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SCHISTOSOMA HAEMATOBIUM AND PLASMODIUM FALCIPARUM CONCOMITANT INFECTION AND HAEMOGLOBIN LEVEL IN CHILDREN OF SCHOOL GOING AGE IN GA SOUTH AND GA WEST MUNICIPALITIES

BY

NYARKO, RUTH TENKORAMAA

STUDENT ID: 10585002

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DECLARATION

I, Nyarko, Ruth Tenkoramaa, hereby declare that except for references made to other people's work which have been duly acknowledged, this work is the result of my own research undertaken under supervision and it has neither in part nor whole been presented for another degree.

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Nyarko, Ruth Tenkoramaa

(Student)

Date ……………………….

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Prof Kwasi Torpey

(Supervisor)

Date ……………………

DEDICATION

This work is dedicated to the Almighty God, and to all the school children in the Ga West and Ga South Municipality. This work is also dedicated to Mr. Carroll Kwabena Owu for his support throughout this period.

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ABSTRACT

Introduction: Urinary Schistosomiasis and malaria are Neglected Tropical Diseases endemic in Sub-Saharan Africa. The overlapping distribution of these parasites may result in a high co-infection rate and hematologic abnormalities especially with hemoglobin concentration.

Objective: The main aim of the study was to assess the association between mono-infection and co-infection status of the two parasites and the hemoglobin concentration in school children.

Method: A cross-sectional epidemiological survey was carried out on a total of 404 school children between ages 9 - 14years (mean age 11.75 ± 1.38years). Urine and blood samples were collected from 404 children (231 males and 173 females) to examine urinary schistosomiasis and malaria and to determine hemoglobin concentration among school aged children in Ga West and Ga South Municipality.

Results: The prevalence of mono-infection was 4.7% and 12.9% for S. haematobium and P. falciparum respectively, while 0.9% were infected with the two parasites. The prevalence of anaemia in the study population was 59.9%. The risk of developing anaemia was not associated with the different infection statuses. There was no difference in the mean hemoglobin concentration with the three infection categories ($p>0.05$). However all respondents with coinfection had anaemia.

Conclusion: Examination of the hemoglobin concentration in patients co-infected with malaria and schistosomiasis is important to reduce the risk of anemia and to improve health of the community.

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LIST OF ABBREVIATIONS

WHO – World Health Organisation

GDHS – Ghana Demographic Health Survey

CDC – Center for Disease Control

UNICEF – United Nations Children's Fund

SES – Social Economic Status

GSS – Ghana Statistical Service

STH – Soil Transmitted Helminths

TB – Tuberculosis

RDT – Rapid Diagnostic Test

NTD – Neglected Tropical Diseases

WHO/TDR – World Health Organisation – Tropical Diseases Research

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Malaria and Urinary Schistosomiasis are parasitic infections that are co-endemic in resource poor communities in sub-Saharan Africa with both health and economic implication. The overlapping distribution of the two parasites may result in a high co-infection rate. Various factors including low socio economic status, poor sanitation, limited access to safe water, development of water resource and poor health awareness play a key role in the transmission and infestation of malaria and schistosome parasites. Children are mostly vulnerable for schistosome and malaria infection due to their weak and developing immune system.

In sub-Saharan Africa, schistosomiasis also known as bilharzia remains a Neglected Tropical Disease. S. mansoni and S. haematobium are the dominant species in Sub-Saharan Africa including Ghana. Urinary schistosomiasis caused by S. haematobium is the most common form of schistosomiasis in Ghana. Dysuria, urinary frequency and urgency, proteinuria and particularly, haematuria are the most frequent symptoms for bilharzia (Bustinduy et al., 2014)(Gryseels & Strickland, 2013). Malaria infection caused by the Plasmodium parasite through bites from the female anopheles mosquito affects the hematological status of infected individuals (Adebayo, Akinyemi, & Cadmus, 2015).

The additive effect of both infections on hemoglobin level has raised a lot of public health issues especially among children of school going age. There is a paucity of information in sub-Saharan Africa on the concomitant occurrence of both parasites and their effect on the hematologic status of children of school going age (Degarege, Animut, Legesse, Medhin, & Erko, 2014) (Morenikeji, Atanda, Eleng, & Salawu, 2014).

This study therefore aims to assess the prevalence and effect of single and concomitant S. haematobium and P. falciparum infection on the haemoglobin concentration of children of school going age in six peri-urban areas located in Ga South and Ga West municipality.

1.2 Problem statement

Malaria and bilharzia are diseases of public health importance particularly among children in sub-Saharan Africa.

About half of the world's population is at risk of malaria, with pregnant women, children and non-immune travelers at higher risk. Between 2000 and 2015, the case incidence of malaria in Sub-Saharan Africa reduced by approximately 7 percent. Sub-Saharan Africa still has a disproportionately high share of the global burden of malaria. In 2015, the region had 88percent malaria cases and 90% malaria deaths (World Health Organisation, 2016). There is a dearth of information on the prevalence of malaria among children of school going age. Data from most studies including the Ghana Demographic Health Survey (GDHS) focuses on malaria prevalence among pregnant women and children under 5. Data from the World Malaria Report, 2014 revealed that about 6 million children between 2 to 10 years are infected with P. falciparum infection (World Health Organisation, 2014). According to Walldorf et al., (2015), "School-age children represent an underappreciated reservoir of malaria infection and have less exposure to antimalarial interventions". The problem of P. falciparum infection anaemia is a major public health problem among school children in peri-urban centers in Ghana which deserves further investment and interventions (Sarpong et al., 2015). A study by Sarpong et al., (2015) revealed a parasitemia prevalence of 41.7% among children of school going age.

Sub Saharan Africa constitutes 93% of the global schistosomiasis burden. Out of the 92 million infected people in sub Saharan Africa, Nigeria contributes approximately 32%, with 21% from Tanzania, 16% each in Congo and Ghana and 14% in Mozambique (Adenowo, Oyinloye, Ogunyinka, & Kappo, 2015). Similar studies on urinary schistosomiasis in Malawi, Tanzania and Rwanda reported prevalences of 46%, 64.3% and 21% for S. haematobium among school aged children respectively (Adenowo et al., 2015)(Magalhães et al., 2011). In the Tono District in Ghana, a survey among children of school going age (6-15years) indicated a prevalence of 33.2% for S. haematobium (Anto et al., 2013). Epidemiological evidence in Ghana suggests children of school going age to be more infected with S. haematobium than adults (Yirenya-Tawiah et al., 2011).

However, occurrence of P. falciparum and S. haematobium infections do not occur in isolation. One of the pathological effects of this co-infection is anaemia as a result of the breakdown of red blood cells, increased spleen clearance of both infected and uninfected red blood cells with urogenital helminths causing loss of blood in the urine, nutritional deficit and loss of appetite due to immunological factors (Alemu, Shiferaw, Ambachew, & Hamid, 2012). The S. haematobium parasite destroys the globulins of the red blood cells and feed on the blood's nutrient whereas P. falciparum breaks down red blood cells and increase the clearance of both infected and uninfected red blood cells. The eggs of the schistosome parasite also induces inflammation and ulceration of the bladder and ureters resulting in bleeding and the formation of lesions in the bladder and ureters increasing the risk of urinary obstruction; a risk factor for renal failure, urinary stasis and bladder cancer (Gryseels & Strickland, 2013). For females in their reproductive age, the eggs can penetrate the urinary system to the genital area producing granulomas in the fallopian tube, ovaries and uterus, resulting in menstrual disorders, anaemia and infertility (Nour, 2010).

Similar studies among school children indicate a high risk of anaemia in children with concomitant S. haematobium and P. falciparum infection. Blood loss in the urine has been shown to be higher in co-infection than in single infection of either of the parasites (Morenikeji, Eleng, Atanda, & Oyeyemi, 2015, C. Naing et al., 2013).

1.3 Justification

Several policies have been put in place to roll back malaria which includes provision of Insecticide treated bed nets and public health education on sanitation and elimination of stagnant waters. These interventions has helped reduce the prevalence and incidence rates, but malaria is still endemic in Ghana. Schistosomia mapping done in Ghana reports a high prevalence among children. As part of WHO's standards, children from high intensity areas are given the chemotherapy; praziquantel yearly, children form moderate intensity areas are given the chemotherapy every other year and areas with low intensity are treated once every three years. In Ghana, school children in endemic communities are giving the chemotherapy once a year.

With the overlapping distribution of these two parasites in Sub-Saharan Africa, most countries have reported a high prevalence of S. haematobium and P. falciparum co-infection rate especially among children of school going age.

In Ghana, studies have assessed the prevalence of co-infections among children; particularly, malaria and soil transmitted helminths (STH) but currently no study has been carried out in Ghana on S. haematobium – P. falciparum concomitant infection and its association on the hemoglobin level in children of school going age.

This study therefore seeks to determine the prevalence of S. haematobium, P. falciparum co-infection among school aged children in two municipalities and the relationship between concomitant infection and the hemoglobin concentration of children of school going age. Information on the prevalence of mono infection of P. falciparum and S. haematobium and anaemia will also be provided.

1.4 Study objectives

1.4.1 General objective

The main aim of the study was to determine the prevalence of concomitant infection of S. haematobium and P. falciparum among children of school going age and to determine the relationship between concomitant S. haematobium and P. falciparum infection and haemoglobin concentration.

1.4.2 Specific objectives

1. To determine the prevalence of malaria and schistosome mono infection in children of school going age.
2. To determine the prevalence of schistosomia and malaria co-infection in children of school going age.
3. To determine the prevalence of anaemia in children of school going age.
4. To determine the relationship between schistosome-malaria co-infection and hemoglobin level in children of school going age.
5. To compare the prevalence of malaria, schistosomiasis and co-infection in children of school going age in two different municipalities.

1.5 Conceptual framework

The conceptual framework underlying this study's analysis on the relationship between S. haematobium, P. falciparum coinfection is shown in figure 1.

The effect of P. falciparum and S. haematobium on red blood cells has been established. Plasmodium falciparum causes hemolysis and increases splenic clearance of both infected and uninfected cells, resulting in low hemoglobin concentration. S. haematobium also destroys the blood globulins and feeds on nutrients in the blood. It causes inflammation of the ureters and bladder which is characterized by the loss of blood in urine.

Both diseases are known diseases of poverty; mostly endemic in rural and peri-urban areas. Poor sanitation and low socioeconomic status has been linked to the incidence of both malaria and urogenital schistosomiasis. Prevalence of urogenital schistosomiasis in most studies carried among school aged children is higher in males than females. Due to the developing immune system of children, they are most likely to get infected than adults which is evidenced in most epidemiological studies. Bathing, washing or drinking from an open water source also increases the risk of infection. Children sleeping in insecticide treated nets are protected from the bite of the female anopheles mosquito, which transmits the plasmodium parasite.

The synergistic effect of both infections will have an impact on blood haemoglobin concentration.

