

**PREVALENCE OF *PLASMODIUM FALCIPARUM* AND HELMINTHS
INFECTIONS AMONG IRRIGATION AND NON-IRRIGATION COMMUNITIES
IN JIBIA LOCAL GOVERNMENT AREA, KATSINA STATE, NIGERIA**

BY

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JUNE, 2016

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BY

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(MSC/SCI/34082/2012-2013)**

**A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE
STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER
OF SCIENCE DEGREE IN ZOOLOGY.**

**DEPARTMENT OF BIOLOGICAL SCIENCES, FACULTY OF SCIENCE,
AHMADU BELLO UNIVERSITY, ZARIA NIGERIA**

JUNE, 2016

DECLARATION

I declare that the work in this dissertation entitled “**Prevalence of *Plasmodium falciparum* and Helminths Infections among Irrigation and Non-Irrigation Communities in Jibia Local Government Area, Katsina State, Nigeria**” has been carried out by me in the Department of Biological Sciences. Information gotten from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

Bature Ojonugwa EMMANUEL

Signature

Date

CERTIFICATION

This Dissertation titled “PREVALENCE OF *PLASMODIUM FALCIPARUM* AND HELMINTHS INFECTIONS AMONG IRRIGATION AND NON-IRRIGATION COMMUNITIES IN JIBIA LOCAL GOVERNMENT AREA, KATSINA STATE, NIGERIA” has been carried out by Bature Ojonugwa EMMANUEL meets the regulations governing the award of the Master of Science degree in Zoology of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

To my mother who would be so proud, my father who is and my children who will be.

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ABSTRACT

The Prevalence of *P.falciparum* and helminths infection among Irrigation and Non-Irrigation Communities in Jibia Local Government Area, Katsina State, Nigeria was determined from July 2014 to May 2015. Venous blood, urine and stool samples were collected from 420 individuals in the communities ranging from ages 1 to \geq 50 years by systematic sampling of households for the detection of *Plasmodium falciparum* parasites, *Schistosoma haematobium* ova and intestinal eggs and oocyst. Thick and thin blood films were made using standard parasitological procedures. The sedimentation method was used to concentrate ova from the urine samples. The formol-Ether concentration method by centrifugation was used to concentrate ova from the stool samples. Structured questionnaires were administered to obtain information on age, sex and other risk factors for infection. Out of the total of 420 (210 each from irrigation and non-irrigation communities) blood samples examined, 150 were positive for *P.falciparum* representing a prevalence of 35.7% of the study population. Out of the total of 420 urine samples examined, 216 were positive for *Schistosoma haematobium* parasite ova with an overall prevalence of 51.4% whereas 137 were positive for intestinal helminths parasite eggs with an overall prevalence of 32.6% of the study population. There is no significant difference ($P > 0.05$) in *P. falciparum* infections between irrigation (40.0%) and non-irrigation (31.4%) communities but the difference was highly significant ($P < 0.05$) for urinary *S. haematobium* infections in irrigation (68.1%) and non-irrigation communities (34.7%) and intestinal helminths infections in irrigation (45.2%) and non-irrigation communities (20.0%) of Jibia LGA. Prevalence of *P. falciparum* infections was significantly associated (OR= 1.8, $P < 0.05$) with gender (male = 52.3%, female = 37.4%) in the irrigation

communities only. *S. haematobium* infections was significantly ($P < 0.05$) associated with irrigation farming (OR= 4.0), male gender (OR= 3.5), 31-40 years age group (OR= 1.8), source of water from dam reservoir (OR= 3.1) , fishing (OR= 4.3), contact with dam reservoir water (OR= 3.6) and use of pit toilet (OR= 1.5) whereas for intestinal helminths infections with irrigation farming (OR= 3.3), male gender (OR=2.1), 1-10 years age group (OR= 1.9), source of water from dam reservoir (OR= 6.4) ,farming (OR= 1.8), schooling (OR= 1.7), contact with dam reservoir water (OR= 5.5) and open field defecation (OR= 3.8). *Ascaris lumbricoides* was the most prevalent of intestinal helminths with prevalence of 14.5% than *S. stercoralis* (9.5%), Hookworm (4.7%), *Enterobius vermicularis* (3.6%). While the least was *Hymenolepis diminuta* which was only observed in the non-irrigation communities with a prevalence of 0.2%. The prevalence of co-infection (15.0%) between *P.falciparum* and helminths infections is low. Intestinal *S.mansoni* was not encountered. The findings of the study suggest that *P.falciparum* and helminths infections occur among irrigation and non-Irrigation Communities in Jibia LGA, Katsina State. It is therefore recommended that epidemiology surveillance and an integrated approach for malaria and helminthiasis that is readily adapted to the local disease spectrum and socio-ecological settings is necessary in order to curb the infections in the communities.

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LIST OF ABBREVIATIONS/ACRONYMS

CAA- Circulating Anodic Antigens

CCA- Circulating Cathodic Antigens

CSP- Circumsporozoite protein

DALYs -Disability Adjusted Life Years

DDT-di-chlorodiphenyl-trichloro-ethane

EDTA –Ethylene- diaminetetra -acetic acid

ELISA- Enzyme Linked Immunosorbent Assay

HRP-II - Histidine-rich Protein 2

IFN -Interferon

IgE- Immunoglobulin E

IgG- Immunoglobulin G

IL- Interleukin

IRS- Indoor Residual Spraying

ITBN- Insecticide Treated Bed Nets

LLIN- Long Lasting Insecticide Treated Nets

MDA -Mass Drug Administration

MDG - Millennium Development Goals

PCR-Polymerase-chain reaction

PfSE- *Plasmodium falciparum* Schizont Antigen

PfSE-IgG3 -Immunoglobulin G3 against *Plasmodium falciparum* schizont antigen

RDT- Rapid Diagnostic Test

RT - PCR-Real Time- polymerase-chain reaction

SEA- Soluble Egg Antigen

SP- sulphadoxine-pyrimethamine

SSA -Sub-Saharan Africa

Th1- T-helper cells type I

Th2 -T-helper cells type II

TNF- Tumor Necrosis Factor

WHO

-World

Health

Organization

CHAPTER ONE

1.0

INTRODUCTION

1.1 Background of the Study

Throughout evolutionary history, humans have been infected with parasites. It is estimated that over one third of the world's population, mainly individuals living in the tropics and sub-tropics, are infected by one or more parasitic helminths (worms) and protozoans (De Silva *et al.*, 2003; Snow *et al.*, 2005). Malaria, schistosomiasis and soil transmitted helminths infections (STH) are considered the most important parasitic infection in Sub-Saharan Africa (Chitsulo *et al.*, 2000; WHO, 2002). The diseases share the same geographical distribution and occur as co-infection in humans and thus interact with regards to susceptibility, infection level, and pathology (De Silva *et al.*, 2003; Utzinger *et al.*, 2004).

Having over half a million deaths to its credit annually, malaria of which approximately half of the world's population is at risk, remains single handedly the number one killer of young children in sub-Saharan Africa where 90% of the deaths occur (Greenwood, 2002). Although the World Health Organization reports that malaria deaths have been reduced by 33% in the WHO African region, a child still dies every minute as a result of malaria (WHO, 2012). Globally, more than two billion people live in areas where they are at risk of contracting malaria and the estimated annual incidence of clinical malaria is greater than 300 million cases. More than one million people die every year from the direct causes of malaria, with children under the age of five years living in sub-Saharan Africa at highest risk (Breman, 2001). In 2001, the disease accounted for an estimated loss of 44.7 million disability adjusted life years (DALYs) with a DALY loss > 87% occurring

in sub-Saharan Africa (WHO, 2003); in 2002, the estimated malaria burden rose to 46.5 million DALYs (WHO, 2004). An estimated 90% of this burden is related to environmental factors (WHO, 2002).

In many developing countries, the most prevalent and important helminths are the soil – transmitted nematodes particularly *Ascaris lumbricoides*, *Strongyloides stercoralis*, *Trichuris trichiura* and hookworms (*Ancylostoma duodenale* and *Necator americanus*) (WHO, 2002). Human schistosomiasis results from an infection by trematode blood flukes of the genus *Schistosoma* (Gryseels *et al.*, 2006). Their distribution is influenced by sanitation, population movement, availability of suitable water bodies for breeding of the snail intermediate host and so on. For example high rates of malaria infection and helminths infections such as hookworm, ascariasis and schistosomiasis were constantly recorded among migrant population working in irrigation schemes in Awash Valley than migrant populations employed in rain-fed agriculture in the semiarid Setit Humora area (Kloos and Leman, 1980). It is known that irrigation and the construction of dams along with poor sanitary practices often result in rapid spread of schistosomiasis, since the aqueous environment provides suitable conditions for the intermediate snail hosts (Mazigo *et al.*, 2010).

In most irrigation systems, water is not only used for agricultural purposes, but also for all kinds of domestic, municipal, industrial and recreational purposes (van der Hoek *et al.*, 2001). These irrigation activities may influence the water quantity, quality or both (Van der Hoek *et al.*, 2001). Canals and drains may create ideal breeding sites for mosquitoes and snails bringing the vectors, intermediate hosts and the disease closer to

the people. Many field studies have described the influence of irrigation on the spread of these water- related diseases such as malaria, schistosomiasis, fascioliasis, filariasis, onchocerciasis, dengue fever, yellow fever, Rift Valley fever and encephalitis (Oomen *et al.*, 1990). The distance between irrigation infrastructure and residence may determine how often and how intensely the population is exposed to vectors or infested water (Oomen *et al.*, 1990; Konradsen *et al.*, 2003; Boelee *et al.*, 2006).

Whether an individual water project triggers an increase in malaria and schistosomiasis, transmission largely depends on the epidemiological setting, socio-economic factors, vector management and health seeking behaviour of the persons at risk of infection (Keiser *et al.*, 2005).

Diseases such as malaria and helminths infections are usually most prominent in the poorest and most economically disadvantaged people of the society. Most times these infections do not occur singly but in a multiple way thereby leading to severe consequences. Individuals co-infected with *P. falciparum* and *S. mansoni* have been observed to develop more severe forms of hepatosplenomegaly compared to individuals infected with either of the parasites (Tschikuka *et al.*, 1996, Booth *et al.*, 2004).

1.2 Statement of the Problem

Despite the growing interest to investigate co-infection and their related clinical consequences worldwide, there are very few longitudinal community based studies that have attempted to investigate the interactions between malaria, schistosomes and STH infection (Egwunyenga *et al.*, 2001, Mwangi *et al.*, 2006). Though these infections often co-exist, most studies focus on individual diseases.

Each year, more than 200 million people contract malaria – a disease that disproportionately affects children and pregnant women. An estimated 10,000 pregnant African women and 200,000 infants die as a result of malaria infection during pregnancy (WHO, 2013). Schistosomiasis is a chronic parasitic disease caused by blood flukes (Trematodes) of the genus *Schistosoma*. Schistosomiasis transmission has been reported from 78 countries (WHO, 2013). In sub-Saharan Africa, schistosomiasis is widespread with foci of high prevalence and high morbidity found adjacent to rivers, lakes and irrigation schemes (Konradsen *et al.*, 2003). In a prevalence study in Katsina State, Idris *et al.* (2001) reported infection rates of 12% and 3.3% for *S. haematobium* and *S. mansoni* respectively among primary schooling pupils.

Soil transmitted helminths (STHs) infection are among the most prevalent of chronic human infection. STHs are transmitted to humans through contact with parasite eggs or larvae that thrive in the warm and moist soil of the world's tropical and subtropical countries. Poverty, inadequate water supplies and sanitation are important determinants of transmission of STH infections. In such conditions, soil-transmitted helminths species are commonly co-endemic (Bethony *et al.*, 2006, WHO, 2002). However, reports on parasitic infection are solely made on malaria or helminths alone.

Several researches on Helminths parasites are carried out among schooling-age children, which are achieved due to the knowledge of prevalence and intensity of the disease in such age-groups, and the ease of access to the age-groups while in schoolings for urine and stool samples. However, surveys for active infection in all the age-groups in the

community may give an overall community data base for the prevalence of the disease (Tchuem *et al.*, 2003).

There are unreported cases of helminth-*Plasmodium* co -infection levels among different households and individuals in the communities of the study area. Research works on helminths in Katsina State were based on single species of either *S. haematobium* (Ofoizie *et al.*, 1996) or *S. mansoni* infection (Ukoli, 1984) and reports of co-infection with both *S. haematobium* and *S. mansoni* species (Idris *et al.*, 2001; Idris and Ajanusi, 2002).

Helminth-*Plasmodium* co-infection have been investigated and the prevalence ranged from 16% in Uganda and Cameroon, (Nkuo-Akenji *et al.*, 2006) to 26.5% in Tanzania (Mazigo *et al.*, 2010) to 60% in Nigeria (Abanyie *et al.*, 2013).

1.3 Justification

The outcome of this research will provide baseline data on the prevalence of *Plasmodium* and helminth infection in the study area. It will also provide parameters for promoting healthy behaviour in agricultural, domestic, occupational and recreational activities which expose them to infection, elucidate the epidemiology of co-infection for formulating intervention strategy, prevention and control efforts in the study area.

The survey of infection in all the age-groups in the community will give an overall community data based on socio-demographic status of members of the communities as well as knowledge on water contact activities. An analysis based on selected countries in Africa, showed that there is a risk ratio of 2.4 and 2.6 for urinary schistosomiasis (caused

by *S. hematobium*) and intestinal schistosomiasis (caused by *S. mansoni*), respectively, among persons living adjacent to dam reservoirs (Steinmann *et al.*, 2006). It is also reported that persons living near land that had been irrigated for agricultural use had an estimated risk of infection ratio of 1.1 for urinary schistosomiasis and 4.7 for intestinal schistosomiasis (Steinmann *et al.*, 2006).

1.4 Aim of the Research

The aim of the study is to evaluate the impact of irrigation farming and other risk factors on the prevalence of *Plasmodium* and helminths infections among irrigation and non-irrigation communities in Jibia Local Government Area, Katsina State

1.5 Objectives

- i. To determine the prevalence of *Plasmodium*, *Schistosoma haematobium* and intestinal helminths infections in irrigation and non-irrigation communities in Jibia LGA, Katsina State.
- ii. To determine the association between some risk factors and prevalence of *Plasmodium*, *S. haematobium* and intestinal helminths infections in irrigation and non-irrigation communities in Jibia LGA, Katsina State.
- iii. To determine the prevalence of co- infections of *Plasmodium*, *S. haematobium* and intestinal helminths infections in irrigation and non-irrigation communities in Jibia LGA, Katsina State.

1.6 Hypotheses

- i. There is no significant differences in the prevalence of *Plasmodium*, *S. haematobium* and intestinal helminths infections in irrigation and non-irrigation communities in Jibia LGA, Katsina State.
- ii. There are no significant associations between some risk factors and prevalence of *Plasmodium*, *S. haematobium* and intestinal helminths infections in irrigation and non-irrigation communities in Jibia LGA, Katsina State.
- iii. There are no *Plasmodium* and helminths co-infections in irrigation and non-irrigation communities of Jibia LGA, Katsina State.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

It is estimated that over a third of the world's population, mainly those individual living in the tropics and sub-tropics, are infected by parasitic helminths or one or more of the species of *Plasmodium* (De Silva et al, 2003). Report also showed that the economically developing world, particularly sub-Saharan African, bear the brunt of premature mortality, morbidity and disability (WHO, 2013). Malaria causes the largest disease burden among the three parasitic infection of interest in this study. About 40% of the world population at risk and 90% of the infection occur in Africa (Greenwood and Mutabingwa, 2002), followed by schistosomiasis that infect 187 million people worldwide, hookworm infects about 740 million people worldwide but mainly in sub-Saharan Africa, the Americas, China and East Asia (De Silva *et al.*, 2003).

2.2 Schistosomiasis

Schistosomiasis (also known as bilharziasis) is a disease caused by blood flukes of the genus *Schistosoma*. Six trematode species are known to cause schistosomiasis in humans, namely *Schistosoma haematobium*, *S. japonicum*, *S. mansoni*, *S. intercalatum*, *S. mekongi* and *S. guineensis* (Utzinger and Keiser, 2004; Gray *et al.*, 2011; Rollinson *et al.*, 2012). The first three species account for the majority of human diseases. Unlike other trematode which are hermaphroditic, schistosomes have male and female gender. The major species in Africa are *S. mansoni* that causes intestinal schistosomiasis and *S. haematobium* that causes urinary schistosomiasis. Aquatic snails of the genus *Bulinus* serves as intermediate hosts for *S. haematobium*, *S. intercalatum* and *S. guineensis*, snails

of the genus *Biomphalaria* serves as intermediate hosts for *S. mansoni*, *Tricula aperta* is the aquatic intermediate host for *S. mekongi* and the amphibious snail of the genus *Oncomelania* is the intermediate host for *S. japonicum* (Gryseels *et al.*, 2006; King, 2009).

2.3 Life cycle of schistosomes

Human schistosomes have a complex life cycle that involves the human host and the intermediate snail host. The snail intermediate hosts shed free swimming cercaria that penetrates the skin of human when in contact with water. After penetration of human skin, within 24 hours, the cercariae transforms into schistosomula, which migrate through the veins and lymph vessels to the lungs and liver where they develop into male and female worms in the portal blood vessels. The female worm lies within the gynaecophoric canal of the male worm. After 4 - 6 weeks, mating takes place and the worm-pair move to their final destinations. *Schistosoma mansoni* adults migrate to the portal veins draining the large intestine, *S. japonicum* migrate to the veins of the small intestines and *S. haematobium* migrate to the plexus of the urinary bladder. The period between penetration of cercariae to egg laying is called the pre-patent period and is about 30 – 40 days for *S. mansoni* and 54 – 84 days for *S. haematobium* (Ukoli, 1984; Sturrock, 1987; Davis, 2009). Eggs produced by female worms penetrate the walls of blood vessels and are shed in urine (*S. haematobium* ova) or in faeces (*S. mansoni* and *S. japonicum* ova) thus completing the cycle. When the eggs reaches water bodies they hatches within a few minutes into free swimming larva, the miracidium. The miracidia can stay in water for about 24 hours before penetrating of a specific snail intermediate host where they develop into a sporocyst and then into a human infective cercariae (Davis, 2009).

