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## EPIDEMIOLOGY OF SINGLE AND MULTIPLE SPECIES OF HELMINTH INFECTIONS AMONG SCHOOL CHILDREN IN BUSIA DISTRICT, KENYA

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### ABSTRACT

**Objective:** To describe the patterns of single and multiple helminth infection in school children from Busia District, Kenya.

**Design:** A cross-sectional school survey using a randomly selected sample, forming part of an evaluation study of an ongoing deworming project.

**Setting:** Budalangi and Funyula divisions of Busia District, Western Province, Kenya.

**Subjects:** One thousand seven hundred and thirty eight school children aged 8-20 years randomly selected from those enrolled in standards 3-8 in 25 randomly selected primary schools.

**Results:** Overall, 91.7% of children were infected with either hookworm, *Ascaris lumbricoides*, *Trichuris trichiura* or *Schistosoma mansoni*. Infection prevalence of each species varied considerably among schools, being most marked for *S. mansoni*, where prevalence was highest in lakeshore schools. Children were typically infected with two or more species of helminth. Infection intensity of each geohelminth species was higher in school children infected with multiple species than in school children with single species infections, and intensity increased with the number of concurrent infections.

**Conclusion:** Helminth infections are exceptionally common among school children in Busia district, thus confirming the good sense of the school-based approach adopted by the control programme. The study also shows that there is an association between concurrent infection and the intensity of infection, which may have consequences for nutritional and educational status.

### INTRODUCTION

Helminth infections are a major public health problem and cause under-nutrition and cognitive impairment(1-4), with school children typically experiencing the heaviest burden of disease(5). For each species of helminth the associated degree of morbidity is related to the intensity of infection(3,6), whilst the degree of morbidity may also be related to the number of different species harboured(7-11). A recent study in Tanzania investigated the relationship between multiple species infections and the intensity of infection of each species and demonstrated that children infected with two or more species of helminths generally carry heavier infections of each species than children carrying single species infections(11).

This paper describes the epidemiological characteristics of single and multiple species infections in school children in Busia District where no surveys have been reported previously, and investigates the relationship between multiple species infections and intensity of infection. The work forms part of an evaluation study of a deworming project being implemented through the current

educational activities of a Dutch NGO, Internationaal Christelijk Steunfonds (ICS). Here we report on the baseline survey, which had two aims: to describe the health status of school children in Busia, and to provide baseline information on health before delivering treatment.

### MATERIALS AND METHODS

**Study population:** The study was conducted in Budalangi and Funyula Divisions of Busia District during January-March 1998. The present analyses describes the baseline survey of a randomised prospective evaluation of the educational impact of schools-based treatment, and includes school children in 25 randomly selected schools from the 75 rural schools in the two divisions. These schools form the initial treatment group in a study with a randomised order of treatment including the remaining 50 schools in two future rounds of evaluation with treatment being provided over successive years.

During parent teacher association meetings, community members had the purpose of the study explained to them in the language they felt most comfortable with and were asked if they wished their children to participate and asked to sign parental consent for treatment. Children were able to withdraw from the

study at any point of the study. The study was approved by the Kenya Ministry of Health Ethical Committee.

**Parasitology:** Fifteen children in each of the standards 3 to 8 were selected randomly. Each child was given a plastic container and asked to provide a faecal sample. Samples were examined in duplicate within 24 hours using the Kato-Katz method for the eggs of hookworms, *Ascaris lumbricoides*, *Trichuris trichiura* and *Schistosoma mansoni*. The concentration of eggs was expressed as eggs per gram (epg).

**Data analysis:** To examine the prevalence of heavy infections, thresholds of intensity were defined. These were chosen in accordance with the distribution of egg counts within the population and were defined at the 90% percentile level.

The effect of age and sex on whether a child was infected or heavily infected was analysed using logistic regression. Since the distribution of egg counts is typically overdispersed, Kruskal-Wallis analyses were used to assess the variation of egg counts by age, sex and multiple species infections. Poisson log linear analysis was undertaken to assess whether combinations of species were present in the same individual more than expected by chance using a simple probabilistic model(11,12).

## RESULTS

A total of 1738 children aged 8-20 years were randomly selected from 25 schools to participate in the study. The mean number of children in each school was 69 (range 44-85).