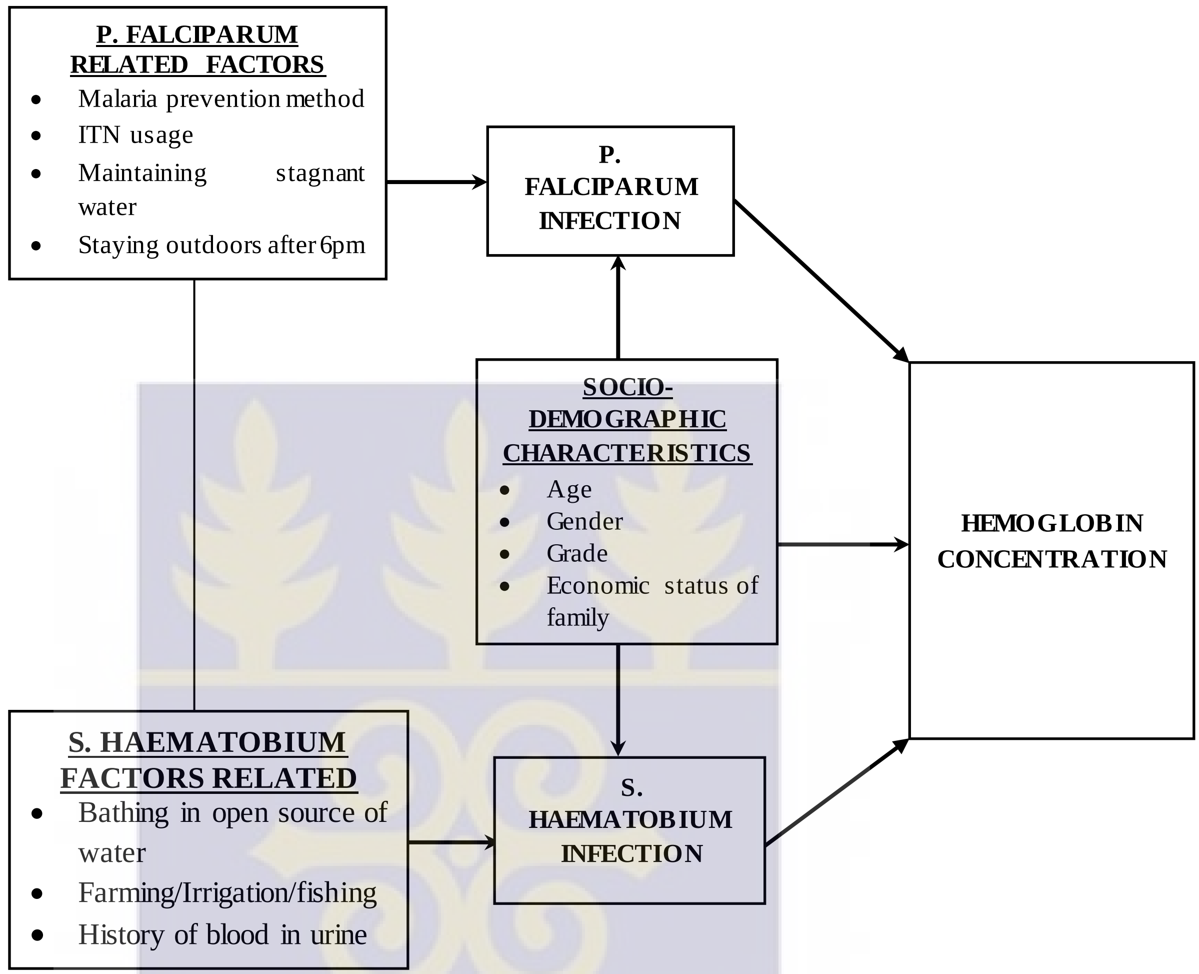

Figure 1: conceptual framework showing study variables

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Schistosomiasis

Schistosomiasis is a parasitic infection caused by schistosoma sp. which belongs to the trematode family. There are three main species of schistosoma affecting humans; S. haematobium, S. mansoni and S. japonicum with some species, prevalent in other continent than others. S. mansoni is common in African countries, South America and some parts of Arabia, Brazil, Venezuela, the Caribbean and Suriname; S. japonicum is prevalent in China, Indonesia and in the Philippines and S. haematobium in Africa, Middle East, Japan and Corsica in France. Intestinal schistosomiasis is as a result of infection from S. mansoni and S. japonicum whereas urogenital schistosomiasis also known as Bilharzia is due to S. haematobium infection. Other rare forms of Schistosomes include S. mekongi and S. intercalatum are common in Cambodia, Lao People's Democratic Republic and the rain forest areas of Central Africa (Fenwick & Zhang, 2010). Schistosomes are often referred to as blood flukes because they live in blood vessels. Transmission of this blood fluke requires the presence of an intermediate and suitable snail host. Contamination of water surfaces with human excreta and urine, releases the primary larvae (miracidiae) which infects the snails and develops to free living secondary larvae in snail host. Water related activities such as swimming, fishing, irrigation or farming, fetching of water and washing clothes or dishes leads to the free living secondary larvae; cercariae to penetrate the skin, infecting humans which completes the life cycle of the trematode. The creation of dams and urbanization develops local snail habitation and consequently, increases local prevalence of schistosomiasis (Bustinduy & King, 2014)(Gryseels & Strickland, 2013).

2.2 Risk factors for schistosomiasis

Urinary schistosomiasis is prevalent in resource poor communities characterized with low socio-economic status, poor sanitation and unsafe sources drinking water (World Health Organisation, 2015). Age, gender, socioeconomic status, water related activities, availability of toilet facilities, source of drinking domestic water and proximity to source of infection are some factors associated with bilharzia. In several studies, males have been found to have increased risk than females which could be due to their recreational, behavioral and gender role play in the community. Anto et al., (2013) in their study on "Water Contact Activities and Prevalence of Schistosomiasis Infection among School-aged Children in Communities along an Irrigation Scheme in Rural Northern Ghana" reported many more males (51.7%; 95% CI: 47.5-55.8) being infected with S. haematobium than females were infected (41.2%; 95% CI: 36.0-46.6). However, a study by Degarege et al., (2015) on urinary schistosoma among school children recorded no difference in the prevalence of urinary schistosoma between males and females which is in discordance with the findings of Anto et al., (2013). Ossai et al., (2014) in Enugu state in Nigeria and Geleta, Alemu, Getie, Mekonnen, & Erko (2015) in Ethiopia also in similar studies reported male gender as a risk factor for S. haematobium infection which is in discordance with the findings of Morenikeji et al., (2015) and Morenikeji et al., (2014) who reported that infection with S. haematobium is not gender dependent with p values of 0.975 and 0.096 respectively. Aryeetey et al., (2000) also in their study on urinary schistosomiasis in Southern Ghana reported high intensity of infection among males than females. Kosinski et al., (2011) in assessing the accuracy of urine filtration and dipstick tests for Schistosoma haematobium infection among Ghanaian school children reported findings indicating higher prevalence among males than females even after three consecutive screening. In a study by Kapito-Tembo et al., (2009) male gender was strongly associated with increased risk of S. haematobium infection. Maseko, Mkhonta, Masuku, Dlamini, & Fan (2016) in assessing knowledge, attitude, practice and other associated factors among primary school children reported gender as a predictor for S. haematobium infection. They also reported water contact activities, human waste disposal and health seeking behaviour as predictors for S. haematobium infection. In a comparative analysis of urinary schistosomiasis among primary school children and rural farmers, prevalence was higher among males and slightly among school children than farmers (Ogbonna et al., 2012).

Awareness of an open source of water was strongly linked to an increase risk in infection, history of schistosomiasis in the past month, distance of less than 1km from school to the nearest open water source and an age range of 8 to 10 years with increasing trend from 6 to 13 years which tapers off at 14 years (Kapito-Tembo et al., 2009). Morenikeji et al., (2015) in their study, on the concomitant S. haematobium and P. falciparum and its effect on renal function reported an increased risk of infection for school aged children within the ages of 6 to 9 years. Similar findings were observed in their study on the effect of concomitant infection of S. haematobium and P. falciparum on hematologic indices.

Findings by Kapito-Tembo et al., (2009), indicated that the odds of a child getting infected from a low or middle income family is high although socioeconomic status was not seen as an independent factor for S. haematobium infection. Also the odds of getting re-infected with S. haematobium infection was four times higher with children having history of urinary schistosomiasis. Ugbomoiko, Ofoezie, Okoye, & Heukelbach (2010) also reported the odds of infection been greater with low income status and proximity to infested water source or a local river. However the peak age for infection was 10 to 15 years similar to the findings of Ossai et al., (2014) and Geleta et al., (2015) in which the peak age for infection was 9 to 12 years and 13 to 14 years respectively. In Galilea and Mahem, the risk of S. haematobium infection increased with proximity and frequent contact with the infested water body. The odds of being infected with S. haematobium was higher among students and fishermen (Aboagye & Edoh, 2010). Infested water, transported home for domestic purposes may also play a role in the transmission of S. haematobium infection. (Bosompem et al., 2004). It is therefore imperative, to consider the source of drinking water or other sources of water for domestic activities as a risk factor in the transmission of S. haematobium infection

2.3 Global burden of schistosomiasis

Of the 2 million people globally infected with schistosomiasis, 85% of them live in sub-Saharan Africa where the prevalence rate is high, especially in poor sanitary areas and people with low socioeconomic status (Fenwick & Zhang, 2010). According to the World Health Organization (WHO) 90% of those requiring treatment for schistosomiasis are resident in Africa. As people move to new areas, it results in urbanization and increased power requirements leading to construction of dams facilitating infection (World Health Organisation, 2015). Although some studies have reported a reduced risk since the year 2000 in sub Saharan Africa, the prevalence rate still remains high. In 2012, 163 million people in sub Saharan Africa were infected with either S. haematobium or S. mansoni of whom 35% were children of school going age. Mozambique recorded the highest prevalence of 52.8% for urinary schistosomiasis among children of school going age. African countries like Rwanda, Burundi, Equatorial Guinea and Eritrea has recorded very low prevalence rates of 10% among children of school going age (Lai et al., 2015). Schur et al., (2011) compiled studies done in West Africa on the prevalence of Schistoma spp. in people less than 20 years. The median prevalence rate in most West African countries ranged from 17.6% to 51.6%. Ghana, Mali, Liberia and Sierra Leone had median prevalence rates higher than 40%. Ghana recorded a prevalence of 46.1%; Mali, 45.1%; Sierra Leone, 51.6% and Liberia a prevalence of 41.5%. Nigeria recorded a median prevalence of 39.4%. Studies in Ethiopia revealed a mean prevalence of 24.54% for urinary schistosomiasis among school aged children (Ketema Deribew, Tekeste, Petros, & Huat, 2013). Among primary school children in Zimbabwe, the prevalence rate of S. haematobium was 52.3% (Midzi et al., 2010). In Nigeria, Morenikeji et al., (2014) and Morenikeji et al., (2015) reported a prevalence of 52% and 75.1% respectively among children of school going age in the same community which reveals a 23.1% prevalence increase in urogenital schistosomiasis. Amuta & Houmsou (2014) in their study on the prevalence and intensity of infection of urinary schistosomiasis, reported a prevalence of 55%. Approximately 87% of their respondents had light infection compared with the 13.3% with heavy infection. Recent studies on the prevalence rates of urogenital schistosomiasis among school aged children in Ghana has been found to range between 14% to 33% (Magalhães et al., 2011)(Anto et al., 2013). Aboagye & Edoh, (2010) in their study on the risk of Infection of Urinary Schistosomiasis at Mahem and Galilea Communities in the Greater Accra Region of Ghana also reported an overall prevalence of 52% in both communities.

