatment		Post-treatment	
	No. schools	No. children	No. schools	No. children
Kakamega South	2	208	2	188
Kakamega East	3	311	3	291
Kakamega Central	2	212	2	186
TOTAL	7	731	7	665

Soil Transmitted *Helminths* (STNs)

Prevalence and Intensity since pre to post treatment

Overall in Pre-Treatment, *Ascaris lumbricoides* was the most predominant STN species, with 43.5% (95% CI: 35.2 – 53.7) of children infected, followed by *Trichiuris trichiura,* with 0.8% (95%CI: 0.4 –1.8) infection and hookworm with 0.3% (95% CI: 0 – 1.9) infection.

The combined STN prevalence was 44.0% (95% CI: 35.8 – 54.2). At Post-Treatment, the combined STN prevalence reduced to 2.3% (95% CI: 1.3 – 3.8) and *Ascaris lumbricoides* still remained the most prevalent STN species at 2.3% (95% CI: 1.3 – 3.8) ***(Table 2).***

The overall mean intensity of infection at Pre-Treatment was 3673 epg (95% CI: 2559 - 5274) for *Ascaris lumbricoides*, 0 epg (95% CI: 0 - 2) for hookworm, and 1 epg (95% CI: 0 - 4) for *T. trichiuria.*

The combined STN mean intensity was 3674 epg (95%CI: 2560 - 5274). At Post- Treatment, the mean intensity of infection reduced to 59 epg (95% CI: 31 - 110) for *Ascaris lumbricoides,* while hookworm and *T. trichiura* mean intensity of infection reduced to 0 epg ***(Table 2).***

Table 2: *Overall Prevalence (%) and Intensities of STNs and the Cure Rate Egg Reduction Rate (%)*

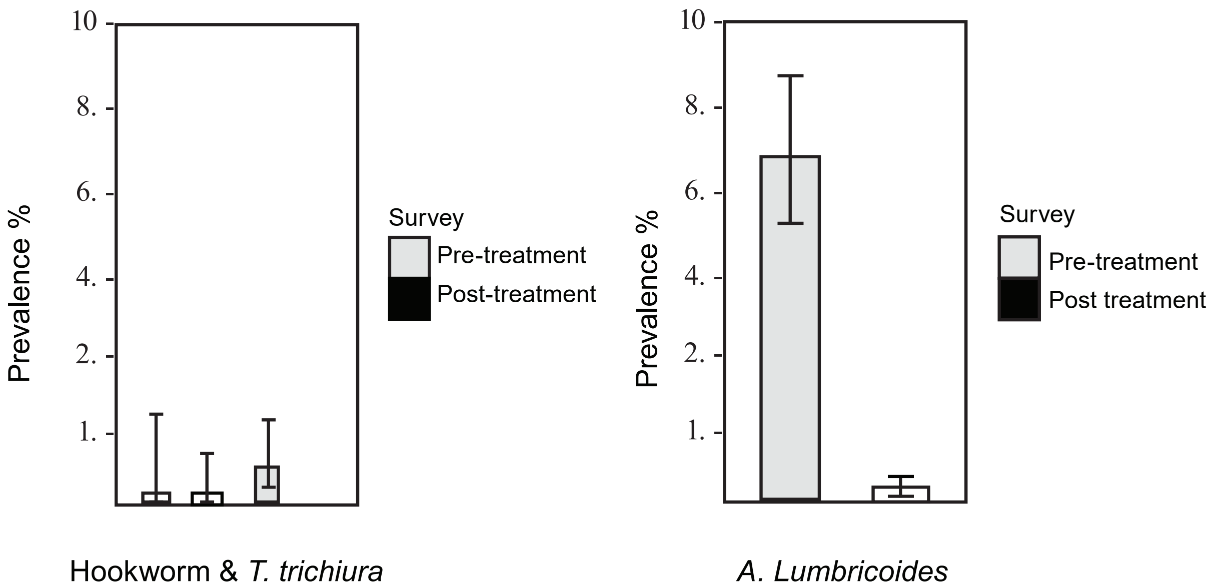
Infection	Pre-treatment Prevalence(%) [95%CI]	Post-treatment Prevalence(%) [95%CI]	Cure rate(%) [p-value]
STH combined	44.0 [35.8-54.2]	2.3 [1.3-3.8]	94.9% [p<0.001]
Hookworm	0.3 [0-1.9]	0.3 [0.1-1.1]	*
A. lumbricoides	43.5 [35.2-53.7]	2.3 [1.3-3.8]	94.8% [p<0.001]
T. trichiura	0.8 [0.4-1.8]	0 [0-0]	100% [p<0.001]
	Epg, Avg. Intensity 95%CI]	epg Avg. Intensity [95%CI]	(ERR) [p-value]
STN combined	3674 [2560-5274]	59 [31-111]	98.4% [p<0.001]
Hookworm	0 [0-2]	0 [0-1]	1.2% [p=0.993]
A. lumbricoides	3673 [2559-5274]	59 [31-110]	98.4% [p<0.001]
T. trichiura	1 [0-4]	0 [0-0]	100% [p<0.001]