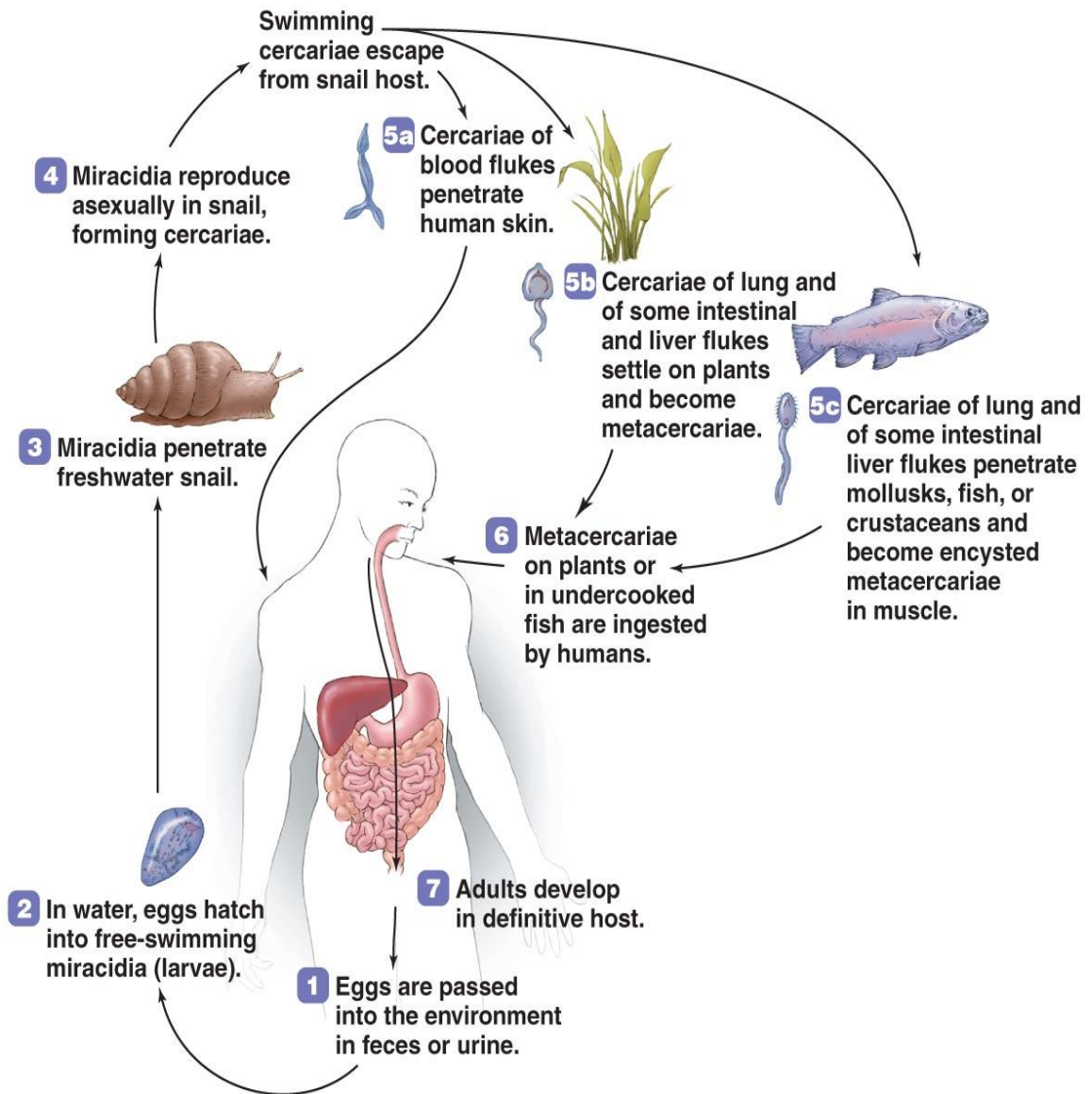


Figure 2.1: Life cycle of *S. mansoni*/ other lung flukes (Reproduced after Davis, 2009).

2.4 Prevalence of Schistosomiasis in Nigeria

Human schistosomiasis is endemic in Nigeria and the first case of the disease was noted in Nigeria in 1908 (Cowper, 1963., Farley, 1991). The national schistosomiasis prevalence survey among children was carried out between 1990 and 1992 and the result revealed that all the states in the Federation had infected cases (Paul *et al.*, 2003). Omudu and Samba (2005) reported a high prevalence of intestinal parasites in selected pupils in Benue State, out of 350 samples, 202 (56.1%) were positive for various helminths infections.

Opaluwa *et al.* (1999) reported a prevalence rate of 9% and 4% for urinary and intestinal schistosomiasis, with gender-related prevalence of 53% males and 47% females. A rapid assessment method to determine the distribution of urinary schistosomiasis in some villages in Abeokuta North and Odeda Local Government Areas showed a prevalence of 72.9% and 51.3% respectively (Mafiana *et al.*, 1997). Dunah and Bristone (2000) reported a prevalence of 27.2% for urinary schistosomiasis in Adamawa State. Similarly, Akogun and Obadiah (1996) reported an overall 65.8% prevalence in Gyawana and plantation schoolings near Numan in Adamawa State. A community-based survey was conducted, for the presence of schistosomiasis among human populace around Lake Geriyo in Adamawa State by Ndams and Livingstone (2000), who reported an overall prevalence of 38.4% and 23.2% for *S. haematobium* and *S. mansoni*, respectively. In the North-western parts of Nigeria, comprising Sokoto, Katsina and Kebbi States, there are about 16 large and many small-scale formal irrigation and many private ones. Here, the prevalence of urinary schistosomiasis was shown to be 22.3% (Ofoezie *et al.*, 1996). In Kano State, Nigeria, a considerable amount of water development projects have been

carried out and more are being proposed which will enhance transmission (Bassey and Umar, 2004). In a prevalence study in Katsina State, Idris *et al.* (2001) reported infection rate of 12% and 3.3% for *S. haematobium* and *S. mansoni* among primary schooling pupils. The study also revealed an association between gender and infection as the gender-specific rate for *S. haematobium* infection was 15.34% in males and 7.44% in females. Tukur and Galadima (1998) reported a prevalence and intensity of *S. haematobium* infection of 50.9% and 151.0 eggs/10ml urine respectively, in Bakolori irrigation project area of Zamfara State. In Lere Local Government Area of Kaduna State, Luka *et al.* (2001) reported prevalence of 12.3% and 11.3% for urinary schistosomiasis and intestinal schistosomiasis. Umar (2001) recorded as high as 28.4% prevalence rate for *S. haematobium* among pupils of 8-10 years in Kura Local Government Area of Kano State which is an area that is extensively irrigated as well as being very rich in ponds and rivers.

2.5 Pathology of Schistosomiasis

An annual mortality rate due to Schistosomiasis in Sub-Sahara Africa is estimated to exceed 200,000. The estimated number of cases with bladder wall pathology, hydronephrosis and hepatosplenic disease is estimated at 18, 10 and 8.5 million, respectively (Van der werf *et al.*, 2003). In schistosomiasis, schistosome eggs may cause tissue damage and blood loss in urine or faeces depending on the species involved. Schistosome disease is caused by immune reaction of the host against deposited eggs. Schistosome eggs provoke host inflammatory response which is a manifestation of a delayed hypersensitivity reaction mediated through T-lymphocytes, macrophages and eosinophils (Davis, 2009). This reaction leads to granuloma formation in the genito-

urinary organs in the case of urinary schistosomiasis, or intestines and liver in the case of intestinal schistosomiasis (Davis, 2009). Chronic infection with *S. mansoni* result into periportal fibrosis, hepatosplenic involvement with liver and spleen enlargement, portal hypertension and oesophageal varices (Warren, 1987; Davis, 2009). In the case of *S. haematobium* infection in late stage include hydronephrosis, bladder wall irregularity, calcification and predisposition to bladder cancer (Warren, 1987). The public-health importance of genital schistosomiasis in women and men (Leutscher *et al.*, 1997; Feldmeier *et al.*, 1999) is now being recognised as a risk factor of numerous genderually transmitted diseases, including human immunodeficiency virus (HIV) (Lawn *et al.*, 2000; Mbabazi *et al.*, 2011).

2.6 Soil Transmitted Helminthiasis

Soil transmitted helminths (STHs) are *Ancylostoma duodenale*, *Necator americanus* (hookworms) and *Trichuris Trichuria* (Whipworm). These infection are most prevalent in tropical and subtropical regions of the developing world where adequate water and sanitation are lacking, with recent estimates suggesting that *A. lumbricoides* infected 807 – 1,121 million people, *T. trichiura*, 604 – 795 million and hookworms 576 – 740 million people in 2013 (WHO, 2013). The greatest number of infection occurs in sub-Saharan Africa, East Asia, China, India and South America. As adult worms, this lives for years in the human gastrointestinal tract (Bethony *et al.*, 2006). It is estimated that 25 to 35 percent of schooling aged children are infected with one or more of these major worm species (De Silva *et al.*, 2003). The high prevalence of STH in tropical countries including Nigeria, is closely linked with poverty, poor environmental hygiene, improper waste disposal, inadequate water supply, gross environmental pollution and the constant

pollution of the air and water bodies (Ukpai and Ugwu, 2003; Amadi *et al.*, 1999; Kalu *et al.*, 2013).

2.7 Life Cycle of Soil Transmitted Helminths

The life cycle of the major STHs hookworm, *A. lumbricoides* and *T. trichiura* have many features in common. The adult parasites inhabit the human intestinal tract. For hookworms, human acquire the infection when third stage larvae in soil penetrate the skin while for *A. lumbricoides* and *T. trichiura*, infection takes place through the oral route by ingestion of contaminated food or water. In some settings, transmission can occur through the practice of eating soil or geophagia (Geissler *et al.*, 1998). Adult worms live in the human intestine and may produce up to 30,000 eggs per day. Eggs are deposited into intestinal lumen from where they are discharged into soil through faeces. In the soil, with the right moisture and temperature, they hatch into free living rhabditiform first-stage larvae. The first stage larva molts twice to form an infective filariform third stage larva which is motile. Upon contact with host skin, the third stage larvae penetrates it, enters vasculature and starts migration reaching the lungs, bronchioles, trachea and down to the oesophagus, stomach and small intestine. In the intestine, the larvae develop into adult worms, attaches to intestinal mucosa and lays eggs. Except for *A. lumbricoides* which does not develop in soil, worm eggs shed into the soil through faeces hatch into first stage larvae which in turn molt twice to form the infective third stage larvae upon contact with adequate moisture and temperature (Hotez *et al.*, 2004; Brooker *et al.*, 2009). Unlike schistosomes, STH life cycle is direct and doesn't involve intermediate hosts. Eggs hatch in the soil and the infective third stage larvae develops in the soil (Ukoli, 1984).

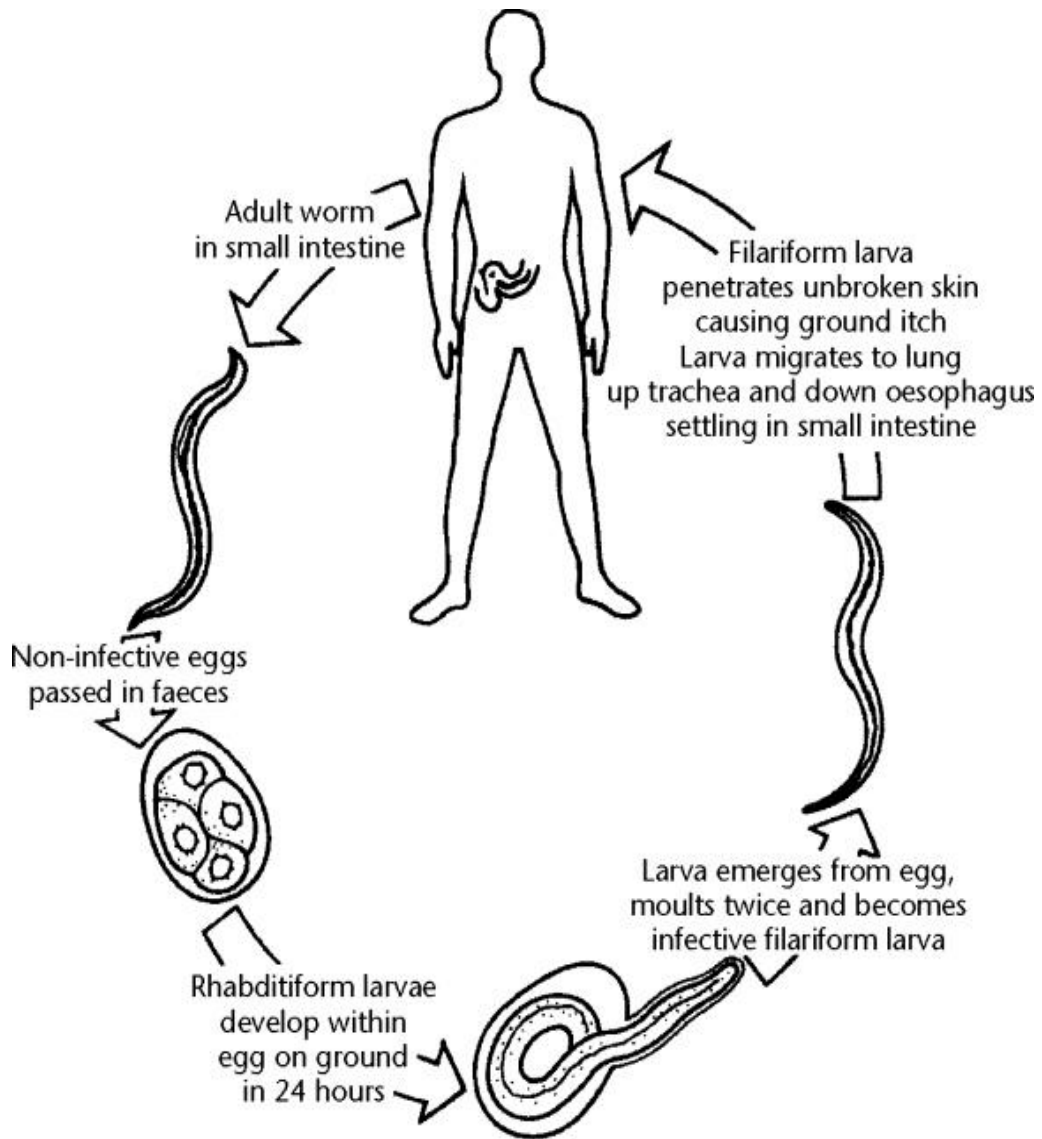


Figure 2.2: Life cycle of hookworm (Brooker, 2009).

2.8 Prevalence of Soil-Transmitted Helminths in Nigeria

A study on school aged children in, Delta State, Nigeria, reported that 54.70% were infected by soil-transmitted helminth. Among these, *A.lumbricoides* had the highest overall infection rate of 48.41%. Prevalence of other STHs was hookworm 29.76% and *T.trichiura* 17.39% (Andy and Palmer, 2005). The prevalence of helminthiasis in 800 stool samples of (both private and public) school children was carried out in Zaria with 52.0% prevalence of which *Ascaris lumbricoides* was 20.7% and soil sample indicated 12.0% prevalence of other parasites (Awodi *et al.*,2000).

Nock and Geneve, (2002) reported the prevalence of cysts and eggs on the handles of water closets in toilets of staff and students toilets in Zaria of which oocysts of coccidian was reported with the highest prevalence of 64%, followed by cysts of *Entamoeba* 16%, eggs of *Schistosoma mansoni* 3%, *Ascaris* 45% and hookworm 32% were observed . Some factors involved in the transmission of schistosomiasis among 1,834 residents of a small settlement within an agricultural establishment near Yola were studied by Akogun and Akogun (1995), where children age group of 5-12 years accounted for 40% of water contacts and contamination of Lake Geriyo with faeces and urine. Parasite prevalence was 98% for *S. haematobium* and 79% for *S. mansoni*.

A survey was carried out on 4000 pupils in five local government areas of Katsina State by Idris (2001). The age range of the pupils was between 5 and 19 years. Pupils infected with at least one species of intestinal parasite were (35.1%). Infection rates of helminths and protozoan species detected were *Ancylostoma duodenale*, (15.55%), *Ascaris*

lumbricoides, (0.70%), *Hymenolepis nana*, (4.13%), *Enterobius vermicularis*, (3.83%), *Trichuris trichiura*, (0.85%), *Strongyloides stercoralis*, (0.4%), *Schistosoma mansoni*, (4.03%), and *Entamoeba histolytica* (0.10%). A study of the helminths infections status of 257 primary school children (4-15 years) in Ikenne local government area of Ogun state showed an overall prevalence of 54.9% in urban, 63.5% in rural and 28.4% in the urban private school. *Ascaris lumbricoides* was the most common parasite followed by *Trichiuris trichuira*, *Taenia* species and hookworm in the three schools (Ekpo, *et al.*, 2010).

2.9 Pathology of Soil Transmitted-Helminths

STH may cause up to 135,000 deaths a year but the major public health significance is related to chronic morbidity on health and nutritional status which compromise physical and intellectual development resulting to stunted growth and poor academic achievement in school children and poor pregnancy outcomes in pregnant mothers (WHO, 2002; WHO, 2011).

Chronic ascariasis leads to reduced vitamin A absorption and lactose intolerance and the constant blood loss resulting from hookworm infection gives rise to iron-deficiency anemia and protein malnutrition (Bethony *et al.*, 2006). Together, these symptoms lead to nutritional deficits which manifest themselves in impaired physical growth and fitness including workers productivity and impact on cognition, schooling attendance and – performance (WHO, 2002; Ezeamama *et al.*, 2005a; Bethony *et al.*, 2006). Most STH infections does not result into clinical disease. This is because clinical disease is

associated with intensity of infection and only in individuals with heavy worm burden show clinical signs (Bundy, *et al.*, 1995).

The major pathogenic injury in STH, infection is related to tissue damage, blood and protein loss. In addition, migration of STH larvae causes tissue damage and haemorrhages in affected organs (Ukoli, 1984; Hotez *et al.*, 2004). In moderate to heavy hookworm infection there is iron deficiency anaemia which results from chronic blood loss, depletion of iron stores and impaired dietary iron intake. In addition, there is loss of protein and albumin which in turn results into hypoproteinaemia, hypoalbuminaemia and generalised oedema. Clinically, hookworm disease is characterised by paleness particularly of mucous membranes (anaemia), weakness, swelling of feet and ankle and low haemoglobin levels. There is also pulmonary and abdominal involvement such as coughing, asthmatic wheezing and abdominal pains (Hotez *et al.*, 2004; Stoltzfus *et al.*, 1997; WHO, 2002). In women of reproductive age, hookworm infection contributes to depletion of iron stores which may causes severe anaemia in women with heavy infection, low birth weight of their infants and neonatal prematurity (Bundy *et al.*, 1995; Christian *et al.*, 2004). In *A. lumbricoides* infection, pathology and disease are caused by adult worms and migration of larva and is related to the intensity of infection. Migrating larvae causes damage of lung tissues, haemorrhages and eosinophilic inflammatory responses. In the liver, migrating larvae cause small areas of necrosis with eosinophil infiltration. Heavy burden of *A. lumbricoides* adult worms cause intestinal colic, intestinal obstruction. *A. lumbricoides* worms also cause mechanical obstruction, intestinal perforation and acute appendicitis. They can also cause obstructive jaundice, liver abscesses, pancreatic necrosis and oesophageal perforation. Granulomatous lesions

are found around dead adult worms and eggs in the liver and bowels. Clinically, *A. lumbricoides* infection is characterised by acute abdominal pain, cough, pneumonitis and asthma (Bundy *et al.*, 1995).

2.10 Some Risk Factors

Parasitic infection is governed by behavioural, biological, environmental, socioeconomic and health systems factors (Yakubu *et al.*, 2003; Aagaard-Hansen *et al.*, 2009).

2.10.1 Environmental and ecological factors

Environmental and ecological factors are essential elements during transmission of any vector-borne disease. The climatic and biologic conditions necessary for this parasite's life-cycle constrain the geographic distribution of disease. Malacologic data (Sturrock, 2001) as well as ecologic studies (Clennon *et al.*, 2004) have provided a thorough characterization of vector species, habitat and distribution of helminths. Transmission is seasonally influenced by both temperature and rainfall. Temperature affects both the mortality and the fecundity of snail populations, which adds seasonal and diurnal cycles to transmission dynamics (Sturrock, 2001). Most importantly, rainfall provides the water necessary for aquatic snail habitats but also causes flooding which may radically alter habitat conditions. *Ascaris* and *Trichuris* eggs are harder than hookworm L3 and therefore survive drier climates better. At low humidity (atmospheric saturation less than 80%), human *Ascaris* ova do not embryonate; there appears to be no upper lethal limit on relative humidity (Brooker and Michael, 2000). Rainfall is also seasonal and prolonged droughts have mortal effects on snail populations despite the ability to survive short dry periods through aestivation. Human risk behaviors also vary with landscape and seasons

since water use and excretion behaviors show seasonal variation (Watts *et al.*, 1998). Biotic as well as abiotic environmental factors are important in the dynamics of schistosomiasis transmission. Biotic factors influencing vector populations include vegetation, food supplies, and the influence of predators, competitors, and pathogens (Sturrock, 2001; Kariuki *et al.*, 2004). Possibly important abiotic factors determining microhabitats of snail populations include calcium and electrolyte levels, NaCl levels and pH, as well as the geomorphology of rocks and soil and water turbidity.

