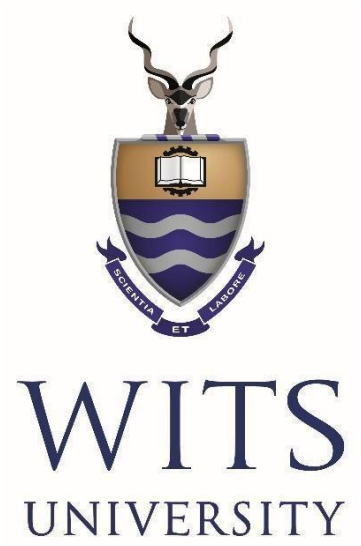
OCCURRENCE, KNOWLEDGE AND MANAGEMENT OF HUMAN HELMINTHIC INFECTIONS IN BIRNIN KEBBI METROPOLIS NIGERIA

ISAH UMAR MUNGADI



A Dissertation submitted to the Division of Pharmacology, Department of Pharmacy and Pharmacology, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree

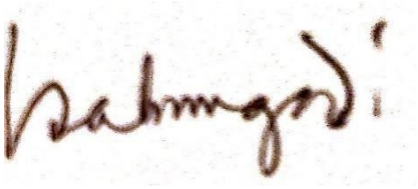
Of

Master of Science in Medicine.

Johannesburg 2024

DECLARATION

I, Isah Umar Mungadi declare that the work on which this dissertation is based is my original work. All the contributions made by other people to this dissertation have been duly acknowledged. It is being submitted for the degree of Master of Medicine (Clinical and Experimental Pharmacology) at the University of the Witwatersrand, Johannesburg, South Africa. This work has not been submitted before for any degree or examination at this or any other university.



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Isah Umar Mungadi (1475422)

DEDICATION

I dedicate this work to my loving parents (of blessed memory): Alhaji Umar Mungadi and Aisha Dandare Kalgo; my wife Fai'za Ahmad Danfulani; my entire family and my kids for their prayers and support throughout the course of this work.

PUBLICATIONS

PUBLICATIONS:

Mungadi IU, Frean J, Schmollgruber S, Van Zyl, RL. *Occurrence knowledge and management of human helminthic infections in Birnin Kebbi Metropolis Nigeria*. In preparation.

ABSTRACT

Helminths are parasitic worms that globally affect more than 1 billion people. Predominantly there are two groups of helminths that affect humans, roundworms (nematodes) and flatworms. In Nigeria, human helminthic infections are endemic and control programs such as mass deworming has been ongoing for years. However, there is paucity of knowledge among healthcare providers, as well as the general public concerning the management of helminthic infections. This study was conducted to determine the occurrence of helminthic infections and to assess the knowledge of anthelmintic management and reporting among healthcare providers and the general public in Birnin Kebbi metropolis, Nigeria. Following ethical approvals, a retrospective study (Part 1) of laboratory stool samples results was conducted at two public hospitals in Nigeria from 2014 to 2020. Part 2 and 3 included a cross sectional study assessed knowledge of healthcare providers and the general public using semi-structured questionnaires. In Part 1, a total of 4,082 stool samples were captured, with only 39 positives for helminths, indicating a 1.0% prevalence of helminthic infection in Birnin Kebbi metropolis from 2014 to 2020. Out of the 39 positive helminthic samples recorded, 87.2% (n=34) were from Sir Yahaya Memorial Hospital ($p<0.01$). The main helminth identified was hookworm (59.0%), while the least were *Trichuris trichiura* (1; 2.6%) and *Taenia* spp. (1; (2.6*%).* In Part 2 and 3, 384 questionnaires were completed by 107 healthcare providers (27.9%) and 277 by the general public (72.1%). Overall, the healthcare providers had poor knowledge (60.7%; n=65) on the management of helminthic infections. Generally, the pharmacists (9; 90%) and doctors (55.6%; n=15) had good knowledge on management, but the nurses (71.9%; n=46) and laboratory scientists (100%; n=6) had poor knowledge ($p<0.001$). In the treatment of helminth infections, the healthcare providers mostly identified mebendazole (50.5%, n=54), while levamisole was the least mentioned (8; 7.5%). In terms of knowledge of intestinal worms in the general public, participants had good knowledge of helminths (66.4%; n=184). There was a statistically significant difference between knowledge of helminths and occupation, gender and level of education of the general public ($p<0.001$). This study indicated that there was a low prevalence of helminthic infection in the investigated clinical cases in the two study sites. Of concern was the poor knowledge among both healthcare providers and poor knowledge among the general public. There is therefore a need for global policy makers to encourage further education for both the community and healthcare providers; along with additional research on unreported human helminthic infections in the Birnin Kebbi metropolis.

