 ISSN: 2394-4404

Concomitant Co-Infections Of Malaria And Schistosomiasis Among School Going Children In The Mining And Agricultural Concession Areas Of Kwale County, Kenya.

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Abstract: Background: The wide and overlapping distribution of parasites in Africa often results in high co-infection rates. The main 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, and common transmission methods. Kwale County has a number of risk factors and a favorable geographical location on the Coast of Kenya. The main risk factors include large fresh water bodies, the ocean, high temperatures, humidity and a high poverty index within the community.

Materials and Methods: A malaria/schistosomiasis co-infection prevalence study was carried out between the months of September and October 2015 in areas surrounding mining and sugarcane growing areas of Kwale County. The study was done as part of a Health Impact Assessment (HIA) Study. Children between the ages of 5 and 15 years were selected from schools in the large scale mining areas and were tested for concomitance presence of Schistosomiasis and Malaria. Participants' demographic data were collected via the administration of questionnaires. Blood and urine samples were collected from the study participant, blood samples were tested for malaria while urine samples were tested for schistosomiasis. A total of 151 children were tested for both malaria and schistosomiasis.

Malaria Rapid Diagnostic (MRD) tests were used to assess children for malaria, this was done using blood samples. Urine filtration tests were used to establish presence of Schistosomiasis using urine samples. Chi-square test and Fisher's exact test were used to test for significance between the independent and dependent variables.

Results: Sixty three out of 181 had malaria (35%, n= 181), 18 out of 151 had schistosomiasis (12%, n=151).

Conclusion: These findings suggest that malaria-schistosomiasis co-infections exist among school going children between ages 5-15 in Kwale County. Co-infection rate was associated with patient characteristics. Children who had Schistosomiasis had malaria infection too except for few cases 4% (6) that had only Schistosomiasis infection. Malaria cases were higher than Schistosomiasis, which calls for integrated disease control interventions to mitigate both malaria and Schistosomiasis and consequent co-infections.

Keyords: Malaria; Schistosomiasis; Malaria-schistosomiasis co-infections, school going children, demographic data, swimming, playing in water.

I. INTRODUCTION

In developing countries, parasitic infections are a major cause of morbidity and mortality. Concomitant parasite infections in human are common; this includes infections like schistosomiasis and malaria which are two of the parasitic infections with heavy economical and social burdens.

Geographical distribution of malaria and schistosomiasis is largely determined by climate, poverty, environmental contamination, presence of water bodies, and lack of effective preventive measures(1,2).

The implications of concomitant malaria and helminths infections have been mainly explored in animals under laboratory conditions. In human populations, a few studies have been conducted, with contradictory results(3,4).

A study of co infection between malaria and schistosomiasis in humans conducted in 2012 in Kenya, has concluded the existence of multiple parasites among children than adults(5).In another study the association between *S.mansoni* and malaria reduced the effectiveness of malaria treatment in S.mansoni high endemic region where mass praziquantel treatment is not used(6).Other studies have shown contradictory results with synergetic associations(4).The current study sought to determine the prevalence of malaria, schistosomiasis, and malaria-schistosomiasis co-infections and risk factors for co-infection in a population of school children in Kwale County in Kenya.

II. METHODOLOGY

STUDY AREA AND STUDY POPULATION

A cross-sectional study was conducted in Kwale County, one of the 47 counties of the Republic of Kenya. Kwale County is the sixth county in the Coastal Region of Kenya. This research study was conducted among school going children along the mining and agricultural concession areas of Ng'ombeni, Kombani, Diani, Mwabungo, Magaoni, Msambweni, Ramisi and Shimba Hills in Kwale County.

RESEARCH DESIGN

The study was a descriptive cross-sectional survey assessing the prevalence of malaria, schistosomiasis, malaria-schistosomiasis co-infections and the risk factors of co-infections among school going children residing in areas bordering large scale mining and agricultural concession areas in Kwale County. The research was part of a bigger study on mitigation of adverse effects of large scale mining and industrial investments on water, health and sanitation in Kwale County, Kenya.

It involved school surveys; pupils from the selected schools were tested for schistosomiasis and malaria. The drawing of samples for testing was done after the children had answered a questionnaire. A mobile clinic was located in each selected school for testing malaria, schistosomiasis and for clinical evaluation and treatment for those with positive diagnosis and symptoms.

SAMPLING DESIGN

The study adopted a multi-stage sampling strategy to draw the participants. The sampling strategy commenced on clustering the study sites into Ng'ombeni, Kombani, Diani, Magaoni, Msambweni, Shimba-Hills and Ramisi, schools were selected from these cluster areas. A purposive sample of nine (9) primary schools was selected for the study. One school was selected from each cluster area except Ramisi and Msambweni which had two schools each included in the study. These two areas have higher populations due to their close proximity to the industries. The schools were selected purposively to include those near the mineral and industrial concession and those along the value chain such as markets and transportation routes. A total of 181 children were randomly sampled from the pre-selected schools.