2.10.2 Urban versus rural environment

Ascaris and Trichuriasis commonly occur both in urban environments, especially urban slums, and in rural areas. In some instances the prevalence of *Ascaris* infection is actually greater in urban environments (Phiri *et al.*, 2000). In contrast, high rates of hookworm infection are typically restricted to areas where rural poverty predominates (Albonico *et al.*, 1997).

The urban-rural dichotomy between *Ascaris-Trichuris* versus hookworm can be partly understood by fundamental differences in the life cycles of these soil-transmitted helminths. The infective stages of *Ascaris-Trichuris* are embryonated eggs having enormous capacity for withstanding the environmental extremes of urban environments. Contained within the inner layer of *Ascaris* eggs is an unsaponifiable lipid known as ascaroside, which confers many of its hardy properties. Viable *Ascaris* eggs have been recovered from soil samples for more than 10 years after having been first deposited (Crompton, 1989a). In addition to ascaroside, *Ascaris* eggs are coated with a mucopolysaccharide that renders them adhesive to a wide variety of environmental

surfaces; this feature accounts for their adhesiveness to everything from door handles, dust, fruits and vegetables, paper money and coins, etc. (Crompton, 1989a). The “five f’s” of parasitology, fingers, feces, fomites, flies and food might have originated with *Ascaris* in mind. Many surveys have shown a high prevalence of these infections in children of slums, shanty towns and squatter settlements (Crompton and Savioli, 1993).

2.10.3 Soil

Ascaris eggs develop best in less permeable clay soils, with survivability increasing with their soil depth (Crompton, 1989a). Clay soils are believed to prevent egg dispersal by water (Mizgajka, 1993). The vulnerability of *Ascaris* eggs to direct sunlight may account for part of this observation. Unlike *Ascaris* and *Trichuris* eggs, hookworm eggs hatch in the soil and give rise to first-stage larvae, which molt to infective larval stages only under precise conditions. Egg development in the soil is dependent upon a number of factors including temperature (optimal development at 20-30° C), adequate shade and moisture (Komiya and Yasuraoka, 1996).

In some endemic areas, soil-transmitted helminths infections exhibit marked seasonality. In some regions where marked rainy and dry seasons occur, hookworm transmission rates are higher during the former (Udonsi *et al.*, 1980). It has been suggested that total rainfall in an area and its seasonal distribution may also help explain observed patterns of infection: wetter areas are usually associated with increased transmission of all three major soil transmitted helminths infections (Brooker and Michael, 2000).

2.10.4 Genetic risk factors

Predisposition soil-transmitted helminths may have either an immunologic, genetic or even a combined immune-genetic basis. For instance, some populations with low worm burdens in Papua New Guinea were noted to be relatively resistant to re-infection. Such individuals were noted to mount parasite specific IgE and eosinophilic responses (Quinnell *et al.*, 1995; Pritchard *et al.*, 1996).

Initial results of a genome scan of a genetically isolated Nepalese populations localized susceptibility to *Ascaris* infection to two genes, one on chromosome 1 and another on chromosome 13 (Williams-Blangero *et al.*, 2002), providing the first evidence that individual quantitative trait loci may influence variation in soil-transmitted helminths likewise recent genome scans have identified a locus possibly responsible for controlling *S. mansoni* infection intensity on chromosome 5q31–33. There is also evidence for genetic control of pathology attributable to *S. mansoni*, with linkage reported to a region containing the gene for the interferon gamma receptor 1 subunit (Quinnell, 1993).

2.10.5 Behavior, occupation and socioeconomic status

Specific occupations and behaviors influence the prevalence and intensity of soil-transmitted helminths infections (Brooke *et al.*, 2004). Engagement in agricultural pursuits remains a common denominator for human hookworm infection. Heavy infections in Sichuan Province, China and in Vietnam, for instance, are attributed to widespread use of feces as nightsoil fertilizer (Humphries *et al.*, 1997). The Chinese nationwide survey of 1988-1992, for instance, found the highest prevalence among vegetable growers and other farmers (Hotez *et al.*, 1997).

2.10.6 Food

Although not classically considered food-borne illnesses, *Ascaris* eggs and hookworm larvae adhere to vegetables and, if not been adequately subjected to treatment, are then readily distributed in food markets and may cause infection. A survey from Japan found that at one time *Ascaris* eggs were present on 1,178 of 2,750 items of vegetables sold in 40 Tokyo shops (Kobayashi, 1980). Children living in an area of Marrakesh, Morocco where raw sewage is used for agricultural irrigation were shown to have significantly higher prevalence of *Ascaris* and *Trichuris* infection when compared to a group of children where this was not a common practice (Bouhoulm and Schwartzbrod, 1997).

2.10.7 Age and gender

Typical age profiles show the highest prevalence and the highest intensity of infection in school-aged children (King *et al.*, 2000). Lower prevalence of infection in adults is explained by lower exposure to infection sites but also by the development of partial immunity in highly endemic areas (Mohmound *et al.*, 2001), while the low prevalence in infant is due to lower rates of exposure. Surveys carried out in areas where Ascariasis and Trichuriasis is endemic and sample sizes are adequate, three patterns become evident. First, prevalence rises rapidly once infancy has passed and tends to remain high. Secondly, intensity rises rapidly and peaks during childhood (among 5 – 15 year-old) before declining steadily. Thirdly, the frequency distribution of numbers of worms per host is over-dispersed (Crompton, 2010). This is in contrast to hookworm infection where more adults are typically infected, and have larger worm burdens. Heavy hookworm burdens still occur among children in some tropical areas (Stephenson *et al.*, 1989).

Gender profiles of *Schistosoma* species infection are more variable across populations due to cultural differences in water use behaviors leading to differing levels of exposure. Research has found gender differentials in infection intensities (Bethony *et al.*, 2001; King *et al.*, 2011), which is hypothesized to be the result of differential duration and extent of exposure by gendered domestic activities as well as the effect of occupation on exposure (Bethony *et al.*, 2001; Huang *et al.*, 1992). In contrast, the overall prevalence of *Ascaris* infection has traditionally been considered higher among females compared with males, regardless of age (Crompton, 1989b). Possibly this is due to occupational exposure (Crompton, 1989b).

2.11 Diagnosis of Helminths Parasites

Many techniques for the diagnosis of helminths parasites had been developed. They can be divided into two broad categories, tools for direct and those for indirect detection of parasites, namely parasitological and immunological methods. The first class directly visualizes parasites or their eggs, either direct or by molecular biological methods, e.g. polymerase chain reaction (PCR) or specific labelled antibodies. The second class relies on the detection of parasite antigens or human antibodies developed in response to the presence of a particular parasite.

2.12 Parasitological Diagnosis

2.12.1 Kato-katz and urine filtration methods

Direct detection of schistosome eggs in urine (*S. haematobium*) and stool samples (*S. mansoni* and *S. japonicum*) under a microscope is the most widely used diagnostic approach in epidemiological surveys of helminths. A commonly employed direct method

for the diagnosis of urogenital schistosomiasis is the standard urine filtration method that involves the detection and quantification of *S. haematobium* eggs in a 10-millimetre filtrate of a mid-day urine specimen (Plouvier *et al.*, 1975; Mott *et al.*, 1982, WHO, 1990). This is the most widely used technique in epidemiological surveys pertaining to intestinal schistosomiasis (Speich *et al.*, 2010). However, when prevalence, and particularly intensity of infection are reduced through treatment, direct methods become less sensitive and should be augmented or replaced by immunological techniques based on antigen or antibody detections (Bergquist *et al.*, 2009; Johansen *et al.*, 2010), or molecular tools such as polymerase chain reaction (PCR)-based approaches (Gomes *et al.*, 2010). It is widely acknowledged that single Kato–Katz thick smear examinations underestimate the ‘true’ prevalence of *S. mansoni* and *S. japonicum* and this issue is particularly important in settings where infection intensities are low (Utzing *et al.*, 2001; Booth *et al.*, 2003; Yu *et al.*, 2007).

2.12.2 Immunodiagnosis

Immunological approaches are based on the detection of antibodies or antigens in urine and stool samples. Although immunodiagnosis usually requires somewhat better equipped laboratories and much more knowledge than direct techniques using microscopy, immunological methods, may yield higher sensitivity, especially for antibody detection (Doenhoff *et al.*, 2004).

However, specificity might be a problem for antibody detection, and since antibody detection is not quantitative, it is difficult to differentiate between light and heavy infection. Moreover, antibody levels remain high for prolonged periods of time following

treatment, which represents a diagnostic dilemma: failure to differentiate between active and cured infection. Finally, there might be a high degree of cross-reactivity in settings where schistosome and other trematode infection co-exist (Bergquist *et al.*, 2009; Johansen *et al.*, 2010).

Detection of schistosome antigens, such as circulating anodic antigens (CAA) and circulating cathodic antigens (CCA) (van Lieshout *et al.*, 2000) or *S. mansoni* soluble egg antigen (SEA) (Chand *et al.*, 2010) in blood or urine, using enzyme-linked immunosorbent assays (ELISAs) hold several advantages over antibody detection. Most notably, active infection can be readily demonstrated. Hence, this approach is useful for anthelmintic drug efficacy trials due to high specificity. The principle of the test is based on a lateral-flow assay using a nitrocellulose strip of the sample with a colloidal carbon conjugate of anti-CCA monoclonal antibodies (Van Dam *et al.*, 2011).

2.12.3 Molecular diagnosis

Diagnostic tool with high sensitivity are required for the detection of light-infection intensities. Several specific and highly sensitive PCR-based assays for schistosomiasis diagnosis had been developed (Gomes *et al.*, 2010). These PCR techniques are able to detect DNA from schistosome eggs (devitalised or containing a living miracidium), including cell-free DNA released from damaged eggs and any juvenile or adult worm DNA breakdown products in faecal, urine and serum samples (Enk *et al.*, 2012).

The method is based on the amplification of a highly repeated DNA sequence, using simple DNA extraction techniques and a rapid two-step PCR approach, which facilitated the amplification of *S. mansoni* DNA in faecal samples. Recently, a multiplex real-time

(RT) - PCR for the detection and quantification of both *S. mansoni* and *S. haematobium* has been developed (Ten Hove *et al.*, 2008)

2.12.4 Metabolic profiling

Metabolic profiling is useful for studying an organism's gene function, drug safety assessment and recovery of biomarkers (Lindon *et al.*, 2004; Holmes, 2010). Metabolic profiling provides a new platform for biomarker discovery and might lead to the generation of novel diagnostic assays.

2.12.5 Clinical diagnosis

Other diagnostic alternatives include asking for clinical signs and symptoms examining rectal biopsies, among others. The use of questionnaires for schistosomiasis screening has been evaluated quite extensively in sub-Saharan Africa (Brooker *et al.*, 2009).

2.13 Control Strategies of Schistosomiasis and Soil -Transmitted Helminths

Sanitation is the only definitive intervention to eliminate intestinal helminths infections, but to be effective; it should cover a high percentage of the population. Therefore, because of the high costs involved, implementing this strategy is difficult where resources are limited (Asaolu and Ofoezie 2003). For schistosomiasis and other intestinal helminths infections, the aim is to reduce contamination of soil and water by promoting the use of latrines and hygienic behavior. Without a change in defecation habits, periodic deworming cannot attain a stable reduction in transmission.

2.14 Treatment of Soil-Transmitted Helminths

Anthelmintic treatment (deworming) is aimed at reducing morbidity by decreasing the worm burden. Repeated chemotherapy at regular intervals (periodic deworming) in high-risk groups can ensure that the levels of infection are kept below those associated with morbidity and will frequently result in immediate improvement in child health and development. For ascariasis and trichuriasis, for which intensity peaks among school-age children, frequent and periodic deworming may reduce transmission over time. Obstacles that diminish the effectiveness of periodic deworming are the low efficacy of single-dose mebendazole and albendazole for the treatment of hookworm and trichuriasis, respectively (Albonico *et al.*, 1994).

2.15 Treatment of Schistosomiasis

Chemotherapy-based interventions for the rapid reduction of infection-related morbidity and community prevalence remain the current mainstay for the control of schistosomiasis and other helminthiasis (Savioli *et al.*, 2005; Fenwick *et al.*, 2009; Hotez *et al.*, 2011). WHO guidelines for the community treatment of helminthiasis are: If the prevalence exceeds 50%, entire communities should receive treatment; if the prevalence is between 10% and 50%, only schooling-aged children receive treatment; if the prevalence is below 10%, schooling-aged children might be treated at least twice, at schooling entry and again before they finish schooling. The drug of choice against schistosomiasis is praziquantel (WHO, 2002; Utzinger and Keiser, 2004; Doenhoff *et al.*, 2008). Praziquantel is usually administered in a single oral dose of 40 mg/kg of body weight. For, large-scale community-based control programmes, praziquantel is administered on a simple, widely validated 'dose pole' (Montresor *et al.*, 2001; Montresor *et al.*, 2002).

Other drugs such as amodiaquine and sulphadoxine-pyrimethamine (SP) were also investigated for their efficacy against schistosomes. Some researchers have shown that drug combinations (e.g. praziquantel + artemether, SP + artemether, amodiaquine + artemether) might produce higher cure rate than a single drug regimen. The aforementioned drugs are generally well tolerated (Utzing *et al.*, 2007).

This has been launched in numerous countries of Africa and elsewhere (Hotez *et al.*, 2007; Fenwick *et al.*, 2009; WHO, 2011; WHO, 2012). Focal mollusciding for schistosomiasis transmission control in specific geographical settings is still important today but it has high costs and is of limited duration and effectiveness, as snails repopulate their habitats shortly after interventions (Chu, 1976).

Integrating helminths control programmes with current efforts to control schistosomiasis are inadequate and a new generation of tools is needed for disease control. One such new generation tool which holds the best prospect for the sustainable control of schistosomiasis is the development of vaccines that will prevent the parasite from completing its life cycle (Bethony *et al.*, 2001; Hotez *et al.*, 2011).

2.16 Malaria

2.17 Biology and Transmission

Malaria is caused by single-celled protozoan parasites of the genus *Plasmodium* and transmitted to humans through the bite of a wide variety of anopheline mosquitoes. There are four known species of *Plasmodium* that causes malaria in human's namely *Plasmodium malariae* (quartian malaria), *Plasmodium vivax* (benign tertian malaria), *Plasmodium falciparum* (malignant tertian malaria, subtertian malaria) and *Plasmodium ovale* (ovale tertian malaria) (WHO, 2013). In recent years, some human cases of malaria have also occurred with *Plasmodium knowlesi* – a species that causes malaria among monkeys and occurs in certain forested areas of South-East Asia. Some genetic factors play a role in determining susceptibility to disease including presence of the hemoglobin S allele, red blood cells negative to Duffy blood group determinants and deficiency of glucose-6-phosphate dehydrogenase enzyme.

Plasmodium vivax does not infect West Africans due to the fact that West Africans do not possess the Duffy Antigen on the red blood cells which the parasite requires to enter the red blood cell (Bates, 2004). Individuals whose haemoglobin genotype is AS are resistant to the lethal effects. This is because the sickle trait prevents the development of high parasitaemia, probably as a result of parasitized red cells sickling in the circulation and being removed by the spleen before they can develop into schizonts (Bates *et al.*, 2004).

Approximately 422 species of *Anopheles* are known, of which 68 are indicated as vectors of malaria (White, 2009). *Anopheles arabiensis* and *Anopheles gambiae* belong to the most effective vectors of malaria parasites in Africa (Coetzee, 2004). Major *Anopheles*

mosquitoes in Nigeria are *An. gambiae*, *An. arabiensis*, *An. funestus* and *An. Melas* (WHO, 2011). *An. gambiae s.s* is highly prevalent in Nigeria, because of its indiscriminate breeding habitats (Ayanda, 2009).

The greatest worldwide mortality is caused by *P. falciparum* (Warrell *et al.*, 1993) and this species is found throughout tropical Africa, Asia and Latin America. The *P. malariae* species is found worldwide but with a patchy distribution whereas *P. ovale* is endemic mainly in tropical West Africa and *P. vivax* is found worldwide in tropical regions, as well as in some temperate zones .However, in Africa, more than 75% of severe disease and deaths are due to *P. falciparum* (White, 2009).

2.18 Life Cycle of *Plasmodium*

The biology of malaria parasites involves a genderual phase (sporogony) in the vector female anopheles mosquito and an agenderual phase (schizogony) in the human host. Sporozoites are inoculated into the human host by feeding female anopheles mosquitoes where they develop in liver parenchyma cells to form hepatic schizonts. The mature hepatic schizont ruptures and releases merozoites which invade red blood cells where they grow and multiply to form blood schizonts. Multiplying blood schizonts destroy red blood cells causing malaria disease. Some forms of the parasites (merozoites) develop into genderual forms called gametocytes which are picked by female anopheles mosquitoes during a blood meal and injected to another susceptible human host, where they start another cycle of development to form human infective sporozoites (White, 2009).

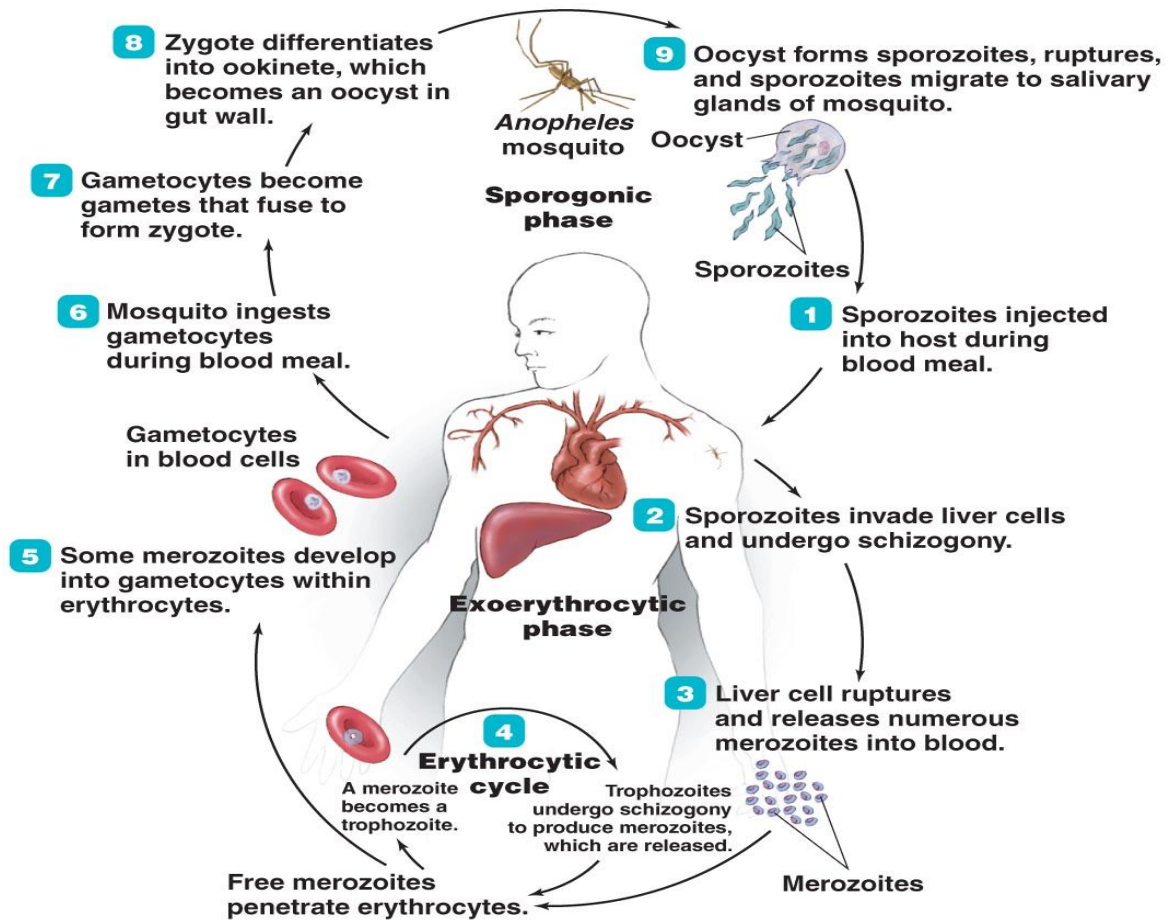


Figure 2.3: Generalised Life cycle of human *Plasmodium* parasite (Davis, 2009).