Key Words: Helminths, management, Birnin Kebbi Metropolis, Nigeria.

ACKNOWLEDGEMENTS

I want to give my sincere gratitude and appreciation to my supervisors; Professor Robyn van Zyl and Professor Shelley Schmollgruber who have made this project possible and who have sacrificed their precious time to make my dream come true.

I'm also grateful to my wife, family and friends for their understanding and prayers throughout the time of my studies.

Special thanks go to the Division of Pharmacology, Department of Pharmacy and Pharmacology for the opportunities given to me to attend courses and training.

I would like to give special appreciation to the various laboratory departments of Sir Yahaya and Federal medical center Birnin Kebbi for the tremendous support they gave me during the time of my data collection.

I'm deeply grateful for the financial support from the Tertiary Education Trust Fund (TETFUND), Nigeria and Faculty of Health Sciences Research Office, University of the Witwatersrand, South Africa.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AIDS:	Acquired Immunodeficiency Syndrome
CDC:	Centers for Disease Control and Prevention
CYP450:	Cytochrome p450
GABA:	Gamma-Amino Butyric Acid
GIT:	Gastrointestinal Tract
HIV:	Human Immunodeficiency Virus
mg/kg:	Milligram/kilogram
STHs:	Soil Transmitted Helminths
WHO:	World Health Organization

CHAPTER ONE:

INTRODUCTION AND LITERATURE REVIEW

1.1 Human Helminthic Infection

Helminths are parasitic worms that globally affect more than 1 billion people (Chong et al., 2022). Predominantly there are two groups of helminths that affect humans: roundworms (nematodes) and flatworms. Roundworms include soil transmitted helminths (STHs) (such as *Ascaris lumbricoides, Trichuris trichiura, Necator americanus, Ancylostoma duodenale*) and filarial worms (causative agents of lymphatic filariasis and onchocerciasis). Flatworms comprise trematodes or flukes (including the causative agents of schistosomiasis) and cestodes (including the causative agents of taeniasis) (Wright, 2018). Globally about 807-121 million, 604-795 million, 576- 740 people were respectively infected with *A. lumbricoides*, whipworm and hookworm (CDC, 2022). Furthermore, taeniasis caused by *Taenia solium* is a serious public health problem in southern and eastern African countries and is estimated to infect 2.5 million people worldwide (Omeragić et al., 2023). *T. saginata* is acquired when humans eat undercooked beef meat and it has less public importance than *T. solium* (WHO, 2022a). In areas endemic with *T. solium*, it is thought to cause 2.78 million disability-adjusted life years per year and responsible for at least 30 -70% of patients presenting with epilepsy (Gonzalez-Alcaide et al., 2023).

1.2 Global Distribution and Burden of Soil Transmitted Helminths and Schistosomiasis

Soil transmitted helminths (STHs) are the most common form of helminthiasis in humans (Karshima, 2018b). Moreover, STHs are neglected tropical diseases that are mostly prevalent in the low- and middle-income countries (Dunn et al., 2016). A greater burden of STHs occurs in sub-Saharan Africa, but the progress towards its eradication is slower in the region as compared to other regions (Karagiannis-Voules et al., 2015). The World Health Organization (WHO) estimated about 24% of the world's population are infected with STH infections, with over 260 million pre-school age children, 654 million adolescents girls and 138.8 million pregnant and breastfeeding mothers residing in places that have high transmission of helminths (WHO, 2023c). Based on the WHO global strategic plan for elimination of helminthic infection by the 2030, the following targets where outlined; 1. Maintain and achieve eradication of STHs morbidity in pre-