III. STUDY PROCEDURES

MALARIA RAPID DIAGNOSTIC TESTS (MRDT) FOR DIAGNOSIS OF MALARIA

Malaria Rapid Diagnostic Tests (MRDTs) were used for malaria testing. MRDTs detect specific antigens produced by malaria parasites. These antigens are present in the blood of infected or recently infected people(7). A positive test was marked by appearance of a control line on the test strips after exposure to a blood sample.

URINE FILTRATION TEST FOR DIAGNOSIS OF SCHISTOSOMIASIS

The microscopic examination of urine and stool remains the golden standard for the diagnosis of schistosomiasis(8). Participants were asked to provide a mid-day urine sample during the examination. Marked containers (10-15mls) were provided for them to put a small amount of urine. The participants were given an hour to get the urine samples. More time was allocated for children who failed to produce samples within an hour. Samples were kept in coolers and transported to the field lab. Presence of *S. haematobium* eggs was determined by microscopic examination of filtered mid-day urine. Urine was concentrated by sedimentation and filtration (8). A fixed amount (10 ml) of urine was forced over a piece of paper, which was later examined and eggs counted directly under the microscope. Samples with more than one egg were recorded as positive.

PHYSICAL EXAM

All children were clinically examined for symptoms of malaria. In brief children were assessed for fever, nausea, joint aches and vomiting to differentiate asymptomatic and symptomatic malaria. Other examinations involved; assessment of pallor, pulse, temperature and an abdominal exam to rule out complications of malaria and schistosomiasis. All children who tested positive for schistosomiasis were treated with praziquantel; children who had complications were referred for further treatment to the nearby hospitals.

INTERVIEWER ADMINISTERED QUESTIONNAIRE

An interviewer administered clinical questionnaire was used to collect socio-demographic and clinical data. Socio-demographic data included age and gender, while clinical data included history of blood stained urine, abdominal pain,

ISSN: 2394-4404

abdominal swelling, headache, joint aches, fever, generalized fatigue, anaemia, enlarged liver, diarrhoea and passing bloody urine.

DATA MANAGEMENT AND STATISTICAL ANALYSIS

Data from the questionnaires were entered into EpiData software after which it was exported to Microsoft Excel, where it was verified and cleaned prior to being exported to R studio version 3.4.3 for analysis. The outcome of interest (dependent variable) was co-infection with malaria and schistosomiasis, while independent variables were demographic characteristics and health history characteristics. Socio-demographic indicators were assessed for their distribution using descriptive statistics and presented as frequencies and percentages.

To determine the prevalence of malaria schistosomiasis co-infections, the proportion of co-infected participants were converted into a percentage of all participants. 95% Confidence Intervals (CIS) were presented. Similarly the proportions of participants testing positive for malaria and schistosomiasis were converted into a percentage of all participants to determine prevalence of malaria and schistosomiasis respectively.

Descriptive statistics were used to analyze both dependent and independent variables and summary was expressed as the exact variable number (n), percentage (%), mean and standard deviation. Both Chi-square test and Fisher's exact test were used to test for significance between the independent and dependent variables. Statistical significance was assessed at the level of 95% ($p<0.05$).

ETHICAL STATEMENT

The study followed ethical principles and was approved by the National Council for Science Technology (NACOSTI) within a grant research where this study was anchored and the Pwani University Ethics Review Committee. Children aged 5-15 years from pre-selected schools whose parents and guardian consented to their involvement in the research were included in the study and only those along the mining and large scale agricultural concession areas who were residents of the sampled areas. The consent was obtained through public forums which included meeting parents and area administrators. Children whose parents/ guardians declined consent were excluded from the study. Participants who tested positive for malaria and schistosomiasis were treated in the mobile clinics and then referred to the nearest medical facilities by the study clinicians for follow ups.

IV. RESULTS

SOCIO-DEMOGRAPHIC CHARACTERISTICS OF SCHOOL GOING CHILDREN IN MINING CONCESSION AREAS IN KWALE COUNTY, KENYA

A total of 181 pupils were interviewed. The study participants were aged between 5-15 years**.** Majority (76.9%) of the participants were aged 6-10 years. Male (47%) and female (53%) participants were sampled for the study. The proportion of male and female were similar (p= 0.6) in the studied schools.

PREVALENCE OF SCHISTOSOMIASIS INFECTION

Schistosomiasis prevalence among children tested was 11.9% (18/151) but the prevalence differed depending on the school (p-value=2.698e-06X-squared = 40.4, df = 8, n=38)for example, the prevalence at Kombani primary school was 4% (6/151) while the prevalence in Duncan Ndegwa was 1%.Children from Ngombeni and Vingujini did not test positive for schistosomiasis.