2.19 Prevalence of Malaria in Nigeria

Annual estimates vary between 300-500 million clinical episodes of malaria and 1.5- 2.7 million deaths worldwide, 90% of which occur in the tropical Sahara (WHO, 2008).

In areas where malaria is highly endemic protective semi-immunity against infection with *P. falciparum* is acquired during the first 10 – 15 years of life and the majority of malaria related morbidity and mortality happens in young children (Sowunmi *et al.*, 2004).

Obianumba *et al.* (2014) conducted a study to determine the prevalence of malaria parasite infection among pregnant women using peripheral blood and microscopy in Ozubulu. A total of 243 pregnant women were sampled for malaria parasites. The result showed a prevalence of 53.9%. It was found that women in their first pregnancy had the highest prevalence of 65.8% (48/73). Highest prevalence of 71.6% (58/81) was also recorded among women in their first trimester. Pregnant women aged 21 -25 years had highest infection rate of 68.8% (33/48). Adefioye *et al.* (2007) and Marielle *et al.* (2003) recorded a prevalence rate of 72% and 70% respectively among pregnant women in Oyo state, Nigeria and Gabon respectively.

The prevalence's above are higher compared 45.0% prevalence reported for placental malaria (PM) among HIV infected mothers in rural Rwanda (Bulterys *et al.*, 2011). It was higher to the 30.0% reported by Okonko *et al.* (2012) among children in Ibadan. It is also higher to the 24.3% reported by Kuadzi *et al.* (2011) among children in Ghana.

The disease accounts for 25 per cent of infant mortality and 30 per cent of childhood mortality in Nigeria. Therefore, it imposes great burden on the country in terms of pains

and trauma suffered by its victims as well as loss in outputs and cost of treatments (Ogungbamigbe *et al.*, 2005). This result is in agreement with earlier observations that Nigeria is known for high prevalence of malaria and it is a leading cause of morbidity and mortality (Sowunmi *et al.*, 2004; Ademowo *et al.*, 2006).

2.20 Pathology

Malaria is a complex disease that varies widely in epidemiology and clinical manifestation in different parts of the world. This variability is due to factors such as the species of malaria parasites that occur in a given area, their susceptibility to commonly used or available antimalarial drugs, the distribution and efficiency of mosquito vectors, climate and other environmental conditions and the behavior and level of acquired immunity of the exposed human populations (Mockenhaupt *et al.*, 2004). The parasites multiply within the red blood cells, causing symptoms that include symptoms of anemia (light headedness, shortness of breath etc.), as well as other general symptoms such as fever, chills, nausea, flu-like illness, arthralgia (joint pain), vomiting, anemia caused by hemolysis, hemoglobinuria, and convulsions and in severe cases, coma and death (WHO, 2004). Consequences of severe malaria include coma and death if untreated, young children and pregnant women are especially vulnerable. Splenomegaly (enlarged spleen), severe headache, cerebral ischemia, hepatomegaly (enlarged liver), hypoglycemia, and hemoglobinuria with renal failure may occur (Trampuz *et al.*, 2003). In endemic areas, treatment is often less satisfactory and the overall fatality rate for all cases of malaria can be as high as one in ten (Mockenhaupt *et al.*, 2004). Over the longer term, developmental impairments have been documented in children who have suffered episodes of severe malaria (Trampuz *et al.*, 2003).

The classical symptom of malaria is cyclical occurrence of sudden coldness followed by rigor and then fever and sweating lasting four to six hours, occurring every two days in *P. vivax* and *P. ovale* infection, while it occurs every three days in *P. malariae* (Boivin, 2002). *P. falciparum* can have recurrent fever every 36-48 hours or a less pronounced and almost continuous fever (Trampuz *et al.*, 2003).

2.21 Risk Factors of Malaria

2.21.1 Age

The distribution of *Plasmodium* species in human populations depends on levels of endemicity. In holoendemic zones, most severe morbidity and mortality occurs in young children who have not acquired the partial immunity accorded to older individuals by repeated infection (Sachs *et al.*, 2002). Peak infection occurs in children between one and five years of age in these zones and 25% of all-cause of mortality in children aged 0-4 years is due to malaria (Bates *et al.*, 2004; Snow *et al.*, 1999). In hypoendemic zones with occasional introduction of the parasite malaria epidemics can occur with severe morbidity and mortality in all age groups due to lack of immunity (Gilles *et al.*, 1996). Some areas have seasonal periods of high transmission often following rains.

2.21.2 Gender

Gender does not appear to be an important factor in determining risk of infection biologically, with the exception of pregnant women, although gender-specific risk behaviors may influence the distribution of malaria in some populations (Bates *et al.*, 2004).

2.21.3 Environmental/ecologic factors

Malaria is highly influenced by environmental and ecologic factors due to the habitat requirements of the mosquito vector species. Perhaps the most important environmental factors in disease transmission are temperature and humidity (Gille *et al.*, 1996). Malaria parasites require a minimum temperature for development and mosquito vectors require temperature and humidity conditions that allow a long enough life span to permit parasite development and multiple blood meals. Several other factors have been identified as contributing to its emergence and spread. These include environmental and socio-economic changes, deterioration of health care and food production systems, and the modification of microbial/vector adaptation (Morse, 1995; McMichael *et al.*, 1998).

2.21.4 Clustered population density

Increase in population density led to an increase in human exposure and more pressure on limited productive land (Lindsay and Martens, 1998). Pressures on productive land, force farmers to clear forests and reclaim swamps. Puddles and elevated temperatures result from lost tree and ground cover, thereby providing ideal breeding sites for mosquitoes (Warsame *et al.*, 1995). Increased flooding could facilitate the breeding of malaria carriers in formerly arid areas. Small geographical changes in the distribution of malaria may expose large numbers of people to infection (Warsame *et al.*, 1995).

2.22 Diagnosis

Direct microscopic examination of intracellular parasites on stained blood films is the gold standard for definitive diagnosis in nearly all settings. However, several other approaches exist or are in development, some of which are discussed here.

2.22.1 Microscopy

Simple light microscopic examination of Giemsa stained and field stain A and B in blood films is the most widely practiced and useful method for definitive malaria diagnosis. Advantages include differentiation between species, quantification of the parasite density and ability to distinguish clinically important asexual parasite stages from gametocytes which may persist without causing symptoms (WHO, 2004). Specific disadvantages are that slide collection, staining, and reading can be time-consuming and microbiologists need to be trained and supervised to ensure consistent eye reliability.

2.22.2 Antigen detection tests (Rapid or “dipstick” diagnostic tests)

This diagnostic approach involves the rapid detection of parasite antigens using rapid immunochromatographic techniques. Multiple experimental tests have been developed targeting a variety of parasite antigens (Bloland, 2001). A number of commercially available kits (e.g. ParaSight-FR, Becton-Dickinson; MalaquickR, ICT, Sydney, New South Wales, Australia) are based on the detection of the histidine-rich protein 2 (HRP-II) of *P. falciparum*. Compared with light microscopy this test yielded rapid and highly sensitive diagnosis of *P. falciparum* infection (WHO, 2003; Craig and Sharp, 1997). Advantages to this technology are that no special equipment is required, minimal training is needed, the test and reagents are stable at ambient temperatures and no electricity is needed. The principal disadvantages are a currently high per-test cost and an inability to quantify the density of infection. Furthermore, for tests based on HRP-II, detectable antigen can persist for days after adequate treatment and cure; therefore, the test cannot adequately distinguish a resolving infection from treatment failure due to drug resistance, especially early after treatment (WHO, 2004).

In addition, a test based on detection of a specific parasite enzyme (lactate dehydrogenase or pLDH) has been developed (OptiMALR, Flow Inc. Portland OR, USA) and reportedly only detects viable parasites, which if true, eliminates prolonged periods of false positivity post treatment (Palmer *et al.*, 1999). Newer generation antigen detection tests are able to distinguish between *falciparum* and non-*falciparum* infection, greatly expanding their usefulness in areas where non-*falciparum* malaria is transmitted frequently (Bloland, 2001).

2.22.3 Molecular test/ PCR test

Detection of parasite genetic material through polymerase-chain reaction (PCR) techniques has become a more frequently used tool in the diagnosis of malaria, as well as the diagnosis and surveillance of drug resistance in malaria. Specific primers have been developed for each of the four species of human malaria. One important use of this new technology is in detecting mixed infection or differentiating between infecting species when microscopic examination is inconclusive (Beck, 1999). In addition, improved PCR techniques could prove useful for conducting molecular epidemiological investigations of malaria clusters or epidemics (Purfield *et al.*, 2004). Primary disadvantages to these methods are overall high cost, high degree of training required, need for special equipment, absolute requirement for electricity, and potential for cross-contamination between samples (Berzins and Anders, 1999).

2.22.4 Serology

Techniques also exist for detecting anti-malaria antibodies in serum specimens. Specific serological markers have been identified for each of the four species of human malaria. A

positive test generally indicates a past infection. Serology is not useful for diagnosing acute infection because detectable levels of anti-malaria antibodies do not appear until weeks into infection and persist long after parasitaemia has resolved. Moreover, the test is relatively expensive, and not widely available (Bloland, 2001).

2.23 Malaria Prevention and Control

Methods used to prevent the spread of disease, or to protect individuals in areas where malaria is endemic, include prophylactic drugs, mosquito eradication, and the prevention of mosquito bites. The continued existence of malaria in an area requires a combination of high human population density, high mosquito population density, and high rates of transmission from humans to mosquitoes and from mosquitoes to humans. If any of these is lowered sufficiently, the parasite will sooner or later disappear from that area, as happened in North America, Europe and much of Middle East (Imperial College London, 2010; Steketee and Campbell, 2010).

2.23.1 Vector control

Malaria has successfully been controlled using dichlorodiphenyltrichloroethane (DDT), in several tropical areas by removing or poisoning the breeding grounds of the mosquitoes or the aquatic habitats of the larva stages, for example by filling or applying oil to places with standing water (CDC, 2004).

2.23.2 Prophylactic drugs

Use of prophylactic drugs is seldom practical for full-time residents of malaria-endemic areas (Wyler, 1993).

2.23.3 Indoor residual spraying

Indoor residual spraying (IRS) is the practice of spraying insecticides on the interior walls of homes in malaria affected areas. After feeding, many mosquito species rest on a nearby surface while digesting the blood meal, so if the walls of dwellings have been coated with insecticides, the resting mosquitoes will be killed before they can bite another victim, transferring the malaria parasite (Jacquerioz and Croft, 2009).

2.23.4 Mosquito nets and bedclothes

Mosquito nets help keep mosquitoes away from people, and thus greatly reduce the infection and transmission of malaria they are often treated with an insecticide designed to kill the mosquitoes. Insecticide-treated nets (ITN) are estimated to be twice as effective as untreated nets, and offer greater than 70% protection compared with no net (Molyneux and Fox, 1993).

2.23.5 Vaccination

Pre-erythrocytic vaccines (vaccines that target the parasite before it reaches the blood), in particular vaccines based on circumsporozoite protein (CSP) make up the largest group of research for the malaria vaccine (Graves and Gelband, 2006). Other vaccines include: those that seek to induce immunity to the blood stages of the infection; those that seek to avoid more severe pathologies of malaria by preventing adherence of the parasite to blood venules and placenta; and transmission-blocking vaccines that would stop the development of the parasite in the mosquito right after the mosquito has taken a blood meal from an infected person (Zavala *et al.*, 1983).

2.24 Helminths and *Plasmodium* Co-Infection in Humans

Malaria infection and soil transmitted infection are among the most prevalent endemic parasitic diseases in sub-saharan Africa, where both diseases have similar geographical distribution and co-infection is common (Snow *et al.*, 2005; Mwangi *et al.*, 2006; Brooker *et al.*, 2007). It has been observed that individuals co-infected with more than one parasite species are not only at the risk of illness associated with each parasite species, but also the risk of developing frequent and more severe disease due to interactions among the infecting parasite species (Tschikuka *et al.*, 1996; Howard *et al.*, 2001). Helminths infected individuals are more likely to develop clinical *P. falciparum* malaria than helminths free individuals (Nacher *et al.*, 2002a; Spiegel *et al.*, 2003). In Nepal, Dreyfuss *et al.* (2000) observed that *P. vivax* malaria and hookworm co-infection in pregnant women were associated with more frequent attacks and severe anaemia than seen in women who harbour only one parasite infection.

A study conducted in Nigeria demonstrated that pregnant women co-infected with *P. falciparum* and helminths produced children with lower birth weight compared to those infected with *P. falciparum* alone (Egwunyenga *et al.*, 2001). However, Muhangi and others found no significant adverse effect of helminths on anaemia in pregnant women in Uganda, but found a significant effect of malaria on anaemia (Muhangi *et al.*, 2007).

Studies in the Philippines has demonstrated that even at low intensity of infection, multiple parasite infection enhance the risk of anaemia (Ezeamama *et al.*, 2005; Ezeamama *et al.*, 2008). Ojuronbe *et al.* (2011) in a study in Osogbo, Nigeria on co-infection between malaria and helminths stood at 26.1%. It was also found that 31.8% of

the children had anaemia in addition to infection with both malaria parasites and helminths these result are higher than those obtained in Buea in Cameroon (Nkuo-Akenji *et al.*, 2006). Parasitological survey revealed that Righetti and colleagues reported a 27.9% co-infection rate with hookworm and *Plasmodium* among schooling-aged children in the Taabo in south-central Co[^]te d'Ivoire (Righetti *et al.*, 2012). In a single village in western Co[^]te d'Ivoire, Raso and colleagues reported that 75% of community members harbored concomitant infection with *plasmodium*, helminth, and intestinal protozoa (Raso, *et al.*, 2004). Helminth-*Plasmodium* co-infection have also been investigated and the prevalences ranged from 16% in Uganda and Cameroon, (Nkuo-Akenji, *et al.*, 2006), to 26.5% in Tanzania (Mazigo *et al.*, 2010) to 60% in Nigeria (Abanyie, *et al.*, 2013).

Several epidemiological and immunological studies have reported both positive and negative associations between malaria and helminths infections (Diallo *et al.*, 2004; Lyke *et al.*, 2006; Hartgers and Yazdanbackhsh, 2006). Meanwhile the nature and mechanisms of interactions in malaria-helminths co-infection and their effects on disease progression and outcome are not fully understood (Hartgers and Yazdanbackhsh, 2006; Lyke *et al.*, 2006; Hartgers *et al.*, 2009), many studies point at immunological modulation as the basis of the observed interactions arguing that chronic helminths infections modulate immune responses to *P. falciparum* infection from a Th1 mediated immune response to a predominantly Th2 mediated immune response (Maizels *et al.*, 2004; Spiegel *et al.*, 2003). As a result of this immunomodulation, helminths infected individuals may have increased susceptibility to *P. falciparum* infection and hence at increased frequency of malaria attacks and severe disease (Tschikuka *et al.*, 1996; Egwunyenga *et al.*, 2001; Nacher *et al.*, 2002; Sokhna *et al.*, 2004). In line with helminths induced

immunomodulation, there is evidence suggesting that treatment of schistosomiasis with praziquantel leads to altered anti-schistosome immune responses (Mutapi *et al.*, 1998; Mutapi *et al.*, 2003) which in turn may lead to changes in the subclasses and levels of anti-*P. falciparum* antibody responses in co-infected individuals (Diallo *et al.*, 2004; Mutapi *et al.*, 2003). Currently, several malaria and helminths control interventions exist which are proven to be efficacious, safe and cost effective. Integrated treatment approach using antimalarials and anthelmintics is proven to be effective (Christian *et al.*, 2004). These include intermittent preventive treatment and artemisinin based combination therapies for malaria (Lengeler *et al.*, 2004; Sarrasat *et al.*, 2008). For helminths infections, mass drug administration (MDA) using low cost, safe and efficacious antihelmintic drugs such as praziquantel and albendazole for schistosomiasis and STHs also exist (WHO, 2002; WHO, 2011). Improved water supply and sanitation, together with health education, are also key strategies to reach sustainable reductions of these parasite infections (Utzinger *et al.*, 2004). Integration of disease control interventions is a strategy of choice when the diseases under consideration share a common population at risk, have the same technical approach to control and if they, collectively exert a huge disease burden to the affected population (Hotez *et al.*, 2007). Integrated control of the major tropical diseases has the potential to contribute to global poverty reduction and attainment of the millennium development goals (Hotez *et al.*, 2007).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Jibia town is located about 43km west of Katsina town. Katsina State Surveyors (1993) revealed that Jibia Local Government Area is located between latitude 12°5' and 13°16'N and longitude 7°2' and 7°49'E, whereas the dam Project is located between latitude 12°5' and 13°9'N and longitude 7°1' and 7°4 E' (Mu'azu *et al.* (2013). Jibia Local Government Area has a population of approximately 169,748 (NPC, 2006). It shares common boundary with Kaita LGA to the east, Batagarawa LGA to the south and Zurmi LGA to the west. To the, north the town shares common boundary with Niger Republic (Mu'azu *et al.*, 2013).

The Jibia dam is the largest irrigation project in Katsina State it was constructed for two purposes, water supply and irrigation. The dam sources its water mainly from runoffs and flowing streams especially from Gada River. The dam is earth filled structure with geomembrane liner, a maximum height of 21 meters and embankment of 3,680 meters. The full storage capacity of the dam is 142 million cubic meters and active storage capacity of 121 million cubic metres. The dam has a catchment area of about 3,666km² as at completion in February, 1991 under Sokoto Rima River-Basin Development Authority (SRRBDA, 1991).

Due to the scattered nature of the human settlements, some houses are located near the dam and canals at a distance of 100-200m. The main reservoir is located in Zandam community with canals linking the dam water to the other communities. Fishing and

irrigational farming are the major activities of the settlements most concentrated at Zandam where gardens for vegetable farming and rice fields are created and served by the canal water. The industrial agricultural potential in the area includes the cultivation of sorghum, groundnut, rice, vegetable crops, red sorrel *Rumex acetosa* (soborodo) acacia, *Nilotica albina* (bagaruwa) and castor seed. Trees species include neem tree, (*Azadirachta indica*), *Adansonia digitata* (Baobab tree), *Balanites aegyptiaca* (Aduwa). Shrubs include *Platisma* (kalgo) and *Cassia singuana* (Runfu). Major cash crops produce in Jibia are millet, guinea corn, groundnut (cowpea), cotton, maize, beans, rice, and wheat. An open irrigation system floods the fields during the dry seasons. There are more than 90 dug out wells in addition to the irrigation project that serve as water sources for the people as well as livestock during the long dry season. There are two main seasons: a wet season from May to October and a long dry season for the rest of the year. The average annual temperature ranges from 25°C to 35°C while total rainfall figures varies from 600-700mm annually (Mu'azu *et al.*, 2013).

3.2 Study Population

The study population was sampled from Jibia irrigational catchment area in Farfaru, Zandam and Matso-matso in Jibia district and non-irrigation area of Bugaje, Nassarawa and Daddara in Daddara district. The population is made up of fishermen, irrigation farmers, house wives, schooling children, civil servants, traders and students/pupils for the detection of malaria parasites and helminths parasites eggs and oocyst.