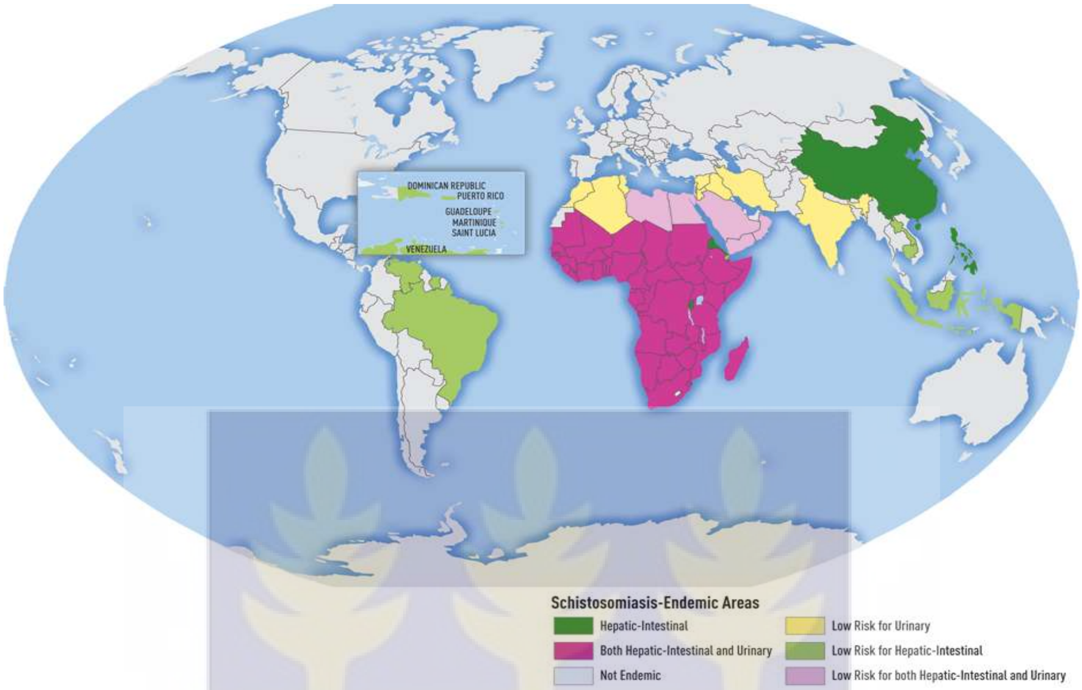

Figure 2: (Centre for Disease Control and Prevention, 2010)

2.4 Schistosoma haematobium infection and hematuria

Infection with S. haematobium results in deposition of egg in the host bladder. The eggs are highly inflammatory resulting in a range of urothelial abnormalities such as ulceration and formation of lesion (Honeycutt, Hammam, & Hsieh, 2015). Blood in urine (hematuria) is a common and early symptom of urinary schistosomiasis. Hematuria is sometimes referred to as the "red flag of schistosomiasis". However, the relationship between infection intensity and degree of hematuria is not linear (Kosinski et al., 2011). In a study by Deribew et al., (2013), hemoglobin level was negatively correlated with the number of S. haematobium eggs/10ml of urine.

2.5 Screening methods for Schistosoma haematobium

Diagnosis is essential in all aspects of urinary schistosomiasis. Determination of individual treatment, assessing morbidity in a population and the effectiveness of treatment and other control measures have need of diagnostic test. Urogenital schistosomiasis can be assessed rapidly by using school based questionnaires to assess self-reported hematuria. However, self-reported hematuria is of limited diagnostic value, because self-reported hematuria declines after administration of praziquantel. Reagent test strips are also useful tools in diagnosing of urinary schistosomiasis and are appropriate for the monitoring of control programs (Utzinger, Becker, van Lieshout, van Dam, & Knopp, 2015). However, diagnosing with reagent strips is unstable thus treatment decision cannot be based on it alone especially in low prevalence setting, emphasizing the need for more accurate diagnostic methods (Krauth et al., 2015). Schistosoma haematobium infection can also be detected by the urine filtration method. The parasite secretes eggs into the urine which can be trapped on a polycarbonate membrane with a pore size of 8 to 30µm after 10ml of a well shaken mid-day urine is pipetted and passed through a syringe. The eggs trapped on the filter is observed under the microscope. The number of eggs per urine determines the intensity of the infection. The threshold for distinguishing light and heavy infection is 50eggs/10ml of urine. Individuals with egg count of less than 50egg per 10ml of urine have light infection whereas heavy infection is classified as an egg count of 50 or more eggs per 10ml of urine (Utzinger et al., 2015). However, urinary egg count can be influenced by a number of factors such as time of collection of urine, seasonal variations and environmental conditions, day to day variation in egg output and unavoidable random errors associated with every test diagnosis (Braun-Munzinger & Southgate, 1992). In low endemic areas, urine filtration method may not detect infections, however it is helpful for the rapid assessment of the intensity of S. haematobium infection (Degarege, Erko, et al., 2015). Thus multiple filtrations over successive days are needed for accurate diagnosis.

Serological test is also used in schistosomiasis diagnosis, by detecting anti schistosome antibodies in human blood which normally develops 6 to 8 weeks after infection. These antibodies are detectable even before schistosome eggs can be found microscopically but it also lacks the ability to distinguish between various schistosoma species (Utzinger et al., 2015).

2.6 Malaria

"Malaria" is an Italian word which literally means "bad air". It was made-up by Italians to be caused by offensive vapors emanating from Tiberian marshes. Malaria is still a major public and global health problem globally. Spread of malaria is common in regions of Africa, central and South America, the Caribbean, Asia, Eastern Europe and the South Pacific. Although uncommon in Europe, the US and other developed countries, it still remains a health concern. Malaria is caused by the Plasmodia protozoan which is transmitted through the bite of female anopheline mosquito. Malaria is the most common cause of fever in the tropics. The most common infections are, P. falciparum, P. vivax, P. malariae, P. ovale and P. knowlesi. Plasmodium falciparum is most common in the African region and P. vivax, in Asia and the Americas. Common manifestation of malaria include fever, chills and rigors, tiredness, anaemia and splenomegaly. Other severe manifestations include pulmonary edema, acidosis, coma and in most instances, death from P. falciparum. Children with severe malaria frequently develop anaemia.

Diagnosis can either be by detecting the parasite antigen using a Rapid Diagnostic Test (RDT) or microscopic visualization of peripheral blood smear (Cobo & Cobo, 2014). "Young children, pregnant women and non-immune travelers from malaria-free areas are particularly vulnerable to the disease when they become infected". Malaria is both preventable and curable with a lot of efforts to reduce global incidence (World Health Organisation, 2014).

2.7 Global burden of malaria

According to WHO, nearly half of the world's population are at risk of malaria with majority of cases and deaths occurring in Sub-Saharan Africa. Between 2000 and 2015, the incidence of malaria has reduced by 37% with a decrease in mortality rate by 60%. According to the WHO release in September, 2015, 214 million cases and 438,000 deaths has been recorded. Currently, the reported malaria cases in Africa is 89% and 91% of deaths (World Health Organisation, 2014). The rate of infection was highest in West Africa, among children between 2 to 10 years in 2013, with a 12% fall between 2000 and 2013 (World Health Organisation, 2014). In areas of high transmission, the burden of malaria and deaths is highest among children. However the epidemiology of malaria among school aged children has received very little consideration until in recent times.

There are disparities in the prevalence of P. falciparum in African school-aged children which varies extensively regionally and within the same country. This variation may be as a result of the mode of transmission and risk factors such as poor sanitation, housing and environmental condition and the season. The incidence of malaria is not well-defined among school aged children in Ghana. This age group is often not counted in the routine household-based cluster surveys such as malaria indicator surveys, demographic health surveys or multiple indicator cluster surveys. Data on the incidence of malaria in this age group is often obtained from World Health Organization (WHO) estimates and from occasional school-based, active case detection studies (Nankabirwa, Brooker, Clarke, Fernando, & Gitonga, 2014).

In Uganda, prevalence of malaria among school aged children has been found to be as low as 14% and as high as 64% between 2008 and 2012 (Nankabirwa et al., 2014) (Kabatereine et al., 2011). The reported prevalence in Kenya between 2002 and 2010 ranged from less than 1% to 47% in a malaria endemic zone. Ivory Coast has consistently reported high malaria prevalence for school aged children (58% to 67%). In Malawi, Walldorf et al., (2015) reported a prevalence of 20% during the dry season, which increased to 32% during the rainy season with over 88% being asymptomatic.

The burden of malaria among school children in Ghana is a major public health concern which warrants intervention measures. A cross sectional study was conducted in Adansi South District of the Ashanti Region and Wa West District of the Upper West Region of Ghana among school aged children between 2 and 14 years of age. The total parasitemia prevalence in both districts was 42% but differed across the 9 schools chosen for the study (from 21% to 63%) (Sarpong et al., 2015).

2.8 Health and psychosocial effects of malaria

Most studies have indicated malaria as a cause of school absenteeism. Educational impact of malaria is severe in primary school students than secondary school students resulting in 11% loss of school years (Nankabirwa et al., 2014). Although cerebral malaria is an uncommon complication of malaria; children surviving it have impaired cognitive function. A study in Zambia, showed a strong relationship between malaria infection, cognitive skills and socio emotional development of young children (Fink, Olgiati, Hawela, Miller, & Matafwali, 2013).

Malaria parasites break down red blood cells and increase splenic clearance of both infected and uninfected red blood cells. Malaria infection has also been associated with destruction of infected red blood cells and, shortening the life span of non-infected red blood cells and reduced production of red blood cells in the bone marrow (Morenikeji et al., 2014). The risk of developing low hemoglobin levels was associated with Plasmodium falciparum infection (Morenikeji et al., 2014). A study by Morenikeji et al., (2015) reported a prevalence of 47.3% for hematuria among children infected with Plasmodium falciparum. Sarpong et al., (2015) in their study on prevalence of malaria parasitemia among school aged children reported 41.7% prevalence for anaemia among school aged children with malaria. Their finding is similar to the findings of McCuskee, Brickley, Wood, & Mossialos, (2014a) who reported malaria as an important correlate in anaemia among children.

2.9 Anaemia

Anaemia is a medical condition in which the number of red blood cells transporting oxygen to the various body parts is not sufficient to meet the needs of the body. Anaemia may result from varied causes but iron deficiency is a major cause of anaemia (Gutema, Adissu, Asress, & Gedefaw, 2014). Micronutrient deficiencies such as folate, riboflavin, vitamin A and B_1. Acute and chronic conditions such as malaria, Human Immune Deficiency Virus, tuberculosis, cancer and other inherited hemoglobinopathies can affect hemoglobin synthesis and consequently, red blood cell formation (World Health Organization, 2011a). Due to the multifaceted nature of anaemia, an integrated approach is required to reduce its prevalence which includes promotion of iron fortification in regions with high prevalence of anaemia and controlling infections in high risk areas. Measurement of hemoglobin concentration, is a good indicator for measuring anaemia at the population level (World Health Organization, 2005).

Anaemia is defined as a hemoglobin concentration of less than 12g/dl. For children between 5 to 11 years, mild anaemia is hemoglobin level of 11 to 11.4g/dl. Haemoglobin concentration of 8.0g/dl to 10.9g/dl is moderate anaemia, an Hb concentration lower than 8.0g/dl is severe anaemia (World Health Organization, 2011b). Measurement can be done by using either capillary blood or venous blood. Most field studies use the capillary blood taken from a finger prick after wiping the fingertip with alcohol (Gutema et al., 2014).