**indicates an increase*

Fig 1: STNs Prevalence for Pre and Post Treatment

The overall reductions for prevalence in Pre and Post Treatment further showed that *Ascaris lumbricoides* dominated the prevalence rate among all the ST*H* parasites investigated

Fig 1: STNs Prevalence for Pre and Post Treatment



STN combined prevalence and intensity per school, sub-county, gender and age-group for pre and post treatment were also analysed ***(Table 3).*** At Pre-Treatment, all schools and sub-counties had high prevalence of above 30% except Iyenga primary school which had below 30%. There was no significant difference in infection among male and female in both pre and post treatment ***(Table 5***). Children aged 4-5 years showed the highest prevalence (67%) of STN combined than other age groups (Table 6).

Table 3: S*TN Combined Prevalence (%) and Intensity for Pre & Post Treatment Per School*

School	**Pre-treatment**		**Post-treatment**		**Cure rate**	**ERR**
	Pr% (95%CI)	Avg Intensity(epg)	Pr% (95%CI)	Avg Intensity(epg)	Prevalence	Intensity
Bukhulanya	34.5(26.7-44.7)	6538(4115-10387)	1.0(0.1-7.1)	0	97.1%***	100%***
Bukusi	55.6(46.6-66.3)	7368(4827-11246)	1.1(0.2-7.8)	0	98.0%***	99.1%***
Iyenga	26.7(19.4-36.9)	11772(6889-20114)	1.1(0.1-7.4)	0	96.1%**	98.6%***
Matende	41.3(32.9-52.0)	9367(6002-14621)	2.2(0.6-8.7)	402(307-527)	94.7%***	99.8%***
Shamusinjiri	39.3(31.0-49.7)	5973(3881-9194)	5.4(2.3-12.6)	1786(761-4190)	86.3%***	95.9%***
Shina	48.5(39.8-59.2)	5584(3820-8161)	1.9(0.5-7.7)	4536(543-37911)	96.0%***	96.8%***
Shitaho	62.6(54.1-72.5)	11667(8400-16205)	3.2(1.0-9.6)	4348(2392-7903)	95.0%***	98.1%***

*PR-prevalence reduction, IR-intensity reduction, ***indicates p<0.001,*

Table 4: *STN Combined Prevalence (%) and Intensity for Pre & Post Treatment Per Sub-County*

	Pre-treatment		**Post-treatment**		**Cure rate**	**ERR**
Sub-County	Pr% (95%CI)	Avg Intensity(epg)	Pr% (95%CI)	Avg Intensity(epg)	Prevalence	Intensity
Kakamega South	44.7(28.4-70.3)	7029(6285-7860)	1.1(1.0-1.2)	1602(239-10724)	97.6%***	99.5%***
Kakamega East	38.3(27.8-52.6)	7125(4594-11050)	2.7(1.1-6.9)	2777(1414-5452)	92.8%***	97.2%***
Kakamega Central	52.1(35.0-77.8)	10768(8822-13144)	2.7(1.9-3.8)	2770(725-10581)	94.8%***	98.7%***

*PR-prevalence reduction, ***indicates p<0.001.*

Table 5: STN Combined Prevalence (%) and Intensity for Pre & Post Treatment Per Gender

	Pre-treatment		Post-treatment		Reduction	
	Pr% (95%CI)	Avg Intensity(epg)	Pr% (95%CI)	Avg Intensity(epg)	Prevalenece (p-value)	Intensity (p-value)
Gender						
Male	44.1(37.2-52.4)	7150(5474-9339)	2.4(1.4-4.2)	3467(2226-5399)	94.6%***	97.4%***
Female	44.0(32.6-59.3)	9549(7250-12577)	2.1(0.9-5.0)	1647(768-3532)	95.2%***	99.2%***

*PR-prevalence reduction, ***indicates p<0.001,*

Table 6: STN Combined Prevalence (%) and Intensity for Pre & Post Treatment Per Age

