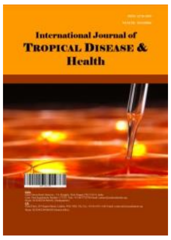

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Soil Transmitted Helminths and *Plasmodium falciparum* Co-infections among School Children in Bugesera District, Rwanda: Implications for National Control Programs

Umwanankundi Marcelline [a], Mazigo D. Humphrey [b], Tumusiime David [a], Mucumbitsi Joseph [c], Arpita Sharma [d] and Barugahare John Banson [e*]

[a] College of Medicine and Health Sciences, University of Rwanda, Rwanda.
[b] Department of Medical Parasitology and Entomology, School of Medicine, Catholic University of Health and Allied Sciences, Mwanza, Tanzania.
[c] Department of Biomedical Laboratory Sciences, Faculty of Applied Fundamental Sciences, INES-Ruhengeri-Institute of Applied Sciences, Ruhengeri, Rwanda.
[d] Department of Medical Laboratory Technology, Faculty of Health Sciences, Career Point University, Kota, Rajasthan State, India.
[e] Department of Microbiology and Immunology, Faculty of Health Sciences, Busitema University, Uganda.

Authors' contributions

This work was carried out in collaboration among all authors. Author UM designed the study, wrote the protocol, and made the first draft. Authors MDH, TD and MJ participated in the study design. Author BJB participated in data analysis and prepared the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Soil Transmitted Helminths and Plasmodium infections are ubiquitous with morbidity and mortality within the tropical and subtropical regions. However, the extent and consequences of STH-Plasmodium co-infection at different spatial scales are poorly understood. This study aimed at

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**Corresponding author: Email: barugahare@googlemail.com, jbbarugahare@fhs.busitema.ac.ug;*

determining the prevalence of Soil Transmitted Helminths and Plasmodium coinfection, and, the impact thereof among school children in Bugesera District of Eastern Rwanda.
Study Design: Cross Sectional Survey
Place and Duration of Study: The survey was conducted in Bugesera district, Eastern Rwanda, between May and December 2020.
Methodology: The survey was conducted among children between ages 5 and 18 years, across 21 randomly selected primary schools. Stool samples were collected and screened for soil transmitted helminths using Kato-Katz, while finger-prick blood samples were examined under the microscope to determine Plasmodium infection.
Results: Overall the prevalence of *A. lumbricoides*, *T. trichiura*, Hookworm and *P. falciparum* was 4.43%, 0.76%, 0.16% and 3.15% respectively. On the other hand, 36.15% were co-infected with *A. lumbricoides* and *P. falciparum.* Surprisingly, the coinfection was higher 41.79%, (P<0.001) in girls than the overall coinfection prevalence.
Conclusion: Helminthiasis and malaria remain dominant, in spite of the continuing and tremendous national control programs. The strikingly surprising higher prevalence of *A. lumbricoides-P. falciparum* co-infection in girls calls for additional investigations.

Keywords: Plasmodium falciparum; soil transmitted helminths and Co – infections.

1. INTRODUCTION

The recent WHO report shows 228 million cases of malaria occurred globally, with sub-Saharan Africa and South East Asia accounting for 97% of the burden. In 2018, there were over 405 000 deaths globally and, children under 5 years accounted for 67% (272 000) of all malaria deaths. *Plasmodium falciparum* remains the most prevalent parasite in the WHO Regions of; African, Eastern Mediterranean, Western Pacific, South-East Asia Region respectively. In fact, the WHO African Region accounted for 94% of all deaths [1]. Soil-transmitted helminthiases (STH) are endemic in 42 countries of the WHO African Region with an estimated 102 million pre-school-aged children and 191 million school-aged children requiring preventive chemotherapy [2].

Helminth and Plasmodium infections are known to proliferate in the favorable - climatic tropical conditions and significantly, among the endemic poorest communities [3,4]. STH and *Plasmodium falciparum* coinfection - ubiquity has been long reported but with conflicting results of both the prevalence and clinical outcomes [5-19]. In as much, these coinfections have not been uncommon in school children including those in East African and Ethiopia, though, consistent with varying consequences [20,21]. The situation is not any different in Rwanda [22-25].