Anaemia is the leading cause of child mortality and impaired development among children. Low haemoglobin concentration causes fatigue, delayed motor development, cognitive development and low productivity and reduces their ability to fight infections making them more vulnerable to other infections (McCuskee, Brickley, Wood, & Mossialos, 2014b).

2.10 Prevalence of anaemia

In 2011, the global mean hemoglobin level of children was 11.1g/dl and the prevalence was 43% (Stevens et al., 2013). In 2005, the global prevalence of anaemia among school aged children was 25.4% whereas in the WHO Africa region, the prevalence was 67.6% among school aged children (World Health Organization, 2005). A study by Deribew et al., (2013) in Ethiopia on urinary schistosomiasis and malaria among school aged children reported an overall prevalence of 31.8% for anaemia based on the WHO anaemia definition. In Bangalore, the prevalence of anemia for children 5 to 15 years was 13.6% with a mean of hemoglobin level of 12.6 ± 1.1g/dl. In this study, prevalence of anaemia was higher in females than males (Muthayya et al., 2007). In a study in Ethiopia with a similar age group, prevalence of anaemia was 23.7%. Majority of the children had mild anaemia with moderate and severe anaemia accounting for 25% and 1.19% of the children with anaemia (Gutema et al., 2014).

Anaemia prevalence greater than or equal to 40% is indicative of a severe public health concern; 20% to 39.9% prevalence is indicative of moderate public health concern and 5% to 19.9% prevalence is indicative of a mild public health concern.

2.11 Prevalence of S. haematobium, P. falciparum co-infection and haemoglobin status

Plasmodium and schistosomia infection are common health problems in sub Saharan Africa. Both infections are known diseases of poverty and they coexist in communities with poor socio cultural and economic development. Environmental contamination of water bodies is a known risk factor for the existence of both diseases. There have been reports about the coexistence of both infections in school children. A study by K Deribew, Tekeste, & Petros, (2013) reported a P. falciparum, S. haematobium coinfection prevalence of 2.84%. In their study, anaemia was significantly higher in children with schistosomia and malaria co-infection than children with single or no infection. Children with co-infection had a mean haemoglobin level of 10.57g/dl, malaria mono-infection was 11.73g/dl and schistosomia mono-infection was 11.60g/dl. There was a negative correlation between the number of S. haematobium eggs/10ml urine and the haemoglobin status. In a Nigeria, studies have reported a coinfection prevalence of 28.2% and 57.1% in Ijaka-Oke and Ijaka-Isale respectively among school aged children (O. a. Morenikeji et al., 2014) (O. A. Morenikeji et al., 2015)

CHAPTER THREE

3.0 METHODS

3.1 Introduction

This chapter provides a description of the methods used in gathering data for this study; the study design, study area, study variables, sampling technique, research instruments, data management and analysis and ethical issues.

3.2 Study design

An analytical cross-sectional study design was used to investigate the relationship between S. haematobium, P. falciparum co-infection and the haemoglobin concentration of school children. Eligible children of school going age were recruited and screened for malaria, urinary schistosomiasis and anaemia. Participants were also interviewed on water related activities and malaria prevention practices.

3.3 Study area

This study was carried out in the Ga West and Ga South Municipality of Ghana. Three schools in each municipality was used for the study.

Ga West shares common boundaries with Ga East and Accra Metropolitan Assembly to the East, Akwapem South to the North and Ga South and Ga Central to the South. Its capital is Amasaman. It occupies a land area of approximately 284.08 sq. km with about 412 communities. Ga South shares boundaries with the Accra Metropolitan area to the South-East, Akwapim South to the North-East, Ga West to the East, West Akim to the North, Awutu-Effutu Senya to the West, Gomoa to the South-West and the Gulf of Guinea to the South. Its capital is Weija. There are two main rivers that drain these districts; the Densu and Ponpon River The larger of the two is the Densu which drains down from the Eastern region through the western portion of the Ga West Municipality to Weija where it enters the sea.

River Densu forms part of the Densu Basin which flows from the thick Atiwa forest in the Eastern region of Ghana and serves as a source of drinking water for more than 4million people living in Greater Accra, Eastern region and Central region. The color and quality of the water changes as it flows through the various regions. Human excreta and other domestic industrial waste are dumped into it. Houses at Nsawam, Adoagyiri and surrounding towns connect pipes from household to drain liquid waste into Densu. Urinals have been erected near its banks. This river drains into the Weija Lake and into the environs of Adjen Kotoku, Akotoshie, Ngleshie Amanfrom and Galilea.

Schools used in this study were located in Medie, Adjen Kotoku, Akotoshie, Weija, Ngleshie Amanfrom and Galilea. The GPS coordinates for the various study sites are; Medie Presby Basic School: 05.76610° N, 000.32515°W, Adjen Kotoku M/A Basic School: 05.736998°N, 000.35776°W, Akotoshie M/A Basic School: 05.75823°N, 000.339600°W, Ngleshie Amanfrom MA3 Primary School: 05.53979°N, 000.40862°W, Weija Presby Primary: 05:57105°N, 000.34030°W and Galilea MA/2 Primary School: 05.54588°N, 000.39608°W.

Figure 3: Medie Presby Primary

Figure 4: Akotoshie MA Basic School

Figure 5: Adjen Kotoku Presby Primary

Figure 6: Ngleshie Amanfro MA/3

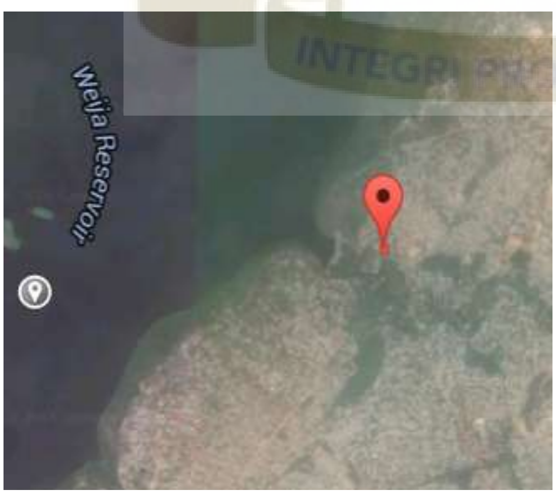

Figure 7: Weija Presby Primary School

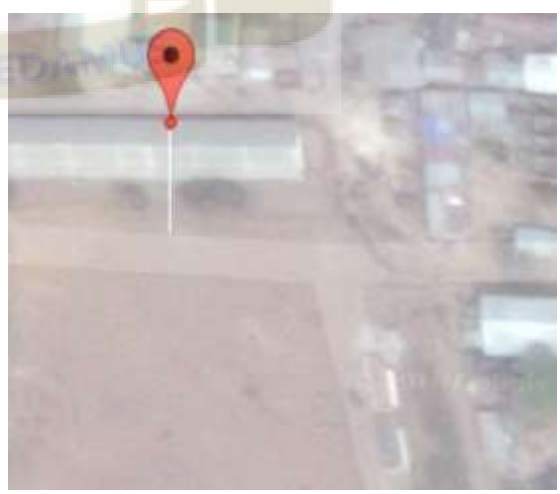

Figure 8; Galilea MA/2 Primary School

3.4 Study population

School children, residing within the Ga West and Ga South Municipality between May and June, 2016 formed the study population for this study.

3.5 Sampling

3.5.1 Sampling frame

The children used for the study were recruited from six schools; three schools from the Ga West Municipality and three schools from Ga South Municipality. The selected schools from the Ga West Municipality were Medie Presby Basic School, Adjen Kotoku Presby School and Akotoshie MA Basic School. In the Ga South Municipality Ngleshie Amanfrom MA/3 Primary School, Weija Presby Primary School and Galilea MA/2 Primary School were the selected schools. Children were selected form grade 3 to grade 6 which constituted an age range of 9 to 14 years.

3.5.2 Sampling size

The minimum sample size was determined by adopting the following statistical formula for minimum sample size calculation (L. Naing, Winn, & Rusli, 2006):

$$\mathbf{n} = \frac{\mathbf{Z^2pq}}{\mathbf{d^2}}$$

Z = z statistic for a 95% confidence level (1.96)

P= a proportion of 0.571 (57.1%) for S. haematobium and P. falciparum coinfection was used

q = 1-proportion of coinfection

d= a precision of 5% was used

From the above;

$$n = \frac{(1.96)^2 (0.571)(0.429)}{(0.05)^2}$$

Based on the above calculation, a minimum sample size of 376 was obtained. Using a 10% non-response rate, the figure was further increased to 414 as the sample size for the study. The additional 38 was to make room for possible incomplete questionnaires, non-respondents.

3.5.3 Sampling procedure

Two main sampling techniques were used in this study; proportionate stratified sampling and simple random sampling technique. Proportionate stratified sampling is a sampling technique in which each selected stratum is proportionate to the population size of the stratum with each strata having the same sampling fraction. With this sampling technique, the number of respondents selected from each class in the schools was proportionate to the number of students in each class.

Subsequently, the simple random sampling, was used to select the participants from each class. Using the roll numbers of the school children in their various class registers, random roll numbers was generated using Microsoft Excel 2013. This technique provided each participant an equal chance of participating in the study.

3.5.4 Inclusion and exclusion criteria

The study included all children who provided both parental consent and assent. Children who could provide blood and urine samples were also included in the study.

Children who did not provide consent and assent were also excluded from the study. Children below 9 years and above 14 years were also excluded from the study.

3.6 Study variable

The table below shows the study variables and how they were operationalized.

Table 1: Variables to be measured in the study

INDEPENDENT VARIABLES	DEPENDENT VARIABLES
Infection status Plasmodium falciparum Infection Schistosoma haematobium Infection Schistosome – malaria coinfection	**Haemoglobin level**
Socio-demographics Length of stay Age Gender Grade Economic status	**Infection status** Plasmodium falciparum Infection Schistosoma haematobium Infection **Hemoglobin level**
Water related activities Fetching water Fishing Washing Swimming Farming/ irrigation	**Infection status** Schistosoma haematobium Infection
Malaria related factors ITN, insecticide, mosquito coil, repellant usage Presence of stagnant water in the communities	**Infection status** Plasmodium falciparum Infection

3.7 Data collection procedure

Community entry was done by first identifying the target communities and visiting those communities to identify the risk factors and way of life of children of school going age in those communities. After surveying different communities in each municipality, the researcher settled on six communities with three communities in each district. The selected communities were Weija, Ngleshie Amanfrom, Galilea, Medie, Akotoshie and Adjen

Kotoku. Introductory letters were sent from the Department of Population, Family and Reproductive Health of the School of Public Health to the Ga South and Ga West Education office for approval. The researcher was further given introductory letters from the education offices in the two selected municipalities to the various heads of the selected schools. The researcher visited each school with the approval letters from the education office in each district and discussed appropriate days and dates for the research to be carried out in each school. Children were informed of the screening beforehand in order to obtain parental consent. Assent was also obtained from the children prior to study.

Data in this study were collected using a structured interviewer-administered questionnaire with both open ended questions providing predetermined options and closed ended questions that required written responses. The questionnaires were administered with the help of research assistants in the form of a face-to-face interview. Blood and urine samples were collected with the help of laboratory personnel form the Noguchi Memorial Institute of Medical Research. Each school was attended to in a day.

