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ORIGINAL PAPER

Coinfection with Malaria, Hookworm and Schistosomiasis among School Children in Zambezi: A School-based Rapid Survey

David G. Rutagwera[1,2] , Thorkild Tylleskär[2] .

[1]Paediatrics Department, School of Medicine, University of Zambia PO Box 50223 Lusaka
[2]Centre for International Health, Faculty of Medicine and Dentistry, University of Bergen Postboks7804 N-5020 Bergen

ABSTRACT

Introduction: A school based rapid survey was conducted from the 17th to the 19th of May 2011in Zambezi District of Zambia to determine the prevalence and coinfection rate of malaria, hookworm and schistosomiasis in schoolchildren in other to inform decision maker.

Methodology: The study design, sampling methods, sample collection and processing used have been described in WHO's guidelines for the evaluation of soil-transmitted helminthiasis and schistosomiasis at community level. Additionally height, weight and haemoglobin were measured and malaria screened.

Results: We report high prevalence of parasitic infections in schoolchildren in Zambezi district with 79.4% (n = 253; 95% CI: 74.1% - 84.1%) of the children tested positive at least to one parasitic infection. Estimated prevalence of malaria, hookworm, haematuria, *S. haematobium*, *S. mansoni*, and *E. vermicularis* were 50.6% (95% CI: 44.5-56.6%), 42.4% (95% CI: 36.4-48.5%), 37.9% (95% CI: 32.2-43.9%), 29.5% (95% CI: 24.2-35.2%), 14.5% (95% CI: 10.6-19.2%), and 1.2% (95% CI: 0.3-3.2%) respectively. Generally these were low intensity infections with the exception of *S. haematobium*. High prevalence of anaemia (46%; 95%CI: 40-52.1) and nutritional deficiency (79.1%; 73.9-83.7) were also detected. The prevalence of multiparasitism was 44.3% (95%CI: 38.2-50.4%) representing 55.7% of all parasitic infections.

Conclusion and recommendations: There is high prevalence and wide distribution of malaria, hookworm and schistosomiasis resulting in high coinfection rates with these parasites in schoolchildren in Zambezi District. Studies are needed to understand the public health importance of this coinfection in the Zambian context. Nevertheless integration of anti malaria and iron status improvement activities in the School Health Nutrition programme is urgently needed to reduce morbidity and accelerate the reduction in the prevalence of parasitic infections.

INTRODUCTION

The wide and overlapping distribution of parasites in Africa often results in high co-infection rates of these parasites[1]. Factors influencing this phenomenon, also known as multiparasitism include high frequencies of parasites in the same population, similar geographical distribution of parasites, shared risk factors, common transmission methods [1] and genetic and immunological predisposition [2, 3]. The geographical distribution of malaria and helminthes is largely determined by climate [4], poverty, environmental contamination, water bodies, and lack of effective preventative measures [5]. Since several parasites are endemic in Zambia and the above mentioned predictors of multiparasitism are common in most parts of the country, it is plausible that some individuals in Zambia may be infected with two or more parasites. Therefore understanding the distribution of multiparasitism may help explain parasitic burden and morbidities such as anaemia in Zambian communities.

Because differences in the age pattern distributions [6, 7, 8], coinfection and co-morbidity of malaria and helminthes may be had to relate. At young age, when malaria is so intense, helminth infections are generally infrequent and relatively of light intensity [9]. In school-aged children where helminth infections are intense, severe malaria is rare while mild malaria episodes do occur but at lower incidence in area of high malaria transmission [10].

Key words: Malaria, Hookworm, *S. haematobium*, *S. mansoni*, and *E. vermicularis*, haemoglobin, anaemia, haematuria, coinfection

Asymptomatic malaria infections are however common in this age group [11]. Malaria and hookworms are also common in pregnant women [12]. Thus, it is among school-aged children and pregnant women that helminth and malaria co-infection is likely to be found. Therefore, this study seeks to determine the co-infection rate of malaria, hookworm and schistosomiasis in a population of schoolchildren in Zambia's Zambezi District who are exposed to malaria, hookworm and schistosomiasis.