The prevalence of infection and mean egg counts are summarised in Table 1. Overall, 91.6% of the children were infected with *A. lumbricoides*, *T. trichiura*, hookworm or *S. mansoni*. Hookworm was the most prevalent helminth (Table 1). For each species of infection there was a wide range in infection prevalences, especially for *S. mansoni* where prevalence was above 30% in only six schools, and only three schools situated directly on the lakeshore had a prevalence above 50%. The overall prevalence of geohelminth species was greater than 50% in all 25 schools surveyed. Multiple species infections were very common: 5.9% of children harboured all four types of infections (range 0%-27.5%, by school); 27.9% harboured three species infections (range 7.4%-63.9%, by school);

31.2% harboured two species infections (range 5.9%-45.9%, by school).

In terms of identifying children requiring treatment for geohelminth and/or schistosome infection, 89.6% of children were infected with any geohelminth infection (range 70.8%-100%, by school). A quarter (26%) of children harboured all three species of geohelminth infection, with 31.1% harbouring both *A. lumbricoides* and *T. trichiura*, although this was typically in combination with hookworm since only 7.7% harboured *A. lumbricoides* and *T. trichiura* without hookworm infection. Overall, 19.8% of children harboured both schistosome and geohelminth infection, although this ranged between schools from 1.4% to 77.3%, being highest in the lakeshore schools. A majority of children (71.9%) were infected either with schistosome or geohelminth species rather than a combination of geohelminth and schistosome infection: 2% of children were infected with *S. mansoni* only: and 69.9% of children were infected with geohelminth species only.

Logistic regression revealed that there was a significant relationship between being infected with *A. lumbricoides* infection and host age ( $p=0.02$ ), with prevalence decreasing from 54.9% among children aged 6-9 years to 44.9% among children aged 18 years and above. In contrast, no significant relationship between host age and infection prevalence was observed for the other helminth species (Hookworm,  $p=0.395$ ; *T. trichiura*,  $p=0.993$ ; *S. mansoni*,  $p=0.711$ ). The prevalence of infection, heavy infection and mean egg count of hookworm infection and *S. mansoni* were significantly higher in boys than in girls (Table 2). There was no significant difference between the prevalence and intensity of *A. lumbricoides* and *T. trichiura* in boys and girls.

After adjusting for the effect of age in the Poisson log-linear analysis, there was evidence of excessive clustering of *A. lumbricoides* and *T. trichiura*, suggestive that concurrent infection with these species occurs at a greater frequency than would be expected by chance (Table 3). However, there was no excessive clustering of other

**Table 1**

*Prevalence and mean egg counts of intestinal schistosomiasis and intestinal nematodes in schoolchildren in Kenya<sup>1</sup>*

Species infection	Prevalence (range in schools) %	Heavy infection <sup>2</sup> (range in schools) %	Intensity (epg)	
			Mean	SD
Hookworms	77.5 (35.1-97.1)	8.6 (0-22.4)	432	1070
<i>A.lumbricoides</i>	41.9 (21.3-93.6)	4.5 (0-27.7)	2322	5138
<i>T.trichiura</i>	55.2 (20.8-94.7)	3.9 (0-14.9)	161	464
<i>S.mansoni</i>	22.0 (2.8-97.3)	4.5 (0-49.9)	89	413

<sup>1</sup>Sample size: 8yrs-25, 9yrs-55, 10yrs-123, 11yrs-137, 12yrs-262, 13yrs-297, 14yrs-289, 15yrs-264, 16yrs-170, 17yrs-77, 18yrs-39

<sup>2</sup>Hookworms 1,250+ epg; *A.lumbricoides* 20,000+ epg; *T.trichiura* 1,000+ epg; *S.mansoni* 500+ epg

species combinations, indicating all other combinations of infections did not occur more or less than expected by a simple probabilistic model(13). This result suggests independence of transmission between these species.

**Table 2**

*The prevalence and mean egg counts of intestinal schistosomiasis and intestinal nematodes by sex*

	Males n=943	Females n=795	Significant difference (P) <sup>2</sup>
% infected			
Hookworms	81.0	73.5	0.0001
<i>A.lumbricoides</i>	42.1	41.6	0.69
<i>T.trichiura</i>	56.5	53.7	0.34
<i>S. mansoni</i>	24.5	18.7	0.004
% heavily infection <sup>1</sup>			
Hookworms	10.2	6.9	0.02
<i>A.lumbricoides</i>	4.0	5.2	0.36
<i>T.trichiura</i>	3.7	4.0	0.74
<i>S.mansoni</i>	5.7	3.0	0.006
Mean egg count			
Hookworms	493	371	0.0001
<i>A. lumbricoides</i>	2247	2410	0.98
<i>T.trichiura</i>	153	169	0.46
<i>S.mansoni</i>	108	66	0.002

<sup>1</sup>Hookworms 1,250+ epg; *A.lumbricoides* 20,000+ epg; *T.trichiura* 1,000+ epg; *S.mansoni* 500+ epg

<sup>2</sup>Significance tested by logistic regression for prevalence and Kruskal-Wallis for egg counts.