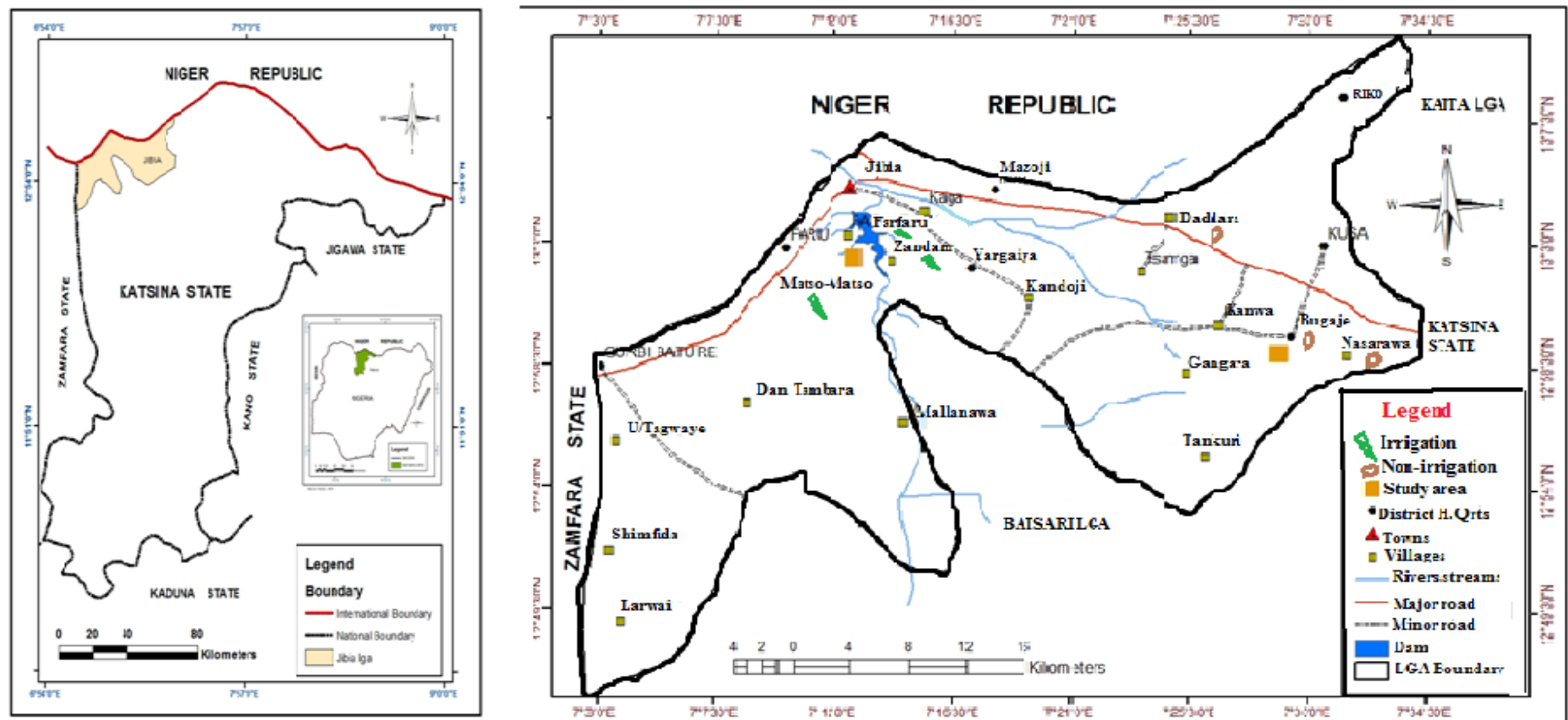


Figure 3.1: Map of Study Area showing the sampling locations in the irrigation and non-irrigation communities.

Source: Adapted and Modified From Administrative Map of Nigeria by NPC (2006).

3.3 Determination of Sample Size

3.3.1 Determination of sample size for *Plasmodium falciparum*

The sample size was determined using the following equation as described by (Naing *et al.*, 2006)

$$n = \frac{z^2 p(1 - p)}{d^2}$$

n=sample size

z=statistics for a level of 95% confidence interval=1.96

P=prevalence from previous study of 51.7% from Taura and Oyeyi (2009).

d=allowable error =5% or 0.05

$$n = \frac{1.96^2 \times 0.517(1-0.517)}{0.05^2}$$

n=384

3.3.2 Determination of sample size for urinary *S. haematobium* and intestinal helminths

The sample size was determined using the following equation as described by Naing *et al.* (2006)

$$n = \frac{z^2 p(1 - p)}{d^2}$$

n=sample size

z=statistics for a level of 95% confidence interval=1.96

p=prevalence from previous study of 37.9 % from Odu *et al.* (2011).

d=allowable error =5% or 0.05

$$n = \frac{1.96^2 \times 0.379(1-0.379)}{0.05^2}$$

n=362

However, 420 each of blood, urine and stool samples were used for this study.

Two hundred and ten (210) each were from the irrigation and non-irrigation communities. Seventy (70) persons were sampled from each of the six communities studied.

3.4 Ethical Clearance

Ethical clearance was obtained from the Katsina State Health, Research Ethics Committee at the Ministry of Health (reference no. MOH/ADM/SUB/1152/1/81). Written informed consent or fingerprints (of illiterate people) were obtained from participants aged 16 years and above, and from parents or guardians on behalf of children (<16 years). Each person that volunteered accepted the terms and condition of the research and signed a consent form. The information on the consent form was explained thoroughly to each subject in Hausa language and any other language of their understanding (Appendix IV).

3.5 Administration of Questionnaires

A structured questionnaire was administered to each individual. Information obtained from each individual includes age, gender, occupational status, sources of water, frequency of water contact activities in dam or canal. The questionnaire was administered by the researcher and the trained and recruited resident health workers.

3.6 Collection of Blood, Urine and Stool Samples

A systematic sampling was used to collect a total of 420 blood, urine and stool samples from the study population ages ranging from 1 to ≥ 50 years of male and female gender.

3.6.1 Collection of blood samples

Safety procedure was adopted in the collection of blood samples by swabbing the finger with 70% alcohol and allowed to dry before collection. Qualified nurses assisted in taking blood from each individual following ethical practice and caution to avoid cross contamination of blood samples.

1ml of each donor venous blood was collected using tunicate, needle and syringe into labeled Ethylene diaminetetra-acetic acid (EDTA) bottles before transporting to the Parasitology and Entomology laboratory of the Department of Biological Sciences, Ahmadu Bello University, Zaria for analysis.

3.6.2 Collection of urine and stool samples

Urine and faecal samples were obtained from the participants into two labeled, sterile wide mouthed screw capped containers (supplied to them) with instructions on how each sample is to be taken. In urine collection, respondents were asked to deposit midstream and terminal urine into the containers between the hours of 10:00am and 2:00am for

maximum number of eggs (WHO, 1990). Thus, for Stool samples were collected between 7:00 am and 10:00 am for maximum number of eggs (WHO, 1990). In both cases, the containers were labeled with the identification numbers to correspond with that on the questionnaire for each person interviewed.

3.7 Laboratory Analyses of Samples

3.7.1 Malaria parasitaemic determination

The rapid method recommended for staining thick blood is Field's Stain which is made from two components. Field's A is a buffered solution of azure dye and Field's B is a buffered solution of eosin. Both Field's A and B are supplied ready for use by the manufacturer (WHO, 2000).

Thick and thin blood films as described by Cheesbrough (2005) were made on clean slide. Field's stain method for thick blood films was done by placing a drop of blood on a microscope slide and spread to make an area of approximately 1 cm² where it was possible to read small print through the thick film. The film was air dried and NOT fixed in methanol and the slide was dipped into Field's stain A for three seconds and then dipped into tap water for three seconds and gently agitated. The slide was further dipped into Field's stain B for three seconds and washed gently in tap water for few seconds until the excess stained was removed and the slide was placed on an upright draining rack to air-dry. The thick films were to identify the parasite densities.

Rapid field's stain for thin films was done by air drying the film, fixed in methanol for one minute and the slide was Flooded with 1 ml of Field's stain B, diluted 1 in 4 with distilled water and immediately, an equal volume of undiluted Field's stain added and

mixed well and allowed to stained for 1 minute and was then rinsed well in tap water and drained vertically to dry. This is a useful method for rapid presumptive species identification of malarial parasites and for definitive species differentiation (WHO, 2000).

3.7.2 Microscopic examination of smears

Stained slides were examined under the light microscope using X100 objective lens in (immersion oil). Morphological identification of malaria parasites was done using published keys (Cheesbrough, 2005).

3.7.3 Urine examination

The sedimentation method as described by Cheesbrough (2005) was used to concentrate ova from the urine samples. Ten (10ml) of well mixed urine was transferred into a conical tube and allowed to settle down. The supernatant was discarded and sediment poured onto a microscopic slide, covered with a cover slip and examined microscopically for detection of *Schistosoma haematobium* ova.

3.7.4 Stool examination

The formol Ether concentration method was used to concentrate the cyst and ova from the stool samples. One gram (1g) of each stool sample was thoroughly emulsified with about 7 ml of 10% formalin and strained into a centrifuge tube. Three ml of diethyl ether was added and the mixture shaken vigorously and centrifuged for two minutes at 2000 rpm and allowed to settle down. The debris on the surface and at the interface between the two liquids was loosened from the wall of the tube with an applicator stick and the supernatant discarded. The upper part of the tube was wiped clear of fatty debris. The

small deposit was shaken up and a drop was placed on to a slide (Ridley and Hawgood, 1956).

All prepared specimens were examined microscopically first under X100 objective for good contrast and X400 objective for detail examination. The egg's of *S. haematobium* was identified by the possession of a terminal spine.

3.8 Data Analyses

The data was analyzed using Epi info® statistical software version 6.04. Prevalence was calculated and expressed in percentages by sex, age and other risks factors. Correlation by regression analysis was used to correlate prevalence of infection with age. Odd's ratio was used to determine the association between the risk factors and prevalence of *Plasmodium*, urinary *S. haematobium* and intestinal helminths infections. Significance level was determined at $P \leq 0.05$ at 95% confidence interval (C.I)

CHAPTER FOUR

4.0

RESULTS

4.1 Prevalence of *Plasmodium falciparum* Infections in the Irrigation and Non-irrigation Communities

Out of the total of 420 blood samples examined, 150 were positive for *Plasmodium falciparum* representing a prevalence of 35.7% of the study population. *P. falciparum* was the only species of *Plasmodium* encountered. Zandam had the highest prevalence of 52.9% of *Plasmodium* infection while Farfaru had the least prevalence of 30.0% in the irrigation communities. Daddara had the highest prevalence of 32.9% *P.falciparum* infection and Nassarawa had the least prevalence of 30.0% in the Non-irrigation communities. *P. falciparum* infection was higher in the irrigation communities with prevalence of a 40.0% than the non-irrigation communities with prevalence of 31.4%. There was an association between irrigation farming and *P.falciparum* infection in the study area (OR=1.455) but the association was not significant ($P > 0.05$) (Table 4.1).

4.2 *Plasmodium falciparum* Infections in the Irrigation and Non-irrigation Communities with Respect to Gender

The males had higher prevalence of 38.4% of *P.falciparum* infection than the females with a prevalence of 32.4% in irrigation and non-irrigation communities. There was association between *P.falciparum* infection and the male gender (OR=1.296), but the association was not significant ($P > 0.05$) (Table 4.2).

4.3 *Plasmodium falciparum* Infections in the irrigation communities with Respect to Gender

Higher prevalence of 52.2% of *P.falciparum* infection was recorded among males in the irrigation communities than the females with prevalence of 37.4%. Significant association was observed between *P.falciparum* infection and male gender in the irrigation communities (OR=1.834) ($P < 0.05$) (Table 4.3).

Table 4.1: Prevalence of *Plasmodium falciparum* infections in the Irrigation and Non-irrigation Communities

Communities	No. Examined	No.positive	(%) Prevalence	Odds ratio	95% C.I	P.value
Irrigation						
Farfaru	70	21	30.0			
Matso-matso	70	26	37.1			
Zandam	70	37	52.9			
Sub-total	210	66	31.4			
Non-irrigation						
Bugaje	70	23	32.9			
Daddara						
Nassarawa	70	21	30.0			
Sub-total	210	66	31.4			
Grand total	420	150	35.7	1.455	0.974-2.173	0.083

Table 4.2: *Plasmodium falciparum* Infections in the Irrigation and Non-irrigation Communities with Respect to Gender

Gender	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P .value
Male	232	89	38.4	1.296	0.865-1.941	0.249
Female	188	61	32.4			
Total	420	150	35.7			

Table 4.3: *Plasmodium falciparum* Infections in the Irrigation Communities with Respect to Gender

Gender	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P .value
Male	111	58	52.3	1.834	1.019-3.308	0.043*
Female	99	37	37.4			
Total	210	95	45.2			

***Significant**

4.4 *Plasmodium falciparum* Infections in the Non-irrigation communities with Respect to Gender

Higher prevalence of 27.8% of *P.falciparum* infections was recorded among the females than the males with prevalence of 25.6%. There was association between *P.falciparum* infection and female gender (OR=1.072) but the association was not significant ($P > 0.05$) (Table 4.4).

4.5 Prevalence of *P.falciparum* Infections in the Study Area with Respect to Age Groups

The ages of the study population ranged from 1- \geq 51 years. The participants were grouped into ten year class intervals and the prevalence of parasites in each age group was summarized in Table 4.5. The highest prevalence of *P.falciparum* infections was recorded in the age group 1-10 years with a prevalence of 40.2% and the least prevalence of *P.falciparum* infections was recorded in the 21-30 years age group with prevalence of 24.1%. There was a weak negative correlation between age and prevalence ($r = -0.31$) indicating that prevalence decrease with increase in age of the study population. The observed trend was so up to the age group 1-30 years after which the prevalence rose sharply in the age group 31-40 years and age group \geq 51. Although, there was an association between prevalence of *P.falciparum* infections with age group 1-10 (OR=1.379), but the association was not significant as recorded in the different age groups ($P > 0.05$).

4.6 Effects of other Risk Factors on the Prevalence of *P.falciparum* Infections

Based on choice of treatment of *P.falciparum* infections those that resort to self medication had the highest prevalence of 39.7% than those that goes to the hospital with prevalence of 34.2%. There was association between self medication and infections (OR=1.264). But, the association was not significant ($P > 0.05$).

Table 4.4: *Plasmodium falciparum* Infections in the Non-irrigation communities with Respect to Gender

Gender	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P .value
Female	89	24	27.8	1.072	0.576-1.995	0.952
Male	121	31	25.6			
Total	210	42	20.0			

Table 4.5: Prevalence of *Plasmodium falciparum* Infections in the Study Area with Respect to Age Groups

Age (years)	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P.value
1-10	164	66	40.2	1.379	0.918-2.071	0.148
11-20	70	24	34.3	0.928	0.541-1.591	0.891
21-30	29	7	24.1	0.552	0.230-1.324	0.252
31-40	102	35	34.3	0.922	0.577-1.473	0.825
41-50	21	6	28.6	0.708	0.269-1.866	0.640
≥ 51	34	12	35.3	0.980	0.471-2.041	0.894
Total	420	150	35.7			

r=-0.31

With regards to the prevention of mosquito bites/transmission of disease, screening of doors and windows with net had the highest prevalence of 37.8% while the least infection was recorded among insecticides users with prevalence of 29.5% (Table 4.6). Although associations were observed between *P.falciparum* infections and factors such as screening of doors and windows with nets and IBTN (OR=1.12., OR=1.188.) respectively, but the associations were not significant ($P > 0.05$) (Table 4.6).

4.7 Prevalence of *Schistosoma haematobium* infections in the Irrigation and Non-irrigation Communities

Out of the total of 420 urine samples examined, 216 were positive for *S.haematobium* ova with an overall prevalence of 51.4%. Zandam had the highest prevalence of 75.7% of *Schistosoma haematobium* infections and Matso-matso had the least prevalence of 62.9% in the irrigation communities. Bugaje had the highest prevalence of 50.0% of *S. haematobium* infections and Daddara had the least prevalence of 25.7% in the Non-irrigation communities.

S. haematobium infections was higher in the irrigation communities with prevalence of 68.1% than the non-irrigation communities with prevalence of 34.7%. There was association between irrigation farming and *S. haematobium* infections (OR= 4.006) and the association was significant ($P < 0.05$) (Table 4.7).

4.8 *S. haematobium* infections in the Irrigation and Non-irrigation Communities with Respect to Gender

Higher prevalence of 65.1% of *S. haematobium* infections was recorded among the males than the females with prevalence of 34.6%. There was association between *S. haematobium* infections and male gender in the study area (OR= 3.528) and the association was significant ($P < 0.05$) (Table 4.8).

Table 4.6: Effects of Other Risk Factors on the Prevalence of *P.falciparum* Infections

Risks factors	No. Examined	No. Positive	No. Negative	Odds ratio	95% C.I	P.value
How do you treat malaria						
Self Medication	116	46(39.7)	70 (60.3)	1.264	0.509-1.230	0.2994
Going to hospital	304	104 (34.2)	200 (65.8)			
Method of preventing malaria						
Door/window net	90	34 (37.8)	56 (62.2)	1.120	0.692-1.814	0.737
Insecticides	61	18 (29.5)	43 (70.5)	0.711	0.399-1.337	0.171
LLINs	204	77 (37.7)	127 (62.3)	1.188	0.781-1.771	0.458
Mosquito Coil	65	21(32.3)	44 (67.7)	0.836	0.476-1.468	0.621

Table 4.7: Prevalence of *Schistosoma haematobium* infections in the Irrigation and Non- irrigation Communities

Communities	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P. value
Irrigation						
Farfaru	70	46	65.7			
Matso-matso	70	44	62.9			
Zandam	70	53	75.7			
Sub-total	210	143	68.1			
Non-irrigation						
Bugaje	70	35	50.0			
Daddara	70	18	25.7			
Nassarawa	70	20	28.6			
Sub-total	210	73	34.7			
Grand total	420	216	51.4	4.006	2.669-6.012	0.000*

***Significant**

Table 4.8: *Shistosoma haematobium* infections in the Irrigation and Non-irrigation Communities with Respect to Gender

Gender	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P .value
Male	232	151	65.1	3.528	2.355-5.283	0.000*
Female	188	65	34.6			
Total	420	216	51.4			

***Significant**

4.9 *Schistosoma haematobium* infections in the Irrigation Communities with Respect to Gender

The males had higher prevalence of 80.2% of *Schistosoma haematobium* infections than the females with prevalence of 42.2% in the irrigation communities. Significant association was observed between *S. haematobium* infections and male gender in the irrigation communities (OR=5.49); (P < 0.05) (Table 4.9).

4.10 *Schistosoma haematobium* infections in the Non-irrigation communities with Respect to Gender

The males had higher prevalence of 51.2% of *S. haematobium* infections than the females with prevalence of 25.8% in the non-irrigation communities. There was a significant association between *Schistosoma haematobium* infections and male gender (OR=3.015) (P < 0.05) (Table 4.10).

4.11 Prevalence of *Schistosoma haematobium* infections in the study Area with Respect to Age Groups

The ages of the study population ranged from 1- ≥ 51 years. The participants were grouped into ten year class intervals and the prevalence of parasites in each age group was summarized in Table 4.11. The highest prevalence of 52.7% of *S. haematobium* infections was recorded in the age group 31-40 years followed by 11-20 years with prevalence of 44.3% the least prevalence of 28.6% was recorded in the 41-50 years age group. There was a negative correlation between age and prevalence (r=-0.55) indicating that prevalence decrease with increase in age of the study population. The observed trend was so up to the age group 1-30 years after which the prevalence rose drastically in the age group 31-40 years and age group ≥ 51. There was an association between prevalence of *S. haematobium* infections with age group 1-10 years and 31-40 years (OR=1.475; 1.839) respectively, but the association was only significant in the 31-40 years age group (P > 0.05).