METHODS

Study design and population

This was a school based rapid survey conducted from the 17th to the 19th of May 2011. The study design and sampling methods used have been described in WHO's guidelines for the evaluation of soil-transmitted helminthiasis (STH) and schistosomiasis at community level [13] and have been used extensively by others [14, 15]. Additionally height and weight were measured and capillary blood was collected by finger prick to screen for malaria and measure haemoglobin. HemoCue blood hemoglobin photometer (HemoCue AB, Angelholm, Sweden) was used to measure haemoglobin while 10% Geimsa stain was used to stain malaria slide and transfer them to the University Teaching Hospital, parasitology laboratory for microscopy.

Data collection and analysis

Lab results were recorded on lab forms while participant's characteristics were collected using and individual questionnaire. Data was entered in an excel sheet and Statistical analysis was performed using IBM SPSS Statistics 20. A wealth index based on sum of household assets was constructed and prevalence was estimated as has been described in WHO's guidelines [13]. Chi square tests were used to test differences between groups. Since missing data was very low (0-4.2%), all children were included in the analysis

Ethical consideration

Good Clinical Practice principles were strictly followed in the course of this study. Ethical approval was obtained from the University of Zambia's Biomedical Research Ethics Committee. Approval was also obtained from the University of Zambia, School of Medicine research forum, Ministry of Health, Ministry of Education and District Education Board Secretary office. Written informed consent forms were obtained from guardians of pupils during school hours (school heads) as commonly done [14, 15].

RESULTS AND DISCUSSION

Population characteristics

A total of 263 children 53.2% of which were females were enrolled into this study. All children provided samples for malaria screening and haemoglobin measurement while 8 children and 2 children failed to provide stool and urine samples respectively. Selected schools were Chilenga, Kawumbu, Lwantembu East, Lwitadi, and Mapachi which contributed 19%, 20.2%, 21.3%, 19% and 20.5% of the study population respectively. Study participants were aged 7 to 19 years old, with a mean age of 11.8 (n=263, SD=2.6) years and were all born and only lived in areas around the schools in which they were recruited from. The mean Body mass index was 17.2 (n=263, SD=2.0) while the mean Haemoglobin concentration was 12.1 (n=263, SD=1.56)

Prevalence of parasites, anaemia and underweight children

We report high prevalence of parasitic infections in Zambezi district with 79.4% (n = 253; 95% CI: 74.1% - 84.1%) of schoolchildren harboring at least one parasite. Malaria, hookworm, *Schistosoma haematobium*, *Schistosoma mansoni* and *Enterobius vermicularis* were detected in our study population. *Ascaris lumbricoides* and *Trichiura trichuris* were not detected probably due to low population density in rural areas and the factor that *A. lumbricoides* and *T. trichuris* are typically restricted to equatorial regions [16]. (See Table 1on next page)

Helminth intensity was interestingly generally low with the majority of hookworm (95.4%), *S. mansoni* (56%), and *S. haematobium* (61%) infections being light infections according to WHO classification [13]. However the 39% heavy *S. haematobium* infections translate into an overall prevalence rate of 11.5% (95%CI: 8.0-15.8%) which classifies the district as category one (high prevalence, high intensity) on the WHO classification of communities for anti-helminthiasis treatment [13]. Malaria intensity was also low with 99.2% of cases having less than 500 malaria parasites per µl of blood.

The prevalence of detected parasitic infections and coinfections did not differ significantly by age and sex with the exception of *S. mansoni* (P=0.021), anaemia (P<0.001) and underweight (P<0.001) which differed significantly across age groups. Only malaria (P=0.001), anaemia (P=0.007) and haematuria (P=0.003) differed significantly across socioeconomic status quintiles while Hookworm (P=0.005), *S. mansoni* (P<0.001), *S.*