Busegera district was selected due to the high prevalence of parasitic infections but with fewer research studies reported [Rwanda Malaria Indicator Survey Report, 2017 and the National school prevalence survey on soil-transmitted helminthiasis and schistosomiasis in, Kigali, Rwanda, 2008 report]. Recent survey information indicated the prevalence of *P. falciparum* as 18 % [Rwanda Malaria Indicator Survey Report, 2017].

2. MATERIALS AND METHODS

2.1 Study Setting

The survey was conducted in Bugesera district, between May and December 2020. Bugesera district is one of the seven districts that constitute the Eastern Province of in Rwanda. It is located in the South West of the Province. It ranges between 30o 05’ Eastern longitude, and 2o 09’ Southern latitude, and covers the surface of 1337 Km^2. This district is characterized by a mixture of plateaus with an altitude varying between 1,100 m and 1,780m and undulating hills dominated by varying heights. The climate is dry with temperature varying between 20 and 30°C. The region has two dry seasons and two rainy seasons. The climatic seasons of Bugesera are quadrat; a short dry season that extends from January to mid-March, a long rainy season from mid-March to June and a long dry season extending from Mid-June to September while the short rainy season extends from mid-October to December. Lately, though, the climate is changing catastrophically and seasons have become irregular. The district hydrographical network is mainly characterized by 3 rivers, namely Akanyaru, Akagera and Nyabarongo. Besides rivers, there are 9 lakes. The soils are generally sandy with a low quantity of humus and are very permeable, therefore, quickly dry up even after heavy rains.

2.2 Enrollment of School Children

Representative school children of the 79 public primary schools in the district were randomly selected with the help of the district education and health officers. The sample size calculation was done once to determine the 21 schools and the number children to be sampled from each school. The 21 schools were randomly selected as well and screened in November 2020, for enrollment into the study. The study enrolled children irrespective of any infections.

2.3 Survey Procedures

Parents/guardians of the children at school were invited to attend sensitization meetings. The study procedures were explained in an exceedingly simpler language they felt most comfortable with. Written consent was obtained from all parents/guardians who were willing to have their children participate in the study. Finger prick blood was collected from every child using a capillary tube. Thick and thin blood smears were prepared for the diagnosis of plasmodium parasites. Plasmodium-positive slides were re-checked by a senior laboratory technician to ensure quality control. Any participant tested positive for malaria infection was treated with Coartem (Novartis; twenty mg artemether/120 lumefantrine) in accordance with the national treatment pointers.

2.4 Statistical Analysis

The data were entered in EPI INFO 7, and statistical analysis was done using SPSS and EXCEL. Chi-square test including odd ratios at 95% CI and One-way ANOVA was used to test for differences in proportions and means, respectively. Values were considered statistically significant when *P*-values are <0.05. Infection intensities were classified into lightweight and moderate to serious infections consistent with the Kato-katz standard method. For functions of this analysis, age was thought-about as categorical variable (5–9, 10–11, and 12–13 and <18 years). Backward-stepwise elimination was considered to generate a minimum adequate model while excluded variables (P > 0.05) were retested within the minimum model.

3. RESULTS AND DISCUSSION

3.1 Results

The 21 schools had a total population of 9,852 children of which consent was obtained for only 2,507 children. These included 1,200 boys, (47.9%) 1,307 girls, (52.1%) as indicated in table1.

3.2 Soil Transmitted Helminths Infections

The most prevalent species was *A. lumbricoides* (4.43%) and highest among boys (*P* <0.001); followed by *T. trichiura* (0.76%) with more girls infected than boys (*P*=0.05) and Hook worm (0.16 %) with more boys infected than girls, (**P**=0.04). Overall boys were more infected than girls as shown in Table 1.

3.3 Malaria Infection

Approximately 3 % of the children were infected with *P. falciparum*, with more boys infected than girls (*P* < 0.001).

3.4 Coinfections

Overall, 36.15% of the children were co-infected with *A. lumbricoides and P. falciparum,* the only coinfection diagnosed. The prevalence of *A. lumbricoides* and *P. falciparum* coinfection differed by sex, surprisingly, with more girls infected than boys (*P* <0.001), since for the respective single infections, boys were infected.