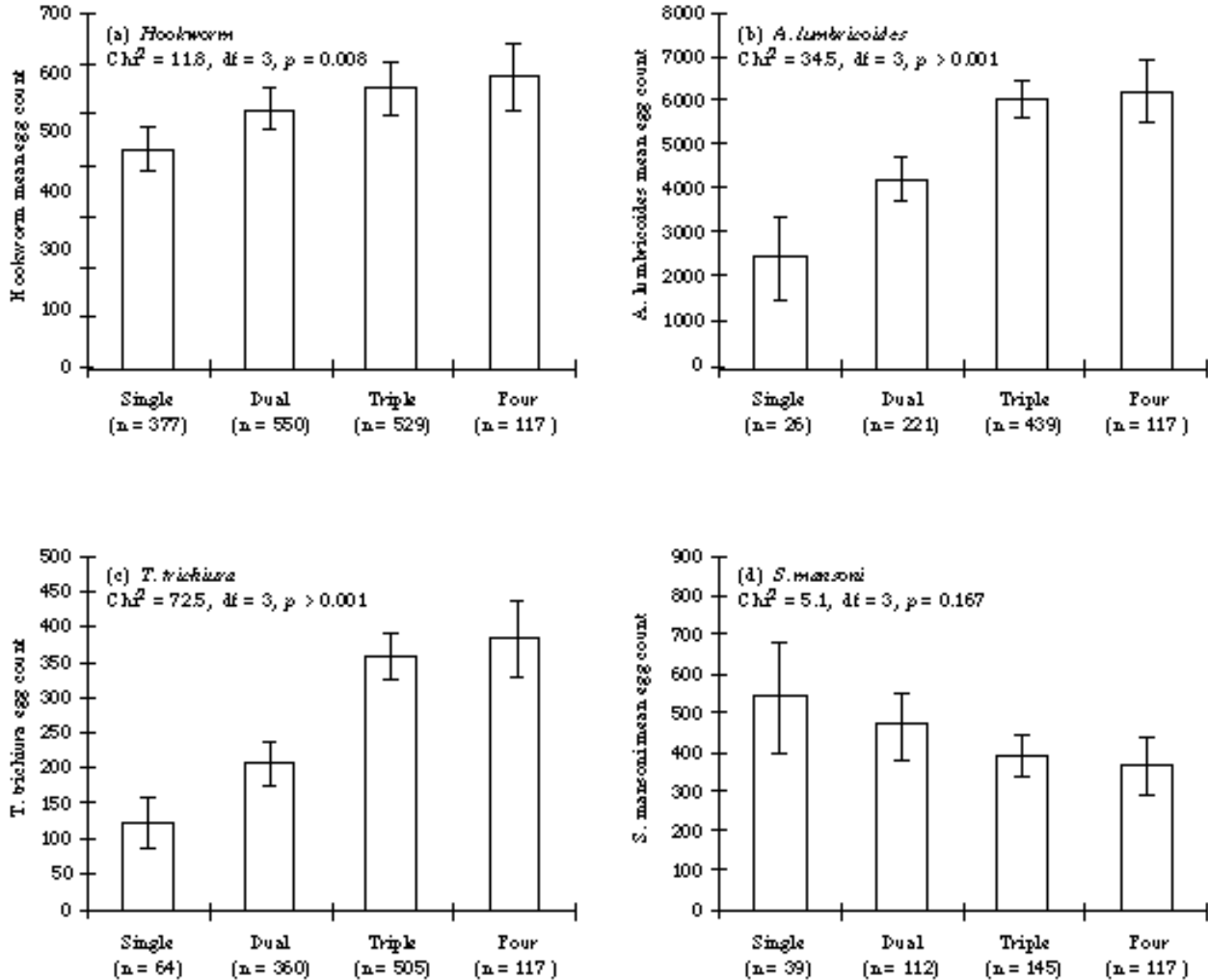
**Table 3**

*Poisson log-linear analysis of the interaction between species prevalence in 1739 school children in Busia District, Kenya. (Sign of regression estimate denotes the direction of the association. Significant result in bold)*