During the study, children from Genesis primary school were not tested for schistosomiasis due to unsatisfactory field laboratory requirements, all the urine samples from this school were left untested due to spillage during transportation, and most of the samples were inadequate for testing. Further analysis revealed that having bloody urine and weakness of body were significant predictors of schistosomiasis infection. Children with bloody urine were six times as likely to have schistosomiasis infection compared to those who did not have bloody urine or ([95% CI] p value)6.2([1.92-20.03]0.04). On the other hand, children with body weakness were three times as likely to have schistosomiasis infection compared to those who did not have body weakness3.32([1.1.19 - 9.25]0.025).

Variable	n	N	%	OR	95% CI	P - Value
Sex						0.094
Female	6	82	7.32	1		
Male	11	69	15.94	2.4	0.84 - 6.88	
Bloody red urine						0.004
No	12	136	8.82	1		
Yes	6	16	37.5	6.2	1.92 - 20.03	
Weakness						0.025
No	10	118	8.47	1		
Yes	8	34	23.53	3.32	1.19 - 9.25	
Spleen palpable						0.055
No	15	141	10.64	1		
Yes	2	4	50	8.4	1.10 - 64.07	

Table 1: Summary of risk factors for schistosomiasis infection

PREVALENCE OF MALARIA INFECTION

Malaria prevalence among children tested was 35% (63/180) but the prevalence differed depending on the school (p-value = 5.47e-08, X-squared = 49.341, df = 8, n=63), for example the prevalence in Duncan Ndegwa was 9% (16/180) while that in Ngombeni primary school was (1/180) was 1%. Determinants of malaria infection included having been treated for malaria recently and having hotness of body, they were considered to augment the findings. Children who had been treated for malaria recently were twice as likely to have malaria compared to those who had not had a recent malaria infection or ([95% CI] p value]; 2.03([1.09-3.80]0.025) (Table, 2). Likewise, participants who had hotness of body were twice as likely to have malaria infection compared to

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those who did not have hotness of body 2.14([1.01-4.51]0.047).

Variable	n	N	%	OR	95% CI	P – Value
Sex						0.185
Female	28	93	30.11	1		
Male	34	86	39.53	1.52	0.82 - 2.82	
Treated For Malaria recently						0.025
No	26	95	27.37	1		
Yes	36	83	43.37	2.03	1.09 - 3.80	
Hotness of the body						0.047
No	40	121	33.06	1		
Yes	19	37	51.35	2.14	1.01 - 4.51	

Table 2: Summary of risk factors for malaria infection

PREVALENCE AND RISK FACTORS OF MALARIA-SCHISTOSOMIASIS CO-INFECTION

The prevalence of malaria-schistosomiasis co-infection was 7.95% (12/151) in the study population.

Risk factors for malaria-schistosomiasis confection included having been treated for malaria recently, having bloody urine and having splenomegaly.The odds of co-infection among those treated for malaria recently was 3.97 ([1.03 - 15.29]0.03) relative to those not treated for malaria recently. On the other hand, the odds of malaria-schistosomiasis co-infection among those who had bloody urine was 5.29 ([1.39 - 20.17]0.024) relative to those who did not have bloody urine. Finally, the odds of malaria-schistosomiasis co-infection among those who had a palpable spleen were 14.56 ([1.83 - 115.70]0.02) relative to those who did not have.

Characteristic	n	N	%	OR	95% CI	P - Value
Sex						0.555
Female	5	81	6.17	1		
Male	6	69	8.70	1.45	0.42 - 4.97	
Treated for Malaria Recently						0.031
No	3	81	3.70	1		
Yes	9	68	13.24	3.97	1.03 - 15.29	
Bloody red urine						0.024
No	8	135	5.93	1		
Yes	4	16	25.00	5.29	1.39 - 20.17	
Swimming/playing water						0.212
No	7	112	6.25	1		
Yes	5	39	12.82	2.21	0.66 - 7.41	
Spleen palpable						0.021
No	9	140	6.43	1		
Yes	2	4	50	14.56	1.83 - 115.70	
age, Median(IQR)		9 (8 - 10)				

Table 3: Summary of malaria-schistosomiasis co-infection characteristics

Test results show that there were no significance differences in the different locations (P value=0.099, df=8, X-squared= 13.6911, n=12).

Group(school)	Malaria Schistosomiasis co-infection		
	No	**Yes**	**Total**
Duncan Ndegwa	14	2	16
Genesis	0	0	0
Kombani	17	3	20
Magaoni	17	3	20
Milalani	18	2	20
Mwakigwena	19	0	19
Ng'ombeni	21	0	21
Ramisi	13	2	15
Vingujini	20	0	20
Total	**139**	**12**	**151**

Table 4: Relationship between school and malaria schistosomiasis co-infection

The ages for co-infection in participants ranged between 8-11 years; while the mean age was 9 years in all the schools. Study test results show that there was no statistically significant differences of co-infection at different ages (P=0.7990).