3.7.1 Data gathering tool

A structured questionnaire was used to collect data from the respondents. The structured questionnaire was developed by the researcher based on the objectives of the study, conceptual framework and guided by the literature review. Both open and closed ended questions were used to enable the researcher obtain as much information as possible. The questionnaire was divided into three main sections containing mostly closed ended questions.

Section A: Sociodemography

Questions in this section included background information of the participant, such as name, age, sex, area of residence and length of stay in the community. This section also included a tool which was used to determine the socioeconomic status of participants. The socio-economic status was measured using a tool developed by the Center for Social Research which has also been used in similar studies (Kapito-Tembo et al., 2009). This tool combined six variables; housing structures, main occupation of household heads, and possession of selected assets such as radios, telephones and televisions. Each variable was assigned a weight ranging from 0 to 2. The sum of the weights of the six variables was used to determine the socioeconomic status for each household. Households were then classified as low SES for those with scores less than 4.0, moderate SES for 4.0–6.0 and high SES for a score more than 6.0. However the tool was modified by the researcher to be relevant to the context within which the study was carried out. Drinking and domestic water sources, toilet facilities and roofing materials were modified to suit the context based on data from the Ghana Statistical Service.

Section B: S. haematobium related factors

Questions in this section provided data on the source of drinking and domestic water. Information regarding water related activities such as swimming, farming and irrigation and toilet facilities used were obtained. Questions on presence of hematuria was also included in this section.

Section C: Malaria related factors

Questions in this section provided data on malaria prevention practices such as the use of Insecticide treated nets, repellents, insecticide spray and mosquito coil. Other factors such as stagnant water in the environs and staying out after 6pm was obtained from the questionnaire.

Plasmodium falciparum infection: Presence of P. falciparum was detected using a Rapid Diagnostic Test Kit (CareStart^{TM}, Access Bio, Inc.). Laboratory personnel wore gloves and laboratory coats as data was collected. The Serial number of participants were written on the test kit. The tip of the finger to be pierced was cleaned using an alcohol swab. The fingertip of the participant was squeezed and the cleaned area of the fingertip was pierced using a lancet. The lancet was discarded in a sharps box. The first drop of blood was wiped out with a sterile cotton. Five microliters of blood was collected using a micro-pipette. Five microliters of the whole blood was added to the "S" well on the test kit and 2 drops of the assay buffer solution was added into the "A" well after which timing was started. The result was read after 20 minutes for each respondent. A test was invalid if the line in the "C" area does not appear. Invalid test were repeated. A negative test had one line in the "C" are and a positive result for P. falciparum had two color bands; one in the "C" and another in the "T".

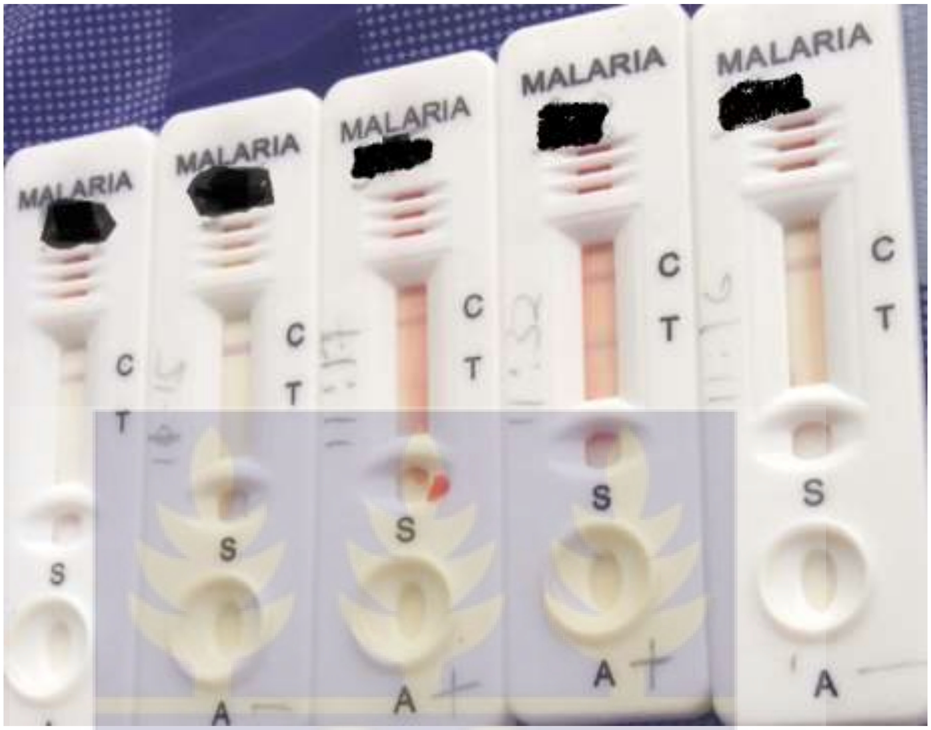

Figure 9: Rapid Diagnostic Test Strips in Use

Haemoglobin level: Haemoglobin (Hb) concentration of respondents were measured using HemoCue Hb 201+ and HemoCue Hb 201+ Microcuvettes. The cuvette holder was put in its loading position. The tip of the finger to be pierced was cleaned using an alcohol swab. The fingertip of the participant was squeezed and the cleaned area of the fingertip was pierced using a lancet. The lancet was discarded in a sharps box. The first drop of blood was wiped out with a sterile cotton. Light pressure was applied towards the fingertip until another drop of blood appeared. When the blood drop was large enough the microcuvettes was filled in one continuous process. Excess blood from the outside of the cuvette was cleaned with a clean paper towel. The microcuvette with the blood sample was placed into the cuvette holder and pushed into its measuring position. Used microcuvettes were discarded in a sharps box.

Urine Samples: Each respondent was provided with a clean, dry, screw capped urine container bearing the same serial number as the questionnaire. Respondents were given instructions on the amount of urine to produce. Urine samples were transported to the laboratory in an ice chest with ice packs for the urine filtration and urine chemistry.

Hematuria was measured using URIT 10V urine reagent strips. A strip from the bottle was taken and reagent areas were completely immersed in the well mixed urine samples. Strips were removed immediately to avoid the dissolving out of reagent areas. Each strip was tapped gently against the rim of the urine containers to remove excess urine. The urine strip was blotted out on an absorbent paper. Each reagent strip was compared with its corresponding color blocks shown on the color chart and the results at the specified times was read. Results on hematuria were obtained by direct color chart comparison.

Urine filtration method was done using Whatman® Nucleopore™ Track-Etched Membranes diameter 25 mm, pore size 12 µm, polycarbonate. The membranes were fitted into membrane holders. 10mls of urine were filtered through the membranes and the membranes were put on slides and viewed under the microscope to determine the presence and intensity of S. Haematobium infection (egg count per 10ml of urine). Light infection was classified as 1-49eggs/10ml of urine and heavy infection was defined by an egg count equal to or less than 50eggs/10ml of urine. Urine samples were disposed immediately after analysis in accordance with the laboratory guidelines for the disposal of biological samples.

3.8 Quality control

3.8.1 Pre-testing of questionnaire

The questionnaire was pre-tested using twelve children of school going age within the age range of the study participants in the Tema Municipal Assembly. Children used in the pre-testing did not form part of the final sample. The purpose of pre-testing the questionnaire was to ensure that respondents would understand the questions, identify possible problems with the questionnaire and to run a preliminary analysis. Minor problems were identified and revisions were made to the questionnaire.

3.8.2 Validity and reliability

Validity and reliability were both ensured in the study. Validity was ensured by using an appropriate methodology, sample size and research instrument. The questionnaire was tailored to suit the context within which data was gathered. Research assistants were properly trained in administering the questionnaire. The researcher cross checked each completed questionnaire at the end of each day's activity.

3.8.3 Data entry and processing

Completed questionnaires were serialized and coded. Data were entered and cross checked for errors using Microsoft Excel 2013 before running the analysis.

3.9 Data analysis

The data entered into Microsoft Excel 2013 was exported into STATA 13. Descriptive statistics was used to analyze the background characteristics of participants and the factors associated with S. haematobium and P. falciparum infection and coinfection. Chi- square test was used to determine the association between the factors associated with urinary schistosomiasis and S. haematobium infection. A chi-square test was similarly used to determine the association between staying out, Insecticide Treated Net usage and P. falciparum infection. Statistical significance of the differences in the prevalence of single and co-infection with each factor was determined via Chi-square analysis. Multivariate logistic regression analysis was used to predict the extent of the association with the different infection status as the dependent variable.

Differences in the mean hemoglobin level of the different infection status and socio-demographic variables was analyzed using a one way Anova. Values were considered to be significant when p-values were less than 0.05.

3.10 Ethical consideration

Ethical acceptability of the study was ensured by designing, conducting and reporting the study in accordance with recognized scientific skill.

3.10.2 Informed consent

An informed consent form was developed based on the WHO guidelines of informed consent. The form covered the basic details of the research such as the research title, academic institution and name of the researcher. It also provided information on the purpose of the study, voluntary participation and procedure for the interview and laboratory examination. Confidentiality, right to refuse or withdraw from the study and the contact information of the researcher and the GHS-ERC administrator were also provided. It also had a certificate of consent which covered the statement that the parent or guardian of the participant has consented for his or her ward to participant in the study.

Assent was also obtained from the participant before been included in the study.

3.10.3 Potential risks/ benefits

There was a temporary discomfort as a result of the finger prick from the needle stick. Each participant was given an incentive in the form of a sachet of yoghurt.

3.10.4 Privacy and confidentiality

Each respondent was interviewed on an individual basis to ensure privacy. Respondents were assured of confidentiality and anonymity. Names were not linked to responses and information obtained was reported without attaching identifiers.

3.10.5 Data storage and Usage

Questionnaires were coded and kept under lock and key in a cupboard, and the key was kept by the principal investigator. Data entered into Excel and STATA were saved on a password protected computer known only to the principal investigator. A copy of the data was stored on an external hard drive. All data will be kept by the Principal investigator for 3 to 4 years to allow for publication of the research after which questionnaires will be destroyed.

3.10.6 Voluntary withdrawal

Participants were given the opportunity to withdraw from the study at any time without any penalty.

3.10.7 Research funding

The study was funded by WHO/TDR.

3.10.8 Conflict of interest

Apart from its academic and public health importance, I have no personal interest in this study.

3.11 Limitations of the study

The study was a subjective method in gathering information on their water related activities, malaria related factors and the tool for socioeconomic status which is subject to information bias.

Hemoglobin concentration of participants is not only affected by S. haematobium and P. falciparum infection but can also be affected by dietary intake and other worm infestations.

CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

This chapter presents the findings of this study. It provides data on the background characteristics of the study participants. It provides data on schistosomiasis and malaria related factors. It also provides data on the prevalence of anaemia, malaria, schistosomiasis and the coinfection of P. falciparum and S. haematobium. The study had a response rate of 97% (404 out of 414 children of school going age responded).

4.2 Background characteristics of study subjects

Out of the 404 respondents, more than half (57.2%) were males. Approximately 63% of the respondents were between 12 and 14 years old. Thirty seven percent were between 9 and 11 years (Table 2). The mean age of respondents was 11.75 ± 1.38years. More than half of the respondents were from families of moderate socioeconomic status (56.2%) with less than a quarter from families with low socioeconomic status (7.4%).