Table 4.9: *Schistosoma haematobium* infections in the Irrigation Communities with Respect to Gender

Gender	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P .value
Male	111	89	80.2	5.49	2.972- 10.14	0.000*
Female	99	42	42.4			
Total	210	131	62.3			

*Significant

Table 4.10: *Schistosoma haematobium* in the Non-irrigation Communities with Respect to Gender

Gender	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P .value
Male	121	62	51.2	3.015	1.666-5.459	0.000*
Female	89	23	25.8			
Total	210	85	40.5			

***Significant**

Table 4.11: Prevalence of *Schistosoma haematobium* infections in the Study Area with Respect to Age Groups

Age (years)	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P.value
1-10	164	94	57.3	1.475	0.994-2.189	0.067
11-20	70	31	44.3	0.709	0.423-1.188	0.239
21-30	29	10	34.5	0.473	0.214-1.042	0.089
31-40	102	64	62.7	1.839	1.164-2.907	0.012*
41-50	21	6	28.6	0.360	0.137-0.947	0.054
≥ 51	34	11	32.4	0.422	0.200-0.890	0.032
Total	420	216	51.4			

*** Significant**

r=-0.55

4.12 Effects of Other Risk Factors on the Prevalence of *Schistosoma haematobium* infections

Out of the three main sources of domestic water supply used by the study population: bore hole, locally dug well and dam, parasites were found at higher prevalence of 70.2% in people that use dam water and the least prevalence of 34.0% was encountered among users of bore hole water. There was significant association between sources of water from the dam (OR= 3.139) and prevalence of *S. haematobium* infections (P <0.05). Based on occupation of the study population, those with the highest prevalence of 80.8% of *S. haematobium* infections were fishermen followed by farmers with prevalence of 55.4% and the least were civil servants with prevalence of 23.1% and there were associations between farming (OR= 1.229), fishing (OR= 4.286) and schooling (OR= 1.178) respectively, but the association was only significant with fishing (P <0.05). Responses on the frequency of water contact activities in the dam revealed that prevalence of 76.2% of 'daily' water contact activities ranked highest followed by weekly 66.4% and the least was 'not at all' 34.6%. There were associations between 'daily' (OR= 3.600), 'weekly' water contact with water in the dam (OR = 2.452) and *S. haematobium* infections and the associations were significant (P <0.05). Responses on type of toilet used showed higher prevalence of 51.1% of the urinary schistosome parasite for those that use pit toilet and prevalence of 54.0% for open field defecation and the least prevalence of 34.6% for those that use water closet. There were associations between open field defecation (OR= 1.141), use of pit toilet (OR= 1.541) and prevalence of *S. haematobium* infections but the association was only significant in those that use pit toilet (P<0.05) Table 4.12.

Table 4.12: Effects of Other Risk Factors in the Prevalence of *Schistosoma haematobium* infections

RISK FACTORS	No. Examined	No. (%) Positive	No. (%) Negative	Odds ratio	95 % C.I.	P.value
Source of water						
Bore Hole	97	33 (34.0)	64 (66.0)	0.395	0.246-0.634	0.000*
Dam	131	92(70.2)	39 (29.7)	3.139	2.020-4.879	0.000*
Well	192	91 (47.4)	101 (52.6)	0.742	0.505-1.091	0.156
Occupation						
Artisan	26	8 (30.8)	18 (69.2)	0.397	0.169-0.935	0.048
Civil-Servant	26	6 (23.1)	20 (76.9)	0.263	0.103-0.669	0.005*
Farming	92	51 (55.4)	41 (44.6)	1.229	0.772-1.955	0.452
Fishing	26	21 (80.8)	5 (19.2)	4.286	1.585-11.59	0.003*
Others	23	9 (39.1)	14 (60.9)	0.590	0.241-1.395	0.318
Pupils/Students	227	121 (53.3)	106 (46.7)	1.178	0.802-1.729	0.462
Water Contact in the Dam						
Daily	63	48 (76.2)	15 (23.8)	3.600	1.945-6.664	0.000*
Not at all	104	36 (34.6)	68 (65.4)	0.400	0.252-0.634	0.000*
Monthly	122	45 (36.9)	77 (63.1)	0.434	0.281-0.661	0.000*
weekly	131	87 (66.4)	44 (33.6)	2.452	1.595-3.771	0.000*
Type of toilet						
Open field Defaecation	102	55 (54.0)	47 (46.0)	1.141	0.721-1.784	0.642
Pit Toilet	237	133 (56.1)	104 (43.9)	1.541	1.045-2.271	0.036*
Water Closet	81	28 (34.6)	53 (65.4)	0.424	0.256-0.703	0.001*

4.13 Prevalence of Intestinal Helminths infections in the Irrigation and Non-irrigation Communities

Out of the total of 420 stool samples examined, 137 were positive for intestinal helminths parasite eggs and oocyst with an overall prevalence of 32.6% of the study population. Zandam had the highest prevalence of 57.1% of intestinal helminths infections while Matso-matso had the least prevalence of 32.9% in the irrigation communities. Bugaje had the highest prevalence of 31.4% of intestinal helminths infections and Daddara had the least prevalence of 14.3% in the Non-irrigation communities. Intestinal helminths infections were higher in the irrigation communities with prevalence of 45.2% than the non-irrigation communities with prevalence of 20.0%. There was association between irrigation farming and intestinal helminths infections in the study area (OR= 3.304) and the association was statistically significant ($P < 0.05$) (Table 4.13).

4.14 Intestinal Helminths infections in the Irrigation and Non-irrigation Communities with Respect to Gender

The males had higher prevalence of 39.7% of intestinal helminths infections than the females with prevalence of 23.9% in the irrigation and non-irrigation communities. There was association between intestinal helminths infections and the male gender of the study population (OR=2.737) and the association was significant ($P < 0.05$) (Table 4.14).

4.15 Intestinal Helminths infections in the irrigation Communities with Respect to Gender

The males had higher prevalence of 47.7% of intestinal helminths infections than the females with prevalence of 26.2% in the irrigation communities. Significant association was observed between intestinal helminths infections and male gender in the irrigation communities (OR=2.566); ($P < 0.05$) (Table 4.15).

Table 4.13: Prevalence of Intestinal Helminths Infections in the Irrigation and Non-irrigation Communities

Communities	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P. value
Irrigation						
Farfaru	70	32	45.7			
Matso-matso	70	23	32.9			
Zandam	70	40	57.1			
Sub-total	210	95	45.2			
Non-irrigation						
Bugaje	70	17	31.4			
Daddara	70	10	14.3			
Nassarawa	70	15	21.4			
Sub-total	210	42	20.0			
Grand total	420	137	32.6	3.304	2.141-5.099	0.000*

***Significant**

Table 4.14: Intestinal Helminths infections in the Irrigation and Non-irrigation Communities with Respect to Gender

Gender	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P .value
Male	232	92	39.7	2.088	1.364-3.197	0.000*
Female	188	45	23.9			
Total	420	137	32.6			

***Significant**

Table 4.15: Intestinal Helminths infections in the Irrigation Communities with Respect to Gender

Gender	No. Examined	No. Positive	Prevalence (%)	Odds ratio	95% C.I	P .value
Male	111	53	47.7	2.566	1.433-4.593	0.002*
Female	99	26	26.2			
Total	210	79	37.6			

***Significant**

4.16 Intestinal Helminths infections in the Non-irrigation communities with Respect to Gender

The males had higher prevalence of 32.2% of intestinal helminths infections than the females with prevalence of 21.3% in the non-irrigation communities. There was association between intestinal helminths infections and male gender (OR=1.752) but the association was not significant ($P > 0.05$) (Table 4.10).

4.17 Prevalence of Intestinal Helminths infections in the Study Area with Respect to Age Group

The highest prevalence of 41.5% of intestinal helminths infections was encountered in the age group 1-10 years followed by prevalence of 32.9% in the age group 11-20 years and the least prevalence of 14.3% was encountered in the age group 41-50 years. There was an overall strong negative correlation between age group and prevalence of Intestinal helminths infections in the study area with respect to age ($r=-0.87$) indicating that prevalence decreased with increased in age of the study population. The trend was observed in age group 1-10 years, age group 11-20 years up to the age group 21-30 years after which the prevalence increased progressively in the age group 31-40 years and age group ≥ 51 years. Although, there were associations between prevalence of intestinal helminths infections with age group 1-10 years (OR=1.92) and age group 11-20 (OR=1.013) the association was only significant between age group 1-10 years ($P < 0.05$). Prevalence of parasites in each age group was summarized in Table 4.17.

Table 4.16: Intestinal Helminths infections in the Non-irrigation Communities with Respect to Gender

Gender	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P .value
Male	121	39	32.2	1.752	0.929-3.304	0.011*
Female	89	19	21.3			
Total	210	58	27.6			

***Significant**

Table 4.17: Prevalence of Intestinal Helminths Infections in the study area with Respect to Age Group

Age (years)	No. Examined	No. Positive	(%) Prevalence	Odds ratio	95% C.I	P. value
1-10	164	68	41.5	1.92	1.267-2.909	0.003*
11-20	70	23	32.9	1.013	0.587-1.75	0.926
21-30	29	06	20.7	0.518	0.206-1.303	0.225
31-40	102	32	31.4	0.927	0.574-1.497	0.852
41-50	21	03	14.3	0.321	0.095-1.139	0.101
≥ 51	34	05	14.7	0.332	0.126-0.877	0.016*
Total	420	137	32.6			

*** Significant**

r = -0.87

4.18 Effects of Other Risk Factors on the Prevalence of Intestinal Helminths infections

Out of the three main sources of domestic water supply used by the study population, parasites were found at higher prevalence in people that use dam water with the prevalence of 61.1% than well water with prevalence of 25.0% and the least prevalence of 9.3% encountered among those that use bore- holed water. There was significant association between sources of water from the dam (OR= 6.385) and prevalence of intestinal helminths infections (P <0.05). Based on occupation of the study population, those with the highest prevalence of 43.3% of intestinal helminths infections were farmers followed by school children with prevalence of 37.9% and the least were civil servants and artisan not infected by intestinal helminth. There were associations between farming (OR= 1.832), fishing (OR= 1.1) and schooling (OR= 1.698) respectively, but the associations were only significant with farming and schooling in the study population (P <0.05). Responses on the frequency of water contact activities in the dam by the study population revealed that ‘daily’ water contact with prevalence of 66.7% ranked highest followed by ‘weekly’ with prevalence of 44.3% and the least is ‘not at all’ with prevalence of 10.6%. There were associations between ‘daily’ water contact in the dam (OR= 5.516) and ‘weekly’ water contact with water in the dam (OR = 2.112) and intestinal helminths infections and the associations were significant (P <0.05). Responses on type of toilet used showed higher prevalence of 55.9% for open field defecation and the least prevalence of 14.8% for those that use water closet toilets. There was association between open field defecation (OR= 3.768) and prevalence of intestinal helminths infections and the association was significant. A summary of the responses to the questionnaires by the study population is presented in Table 4.18.

Table 4.18: Effects of Other Risk Factors on the Prevalence of Infection Intestinal Helminth

RISK FACTORS	No. Examined	No. (%) Positive	No. (%) Negative	Odds ratio	95 % C.I.	P.value
Source of water						
Bore Hole	97	09 (9.3)	88 (90.7)	0.156	0.076-0.320	0.000*
Dam	131	80 (61.1)	51 (38.9)	6.385	4.05-10.07	0.000*
Well	192	48 (25.0)	144 (75.0)	0.521	0.342-0.793	0.003*
Occupation						
Artisan	26	00 (0.0)	26 (100)	0.000	0.000-0.000	0.000*
Civil-Servant	26	00 (0.0)	26 (100)	0.000	0.000-0.000	0.000*
Farming	92	40 (43.5)	52 (56.5)	1.832	1.139-2.947	0.017*
Fishing	26	09 (34.6)	17 (65.4)	1.100	0.478-2.536	0.993
Others	23	02 (8.7)	21 (91.3)	0.185	0.043-0.800	0.022*
Pupils/Students	227	86 (37.9)	141 (62.1)	1.698	1.119-2.578	0.017*
Water Contact in the Dam						
Daily	63	42 (66.7)	21 (33.3)	5.516	3.107-9.792	0.000*
Not at all	104	11 (10.6)	93 (89.4)	0.178	0.092-0.347	0.000*
Monthly	122	26 (21.3)	96 (78.6)	0.456	0.279-0.747	0.002*
weekly	131	58 (44.3)	73 (55.7)	2.112	1.339-3.321	0.000*
Type of toilet						
Open field Defaecation	102	57 (55.9)	45 (44.1)	3.768	2.365-6.004	0.000*
Pit Toilet	237	68 (28.7)	169 (71.3)	0.665	0.441-1.002	0.064
Water Closet	81	12 (14.8)	69 (85.2)	0.298	0.155-0.571	0.000*

*

4.19 Species-Specific Prevalence of Intestinal Helminth, Urinary Schistosome and *Plasmodium* Infection in Irrigation and Non-irrigation Communities

Based on study populations, the prevalence of 22.6% of intestinal helminth, 30.4% of *S. haematobium* recovered from urine and prevalence of 20.0% of *P.falciparum* were encountered in the irrigation communities respectively. The prevalence of 10.0% of intestinal helminth, 17.4% of *S. haematobium* and prevalence of 15.7% of *P.falciparum* respectively were encountered in the non-irrigation communities. Based on communities, the highest prevalence of 9.5% of intestinal helminth, prevalence of 12.6% of *S. haematobium* and prevalence of 6.2% of *P.falciparum* respectively were encountered in Zamdam in the irrigation communities. The least prevalence of 5.5% of intestinal helminths and prevalence of 10.5% of *S. haematobium* was recorded in Matso-matso respectively while prevalence of 6.2% of *P.falciparum* was encountered in Farfaru in the irrigation communities. The highest prevalence of 4.0% of intestinal helminths and prevalence of 8.3% of *S. haematobium* respectively were encountered in Bugaje and prevalence of 5.6% of *P.falciparum* was encountered in Daddara in the non-irrigation communities. The least prevalence of 2.4% of intestinal helminths and prevalence of 4.2% of *S. haematobium* was recorded in Daddara and prevalence of 5.0% of *P.falciparum* was encountered in Nassarawa in the non-irrigation communities. *Ascaris lumbricoides* was the most encountered intestinal helminths with prevalence of 14.5% of the study population followed by *S. stercoralis* with prevalence of 9.5%, hookworm with prevalence of 4.7%, *Enterobius vermicularis* with prevalence of 3.6%. The least parasite encountered was *Hymenolepis diminuta* which was only encountered in the non-irrigation communities with a prevalence of 0.2% (Table 4.19).

Table 4.19: Species-Specific Prevalence of Intestinal Helminths, Urinary schistosome and *P.falciparrum* Infection in Irrigation and Non-irrigation Communities

Communities	No. Examined	Hookworm (%)	<i>A.lumbricoides</i> (%)	<i>S. stercoralis</i> (%)	<i>E.vermicularis</i> (%)	<i>H.diminuta</i> (%)	Intestinal helminths (%)	<i>S. haematobium</i> (%)	<i>P.falciparrum</i> (%)
Irrigation									
Farfaru	70	6 (1.4)	9 (2.1)	6 (1.4)	4 (1.0)	0 (0.0)	25 (7.6)	46 (10.9)	21 (5.0)
Matso-matso	70	4 (1.0)	18 (4.3)	10 (2.4)	5 (1.2)	0 (0.0)	36 (5.5)	44 (10.5)	26 (6.2)
Zandam	70	4 (1.0)	20 (4.8)	11 (2.6)	5 (1.2)	0 (0.0)	40 (9.5)	53 (12.6)	37 (8.8)
Sub-total	210	14 (3.3)	47 (11.2)	27 (6.4)	14 (3.3)	0 (0.0)	101 (22.6)	143 (30.4)	84 (20)
Non-irrigation									
Bugaje	70	5 (1.2)	7 (1.6)	6 (1.4)	0 (0.0)	1 (0.2)	19 (4.0)	35 (8.3)	22 (5.2)
Daddara	70	1 (0.2)	3 (0.7)	5 (1.2)	0 (0.0)	0 (0.0)	09 (2.4)	18 (4.2)	23 (5.6)
Nassarawa	70	0 (0.0)	4 (1.0)	2 (0.5)	1 (0.2)	0 (0.0)	07 (3.6)	20 (4.8)	21 (5.0)
Sub-total	210	6 (1.4)	14 (3.3)	13 (3.1)	1 (0.2)	1 (0.2)	35 (10)	73 (17.4)	66 (15.7)
Grand Total	420	20 (4.7)	61 (14.5)	40 (9.5)	15 (3.6)	1 (0.2)	137 (32.6)	216 (51.4)	150 (35.7)

4.20 Prevalence of Double Infections with *P.falciparum* and Helminths Parasites in the Study Area

The overall prevalence of *Plasmodium* and helminths double infections was 15.0%. The highest prevalence was *P.falciparum* and *S.haematobium* with prevalence of 9.5% followed by *P.falciparum* and *A. lumbricoides* with prevalence of 2.4% while *P.falciparum* and *E. vermicularis* with prevalence of 0.2% was the least reported (Table 4.20).

4.21 Prevalence of Double Infections with Helminths parasites in the Study Area

The overall prevalence of helminths double infection was 3.8%. The highest prevalence was recorded in the *S.haematobium* and *S.stercoralis* combination with prevalence of 1.4% while *A. lumbricoides* and *S.stercoralis* as well as hookworm and *A. lumbricoides* had the prevalence of 0.2% each and was the least reported (Table 4.21).

4.22 Prevalence of Triple Infections with *P.falciparum* and Helminths Parasites in the Study Area

Triple infection with *Plasmodium* and helminths were 2.6%.The triple combination of *S.haematobium*, *A. lumbricoides* and *P.falciparum* with prevalence of 1.0% ranked highest, followed by *S.haematobium*, hookworm and *P.falciparum* with prevalence of 0.7% and the least was that of *S. haematobium*, *E. vermicularis* and *P.falciparum* as well as *S. haematobium*, *S. stercoralis* and *P.falciparum* with prevalence of 0.2% each (Table 4.22).

Table 4.20: Prevalence of Double Infections with *P.falciparum* and Helminths Parasites in the Study Area

Double <i>Plasmodium</i> and helminths infections (N=420)	No. (%) infected
<i>Plasmodium falciparum</i> + <i>Ascaris lumbricoides</i>	10 (2.4)
<i>Plasmodium falciparum</i> + <i>Enterobius vermicularis</i>	1 (0.2)
<i>Plasmodium falciparum</i> + Hookworm	7 (1.7)
<i>Plasmodium falciparum</i> + <i>Schistosoma haematobium</i>	40 (9.5)
<i>Plasmodium falciparum</i> + <i>Strongyloides stercoralis</i>	5 (1.2)
Total	63 (15.0)

Table 4.21: Prevalence of Double Infections with Helminths parasites in the Study Area

Double Helminths infections	No. (%) infected
(N=420)	
<i>Ascaris lumbricoides</i> + <i>Strongyloides stercoralis</i>	1 (0.2)
Hookworm + <i>Ascaris lumbricoides</i>	1 (0.2)
<i>Schistosoma haematobium</i> + <i>Ascaris lumbricoides</i>	5 (1.2)
<i>Schistosoma haematobium</i> + Hookworm	3 (0.7)
<i>Schistosoma haematobium</i> + <i>Strongyloides stercoralis</i>	6 (1.4)
Total	16 (3.8)

Table 4.22: Prevalence of Triple infections with *Plasmodium falciparum* and Helminths Parasites in the Study Area

Triple infections with <i>Plasmodium</i> and Helminths (N=420)	No. (%) Infected
<i>Schistosoma haematobium</i> + <i>Ascaris lumbricoides</i> + <i>Plasmodium falciparum</i>	4 (1.0)
<i>Schistosoma haematobium</i> + <i>Ascaris lumbricoides</i> + <i>Strongyloides stercoralis</i>	2 (0.5)
<i>Schistosoma haematobium</i> + <i>Enterobius vermicularis</i> + <i>Plasmodium falciparum</i>	1 (0.2)
<i>Schistosoma haematobium</i> + Hookworm + <i>Plasmodium falciparum</i>	3 (0.7)
<i>Schistosoma haematobium</i> + <i>Strongyloides stercoralis</i> + <i>Plasmodium falciparum</i>	1 (0.2)
Total	11 (2.6)

CHAPTER FIVE

5.0 DISCUSSION

The result of the present study established the occurrence of *Plasmodium falciparum* in Jibia Local Government Area of Katsina State, Nigeria. Out of the total 420 blood samples examined (150/420) 35.7% were infected with *P. falciparum*. This is lower compared to the prevalence of 59.9% reported in a study by Ojo and Mafiana (2005) among children <15 years in Abeokuta, Southwestern Nigeria and 51.5% documented in a study by Epidi *et al.* (2008) in Abakaliki, Southeastern Nigeria. The percentage prevalence in this study may be attributed to the administration of anti-malarial drugs given at no cost to pregnant women and children at the health centers and free distribution of long lasting insecticide treated nets (LLIN) or alternative intermittent preventive treatment with pyrimethamine-sulfadoxine in the study area. It may also be attributed to the prevailing environmental and ecological conditions of the different study localities and varying transmission patterns of the parasites. The study area has drier climatic conditions when this work was carried out.