Infection combination	Estimate	Standard error	Chi-square	P
<i>A.lumbricoides</i> *Age	-0.041	0.039	1.1	0.3015
<i>T.trichiura</i> *Age	-0.013	0.035	0.1	0.7059
Hookworm*Age	0.059	0.026	5.3	0.0216
<i>S.mansoni</i> *Age	0.001	0.039	0.001	0.9713
<i>A. lumbricoides</i> * <i>T. trichiura</i>	1.120	0.424	6.996	<b>0.008</b>
<i>A. lumbricoides</i> *Hookworm	0.398	0.498	0.6	0.4434
<i>A. lumbricoides</i> * <i>S. mansoni</i>	-0.145	0.499	0.08	0.7714
<i>T. trichiura</i> *hookworm	0.726	0.498	2.1	0.1447
<i>T. trichiura</i> * <i>S.mansoni</i>	0.098	0.514	0.03	0.8475
Hookworm* <i>S.mansoni</i>	-0.025	0.552	0.002	0.9644
<i>A. lumbricoides</i> * <i>T. trichiura</i> *Age	0.013	0.031	0.2	0.6679
<i>A. lumbricoides</i> *Hookworm*Age	0.007	0.038	0.02	0.8641
<i>A. lumbricoides</i> * <i>S. mansoni</i> *Age	0.004	0.037	0.01	0.9145
<i>T. trichiura</i> *hookworm*Age	-0.019	0.036	0.3	0.5989
<i>T. trichiura</i> * <i>S. mansoni</i> *Age	0.042	0.037	1.3	0.2629
Hookworm* <i>S. mansoni</i> *Age	-0.03	0.402	0.6	0.4386
Age	0.009	0.023	0.2	0.6803

Figure 1

Comparison of mean egg counts in the presence of single and concurrent species infection in 1739 school children in Busia district (vertical bars represent standard errors of the mean values and sample sizes are given in parenthesis) (a) hookworm; (b) *A. lumbricoides*, (c) *T. trichiura* and (d) *S. mansoni*



The relationship between multiple helminth species infection and mean intensity is depicted in Figure 1. For the geohelminth species, mean egg counts are significantly and increasingly higher in children with two or more species than children infected with single species. There is no significant difference in mean egg count of *S. mansoni* and the number of helminth species present and the trend in the data suggests an inverse relationship.

## DISCUSSION

School-based helminth control programmes have been identified as one of the most cost-effective health interventions both in theory(5) and in practice(14,15). For these reasons national and international organisations are promoting helminth control programmes which deliver praziquantel to treat schistosome infections and albendazole to treatment intestinal nematodes through the existing educational infrastructure(16). However, prior to

implementing such programmes it is necessary to evaluate the extent of the problem in the population(17). All of the schools surveyed in the present study had geohelminthiasis prevalence in excess of 50%, thereby warranting mass treatment(17). However, mass treatment for schistosomiasis would be warranted in three schools only using the 50% threshold. It is notable that these schools were confined to the lakeshore. This strict relationship between *S. mansoni* prevalence and proximity to the lakeshore has been discussed elsewhere around Lake Victoria(18) and is attributed to the distribution of the intermediate snail hosts.

In accordance with other studies(11,13,19), the results demonstrated an association between the school prevalences of *A. lumbricoides* and *T. trichiura* (data not shown) and evidence of clustering of infection among individuals (Table 3). In contrast, there was evidence of independent transmission of hookworm and *S. mansoni* with all other species. This result is not surprising given the similarity of mode of transmission and epidemiology

of *A. lumbricoides* and *T. trichiura*, and dissimilar transmission and epidemiology of hookworm and *S. mansoni*.

Our findings confirm that many children harboured several helminth species, which appears to be the norm rather than the exception in Kenya(20,21). We have demonstrated that children with multiple species infections have a higher egg count of each geohelminth species than children with single species infection. This agrees with similar observations on school children in Pemba(11), but contrasts with the results of a study in Morogoro, Tanzania.

This is an important observation since it implies that children with multiple species infections may also suffer multiple morbidity insults due to each species infection. Evidence from South Africa has indicated that school performance is related to concurrent infections, with children carrying multiple species infections having poorer school performance than those children uninfected or infected with a single species(10). However, this study looked at a small number of mainly cognitive outcome measures and it was unclear what would be the effect of parasite load on a broad range of educational indicators.

In conclusion, the overall prevalence of infection confirms the good sense of the school-based approach adopted by the control programme. This study has shown that children in Busia district are heavily infected and typically harbour multiple species infections, and that there is an association between concurrent infection and the intensity of infection. Future work will evaluate the impact of these multiple species infections, and the effect of intervention on a range of nutritional and educational outcomes.

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