Table 2: Background characteristics of school children

Background characteristics	Frequency (n)	Percent (%)
Sex		
Male	231	57.2
Female	173	42.8
Age		
9 – 11	151	37.4
12 – 14	253	62.6
School		
Medie Presby Primary	69	17.1
Kotoku Presby Primary	69	17.1
Akotoshie M/A Primary	70	17.3
Ngleshie Amanfro M/A 3 Primary	69	17.1
Weija Presby Primary	58	14.3
Galilea M/A 2 Primary	69	17.1
Grade		
Grade 3	98	24.3
Grade 4	105	25.9
Grade 5	97	24.0
Grade 6	104	25.8
Socio-economic status		
Low	30	7.4
Moderate	227	56.2
High	147	36.4

4.3 Factors associated with urinary schistosomiasis

Sachet or bottled water was the major source of drinking water among respondents (64.9%) as shown in Table 3. Domestic water sources are water sources used by respondents for domestic activities such as washing, bathing, cooking and cleaning. Most respondents used more than one source of water for domestic purposes. Pipe borne water was used by 78.2% of the respondents. Approximately 44.3% used the pit latrine compared to the 10% who have no toilet facility and thus used bushes or fields. Sixty five percent of the respondents reported having knowledge of an open water source such as a dam, river or stream with more males (74%) having knowledge of an open water source than females (58%).

Thirty two percent of the children also reported bathing, swimming or playing in an open source of water as shown in Table 3. More males (47.4%) swim, play or bath in an open water source compared to females (20.8%). Male gender was a strong predictor of swimming, bathing or playing in an open water source [OR = 3.44 (95% CI = 2.22 – 5.31), $p<0.001$].

Approximately 20% of the children reported being engaged in farming, fishing or irrigation. 19.8% of the respondents also reported seeing blood in their urine. The odds of seeing blood in urine was 4.12 times greater in males than in female respondents [OR = 4.12 (95% CI = 2.43 – 7.01), $p<0.001$].

The risk of S. haematobium infection increased with increasing age, presence of blood in the urine and the absence of a toilet facility (table 5 and table 6).

4.4 Factors associated with P. falciparum infection

Most respondents reported using more than one malaria prevention method. Out of the 404 respondents, 72.6% of the school children reported using mosquito coil at home as a malaria prevention method compared with 42.3% of them who use insecticide treated nets. Approximately 70% of the respondents reported having stagnant water in their area of residence. Fifty six percent of them also reported staying out after 6pm (Table 3). More males reported staying out late than females although the difference was not statistically significant (Table 4). Age group was also not a predictor for staying late. Infection with P. falciparum was associated with a child's grade [(OR=0.73, CI=0.56-0.95), P-value< 0.05] and ITN usage (table 6). Prevalence increased with decreasing grade.

Gender, age and socioeconomic status were not associated with P. falciparum infection, although infection was highest among the 9 to 11years age group, females, and children from households with moderate socioeconomic status.

Table 3: Factors associated with P. falciparum and S. haematobium infection

	Frequency	Percent
Source of drinking water		
Pipe borne water	207	51.2
Open well	11	2.7
Protected well/borehole	16	3.9
Stream/ river	2	**0.5**
Pond/ lake/ dam	2	**0.5**
Sachet/ bottled	262	**64.9**
Rain water	37	9.2
Domestic source of water		
Pipe borne water	316	**78.2**
Open well	31	7.7
Protected well/ borehole	54	13.4
Stream/ river	7	**1.7**
Pond/ lake/ dam	15	3.7
Rain water	39	9.7
Toilet facilities		
None (bush/beach/field)	43	**10.6**
WC	75	18.6
Pit latrine	179	**44.3**
KVIP	107	26.5
Knowledge of open water		
Yes	264	**65.4**
No	140	34.7
Play/swim/bath in open water		
Yes	130	32.2
No	274	**67.8**
Farm/ irrigation		
Yes	81	20.1
No	323	**79.9**
Blood in urine		
Yes	80	19.8
No	324	**80.2**
Malaria prevention methods		
Insecticide treated nets	171	42.3
Repellents	31	**7.6**
Mosquito coil	292	**72.6**
Insecticide spray	153	37.9
Stagnant water	284	70.3
Staying out late (after 6pm)	226	56.2

Table 4: A multivariate analysis of the factors associated with S. haematobium and P. falciparum infection by age and sex.

Factors	Sex					Age group				
	Male (%)	Female (%)	OR	95% CI	P – value	9 – 11 (%)	12 – 14 (%)	OR	95% CI	P – value
Knowledge of open source of water	128 (73.9)	136 (58.9)	**1.98**	**1.29 – 3.05**	**0.002**	97 (64.2)	167 (66.0)	1.08	0.71 – 1.65	0.718
Swim/play/bath in open source of water	82 (47.4)	48 (20.8)	**3.44**	**2..22 – 5.31**	**0.000**	47 (31.1)	83 (32.8)	1.08	0.70 – 1.67	0.726
Farm/ fishing/irrigation	38 (21.9)	43 (18.6)	1.23	0.75 – 2.00	0.405	32 (21.2)	43 (18.6)	0.89	0.54 – 1.47	0.658
Blood in urine	56 (32.4)	24 (10.4)	**4.12**	**2.43 – 7.01**	**0.000**	29 (19.2)	51 (20.2)	1.06	0.64 – 1.77	0.816
Stay out late	100 (58.5)	126 (54.6)	1.17	0.78 – 1.75	0.432	84 (56)	142 (56.4)	1.01	0.67 – 1.52	0.946

4.5 Schistosoma haematobium, Plasmodium falciparum and coinfection prevalence pattern

S. haematobium was found in 4.7% of the school children. The prevalence in the schools ranged from 0% to 10.3%. Prevalence was higher in Galilea and Kotoku than the others. Although the prevalence was higher in Ga South Municipality than Ga West municipality, the difference was not statistically significant. 5.2 percent of the males in the study were infected, compared to the 4.3% infected among females but the difference was not statistically significant. Prevalence of urinary schistosomiasis showed an increasing trend with increasing age, with the highest prevalence recorded for the age group 12 to 14 years compared to the 9 to 11 years age group [6.3%, (OR=3.87, CI=1.03-14.41), P-value=0.044]. Children in grade 4 recorded the highest prevalence of 7.6%. Prevalence was also highest with moderate socioeconomic status (6.61%) although the difference was not statistically significant (Table 6).

The prevalence of P. falciparum infection among the study population was 12.9%. Prevalence was higher in Ga West (18.8%) municipality than in Ga South (6.6%) [(OR=3.87, CI=0.16-0.59), P-value <0.001] (Table 5). Grade 4 recorded the highest prevalence of 15.2% as shown in table 5.

The coinfection prevalence, recorded in the study population was 0.9% (Table 6). Plasmodium falciparum and Schistosoma haematobium coinfection was not associated with gender, municipality, socioeconomic status, grade and age group. All the co-infected respondents had moderate socioeconomic status with a greater proportion of them in grade 5 (3.1%).

Table 5: Factors associated with P. falciparum and S. haematobium infection

	S. haematobium infection		
	Number examined	**Number infected (%)**	**P - value**
Knowledge of an open source of water			
Yes	264	16(6.1)	0.77
No	140	3 (2.1)	
Play/ swim/bath in open source water			
Yes	130	10 (7.7)	0.051
No	274	9 (3.3)	
Farming/ fishing/ irrigation			
Yes	81	5 (6.2)	0.485
No	323	14 (4.3)	
Toilet facility			
None (bush, field, beach)	43	5 (11.6)	**0.0107**
WC	75	3 (4.0)	
Pit latrine	179	3 (1.7)	
KVIP	107	8 (7.5)	
History of Blood in urine			
Yes	324	11 (3.4)	**0.012**
No	80	8 (10.0)	
Hematuria			
Yes	21	7 (33.3)	**0.000**
No	383	12 (3.1)	

	P. falciparum infection		
	Number of examined	**Number infected (%)**	**P – value**
Use Insecticide Treated Net			
Yes	233	22 (9.4)	**0.016**
No	171	30 (17.5)	
Stagnant water			
Yes	284	36 (12.7)	0.857
No	120	16 (11.9)	
Stay out after 6pm			
Yes	226	27 (11.9)	0.503
No	176	25 (14.2)	

Table 6: A multivariate analysis showing the prevalence pattern of S. haematobium, P. falciparum and coinfection

	Number examined	P. falciparum (%)	OR (95% CI)	P - value	S. haematobium (%)	OR (95% CI)	P – value	Coinfection (%)	P – value
Total	**404**	**52 (12.9)**			**19 (4.7)**			**4 (0.9)**	
District									
Ga West	208	39 (18.8)	**0.31**	**0.000**	9 (4.3)	1.19	0.713	2 (0.9)	0.952
Ga South	196	13 (6.6)	**(0.16-0.59)**		10 (5.1)	(0.47-2.99)		2 (1.0)	
Sex									
Male	231	21 (12.1)	0.89	0.704	9 (5.2)	1.21	0.682	2 (0.9)	0.771
Female	173	31 (13.4)	(0.49-1.61)		10 (4.3)	(0.48-3.05)		2 (1.2)	
Age group									
9 – 11	151	21 (13.9)	1.17	0.635	3 (1.9)	**3.87**	**0.044**	0 (0.00)	0.120
12 – 14	253	31 (12.3)	(0.61-2.24)		16 (6.3)	**(1.03-14.41)**		4 (1.6)	
Socioeconomic status									
Low	30	8 (26.7)	0.87	0.593	1 (3.3)	0.61	0.194	0 (0.00)	0.207
Moderate	227	23 (10.1)	(0.54-1.43)		15 (6.6)	(0.28 – 1.29)		4 (1.8)	
High	147	21 (14.3)			3 (3.1)			0 (0.00)	
Grade									
Grade 3	98	17 (17.4)			3 (3.1)			0 (0.00)	
Grade 4	105	**16 (15.2)**	**0.73**	**0.020**	8 (7.6)	0.84	0.447	1 (0.9)	0.094
Grade 5	97	12 (12.4)	**(0.56-0.95)**		3 (3.1)	(0.54 – 1.31)		3 (3.1)	
Grade 6	104	7 (6.7)			5 (4.8)			0 (0.00)	

Table 7: Intensity of infection and sociodemographic variables

	Number examined	No infection	Egg intensity Light infection (<50/10ml urine)	Heavy infection (≥50/10ml urine)	P – value
Total	404	385	12 (2.9)	7 (1.7)	
District					
Ga West	208	199 (95.7)	5 (2.4)	4 (1.9)	0.515
Ga South	196	186 (94.9)	7 (3.6)	3 (1.5)	
Sex					
Male	231	164 (94.8)	7 (4.1)	2 (1.2)	0.210
Female	173	221 (95.7)	5 (2.2)	5 (2.2)	
Age group					
9 – 11	151	148 (98.0)	2 (1.3)	1 (0.7)	0.891
12 – 14	253	237 (93.7)	10 (3.9)	6 (2.4)	
Socioeconomic status					
Low	30	29 (96.7)	1 (3.3)	0 (0.0)	0.228
Moderate	227	212 (93.4)	8 (3.5)	7 (3.1)	
High	147	144 (97.9)	3 (2.0)	0 (0.0)	
Grade					
Grade 3	98	95 (96.9)	3 (3.1)	0 (0.0)	0.497
Grade 4	105	97 (92.4)	4 (3.8)	4 (3.8)	
Grade 5	97	94 (96.9)	2 (2.1)	1 (1.0)	
Grade 6	104	99 (95.2)	3 (2.9)	2 (1.9)	

4.6 Intensity of S. haematobium infection

Respondents infected with S. haematobium were categorized into light and heavy infection. Light infection in the study was defined as an egg count of less than 50eggs/10ml of urine whereas heavy infection was an egg count of 50 or more eggs per 10ml of urine. Among the study population, majority of school children who were infected with S. haematobium had light infection. The minimum egg count was 1 and the maximum egg count was 204eggs/10ml of urine. Although the age group, 12-14 were heavily infected compared to 9-11 years age group, the difference was not significant. All children with heavy infection had moderate socioeconomic status however socioeconomic status was not associated with the intensity of S. haematobium infection (Table 7).