Table 1: Prevalence of single and multiple infections

Prevalence of single and multiple infections			
	n	Prevalence (%)	95% CI (%)
Single infections			
Ascaris lumbricoides	255	0.0	0 - 1.2
Trichiura Trichuris	255	0.0	0 - 1.2
Enterobius vermicularis	255	1.2	0.3 - 3.2
Hookworm	255	42.4	36.4 - 48.5
Schistosoma mansoni	255	14.5	10.6 - 19.2
Schistosoma haematobium	261	29.5	24.2 - 35.2
Malaria	263	50.6	44.5 - 56.6
Co -infections			
Malaria -hookworm -*S. haematobium*	258	8.9	5.9 - 12.9
Malaria -hookworm -*S. mansoni*	255	2.7	1.2 - 5.3
Malaria -hookworm -*enterobius*	255	0.4	0 - 1.9
Malaria -*S. haematobium* -*enterobius*	255	0.4	0 - 1.9
Hookworm -*S. haematobiu m* -*S. mansoni*	255	0.4	0 - 1.9
Malaria -hookworm	255	11.8	8.2 - 16.2
Malaria -*S. haematobium*	262	10.7	7.4 - 14.9
Malaria -*S. mansoni*	255	2.7	1.2 - 5.8
Hookworm -*S. haematobium*	255	4.3	2.3 - 7.4
Hookworm -*S. mansoni*	255	2.0	0.7 - 4.3
Hookworm -*enterobius*	255	0.4	0 - 1.9
S. haematobium -*S. mansoni*	255	0.8	0.1 - 3.1
Number of infections per child			
Zero	252	20.6	15.5 - 25.9
One	252	35.2	29.5 - 41.2
Two	252	31.2	25.7 - 37.1
Three	252	13.0	9.3 - 17.6
Conditions			
Anaemia	263	46.0	40.0 - 52.1
Haematuria	261	37.9	32.2 - 43.9
Nutritional deficiency	263	79.1	73.9 - 83.7

haematobium (P<0.001), malaria (P<0.001), anaemia (P<0.001) and haematuria (P<0.001) differed significantly in schools. Hookworm, *S. haematobium* and malaria were detected in all schools indicating a wide and overlapping distribution of these parasites in Zambezi District. On the other hand, *S. mansoni* was detected in 3 of the 5 schools and most of its infections (81.1%) were in one school, indicating a focal distribution of *S. mansoni* in the district. (see Table 2, 3 and 4)

Like many other studies [1, 17, 18], multiparasitism was common in Zambezi district with 44.3% (95%CI: 38.2-50.4%) schoolchildren harboring 2 or more parasites and 55.7% (95%CI: 48.8-62.4%) of all parasitic infections being multiparasitic in nature. The highest number of parasites found in a child was 3 found in 13% (95%CI: 9.3-17.6%) of the infected children. About 90% of this triple multiparasitism was due to coinfection with malaria, hookworm and schistosomiasis. Coinfection with Malaria, hookworm and S. haematobium caused three quarters (¾) of all malaria, hookworm and schistosomiasis coinfections while the remaining quarter (¼) was due to coinfection with malaria, hookworm and S. mansoni. Double and triple coinfections were detected in all schools and their prevalence in schools did not differ significantly suggesting a wide distribution of malaria and helminth multiparasitism in Zambezi District as has been reported elsewhere in Africa [19].

Malaria and helminth multiparasitism has been studied in several places but results from these studies are often conflicting [19, 20, 21, 22] and as such difficult to generalize. Studies are therefore needed to highlight the public health importance of this phenomenon in the Zambian context. However, because Zambezi District is classified as a high prevalence high intensity community, there is urgent need for helminth control. Clearance of the malaria reservoir is also needed. Helminth control programs in Zambia focus on schoolchildren. With an overall malaria and gametocytes prevalence of 50.6% (95%CI: 44.5-56.6%) and 4.9% (95%CI: 2.8-8.1%) respectfully, schoolchildren are also an important active human reservoir of malaria parasite in Zambezi District providing a continuous source of malaria parasites to mosquitoes. Therefore integration of helminth and malaria control programmes would benefit both programmes. Such integrated packages have already been described and have shown to be efficient and cost effective [19, 23, 24, 25]. This could be easily achieved through consolidation of the school health and nutrition programme to include Provision of intermittent