The 35.1% overall prevalence of *P. falciparum* reported in this study is comparable to the 30.0% reported by Okonko *et al.* (2012) among children in Ibadan. Similar prevalence has also been reported previously by Olasunkanmi *et al.* (2013) who reported a prevalence of 31.6% in Abeokuta, Ogun State, Nigeria. The *Plasmodium* species reported in this study agreed with a previous report that *P. falciparum* is the most prevalent species in Nigeria accounting for about 98% of malaria cases in the country (FMH, 2010). (Steffen *et al.*, 2003) reported that 80-95% of malaria infections in Tropical Africa are caused by *P. falciparum*. Overall malaria deaths (91% of cases) and deaths in the age

group 0-5 years (86% of cases), are mostly caused by *P. falciparum* (98% of all cases), (WHO, 2012).

The environmental conditions created by the irrigation facility provide ideal breeding grounds for the *Anopheles* female mosquitoes therefore contributing to the high prevalence of infection in Zandam. Climatic conditions may influence mosquitoes breeding and hence transmission of malaria. These findings agreed with report of Konradsen that people living within 750 metres of the local stream, which was the established vector- breeding site, were at much higher risk of malaria than people living further away (Konradsen *et al.*, 2003). *Anopheles* mosquitoes breed in temporary pools such as roadside ditches and drains, burrow pits, hoof prints, wheel nuts, and puddles which are commonly seen in the irrigation communities with the highest prevalence. There was significant association between prevalence of *P. falciparum* and male gender.

Malaria infection was higher in males than in females in the irrigation communities probably due to higher night activities by men than by women such as drying of fishing net, cleaning of fishing tools, processing of farm produce, washing clothes, utensils; bathing and swimming done during the dusk hours which exposes males to risk of infection because the biting pattern of the female *Anopheles* mosquito is mostly in the night between dusk to dawn (Cheesbrough, 2005).

The life style of the people such as sleeping outside, watching television or visiting the video centres and cinema centre get them exposed to the exophilic species while most women especially pregnant women sleep under the LLINs. Although in the non-irrigation communities there was insignificant ($P > 0.05$) association between infection and gender.

The female had higher rate of infection. Vector homogenous bitten pattern is not gendered dependent but both males and female are at the risk of the vector which seeks for the host not the host seeking for the vector. Long Lasting Insecticides Nets reduce human – vector contact by killing or repelling vector mosquitoes thus reducing malaria – related illness and death (Gomes *et al.*, 2010). But ownership and use of LLINs remains low especially in the rural areas compared to urban areas (Mazigo *et al.*, 2010). Thus, more rural women are exposed to the risk of acquiring compared to their urban counterparts. It is observed that the risk of getting malaria was greater for inhabitants of houses which are incomplete with thatched roofs and walls made of mud, compared with inhabitants of better constructed houses with complete brick and plastered walls and iron roofs (Konradsen *et al.*, 2003). Having houses surrounded with low vegetations and bushes around the compound provide resting grounds for malaria transmitting mosquitoes and thus increases individual risk for malaria. In the hot dry seasons, substantial number of people may sleep outside in the open air, as a consequence being bitten more frequently by exophagic species of mosquitoes. During the wet season the species multiply rapidly thus increase their population and biting frequency.

There was no significant association with prevalence of infection with age, the 1-10 years age group had the highest rate of *Plasmodium* infection. This agrees with the findings of Bates *et al.* (2004); and Snow *et al.* (1999) that noted that Peak infection occurs in children between one and five years of age and 25% of all-cause mortality in children aged 0-4 years is due to malaria. This is due to immune responses and age-specific behaviors that determine exposures to infectious agents (Raso *et al.*, 2010). Lower

prevalence in adults is as a result of lower exposures to infection sites and the development of partial immunity in highly endemic areas (Mohmound *et al.*, 2001). Age-specific prevalence shows that infection rate decreased with increasing age. The weak negative correlation between infection and the age of the study population may be because of the inconsistency in the trend of infection across age line. Also, individual in the same age group have no consistent characteristics on health, exposure and prevention of diseases. In addition to nature of housing and pollution, proximity of housing to mosquito- breeding sites has also been found to be an important determinant of incidence of malaria in children and in the general population (Van Der Hoek *et al.*, 2001).

This study showed insignificant association between self medication and infection as choice of treatment. Location of health centres in terms of 'proximity' and 'affordable treatment cost' made some subject/population to resort to choice of treatment. Another major problem with the treatment of malaria is the high level of treatment failures resulting in the large part from the high prevalence of counterfeit drugs bought by the patients. This made some people resorted to use of herbal drugs which have been rumored to have therapeutic effects on the malaria infection but their efficacies, doses, expiration date and side effect have not been documented. As Bates *et al.* (2004), clearly put it, access to health care is affected by both demand-side and supply-side factors. Demand-side factors include lack of resources and fear of social consequences. Supply-side factors include the geographic distribution of health facilities and staff, rates of formal and informal fees, and perception of the quality of care offered. From the questionnaires responses it was observed that most individuals are not aware that anti-malaria drugs are given at no cost to pregnant women and children less than five years at

the health centers. Lack of funds to pay for treatment or to purchase drugs made going to health centers usually the last resort. Self medication with drugs has been reported to be a common practice in many endemic areas worldwide (Yeneneh *et al.*, 1993). Cultural and social factors have been reported to influence treatment-seeking behaviour (Mwenesi *et al.*, 1995).

Most of the houses in the communities do not have proper drainage systems, so almost all the people depend on insecticides and insecticides treated bed nets for mosquito control or protection. The effectiveness of LLINs in reducing malaria morbidity and mortality has been documented in areas of both high and low malaria transmission, and among children as well as adults (Kwadzi *et al.*, 2011). These bed nets have been shown to confer protection at a community level, even in non-users, in areas with high coverage. These mosquito nets that have been treated with pyrethroids are known to be deleterious to mosquitoes (WHO, 2005). ITBNs have been shown to be safe and devoid of toxicity when used according to instructions (WHO, 2005). The nets are expected to be retreated every 6 months with pyrethroid. High infection rates among LLINs users might be possible that treated nets are widely used by individuals experiencing malarial symptoms or pregnant women than other populations under study and possibility of holes or damages on the LLINs creating passage for the mosquitoes as well as the nets losing its efficacies due to over usage for long period of time without re-treatment or improper usage.

The prevalence of (216/420) 51.4% of *S. haematobium* infections in this study is similar from those recorded in other studies. A rapid assessment method to determine the

distribution of urinary schistosomiasis in some villages in Abeokuta North and Odeda local government areas showed a prevalence of 51.3% (Mafiana *et al.*, 1997). Dunah and Bristone (2000) reported a lower prevalence of 27.2% for urinary schistosomiasis in Adamawa State. Similarly, Akogun and Obadiah (1996) reported a higher prevalence of 65.8% in Gyawana and plantations and among school children near Numan in Adamawa State. The variability found in the prevalence of the infection among the communities examined could be attributed to the fact that people living in irrigation area of Zandam, Farfaru and Matso-Matso depend on dams, rivers, pond and wells for their every day water demand for domestic and economic. The high prevalence in Zandam may be connected with the heavy contamination of the perimeter of the water canal in the area as well as increased water usage by the irrigation communities. Most of these water bodies are main transmission foci in the communities. These ensure that the people continue to be infected and re-infected even after medication. These water sources serve as meeting point for the parasites in the irrigation communities which is larger than pockets of drains and shallow rivers in the non-irrigation communities. The high prevalence of infections in Bugaje could have been as a result of wash off into the canal from the adjacent land upstream that connect with the dam and carried downstream and serving as a means of infection for the communities that make use of the canal.

This agrees with Opaluwa (2009) who stated that the observed variation in infection may be attributed to the combined effects of the relative infectivity of water contact sites used, frequency of water contact and the ability to express developed immunity and resistance to infection.

S. haematobium infections have been shown to increase with the construction of irrigational facilities due to the creation of ideal environmental conditions for the snail intermediate host. The absence of *S. mansoni* can be attributed to the fact that the preferred habitat of the intermediate snail host *Biomphalaria* species require more stable water levels than *Bulinus* species and thus are likely to benefit more from intensive irrigation. Urinary schistosomiasis often increased in populations living close to large dam reservoirs while the introduction or spread of *S. mansoni* was associated with smaller water bodies (Jobin, 1999). It has also been suggested that lack of *S. mansoni* transmission in an area is due to the intolerance of *S. mansoni* transmitting snails, *Biomphalaria* species to the high temperatures (Sturrock, 2001).

There was significant association of *S. haematobium* infections with gender in both irrigation and non-irrigation communities, males show higher prevalence than females. This is probably because males are more involved in activities such as farming and higher water contact behaviors particularly fishing as well as bathing and swimming in cercarial infested water. Several research reports, (Ndams and Livingstone, 2000 and Ugbomoiko, 2000); have indicated higher prevalence of urinary schistosomiasis in males than in females. This was supported by Idris and Ajanusi (2002) who reported that human water contact activities go side by side with the amount of contamination and even incidence of infection, especially when the right species of snail vector are in abundance. This high prevalence in males than in females may also be connected with the socio-cultural setup of the people of the study area. These people are predominantly Muslims, Hausa and Fulani by tribe. Majority of the females are restricted to their houses therefore they have less contact with infested water compared to their male counterparts. Swimming and

bathing in the open water bodies is also very uncommon among females in the communities. This is in line with the observation made by other authors (Idris and Ajanusi, 2002; Ezeamama *et al.*, 2005; Dunah *et al.*, 2000).

It was further observed that even among the informed males awareness level did not play any significant role in discouraging water contact activities as such practices have become necessary as they are the major means of subsistence; in terms of irrigation agriculture and body cleansing, according to some of the respondents.

The high prevalence of urinary schistosomiasis in 31-40 years age group are due to their constant involvements in manual labour on farms and fetching of water from the dam which predisposes them to infection and availability of breeding sites for the intermediate host (fresh water snail). It was however observed that infection with schistosomiasis occurred in all the age groups probably because they all have contact with the irrigational facility in one way or the other and for various purposes by virtue of their location and/or occupation.

The negative correlation between infection and age may be because as the age increases, the children tend to exhibit more hygienic behaviour in their day to day activities. Major behavioural factors play a role in disease transmission. In endemic situations, typical age-related *Schistosoma* intensity patterns are usually observed, with a rapid increase in children, a peak in adolescents, and a strong decline in adults. Another inference is the possibility of developed immunity by the aged people who might have contracted the disease in their young age. This finding is similar to that of Ndams and Livingstone (2000) who reported that the decrease in prevalence as age increased might be as a result

of less contact with water among the older folks and, who have developed immunity against *Schistosoma* infection. This has been attributed to age-related differences in exposure as well as resistance (Bundy and Blumenthal, 1990).

Another observation was the contamination behaviour of the young and even adult males around the perimeter of the canals after which they proceed to the water bank to wash themselves. This observation was earlier made by Tayo *et al.* (1980) who observed that subjects often defaecated and urinated near the edge of the water and then washed themselves by squatting close to the water edge. From these reports, therefore, high rates of water exposure and contamination by males can be attributed to lack or inadequate supply of pipe-borne water and provision of boreholes coupled with the known occupation of irrigated farming in the area which predispose the young adults to infection with *Schistosoma*.

Contrary to the report of Luka *et al.* (2001) that showed no significant association between infection and source of drinking water, this study revealed association of infection with source of water from the dam. This may be due to indiscriminate defaecation which might lead to contaminated soil particles being washed into dams, open wells and streams and when used by household without boiling or treatment, the household get infected.

The prevalence of infection among the different occupational groups varied with associations with fishing, farming and schooling but was only significant with fishing. Fishing and farming were the most prominent water contact activities for economic reasons. The frequency of contact with water bodies is related to the risk of the infection.

Fishermen used boats, sorted fish, wash fishnets, bathed and washed clothes and farmers are unavoidably in contact with infected water this exposes limbs of the farmers to contaminated water and possible infection throughout the period that they work on the infested water. On the contrary, civil servants were very much enlightened, more conscious of their health and surrounding, have much better toilet facilities, high income and practicing good personal hygiene. This was supported by (Idris, 2002).

Majority of the inhabitants had 'daily' water contact activities with water from the dam and the canal especially those in the irrigation communities thus a cycle of infection is created. Prevalence of infection is influenced considerably by the frequency, duration and intensity of human contact with infective water. Most of the farming activities including transplanting of seedlings and the application of fertilizer for side-dressing are done while the farms are flooded. This practice exposes the limbs of the farmer to contaminated water. In the process of irrigating the farms, the water can also aid in transporting the intermediate host snails to other locations where they originally did not exist. The data obtained in this study showed that not going to the dam significantly reduce the risk of infection while those that go the dam for fetching water, processing of farm produce, washing clothes, utensils; bathing and swimming are at risk of infection.

This study further revealed significant association of infection with *S.haematobium* and use of pit toilets. In the same vein, individual who had pit toilets and who defecated openly had higher prevalence than their counterparts with water closets. Soil pollution is a major factor in the transmission of the *S.haematobium* in communities. Information gathered from the district leaders and members of these communities indicated that there

were no toilet facilities for members of the various communities, hence they resort to open defecation which could easily be washed into the various water bodies when it rained, contaminating waters which became sources of infection.

The result of the present study established the occurrence of five intestinal helminths parasites in Jibia Local Government Area of Katsina State, Nigeria. Out of the total 420 stools samples examined 32.6% (137/420) were positive for intestinal helminths parasites eggs and oocyst which included: *Enterobius vermicularis*, *Hymenolepis diminuta*, *Strongyloides stercoralis*, *Ascaris lumbricoides* and hookworm. *Entamoeba histolytica* was equally encountered in the study.

The parasitic prevalence in the irrigation and non-irrigation communities may be due to their non-compliance with certain rules of hygiene. Equally, important factors that aid the transmission in the study area are poverty, inadequate water supplies and poor sanitary conditions. Most of the children were seen eating food and snacks wrapped with papers and nylons got from doubtful sources and which might be contaminated. There is a high level of contamination of objects that frequently change hands and this is a reflection of poor local level of environmental sanitation and personal hygiene.

Zandam, Farfaru and Matso-Matso depend on dams, rivers, pond and wells for their every day water demand for domestic and economic needs. Intestinal helminths infections and other water-related diseases are expected to remain as serious public health problems; these infection are expected to increase and become more acute due to increase in population and high demand for food and energy that would eventually result in the expanded and intensified exploitation of water resources (Boelee *et al.*, 2006).

This study is not very different from those recorded in other studies. Odu *et al.* (2011a) reported an overall prevalence of 30.7% intestinal helminths parasites among schooling children in rural and urban communities in Rivers State, Nigeria. Egwunyenga *et al.* (2001) reported 33.3% in South-East, Nigeria.

The prevalence in this study was contrary and lower to the findings, some workers in Nigeria had earlier reported. Nwosu *et al.* (2004) reported a prevalence of 52.0% intestinal helminths parasites in schooling children in Abia and Imo States of Nigeria. Odikamnor and Ikeh (2004) reported a prevalence of 51.5% among the Kpiri-kpiri communities of Abakiliki of Ebonyi State, Nigeria. Chukwuma *et al.* (2009) in their study on the prevalence of parasitic helminths infections of primary schooling children in Ebenebe Town, Anambra State, reported a prevalence rate of 53.6%.

Data showed among intestinal helminths infections revealed that *A. lumbricoides* and *S. stercoralis* infection are the most prevalent intestinal helminths infections followed by hookworm, *E.vermicularis* and *H. diminuta* were least encountered respectively. The parasites encountered are similar to the parasites reported by (Bethony *et al.*, 2006; Ekpo, *et al.*, 2010; Odu *et al.*, 2011a) which included *Ascaris lumbricoides*, hookworms, *Trichuris trichiura*, *Strongyloides stercoralis*, *Giardia lamblia*, *Enterobius vermicularis*, *Ancylostoma duodenale*, *Necator americanus*, and some species of *Schistosoma* as well as *Entamoeba histolytica*.

Though there was significant ($P < 0.05$) association of infection with gender in both irrigation and non-irrigation communities, males showed higher level of exposure to infection, which corresponded with the reports of Alemu, *et al.*, (2011), Leykun, (2001), Sehgal, *et al.*, (2010). This is probably because males are more involved in activities such as farming, fishing, and swimming. Another reason could be the behaviour of the males contaminating water bodies with faeces by defaecation as females are less likely to be seen defaecating in the open possibly because of culture and religious inclination especially among adult. Similar finding was also observed that the high prevalence of these infection in young males is not unconnected with water exposure by these individuals in their communities, who are demographically and economically supposed to be the most active and productive of the populace in the communities and thus are more exposed to occupational hazard of farming and related water contact activities that predispose them to infections.

High prevalence of intestinal helminths infections among schooling age pupils has been consistently reported in other studies (Mafiana *et al.*, 1997; Nock *et al.*, 2003; Ukpai and Ugwu, 2003; Egwunyenga *et al.*, 2001). It was observed that majority of the parents of these male children are either farmers or nomadic cattle rearers, and also uninformed about good hygienic behaviour and so, children are not under adult supervision of their sanitation habits even at home.

Moreover, the occurrence of intestinal helminths infections at higher rate among children which showed significant association with age group 1-10 years is indicative of faecal pollution of soil and domestic water supply around homes and schools due to poor sanitation, ignorance of the mode of transmission of these worms and improper sewage

disposal has been found to be a predisposing factor to infection and most of the children do not practice what they might have learned in health education. The high prevalence of intestinal helminths infections in 31-40 age group are due to their constant involvements in manual labour on farms and fetching of water from the dam which predisposes them to infection. This agreed with report of Omudu *et al.* (2005) where intestinal helminths infections were high among the young adult.

The strong negative correlation between infection and age may be because as the age increases, the people tend to exhibit more hygienic behaviour in their day to day activities. Major behavioural factors play a role in disease transmission (Habbari, *et al.*, 1999). This differed from the report of Lekun (2001) who found insignificant association between age and intestinal helminthes infections.

This study revealed association of infection with source of drinking water in the dam. This may be due to indiscriminate defaecation which might lead to contaminated soil particles been washed into dams, open wells and streams and serve as sources of intestinal helminths infections.

The prevalence of infection among the different occupational groups varied significantly. Intestinal helminths infections shows associations with fishing, farming and schooling but was only significant with schooling. Fishing and farming were the most prominent water contact activity for economic reasons. The frequency of contact with water bodies is related to the risk of the infection. The high prevalence rate of intestinal helminths infections among schooling children as obtained could be attributed to carelessness and unhygienic habits practiced by these children both at home and in schools. Lack of good

sanitation in these schools might have also contributed to the high prevalence. On the contrary, civil servants were very much enlightened, with higher economic status they are able to afford medical care or employ preventive methods.

There were significant associations with 'daily' and 'weekly' contact with the dam. About 66.7% and 44.3% of the inhabitants had 'daily' and 'weekly' water contact activities with water from the dam and the canal especially those in the irrigation communities thus a cycle of infection is created. The prevalence obtained in this study showed that not going to the dam reduces the risk of infections.