School aged children, 2. Decrease the number of tablets required in preventive chemotherapy for STHs, 3. Set up a productive STH control programme in adolescent, pregnant and breastfeeding mothers, 4. To make sure universal access to at least basic sanitation and hygiene in areas that is endemic for helminths (WHO, 2023c). People that are more vulnerable to STH infections include pregnant women, pre-school and school age groups (Shumbej et al., 2015). Poor sewage disposal and sanitary conditions, overcrowding, inadequate drinking water, eating raw or semi- raw meat are some of the risk factors that allow parasites to thrive (Chala, 2013). A systematic review conducted by Houweling et al. (2016) reported that STHs are more prevalent in socioeconomic deprived households in Nigeria, Brazil, China, Pakistan and India. However, a similar study reported that there was a marked decrease in the prevalence of disease burden in the developed world largely because of the implementation of control programs and improved living conditions (Pullan and Brooker, 2012). After malaria and STHs, schistosomiasis is the third most damaging tropical disease in terms of morbidity and mortality that affects more than 78 countries globally including Africa, Asia, Middle East and Caribbean (Ross et al., 2017). Schistosomiasis affects almost 251.4 million people worldwide, with more than 90% of people requiring preventive treatment living in Africa. People living in endemic areas are infected with various species of schistosomiasis, including *S. haematobium, S. mansoni, S. japanicum, S. mekongi, S. intercalatum,* and *S. guineensis* (WHO, 2023b). Nigeria has the highest burden of schistosomiasis in the world, predominantly by two species, *S. haematobium* and *S. mansoni* (Saidu et al., 2023). *S. intercalatum* is mainly found in west-Africa including Nigeria while S. guinessis is mainly found in Central Africa(Aula, McManus et al. 2021). *S. japonicum* is found mainly in Asia including Myanmar(Nelwan 2020). Urogenital schistosomiasis is caused by *S. haematobium,* while rectal and intestinal schistosomiasis is caused by remaining schistosomes. Intestinal schistosomiasis is the most common form of schistosomiasis and is a serious public health issue in tropical and subtropical countries (Gebreyohanns et al., 2018)**(Figure 1.1).**

1.3 Epidemiology of Soil Transmitted Helminthiasis and Schistosomiasis in Nigeria

Soil transmitted helminth infections are endemic in Nigeria with an estimated 55 million, 34 million and 38 million cases for *Ascaris,* trichuriasis and hookworm, respectively (Idowu et al., 2022). Nigeria has the highest burden of STHs and schistosomiasis in sub-Saharan Africa (Hotez,

2009), with the four most common species being *A. lumbricoides*, *T. trichiuria*, *A. duodenale* and *N. americanus* (Oyeyemi and Okunlola, 2023).

The high burden of helminthic infection in Nigeria is as a result of lack of access to clean water, poor sanitation, overcrowding, poor personal hygiene and low literacy level (Chidi et al., 2023). The four main species of STHs found in Nigeria are *A. lumbricoides, N. americanus, A. duodenale* and *T. trichiura* (Oyeyemi and Okunlola, 2023*).* More than 47 million pre-school-aged children and school-going children required preventive chemotherapy in Nigeria **(Figure 1.1).** Despite several studies being done on STHs in Nigeria, there is still paucity of data in several regions and locality regarding prevalence of STH (Odinaka et al., 2015). Epidemiological data on the prevalence of helminthic infection in Birnin Kebbi local government is scanty with no current control program taking place.