	Pre-treatment		Post-treatment		Cure rate	ERR
	Pr% (95%CI)	Avg Intensity(epg)	Pr% (95%CI)	Avg Intensity(epg)	Prevalence (p-value)	Intensity (p-value)
Age Group						
4-5 yrs	67.5(55.6-82.1)	8913(4740-16761)	2.5(0.3-18.7)	0	96.3%**	98.2%***
6-7 yrs	44.0(30.3-63.8)	10752(6778-17055)	1.4(0.2-10.3)	0	96.9%**	100%***
8-9 yrs	45.9(31.8-66.3)	8654(6954-10770)	3.6(1.1-11.6)	2050(1290-3256)	92.2%***	98.2%***
10-11 yrs	40.2(31.3-51.6)	6837(5349-8738)	2.0(0.8-5.5)	4884(2232-10686)	94.9%***	96.4%***
12-13 yrs	42.1(34.8-50.9)	9217(6888-12333)	1.9(0.5-7.3)	1612(772-3365)	95.4%***	99.2%***
14-16 yrs	43.3(31.9-58.7)	6044(3943-9264)	1.7(0.2-11.2)	0	96.1%**	100%***

*PR-prevalence reduction, ***indicates p<0.001, **indicates p<0.005*

Reduction Of Moderate-Heavy Intensity Of Infection Pre To Post Treatment

Pre to post treatment prevalences after examination , showed that STNs infections were mostly of light infections. From STN combined infections, there were significant reduction in light and moderate intensity infections of 92.1% (p<0.001) and 98.5% (p<0.001) respectively. For hookworm and *Trichiuris. trichiura*, there were no noticeable reductions in moderate and heavy intensity of infection. While for light intensity, a non–significantly increased of 9.8% (p=0.944) for hookworm was recorded and significantly reduction of 99.2% (p<0.001) for *Trichiuris. trichiura was* recorded (Table 7). In *Ascaris lumbricoides,* reductions were 91.9% (p<0.001) and 98.5% (p<0.001) for light and moderate intensity of infections respectively ***(Table 7).***

Table 7: *Prevalence of light, moderate and heavy intensity of infection % (95%CI)*

	Light	Moderate
STN combined		
Pre-treatment	24.6(20.1-30.1)	19.4(14.1-26.7)
Post-treatment	2.0(1.1-3.5)	0.3(0.1-1.0)
Relative reduction	92.1%(p<0.001)	98.5%(p<0.001)
Hookworm		
Pre- treatment	0.3(0-1.9)	0
Post- treatment	0.3(0-1.1)	0
Relative reduction	Increase [9.8%, p=0.944]	**
A. lumbricoides		
Pre- treatment	24.1(19.7-29.4)	19.4(14.1-26.7)
Post- treatment	2.0(1.1-3.5)	0.3(0.1-1.0)
Relative reduction	91.9%(p<0.001)	98.5% (p<0.001)
T. trichiura		
Pre- treatment	0.8(0.4-1.8)	0
Post- treatment	0	0
Relative reduction	99.2%(p<0.001)	**

DISCUSSION

In our study, *Ascaris lumbricoides* was the predominant STN. After treatment, prevalence of the observed STN dropped significantly; *Ascaris lumbricoides* (2.3%; P< 0.001); T. trichiura (0%; P< 0.001).

Though hookworm non significantly increased, the results indicated satisfactory therapeutic efficacy of *albendazole*. Current study results are not consistent with what was reported in Bumula after 15 months of ALB treatment follow-up, where 9.7% of children still had STN infections [26].

This variation in prevalence could be due to the factor in Bumula, where more schools were covered from different counties in different geographical parameters Unlike the current study. Time taken in Bumula study between 2012 and follow up assessment (2014) was longer [27] than the period between pre-treatment survey and post treatment survey in the current study.

Differences may have been caused by the rate of reinfection within the treatment. This study had *Ascaris lumbricoides* and *T. trichiura* infections in the pre-post surveys significantly reduced by 94.8% and 100% respectively.

At Post-Treatment, the combined STN prevalence reduced to 2.3% (95% CI: 1.3 – 3.8) and *Ascaris lumbricoides* still remained the most prevalent STN parasites at 2.3% (95% CI: 1.3 – 3.8) ***(Table 2)***. It remained the common STN in post treatment survey.

This supports evidence from earlier reports that suggest *A. lumbricoides* is the most prevalent compared to the rest of *helminth* infections [28].