4.7 Hemoglobin concentration of school children

The mean haemoglobin level among respondents was 11.59g/dl ± 1.46 with a range of 5.5 g/dl to 15.1 g/dl. Age and grade were associated with hemoglobin concentration of respondents (Table 8). Children within the age group 12-14 years had a higher mean hemoglobin concentration compared with 9-11 age group. Grade 6 children had the highest hemoglobin concentration whereas grade 4 respondents had the least hemoglobin level. S. haematobium infected children had a higher mean hemoglobin level than children who were negative for S. haematobium but the difference was not statistically significant. However, there was a significant difference in the mean hemoglobin concentration of respondents with light and heavy infection for S. haematobium. Children with heavy infection had a lower mean hemoglobin level than children with light infection. P. falciparum infected children had lower hemoglobin concentration compared with P. falciparum negative children (Table 8).

There was no significant difference in the mean hemoglobin level in the different infection statuses (table 8).

Table 8: A one-way ANOVA of Hemoglobin concentration and infection status

	Hemoglobin concentration			
	Hb(g/dl) ± SD	Minimum Hb(g/dl)	Maximum Hb(g/dl)	P – value
Total	**11.59 ± 1.46**	**5.5**	**15.1**	
District				
Ga West	11.48 ± 1.42	5.5	14.5	0.146
Ga South	11.69 ± 1.49	7	15.1	
Age				
9 – 11	11.28 ± 1.52	5.5	14.2	**0.001**
12 – 14	11.77 ± 1.39	7	15.1	
Sex				
Male	11.65 ± 1.29	7.7	15.1	0.431
Female	11.54 ± 1.57	5.5	15.1	
Socioeconomic status				
Low	11.41 ± 1.74	5.5	14.1	0.103
Moderate	11.72 ± 1.39	6.2	15.1	
High	11.42 ± 1.47	7	14.7	
Grade				
Grade 3	11.69 ± 1.29	7.9	14.7	**0.0004**
Grade 4	11.21 ± 1.49	5.5	14.8	
Grade 5	11.45 ± 1.42	7.2	14.4	
Grade 6	12.01 ± 1.48	6.2	15.1	
Hematuria				
Present	12.33 ± 1.36	10.2	15.1	**0.016**
Absent	11.55 ± 1.45	5.5	15.1	
Infection status				
No infection	11.58 ± 1.47	5.5	15.1	0.073
Schistosomiasis	12.57 ± 1.89	8.5	15.1	
Malaria	11.39 ± 1.18	8.6	13.5	
Coinfection	11.63 ± 1.49	10.2	13.7	
Intensity of S. haematobium infection				
light infection	12.90 ± 1.5	10.7	15.1	**0.003**
heavy infection	11.2 0± 1.5	8.5	13.3	

4.8 Anaemia and hematuria prevalence pattern

Anaemia was defined as an Hb concentration of less 12g/dl. Severe anaemia refers to an Hb of less the 8g/dl, moderate anaemia is an Hb level of 8g/dl to 10.9g/dl and mild anaemia is an Hb concentration of 11g/dl to 11.9g/dl. Respondents with Hb of 12g/dl or more were classified as not having anaemia. The total prevalence of anemia within the study population was 59% (Table 9). Prevalence was high in the Ga West municipality (62%) than it was in Ga South. More males were anemic compared to females. With P. falciparum infection, prevalence of anaemia was higher in respondents who tested positive whilst prevalence was higher in respondents who tested negative for S. haematobium. Majority of the respondents had mild anaemia (32.4%) with only 7 percent having severe anemia. The severity of anemia, was significantly associated with the socioeconomic status and grade of the respondent. Prevalence of anaemia, increased with decreasing grade whereas with socioeconomic status, prevalence for severe and mild anaemia increased with a decrease in socio-economic status. (Table 10)

In the study population, 5.2 percent of study respondents had hematuria. Prevalence was higher in Ga South than in Ga West municipality. Prevalence of hematuria was associated with age group. 7.9 percent of children 12-14 years had hematuria compared with 0.7 percent for the 9-11 years age group. Although prevalence of hematuria was not associated with socioeconomic status, majority of the respondents with hematuria had moderate socioeconomic status (Table 10). As shown in table 8, all school children who had P. falciparum, S. haematobium coinfection had anaemia.

The risk of having anemia was not associated with any of the three infection categories (table 9).

Table 9: A multivariate analysis of the prevalence pattern of anaemia

	Anaemia prevalence				
	Number examined	Number with anaemia (Hb<12g/dl)	Prevalence of anaemia (%)	OR (CI)	P – value
Total	404	242	59.9		
District					
Ga West	208	129	62.0	0.83 (0.55-1.24)	0.371
Ga South	196	113	57.1		
Gender					
Male	231	110	63.6	0.78 (0.87-1.96)	0.191
Female	173	182	57.1		
Age					
9 – 11	151	96	63.0	0.78 (0.51-1.18)	0.244
12 – 14	253	146	57.7		
Socioeconomic status					
Low	30	20	66.7	1.15 (0.82-1.61)	0.402
Moderate	227	127	55.9		
High	147	95	64.6		
Grade					
Grade 3	98	57	58.2	0.79 (0.67-0.95)	0.015
Grade 4	105	77	73.3		
Grade 5	97	62	63.9		
Grade 6	104				
P. falciparum infection					
Positive	52	37	71.2	1.77 (0.93-3.34)	0.079
Negative	352	205	58.1		
S. haematobium infection					
Positive	19	9	47.4	0.58 (0.23-1.47)	0.258
Negative	385	233	60.5		
Coinfection					
Present	4	4	100.00	1.00	0.100
Absent	400	238	59.5		

Table 10: A multivariate analysis showing the prevalence pattern of Hematuria and anaemia

	Number examined	Hematuria (%)	OR (95% CI)	P-value	Anaemia				P-value
					Severe (Hb<8g/dl)	Moderate (8-10.9g/dl)	Mild (11-11.9g/dl)	Non-anaemic (>12g/dl)	
Total	404	21 (5.2)			7(1.7)	104 (25.7)	131 (32.4)	162 (40.1)	
District									
Ga West	208	8 (3.9)	1.77 (0.72-4.38)	0.213	4 (1.9)	58 (27.9)	67 (32.2)	79 (37.9)	0.720
Ga South	196	13 (6.6)			3 (1.5)	46 (23.5)	64 (32.7)	83 (42.4)	
Gender									
Male	231	6 (3.5)	0.55 (0.21- 1.49)	0.245	2 (1.2)	42 (24.3)	66 (38.2)	63 (36.4)	0.178
Female	173	15 (6.5)			5 (2.2)	62 (26.8)	65 (28.2)	99 (42.9)	
Age group									
9 – 11	151	1 (0.7)	11.14(1.42-87.3)	**0.022**	5 (3.3)	47 (31.1)	44 (29.1)	55 (36.5)	0.05
12 – 14	253	20 (7.9)			2 (0.8)	57 (22.5)	87 (34.4)	107 (42.3)	
Socioeconomic status									
Low	30	0 (0.0)			2 (6.67)	4 (13.33)	14 (46.67)	10 (33.3)	
Moderate	227	16 (7.1)	0.90 (0.44 – 1.84)	0.775	3 (1.32)	53 (23.35)	71 (31.28)	100 (44.1)	**0.041**
High	147	5 (3.4)			2 (1.36)	47 (31.97)	46 (31.29)	52 (35.4)	
Grade									
Grade 3	98	3 (3.1)	1.13 (0.73-1.76)		1 (1.0)	21 (21.4)	35 (35.7)	41 (41.8)	
Grade 4	105	6 (5.7)		0.572	3 (2.9)	36 (34.3)	38 (36.2)	28 (26.7)	**0.007**
Grade 5	97	1 (1.0)			1 (1.0)	29 (29.9)	32 (32.9)	35 (36.1)	
Grade 6	104	11 (5.2)			2 (1.9)	18 (17.3)	26 (25.0)	58 (55.8)	

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Factors associated with S. haematobium infection

Urinary schistosomiasis is prevalent in resource poor communities. Factors that have been associated with its infection in similar studies included; low socio economic status, age, gender, water related activities such as fishing, swimming and irrigation and availability of toilet facilities.

In this study, S. haematobium infection was significantly associated with age 12 to 14 years compared to those 9 to 11 years. History of blood urine, presence of hematuria and type of toilet facility used were associated with an increased risk of S. haematobium infection. This is similar to the findings of Kapito-Tembo et al., (2009) in which history of blood in urine and age of 8 to 13 years were significantly associated with S. haematobium infection.

In this study, gender was not significantly associated with S. haematobium infection although more males reported having a history of blood in urine than females ($p<0.001$). This is in accordance with the findings of Morenikeji, Atanda, Eleng, & Salawu, (2014) and Morenikeji, Eleng, Atanda, & Oyeyemi (2015). Although infection status was not significantly associated with gender, prevalence of infection was higher among male respondents than female respondents. The high prevalence of infection among males can be associated with the fact that male respondents were more knowledgeable of the existence of an open source of water in their area compared to the female respondents ($p<0.005$). Male respondents had more open water contact such as playing, swimming or bathing in an open source of water than female respondents ($p<0.001$). This is because males are usually more adventurous and are more likely to be knowledgeable of their environments including water bodies and therefore are more likely to play in them compared to females (Kapito-Tembo et al., 2009). Gender role play in the community could also explain why males are more likely to engage in open water contact activities than females (Anto et al., 2013).

Findings from this study showed that socioeconomic status was not significantly associated with S. haematobium infection. Similar findings was reported by Kapito-Tembo et al., (2009). Based on my findings, improving socioeconomic status alone may not significantly reduce the rate of infection among this population.

5.2 Factors associated with P. falciparum infection

In this study, ITN use was protective against P. falciparum infection. This is at variance with findings by Sarpong et al., (2015) who reported a slightly higher risk of infection with ITN use. They explained that it may be due to chance or could have been confounded by transmission heterogeneity. However, the reported prevalence of bed net usage in this study was lower than the prevalence reported by Walldorf et al., (2015). The risk of infection was also higher among children in grade 4 than children in other grades.