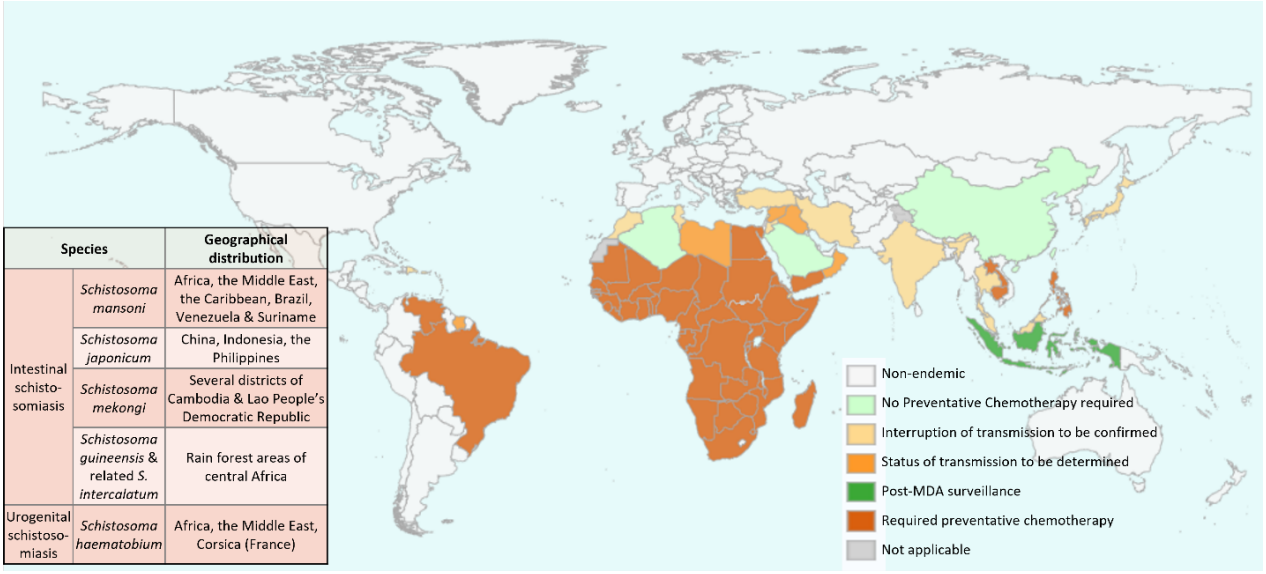

Figure 1.1: Global distribution of schistosomiasis (adapted from the WHO, 2022). With 241,280,099 cases in Africa in 2022 with an estimated 27,806,454 individuals in Nigeria requiring preventative chemotherapy annually but none was available.

1.4. Life Cycle of Soil Transmitted Helminths

Soil transmitted helminths have a typical life cycle that consist of 3 stages of development; eggs, larvae and adults, with the adult worm living in the definitive host, larvae may be free-leaving or have an intermediate host. Eggs are produced by adult worms inside its host and deposited on the warm and moist soil via human faeces (Bharti et al., 2018a)**(Figure 1.2).** Eggs take several days or months to become infective; where *A. lumbricoides* eggs need 10-14 days, hookworm species

14 days, and *T. trichiuria* eggs up to 2-4weeks (YU, 2019). Soil transmitted helminths are transmitted via faeco-oral or transdermal route. *Ascaris lumbricoides* and *T. trichiura* are transmitted via faecal-oral, while *A. duodenale* and *N. americanus* are transmitted transdermally through penetration of human skin with infective larvae (Stella and Chijioke, 2018). *A. duodenale can* also be transmitted via feco-oral root (YU, 2019).