Our study partly agrees with [29] where after two treatment rounds, where STN prevalence dropped to 16.4, 2.3, 11.9 and 4.5 % with mean intensities of 985, 8,960 and 17 epg for STN combined, hookworms, *A. lumbricoides* and *T. trichiura, respectively.*

This scenario can be attributed to varied infection control approaches and dynamic parasite distinctive features. Moreover, our results consistent with recent studies carried out in Kenya [30], where combined STN prevalence has gradually reduced over time across the country.

Our study is in agreement with previous reports confirmed in reviewed studies that single dose ALB treatment is most effective for *Ascaris lumbricoides* infection, followed by hookworm [31].

Our results concur with others from elsewhere, that a single dose of 400 mg albendazole was highly effective against *Ascaris lumbricoides* [32, 33].

Our results are however dissimilar with some studies, where, a 3-day ALB dosage is required to achieve satisfactory effectiveness, unlike the 100% cure rate observed for T. trichiura in our current study [31].

Tefera and colleagues findings indicated that *Albendazole* among three different brands at 400mg single dose was effective against the three STNs [34].

Their findings further also noted, marked effectiveness observed for light infection than moderate infection [34]. This is an indication that ALB was effective on *trichuriasis* in light infections a fact that is upheld by our findings because prevalence of T. Trichura was quite low and were light infections.

Threshold used to evaluate *T. trichiura anthelminthic* effectiveness (FECR <50%), could therefore be misleading because it has been shown that ALB is efficacious on *trichuriasis* in low prevalence and where infections are light [24].

Our results recorded 94.8 % cure rate and 98.4% egg reduction rate for *Ascaris lumbricoides.* This almost agrees with a study in Ethiopia, the respective cure rate and egg reduction rates of 83.9% and 96.3% were reported for *Ascaris lumbricoides* [35].

In the Ethiopian study, respective cure rate and egg reduction rates reported for hookworms were 84.2% and 95.0%, which were totally dissimilar our current findings where hookworm infections non significantly increased (p=0.933) [35].

Therefore in Ethiopia ,400 mg of *albendazole* as a single dose was highly effective against both *Ascaris lumbricoides* and hookworm infections unlike in our study where *albendazole* was not effective on hookworm infections.

This agrees with [27] where *A. lumbricoides* reductions were influenced by environmental conditions, advanced sanitation both at schools and within the community.

For *A. lumbricoides* hookworm infections our results are supported by another study that assessed WASH factors in western Kenya.

Whereby, school based interventions reduced *A. lumbricoides* reinfection rates, except those for hookworms and *T. trichiura* [36].

In the current study the intervention reduced all the STNs but in varied rates despite the slight increase in hookworm ***(Table 2).***

Therefore, future survey need to examine hygiene and sanitation factors that may be needed to achieve a marked control STN transmission in Kenya [37].

Current study compares with what has been observed elsewhere . It is worth noting that Bunyala District, Western Province and Kwale county, Coast Province have witnessed reduced STN infection prevalence. In these deworming has been implemented since 1998 [38, 39].

Distribution of *albendazole* in the above areas has been going on in National Programme for Elimination of *Lymphatic Filariasis* [40].

The study shows hookworm prevalence instead slightly increased. This is negligible but ALB has failed in the treatment of hookworm infections in Ghana [41].

In Bomet county, lower infection levels were observed in some schools for *A. lumbricoides* and hookworm. This could have been due to suitable surface temperatures and less infective larvae and few reproduction numbers in the environment [42, 43].

In West Africa and in Australia [44, 45], treatment on hookworms using *Benzimidazole* display resistance in *Necator americanus* and pyrantel resistance in Ancylostoma duodenale.

This gives a strong indication that hookworm may require new class of *anthelminthic* in future.

Other studies have shown conflicting results that *albendazole* has high cure rate for both hookworm and *Ascaris lumbricoides* infections [46].

Several factors could be the cause of the above situation such as infective stages in *refugia*. Our findings and the ones above may not conclusively indicate reduced effectiveness of *albendazole* on hookworm.

More studies are required considering the shorter life expectancy (3-10 days for hookworm unlike several months for *A. lumbricoides* eggs and indication of higher viability [41, 42, 47].

Reduction for *T.trichiuris* (100%) in this study is not consistent with a previous studies in Western Kenya where infections on *T. trichiura* were explained by the recognized low effectiveness of *albendazole* against it and in other studies where treatment with a single oral dosage of current *anthelminthics* was reported unsatisfactory [48, 49, 50].