This study further revealed significant ($P < 0.05$) association of infection with open field defaecation. Individual who had pit toilets and who defecated openly had higher prevalence rate than their counterparts with water closets. Transmission occurs through poor sanitary habits of indiscriminate defecation due to inadequate sewage and refuses disposal. This agrees with the findings of Ogomaka *et al.* (2012) and Okoli, (2009).

Ascaris lumbricoides infection was the most encountered intestinal helminth. The possible reason for this is not far -fetched. It is well established that the infective stages of *A. lumbricoides*, the embryonated eggs have enormous capacity for withstanding the environmental extremes of urban environments. Furthermore, *Ascaris* eggs are coated with a muco-polysaccharide that renders them adhesive to a wide variety of environmental surfaces; this feature accounts for their adhesiveness to everything from door handles, dust, fruits and vegetables, paper money and coins. Infection is spread through eggs, which are swallowed as a result of ingestion of contaminated soil or contact between the mouth and the various objects carrying the adherent eggs. *Ascaris*

ova are spread through the agents of flood and coprophagous animals, and can thus be transported to locations far from the defecation sites (Mordi and Ngwodo, 2007). The use of human feces as fertilizer increase rate of infection too.

Hookworm was relatively among the least most common intestinal helminths infections reported in this study. This may be due to the generalized biological life cycle of the hookworm that requires environmental conditions conducive to its survival, and is able to proceed when the temperature reaches over 65°F or 18°C (John, 2012). The average temperature in the study area ranges from 25°C - 35 °C which is high while total rainfall figures vary from 600-700mm annually which is low (Muazu *et al.*, 2013). This study was however carried out mostly during the dry season and low prevalence trends were observed. Hookworm infection transmission has been found to be highly seasonal and occur mostly during the rainy season when their eggs hatch and make quick penetration into the host skin. Similar findings have been reported by Amadi *et al.* (1999) and Ogomaka *et al.* (2012).

Co-infection with *P.falciparum* and helminths obtained in this study was similar to the study of Ojurongbe *et al.* (2011) in Osogbo, Nigeria who reported co-infection between *P.falciparum* and helminth. Although both malaria and helminths have distinct means of transmission patterns, a variety of environmental and host factors may influence their epidemiological and geographical patterns of infection. The risk of exposure to co-infection and co-morbidity depend on the level of transmission of the parasite species in the area, the age of exposed individuals and or acquisition of immunity. Mechanisms behind these associations are likely to include increased exposure to infectious agents,

environmental contamination, water bodies, lack of effective preventative measures, poor quality of house construction, lack of access to prevention and treatment of disease, increased susceptibility to infection due to poor nutrition and increased transmission due to crowded households. Co-infection in a population results from several conditions which includes high frequencies of parasites in the same population, similar geographical distribution of parasites, shared risk factors and common transmission methods, genetic and immunological predisposition which may lead to increased susceptibility of helminths infected individuals to *P.falciparum* infection (Maizels *et al.*, 2004; Spiegel *et al.*, 2003; Sokhna *et al.*, 2004).

Mwangi *et al.* (2006) stated that majority of children who were infected with *P. falciparum* were concurrently infected with one or more helminths species. Helminths infected individuals are more likely to develop clinical *P. falciparum* malaria than helminths free individuals (Nacher *et al.*, 2002a; Spiegel *et al.*, 2003).

Co-infection was low in the irrigation and non-irrigation communities which can be attributed to the findings of Chandler and Read (1960), who reported that low prevalence of mixed infection may be attributed to the fact that the parasite that invades the host first circulates its antigen round the body of the host which may hinder the survival or reduce the chances of invasion by other parasites.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

There is no significant difference ($P > 0.05$) in *P. falciparum* infection between irrigation (40.0%) and non-irrigation (31.4%) communities but the difference was highly significant ($P < 0.05$) for urinary *S. haematobium* infection in irrigation (68.1%) and non-irrigation communities (34.7%) and intestinal helminths infections in irrigation (45.2%) and non-irrigation communities (20.0%) of Jibia LGA.

Prevalence of *P. falciparum* infections was significantly associated (OR= 1.8, $P < 0.05$) with gender (male = 52.3%, female = 37.4%) in the irrigation communities only. *S. haematobium* infections was significantly ($P < 0.05$) associated with irrigation farming (OR= 4.0), male gender (OR= 3.5), 31-40 years age group (OR= 1.8), source of water from dam reservoir (OR= 3.1), fishing (OR= 4.3), contact with dam reservoir water (OR= 3.6) and use of pit toilet (OR= 1.5) whereas for intestinal helminths infections with irrigation farming (OR= 3.3), male gender (OR=2.1), 1-10 years age group (OR= 1.9), source of water from dam reservoir (OR= 6.4), farming (OR= 1.8), schooling (OR= 1.7), contact with dam reservoir water (OR= 5.5) and open field defecation (OR= 3.8).

The prevalence of *P. falciparum* and helminths co-infection is low. The prevalence of *P. falciparum* and helminths double infection was 15.0% and 2.6% for triple infections. Intestinal *S. mansoni* was not encountered.

6.2 Recommendations

Based on the results of the study the following recommendations are hereby suggested:

i. Establish an integrated approach for malaria and helminthiasis that is readily adapted to the local disease spectrum and socio- ecological settings.

ii Community based de-worming exercise should be carried out especially mass treatment for helminths infection for persons in the irrigation communities.

iii. Malacogy is important to time schistosomiasis and soil-transmitted helminths transmission in the study area which will help optimizing the best timing for treatment and control strategy.

iv. Construction of latrine facilities and supply of safe water and inculcation of proper behavior in the use of available water facilities through education and public awareness.

v. To further reduce the incidence of malaria, long lasting insecticides nets (LLINs) made available either at a subsidized price or for free to the communities. Adequate supply of anti -malaria drugs should be included in free health care for children less than five years in order to ensure prophylaxis care for the children.

vi. Collaboration among major stakeholders including all tiers of Government and the community to devise holistic, effective and cost-saving methods for prevention, control and treatment of the diseases.

vii. Malaria and Helminthiasis reduction strategies should be incorporated into Nigeria's Poverty Reduction Strategy. This will help in improvement of health status and quality of life thereby contributing to the achievement of the Millennium Development Goal number two (universal primary education) and accelerating the achievement of Goal number six (disease eradication).

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APPENDICES

Appendix I

The Questionnaire Sample
Department of Biological Science,
Faculty of Science,
Ahmadu Bello University,
Zaria.

Dear Sir/Ma.

I am a student of Ahmadu Bello University, Zaria. This is a postgraduate research on the topic: Prevalence of *Plasmodium* and Helminths parasites among irrigation and non-irrigation communities in Jibia Local Government Area, Katsina State, Nigeria. Kindly fill-in the Questionnaire as honest as you can. Any information you give will be treated with confidentiality and used for the purpose of this research work only.

Thank you for your unalloyed cooperation.

Bature Ojonugwa Emmanuel.

1. Serial number 2. Name of Village.....

3. Gender a) Male b) Female

Age a) 1-10 b) 11-20 c) 21-30 d) 31-40 e) 41-50 f) 50 and above

Circle the appropriate answer/answers

1 - Occupation

a) Farming b) Fishing c) Artisans d) Student/Pupil e) civil servant

2- Source of water for household use? a) Pipe borne b) Borehole c) Well d) Dam

3 –Water contact in the dam a) Daily b) weekly c) monthly d) Not at all

4-Type of toilet used a) pit toilet b) water closet c) open fielddefecation

5- How do you treat malaria infection?

a) Self medication b) Herbalist c) Hospital d) others (specify)

6- Which method do you use to prevent mosquito bite/transmission of malaria Infection?

a) Window/door nets b) ITBN c) Insecticide spray d) Mosquito repellent creams e)

mosquito coils mosquito f) others

Appendix II: Morphologic Characteristics of Human Malaria Parasites

Morphologic Characteristics of Human Malaria Parasites				
	<i>P. falciparum</i>	<i>P. vivax</i>	<i>P. ovale</i>	<i>P. malariae</i>
Agenderual parasites	Usually only fine blue ring forms (some resembling stereo headsets) are seen. Parasitemia level may exceed 2%.	Irregular, large, fairly thick rings become highly pleomorphic as the parasite grows. Parasitemia level is low.	Regular, dense ring enlarges to compact, blue, mature trophozoite (rectangular or band-form). Parasitemia level is low.	Dense, thick rings mature to dense, round trophozoites. Parasitemia level is low.
Schizonts	Rare in peripheral blood; 8–32 merozoites, dark brown-black pigment	Common; 12–18 merozoites, orange-brown pigment	8–14 merozoites, brown or black pigment	8–10 merozoites, dark brown or black pigment
Gametocytes	Banana-shaped; male: light blue; female: darker blue; a few scattered blue-black pigment granules in cytoplasm	Round or oval; male: round, pale blue; female: oval, dark blue; triangular nucleus, a few orange pigment granules	Large, round, dense, and blue (like <i>P. malariae</i>), but prominent James's dots; brown pigment	Large, oval; male: pale blue; female: dense blue; large black pigment granules
RBC changes	RBCs are normal in size. As the parasite matures, the RBC cytoplasm becomes pale, the cells become crenated, and a few small red dots may appear over the cytoplasm (Maurer's clefts).	RBCs are enlarged. Pale red Schüffner's dots increase in number as the parasite matures.	RBCs become oval with tufted ends. Red James's dots are prominent.	RBCs are normal in size and shape. No red dots are seen.

Appendix III



PLATE I: *Enterobius vermicularis* egg

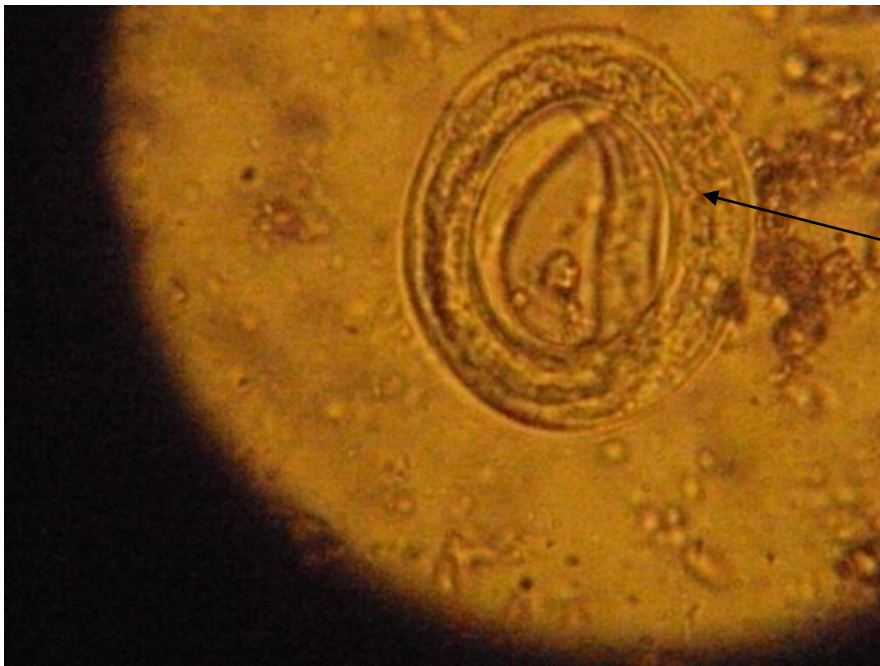


PLATE II: *Strongyloides stercoralis* larva



PLATE III: Fertile *Ascaris lumbricoides* egg

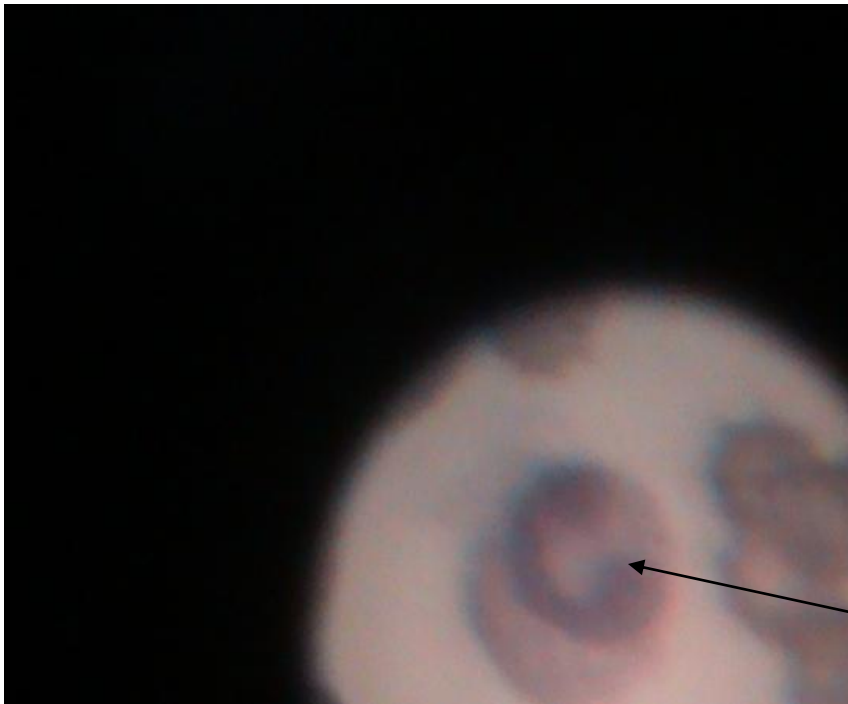


PLATE IV: Trophozoite of *Plasmodium falciparum*

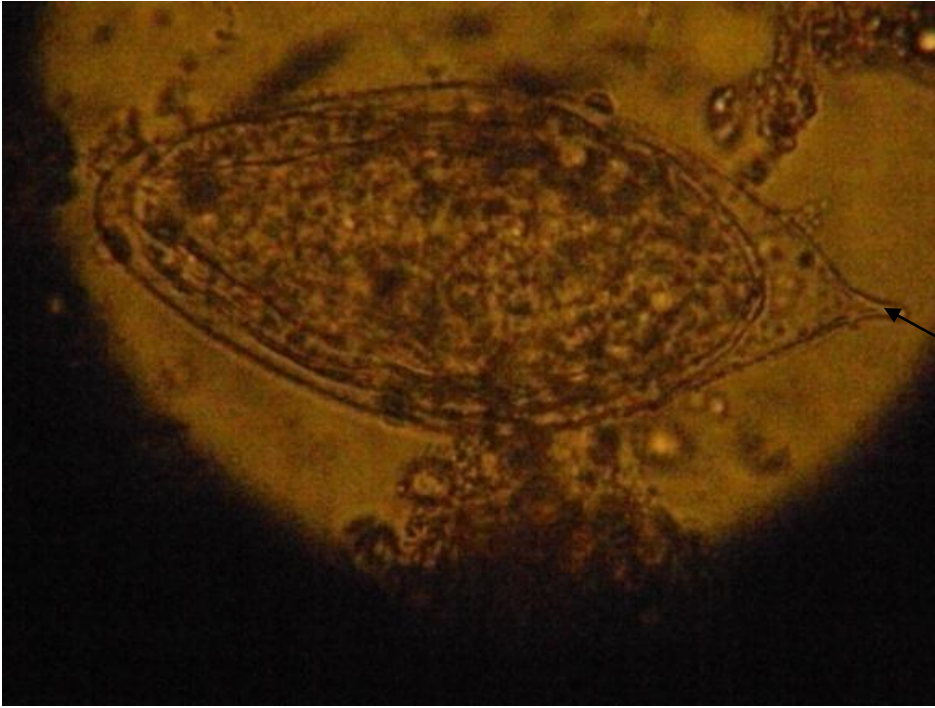


PLATE V: *Schistosoma haematobium* ova

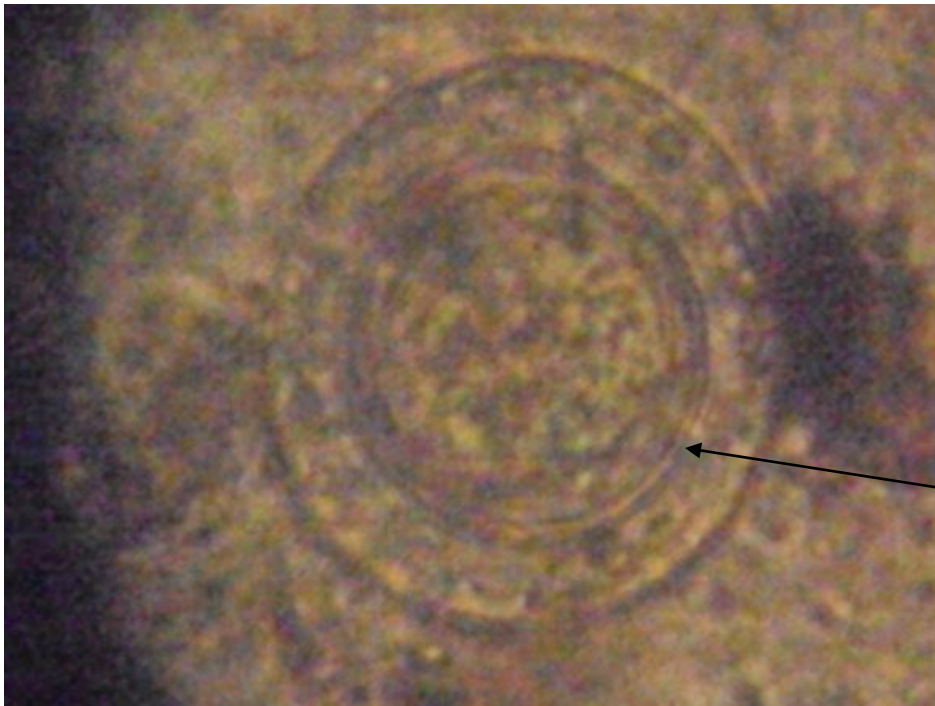


PLATE VI: *Hymelopsis diminuta* egg



PLATE VII: Hookworm egg

Appendix IV



MINISTRY OF HEALTH
KATSINA STATE

Tel" Hon. Commissioner 065-434537(DL)
434518(DL)

Permanent Secretary 065-34554

SECRET

State Secretariat Complex,
I. B. B. Way Dandagoro
P.M.B. 2075, Katsina

Our Ref: MOH/ADM/SUB/1152/1/81

Date: 16/12/2014

Your Ref: KATSINA HREC FULL ETHICAL CLEARANCE CERTIFICATE

Re: "HELMINTS AND *PLASMODIUM* INFECTIONS AMONG IRRIGATION AND NON-IRRIGATION COMMUNITIES IN JIBIA LOCAL GOVERNMENT AREA, KATSINA STATE, NIGERIA."

Katsina HREC assigned number - MOH/ADM/SUB/1152/1/81
Name of Principal Investigator - BATURE OJUNUGWA EMMANUEL
Address of Principal Investigator - Dept of Biological Sciences ABU Zaria
Date of Receipt of valid Application -08/08/2014
Date of ERC meeting and approval -04/12/2014

This is to inform you that the research described in the submitted protocol, the consent forms, and other participants information materials have been reviewed and given full approval by the Katsina State Health Research Ethics Committee and accordingly by the Honorable Commissioner of Health.

Please note; this approval dates from 04/12/2014 to 04/12/2015

No participant recruited into this research may be conducted outside these dates.

All informed consent forms in this study must carry the Katsina HREC assigned number and the duration of the Katsina HREC approval for the study.

The HREC expects that you submit your application as well as an annual report for ethical clearance renewal 3 months prior to the expiration of the study dates. This is to enable you obtain renewal of your approval and avoid interruption of your research.

If there is a delay in starting the research, please inform the Katsina HREC so that starting dates can be adjusted accordingly.

No changes are permitted to the research without prior approval by Katsina HREC except in circumstances outlined in the national code for health research ethics. <http://www.nhrec.net>

Katsina HREC reserves the right to conduct compliance assessment to your research site without prior notification.

Dr Abduljalil U Abdullahi
Director Public Health
For Chairman, Katsina HREC

"Home of Heritage and Hospital"