3.5 Discussion

STH and malaria remain a heavy health burden of the WHO African Region including Rwanda, despite all the control measures and efforts [2]. Our study reports *A. lumbricoides* as the most predominant infection (4.43%) with more infections in boys (P <0.001); followed by *T. trichiura* (0.76%) with more girls infected than boys (P=0.05) and Hook worm (0.16 %) with more boys infected than girls, (P=0.04). Overall boys were more infected than girls. The STH results of this study are similar with previous study conducted in the same district but with a significant reduction in the respective prevalence [22]. This is evidence of the positive impact and enforcement of the control programs in the Eastern Province of Rwanda. This reduction, though, is contrary to a recent report from the Western Province of Rwanda where the prevalence of the STH was respectively higher [14].

The overall prevalence *P. falciparum* infection was 3.15 %, with more boys infected than girls (*P* < 0.001). This is extremely lower than earlier reported [22] but consisted with the tremendous positive trend of the control programs.

Table 1. Summary of the overall description of study participants and results

Characteristic of participants				
Characteristic	Overall (n = 2,507)	Boys (n = 1,200), (47.9%)	Girls (n = 1,307), (52.1%)	p-value
Mean age (years, SD)	11.29 (2.96)	11.11 (2.79)	11.45 (3.09)	<0.0001
Age-group (years, n (%))				
5-8	452 (18.0)	212 (17.7)	240 (18.4)	0.004
9-10	560 (22.3)	277 (23.1)	283 (21.7)	
11-12	594 (23.7)	334 (27.8)	260 19.9)	
13-18	901 (35.9)	377 (31.4)	524 (40.1)	
Class (n, (%))				
Prevalence of helminth and *P. falciparum* infections				
A. lumbricoides (%, 95 % CI)	4.43 (12.28-29.65)	4.50 (9.89-35.26)	4.36 (7.17-31.71)	<0.001
T. trichiura (%, 95 % CI)	0.76 (2.62-7.27)	0.58 (0.41-8.16)	0.92 (1.97-8.70)	0.05
Hookworm (%, 95 % CI)	0.16 (0.70-3.30)	0.17 (0.50-8.85)	0.15 (0.61-7.85)	0.04
P. falciparum infection (%, 95 % CI)	3.15 (144.57-828.39)	3.33 (156.72-971.08)	2.98 (194.96-414.07)	<0.001
Prevalence of Coinfections				
T. trichiura- A. lumbricoides (%, 95 % CI)	3.08 (4.34-17.16)		5.97 (4.34-17.16)	
A. lumbricoides-P. falciparum (%, 95 % CI)	36.15 (9.90-11.89)	30.16 (8.08-11.08)	41.79 (10.50-13.07)	<0.001

Interestingly there was one principal common coinfection of Ascaris - Plasmodium with the overall prevalence of 36.15% but surprisingly with higher prevalence in girls than boys - approximately 42% (P<0.001). This is still lower than previously reported from the study in the same district [22]. Nevertheless, the higher prevalence in girls is still striking given that the respective single infections were higher in boys. This outstanding discrepancy could be due additional microbiota infections in girls that have been reported associated with increased Plasmodium infection elsewhere [19]. STH – Plasmodium coinfections have been associated with different malaria outcomes including uncomplicated to severe malaria as earlier reported from the study from this district and elsewhere [10,16,18,22,26,27]. Nevertheless, our results could differ with the malaria outcome especially from the previous study conducted in the same region now that, there is evidence that additional microbiota infections moderate Plasmodium infections differently.

Our finds though, are not without limitations. First, the diagnosis was supported by routine parasitological procedures that might miss lightweight infections in comparison to a lot of sensitive molecular strategies where one stool sample might underestimate the prevalence of parasitic worm infection [28,29].

4. CONCLUSION

Helminthiasis and malaria remain dominant in Rwanda, in spite of the continuing and tremendous national control programs. The strikingly surprising higher prevalence of *A. lumbricoides-P. falciparum* co-infection in girls calls for additional investigations.

CONSENT

All participants and parents/guardians gave consent to participate.

ETHICAL APPROVAL

The approval was provided by the University of Rwanda IRB (No380/CMHS) and permission was granted by leader of Bugesera district as well.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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