The findings of high efficacy on *T. trichiura,* are supported by [51] where fecal egg counts are low. This explains the high efficacy of *albendazole* against *T. trichiuris* in this study where pre treatment intensity was quite low. This is also supported in the fact a dose of 400mg *albendazole* was adequate to treat *ascariasis,* hookworm infection and *trichuriasis* in Ethiopia irrespective of the infection status in both single or multiple infections [52].

From the findings of these pre-post surveys, all schools recorded over 85% significant reductions in STN combined prevalence and intensity. Whereas, all sub-counties showed over 90% significant reductions.

Strong significant reduction was observed in all schools p > 0.001) except in prevalence reduction in Iyenga school.

The significant decline could be attributed to the benefit of the school-based Mass Drug Administration, improved sanitation behavioural practices that break the STN transmission cycles. School health education enhanced Socio-economic index that raised living standards and conditions in the region..

At Post-Treatment, the mean intensity of infection reduced for *A. lumbricoides,* while hookworm and *T. trichiuris* mean intensity of infection reduced to 0 ***epg. [Table 2].***

This strongly emphasize that in this survey, albendazole reduced the ***epg*** to zero for some of the STNs, an indication transmission intensity and disease burden were effectively reduced [53].

These overall reductions shows that *A. lumbricoides* dominated the prevalence rate among all the STN parasites investigated.

There was no significant difference in infection among male and female in both pre and post treatment. However children aged 4-5 years showed the highest prevalence (67%) of STN combined than other age groups.

This could be attributed to low hygiene practices and poor sanitation behavioural practices at such an early age.Especially in schools environment leading to high STN transmission among the Early Childhood fraternity.

Though some studies have reported reduced efficacy of *anthelmintic*. There is no conclusive evidence of drug resistance among human STN, though there are warning signs.

A lot require to be examined especially dosage levels, varied locations and diagnostic procedures. Drug effectiveness of available *anthelmintic* is known to vary by STN species [49]. Such that, the effect of treatment will also be influenced by the relative prevalence of the different STN species and the type of drugs used.

Guideline should be availed by lead persons in the control programmes. In school setting, health teachers are involved in these programmes, The study leader emphasise that the health teachers be keen when administering the drug because some pupils may fail to swallow.

Surveys for monitoring drug efficacy need to be undertaken regularly. Implementing this, will guarantee successful results.

Consistency and uniformity cannot be under estimated for efficient implementation standards operating procedures

Notwithstanding, the study results indicate school deworming is effective. In that respect, the infection reduction could be attributed to improved living standards, hygene and behavioural practices.

When planning MDA, seasonal of transmission and the proportion of STN stages in the environment ***(refugia)*** and in the host are dynamics that require thorough considerations.

In the wet season, STN stages are spread in the environment (large refugia). MDA may be less effective in reducing transmission, because it only hits worms that are in the host. Free-living stages could be few in dry season (small *refugia)* but most of the parasite population will be in the host [50].

Conclusion.

Despite the high effectiveness of ALB on STNs in this study, community based control programmes should be corporated with national deworming administration.

This will ensure break of transmission cycles because infections would still be acquired from non-treated persons in the community.

The untreated children and the rest of the members of the community may provide the source of transmission of STN.

Effective control by the school-based strategy may not be successful if other infected members of the community are not treated especially those at high risk, like farmers and those prone to high levels of infection but are not reached by school-based treatment programs.

Such groups act as focal points of STNs transmission. Communities involvement, both for implementing school-based treatment and for increasing coverage to all those at risk, has not been effectively employed.

Ethical Approval

The study protocol received ethical approval from Kenyatta University Ethical Review Committee (PKU/150/1 131). Additional approval was provided by the appropriate county-level health and education authorities. The parents were briefed about the survey.

Consent

Our study had parental consent was based on passive, opt-out consent rather than written opt-in consent owing to the low risk and routine nature of the study procedures. Individual assent was obtained from each child before participation in the survey. Information was given to publish results without revealing identification of the participants.

Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

1. **Teresia Ngonjo** - participated in the survey design, data collection, and development of the paper.

2. **Collins Okoyo** - participated in the data analysis.

3. **Julius Andove and Elses Simiyu** - were responsible for fieldwork supervision and contributed to the final paper.

4 **Jimmy Kihara, Agola Eric Lelo, Ephantus Kabiru,** and **Charles Mwandawiro** were responsible for the study design, interpretation, and scientific guidance.

All authors read and approved the final paper.

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