V. DISCUSSION

The results of this study demonstrated that about a third of the children had malaria infection while about one in every ten children had either schistosomiasis or malaria-schistosomiasis co-infection respectively. These findings are supported by other studies in the sub-Saharan Africa (9–14). A study by Yapi and colleagues in Côte d'Ivoire (14)found helminth-malaria co infections in children with very high *P.falciparum* of 63%, in their study 1 out of six children was co-infected. In Tanzania concurrent *P.falciparum, S.mansoni* and *S.haematobium* infections are also common in school children (15), this infections are more prevalent in children than adults(5). They increase the risk of lower Hb level and Anemia (15). Kenyan children are also more likely to be co-infected than adults with *P.falciparum, S.haematobium* and *S.mansoni*(16), this may be due to their play activities.

In the current study malaria was more prevalent than schistosomiasis, this observation concurs with the findings of the study of Kabatereine *et al*(17), which reported higher occurrence of malaria parasites compared to schistosomiasis and other helminthes. However, the prevalence of malaria-schistosomiasis co-infections was lower compared to studies in Tanzania and Uganda where the cases of malaria-schistosomiasis co-infections were higher(17,18).Apparently, the prevalence of co-infection in this study was lower compared to another study by *Samuels et al*(19)in Nyanza Province, Kenya.

The observed prevalence of *P.falciparum* is in concordance with other studies in Kenya and is related to proximity of water bodies and favorable weather conditions(20,21). The low prevalence of schistosomiasis maybe as a result of relatively younger age of most of the children examined(13).

Results of this study demonstrated that children with schistosomiasis were more likely to have malaria (except for six children who were found to have schistosomiasis alone).The odds of heavy and light schistosomiasis have shown to increase with increasing plasmodium intensity showing that there are unmeasured biological factors in determining co-infection(16).Heavy *S. mansoni* infections have been found to be associated with a significant increase in the incidence of malaria among school-age children(22).The parasite alters the host's susceptibility to malaria infection leading to higher cases of malaria attacks(22). *S.haematobium* on the other hand plays a protective role against malaria attacks (23).This may explain why many children had co-infections with no active malaria infections.

Weakness of the body was a risk for schistosomiasis in the current study, it is expected that children who are infected with parasites , schistosomiasis being one of them, have general body weakness due to anemia and chronic complications(24).Malaria and schistosomiasis cause many complications (25). They include malnutrition, anemia and physical disability (19,23,2 5).

In the current study children who had bloody urine were more likely to be co-infected, as expected, urinary schistosomiasis usually presents with passing of bloody urine (26). These participants who had bloody urine most likely had schistosomiasis. The pathogen *S. haematobium* causes inflammation of the urinary bladder (cystitis), painful micturation and terminal *haematuria* (bloody urine) (27). Apparently, gender was not statistically significant for co-infection even though male children had higher cases of malaria-schistosomiasis co-infections as compared to their female counterparts; this is likely because of the few numbers studied. In other studies boys are more likely to be infected than girls, male children are more likely to play with water and to be found outside in the evenings(16). It is also expected that boys in the villages in Africa go fishing with their fathers, rare cattle up to late and play in the pools of water, exposing themselves to mosquito bites and eventually malaria (28). This finding on boys corroborates those of other studies which found that boys have an increased risk of infection compared to girls (29,10,24,28).

Overlap of schistosomiasis, soil-transmitted helminthes and *P. falciparum* malaria depends on conditions that favor multiple parasitic species survival and transmission (9).In malaria endemic areas, co-infections with multiple parasites, including schistosomiasis species are common. Playing in water and swimming did not show any statistical significant difference for this study, even though studies have shown associations(30).

Environmental factors including water bodies like lakes, swamps, dams and rivers in close vicinity to households and favorable climate conditions influence occurrence of infections(30). Kwale County's close proximity to Indian Ocean makes it favorable for malaria- schistosomiasis infections and other infections.

VI. CONCLUSION

This study demonstrated that children with schistosomiasis are more likely to have malaria. Accordingly, this study concludes that Malaria-schistomiasis co-infection is a problem among school going children in large scale agricultural and mining concession areas in Kwale County.

VII. RECOMMENDATIONS FOR FURTHER RESEARCH

There is need for more studies of this nature to be conducted to cover other schools and children in other areas where large scale agriculture and mining is going on or is to be started such as around Mrima hills in the county. It would be interesting to carry out descriptive prospective studies in these schools to be able to clearly assess other health problems among the children in these schools apart from malaria, schistosomiasis and malaria-schistosomiasis co-infection.

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