5.3 S. haematobium, P. falciparum and coinfection prevalence pattern

Prevalence of S. haematobium was higher in Kotoku and Galilea than in the other communities. The source of infection was much closer to these communities. The overall prevalence of 4.7% reported in this study was less than the prevalence reported in similar studies. In Nigeria, Morenikeji et al., (2014) and Morenikeji et al., (2015) reported a prevalence of 52% and 75.1% respectively. In Ethiopia the reported prevalence for urinary schistosomiasis in a similar population was 24.5% (Ketema Deribew et al., 2013). Previous studies in Galilea by Aboagye & Edoh, (2010) reported a prevalence of 52% which is higher than the prevalence reported in this study. Anto et al., (2013) also reported a prevalence of 33.2%. The reduced prevalence in this study may be attributed to differences in study size and methodology, improvement in sanitation, supply of safe water, awareness about the disease and the year to year administration of praziquantel to school children (Deribew, Tekeste, & Petros, 2013). Prevalence of light infection was higher than heavy infection although the difference was not statistically significant. This agrees with findings from similar studies by Amuta & Houmsou, (2014) and Kapito-Tembo et al., (2009) who also reported higher prevalence for light infection.

The total prevalence for P. falciparum (12.9%), reported in this study was lower than the prevalence in similar population (Sarpong et al., 2015). The observed difference could be associated with the use of malaria prevention methods, differences in study size and diagnostic method.

The prevalence of coinfection in this study was 0.9% which is far less than coinfection prevalence reported in similar studies. Morenikeji et al., (2014) and Morenikeji et al., (2015) reported a coinfection prevalence of 28.2% and 57.1% respectively. However Deribew et al., (2013) also reported a lower prevalence of 2.84% for concurrent S. haematobium and P. falciparum infection among children of school going age. The reduced coinfection prevalence can attributed to many factors such as improvement in sanitation, year to year praziquantel chemotherapy for urinary schistosomiasis, ITN usage and other malaria prevention methods and improvement in living conditions

5.4 Anaemia and hematuria prevalence pattern

The total prevalence of anaemia in the study was 59.9% which is indicative of a severe public health problem (World Health Organization, 2011b). This prevalence was higher than what was reported by Deribew et al., (2013). Several factors might have contributed to the high prevalence of anaemia in this study, including inadequate nutritional intake, socioeconomic status and worm infestation.

Although other studies have reported an increased risk of anaemia among females than males Muthayya et al., (2007), gender was associated with anaemia in this study.

The mean hemoglobin concentration of the study population was 11.59 ± 1.46g/dl. This observed value is high as a result of the high prevalence of mild anaemia than moderate and severe anaemia. This agrees with the work of Gutema, Adissu, Asress, & Gedefaw (2014) who also reported higher prevalence for mild anaemia. Sarpong et al., (2015) also reported a mean Hb level of 11.3 ± 2.1g/dl.

Out of the 19 respondents who were infected with S. haematobium, 47.4% had anaemia. The hemoglobin concentration of respondents with S. haematobium mono-infection was higher than the haemoglobin concentration of respondents with P. falciparum mono-infection or coinfection. This can be associated with the fact that the prevalence of light infection for S. haematobium infection was greater than the prevalence of heavy infection. Respondents with light infection had a significantly higher haemoglobin concentration compared with respondents with heavy infection (p-value < 0.05) thus contributing to the higher haemoglobin concentration in S. haematobium infected respondents. Light infected children had a higher haemoglobin concentration because they are less likely to have hematuria. This is consistent with the findings of Ketema Deribew et al., (2013) who reported a lower mean haemoglobin concentration for children with high intensity S. haematobium infection.

Out of the 52, P. falciparum infected children, 71.2% of them had anaemia. The haemoglobin concentration of respondents with P. falciparum mono-infection was lower than the haemoglobin concentration of respondents with S. haematobium mono-infection and coinfection. This is because, the malaria parasites breaks down red blood cells and increase the clearance of both infected and uninfected red blood cells. Morenikeji et al., (2014) also reported similar findings of higher risk of lower hemoglobin concentration with P. falciparum infection.

There was no difference in the mean hemoglobin concentration with the three infection categories ($p>0.05$). However, all respondents with coinfection had anaemia. The combined presence and interaction of both parasites could have enhanced the risk of anaemia in the respondents who had coinfection. Deribew et al., (2013) however reported a lower mean hemoglobin concentration for children with concurrent infection than children with mono-infection or no infection.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Urinary schistosomiasis and malaria are both serious parasitic infections prevalent in Ghana. Both diseases can cause anemia but there is a dearth of information on the association between anaemia and children of school going age who are co-infected with both parasites. This research however revealed that there was not a statistically significant reduction in the mean hemoglobin concentration in children with the co-infection as compared to those who were healthy or had mono-infection with either of the parasites.

Prevalence of malaria and schistosome infection were lower compared to earlier studies in similar population. This could be attributed to improved sanitation and standard of living, yearly administration of praziquantel to school children and use of malaria prevention methods. Prevalence of S. haematobium infection was similar in both districts. The prevalence of P. falciparum infection was significantly higher in Ga West than in Ga South municipality. Although the prevalence of concurrent infection was low, all children with concurrent infection had anemia which could be due to a combined interaction and effect of both parasites. Also more than half of the school children had anaemia.

6.2 Recommendations

From the study, the following recommendations are made;

A large number of schools should be screened in both districts to provide representative figures for a district.

There is need to put in an intervention to address the high prevalence of anaemia identified in the study population.

There is also a need to laud the work done in administering praziquantel to school children and to strengthen it in order to maintain the low prevalence rate recorded for S. haematobium infection.

Prevalence of anaemia was high in this study which could be influenced by worm infestation, Schistosoma mansoni infection and poor nutritional intake. Thus future studies on Schistosoma-malaria co-infection should explore these possible confounders.

This study was done among children of school going age who were in school. A similar study should be done among children of school going age who are out of school to compare the prevalence of mono-infection and coinfection between out of school children and children of school going age who are in school.

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APPENDICES

Appendix A: Consent form

Informed Consent

We are asking your ward to take part in a research study on "Schistosoma haematobium and Plasmodium falciparum coinfections and haemoglobin level in children of school going age"

I want to be sure that you understand the purpose and your responsibilities in the research before you decide if you want your ward to be in it.

This is a research study that would involve taking urine and blood sample from your ward to determine the presence of malaria and schistosoma infestation and their hemoglobin level. A small amount of blood will be taken by finger prick to test for malaria and blood haemoglobin level. **There will be a temporary discomfort as a result of the finger prick from the needle stick.**

Any child with malaria or schistosome infestation will be referred to the nearest clinic for treatment. You are free to decide if you want your ward to partake in this study.

We will protect information about your ward's taking part in this research to the best of our ability. We will neither use your child's name in any reports nor discuss his or her participation with anyone outside the research team. No payment will be made to your ward. Your ward may end participation at any time with no negative consequence to him or her.

This research has been reviewed and approved by Ghana Health Service Ethical Review Board. If you have any questions about how your ward is being treated by the study or his or her rights as a participant you may contact:

Ruth Tenkoramaa Nyarko (Principal Investigator): 0202885601, e-mail ruthnyarko@gmail.com

Hannah Frimpong (Ghana Health Service Ethical Review Committee Administrator): 0507041223

VOLUNTEER AGREEMENT

I understand all that has been explained to me about the study – objectives, benefits, risks and my child's rights, and I agree that my ward participate in this study.

__________________________________ ______________________

Signature of Parent Date

Appendix B: Questionnaire

Section A: Sociodemography

Name of pupil ……………… Name of school………… Gender: Female (0) Male (1)

Age in years ……………... Grade………….. Area of residence………………………

Length of stay in the community……………

Socio Economic Status (Tick Which Is Appropriate)

Roof materials
- ☐ Grass
- ☐ Plastic sheets
- ☐ Aluminum sheets
- ☐ Tiles/cement/bricks

Water source
- ☐ Piped water/sachet/bottles water
- ☐ Open well
- ☐ Protected well/ Borehole
- ☐ Lake/pond/ Stream/river

Occupation of household head
- ☐ none
- ☐ Farming
- ☐ Self employed
- ☐ Salaried
- ☐ Piece work

TOILET FACILITY
- ☐ None
- ☐ WC
- ☐ Pit latrine
- ☐ KVIP

FLOOR MATERIAL
- ☐ Earth/ mud
- ☐ Cement/concrete/tiles/terrazzo
- ☐ Wood planks
- ☐ Carpet

HOUSEHOLD ASSETS
- ☐ Electricity
- ☐ Radio
- ☐ Television/Phone
- ☐ Refrigerator
- ☐ Bicycle
- ☐ Motor
- ☐ Car/ truck

SECTION B: Schistosomiasis Related Factors (Tick Which Is Appropriate)

1. What is your source of drinking water?

   ☐ Pipe borne water ☐ Open well ☐ protected well/borehole ☐ Stream/river

   ☐ Pond/Lake/dam ☐ Sachet/ bottled water ☐ rain water ☐ other………………

2. What is your source of water for other domestic use?

   ☐ Pipe borne water ☐ Open well ☐ protected well/borehole ☐ Stream/ river

   ☐ Pond/Lake/dam ☐ rain water ☐ other………………

3. Do you know of an open source of water? ☐ YES ☐ NO
4. Distance from school to open source of water? ☐ Far/very far (more 15mins)

   ☐ close/very close (15mins or less) ☐ N/A

5. Distance from home to open source of water? ☐ Far/very far (more 15mins)
   ☐ close/very close (15mins or less) ☐ N/A
6. a. Do you play/ swim/ bath in an open water source? ☐ Yes ☐ No
7. How often? ☐ Daily ☐ weekly ☐ monthly ☐ rarely ☐ never
8. a. Do you farm or irrigate? ☐ Yes ☐ No
   b. How often? ☐ Daily ☐ weekly ☐ onthly ☐ rely ☐ er
9. Toilet facilities?
   ☐ None (bush/beach/field) ☐ WC ☐ Pit latrine ☐ KVIP
   ☐ other……………
10. Do you see blood in your urine? ☐ Yes ☐ No
11. a. Did you seek treatment? ☐ Yes ☐ No
   b. If yes where did you seek treatment? ☐ Health facility ☐ home base treatment/ ☐ self- medication ☐ Traditional healer ☐ other …………………………

Section C: Malaria Related Questions (Tick Which Is Appropriate)

1. Which of these malaria prevention methods do you use? ☐ Mosquito net
   ☐ repellent ☐ insecticide spray ☐ mosquito coil ☐ other
   ……………….
2. a. Do you sleep in mosquito net? ☐ Yes ☐ No
   b. How often? ☐ Daily ☐ weekly ☐ monthly ☐ Rarely ☐ N/A
3. Is there stagnant water in your community? ☐ Yes ☐ No
4. a. Do you stay out after 6pm? ☐ Yes ☐ No
   b. How long do you stay out after 6pm? …………………………
5. When was the last time you were diagnosed with malaria? ☐ 1 month
   ☐ 2-3 months ☐ 4-6 months ☐ more than 6 months ☐ cannot remember
   ☐ don't know
6. Did you seek treatment? ☐ Yes ☐ No
   b. Where did you go for treatment? ☐ Health facility ☐ home based treatment/ self- medication ☐ Traditional healer ☐ other ……………………

Appendix C: Laboratory Analysis Form

Ser. No	Name	Sex	Age	Received		Hb Level	RDT	CHEMICAL ANALYSIS										Microscopy Eggs/10ml
				Urine	Blood			Leu	Uro	Bil	Blood	Nit	ph	SG	Prot	Glu	Ket	