Table 2: Prevalence of several variables by age and sex

	Prevalence of infections by age and sex						
Parasitic infection	7 - 10	11 - 14	15 - 19	P value*	Female	Male	P value**
Hookworm	42.9	39.8	50.0	0.638	39.1	46.2	0.315
S. mansoni	6.0	18.8	18.4	**0.021**	14.5	14.5	1.000
S. haematobium	31.0	27.2	34.2	0.926	30.2	28.7	0.893
Haematuria	39.1	37.5	36.8	0.787	42.4	32.8	0.140
Malaria	44.8	55.8	44.7	0.606	49.3	52.0	0.748
Anaemia	69.0	37.0	26.3	**<0.001**	40.7	52.0	0.087
Underweight	96.6	78.3	42.1	**<0.001**	75.7	82.9	0.199
Zero infection detected	27.6	17.4	10.5	**0.016**	23.6	15.4	0.135
One infection detected	31.0	35.1	44.7	0.159	31.4	39.7	0.215
Two infections detected	27.4	33.6	31.6	0.497	29.9	32.8	0.728
Three infections detected	13.1	13.0	13.2	1.000	14.6	11.2	0.541

* : Linear by linear χ^2 P value

**: Continuity corrected χ^2 P value

Table 3: Prevalence of several variables by socioeconomic status

	Prevalence by socioeconomic status quintiles					
Variables	Low	2nd	3rd	4th	High	P value*
Hookworm	41.5	47.3	41.3	42.6	33.3	0.551
S. mansoni	9.2	9.1	19.0	14.9	29.2	0.019
S. haematobium	34.3	25.9	35.4	29.8	4.2	0.074
Haematuria	50.0	31.5	43.1	36.2	4.2	**0.003**
Malaria	61.4	53.6	53.8	40.4	20.8	**0.001**
Anaemia	52.9	53.6	47.7	36.2	25.0	**0.007**
Underweight	85.7	75.0	76.9	73.7	87.5	0.469
Zero infection detected	18.6	19.6	12.3	21.3	41.3	0.120
One infection detected	27.7	39.6	41.3	34.0	33.3	0.538
Two infections detected	38.5	22.6	30.2	38.3	20.8	0.504
Three infections detected	13.8	17.0	15.9	6.4	4.2	0.116

* : Linear by linear χ^2 P value

Table 4: Prevalence of several variables by school (location)

	Prevalence by school					
Variables	Chilenga	Kawumbu	Lwantembu East	Lwitadi	Mapachi	P value***
Hookworm	51.0	56.6	32.7	46.9	25.0	**0.005**
S. mansoni	6.1	7.5	0.0	0.0	57.7	**<0.001**
S. haematobium	18.0	13.7	78.6	32.0	1.9	**<0.001**
Haematuria	20.0	29.4	83.9	54.0	0.0	**<0.001**
Malaria	36.0	37.0	67.9	66.0	44.4	**<0.001**
Anaemia	56.0	43.4	57.1	68.0	7.4	**<0.001**
Underweight	78.0	81.1	80.4	78.0	77.8	0.989
Zero infection detected	36.0	26.4	7.1	16.0	14.8	**0.002**
One infection detected	26.5	37.3	26.9	34.7	50.0	0.082
Two infections detected	26.5	23.5	42.3	36.7	26.9	0.197
Three infections detected	10.2	11.8	23.1	12.2	7.7	0.173

preventive treatment (IPT), long lasting insecticide treated nets (LLINs), health education for prevention and prompt malaria treatment and regular treatment with albendazole and praziquantel [23].

Due to financial constraints, the study only collected one stool and one urine sample from each participant instead of collecting several successive samples. This could have resulted in under detection of helminthes as egg shedding in helminthes is not constant. Another source of potential underreporting of helminthes is egg hatching before microscopy particularly in hookworms and S. haematobium. To minimize this helminth microscopy was done on site soon after sample collection. Using microscopy to screen for malaria may also result in underreporting but the factor that we used very experience technicians minimized the effect this would have on our estimation. Because of our study was localized and population restricted, extrapolating results to other districts or other sub population groups may not be possible.

CONCLUSION AND RECOMMENDATION

Malaria, hookworm and schistosomiasis occur in high frequencies but mainly in low intensity among schoolchildren in Zambezi district. The majority of infections detected were multiparasitic in nature and up to three parasites were found in a child. Therefore there is need to include intermittent malaria treatment, provision of mosquito nets and deworming in the School Health and Nutrition program in Zambezi district to supplement deworming. Further research is also needed to determine the effect of multiparasitism on parasitic morbidity in the Zambian context.

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