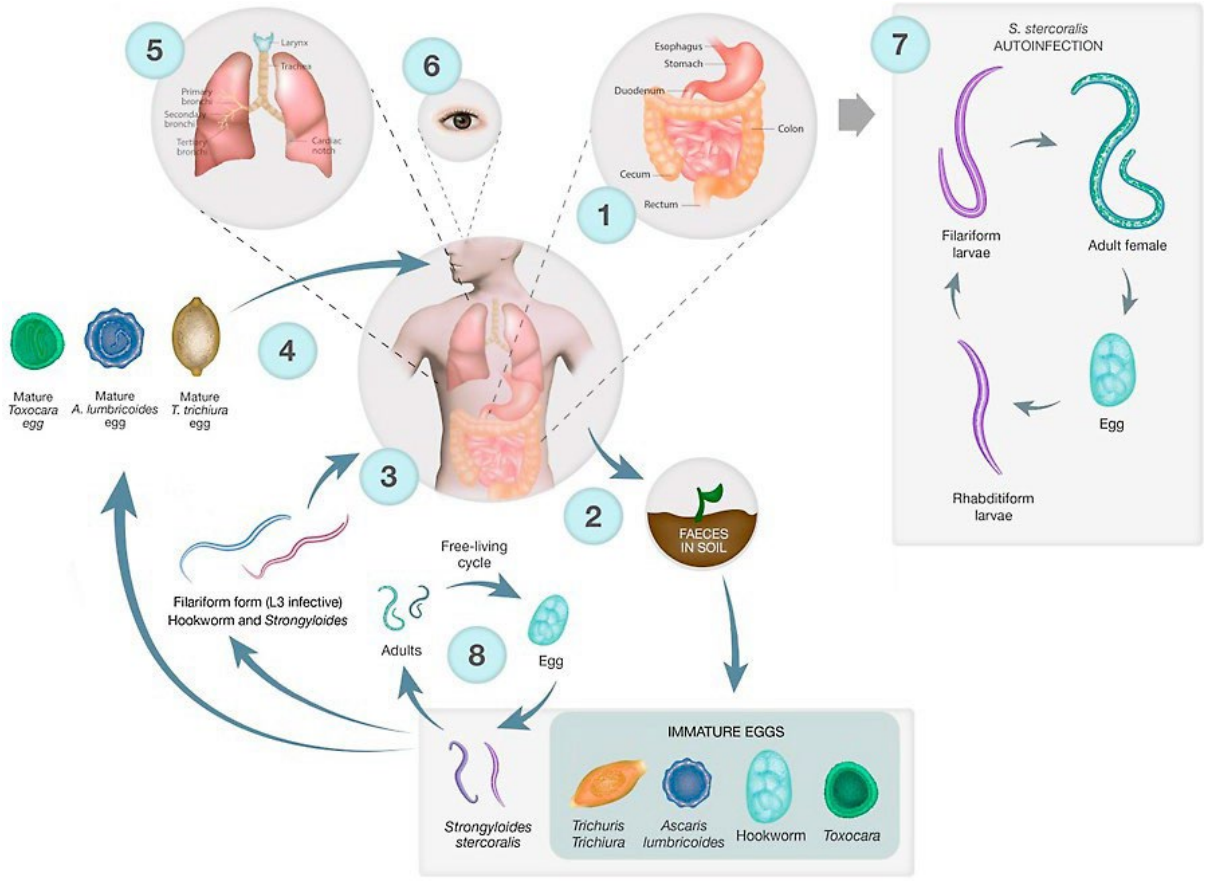

Figure 1.2: Life cycle of helminths, *Strongyloides stercoralis, Trichuris trichiura, Ascaris lumbricoides*, hookworm and *Toxocara* (Gordon, et al., 2017). **(1)** Both adult forms of hookworm, *A. lumbricoides*, and *S. stercoralis* reside in the gastro-intestinal tract (GIT) where female helminths produce eggs that are passed in the stool of an infected person. **(2)** Eggs hatch into rhabditiform larvae, then mature into infective filariform larvae or free adults in the soil. **(3)** Filariform larvae of hookworm and *S. stercoralis* penetrate the skin directly and reach the GIT after passing into the lumen of the lungs. **(4)** Mature eggs of *Toxacara, A. lumbricoides*, and *T. trichiura* are swallowed by the host where they hatch and release the larvae into the GIT. **(5)** Hookworm and *A. lumbricoides* larvae penetrate the alveolar walls and reach the throat and are swallowed. **(6)**. Toxocara larvae can be carried to any organ or tissue, and rarely may cause disease during migration through the eyes, brain, or viscera. **(7)** *S. stercoralis* can also undergo auto-infection. **(8)** *Strongyloides* rhabditiform larvae develop into free-living adults that produce eggs from which rhabditiform larvae hatch. Rhabditiform larvae then develop into infectious filariform larvae and penetrate a human host. The free- living cycle exists for one generation cycle only.

1.4.1 Life Cycle of Schistosomiasis

There are two stages of schistosomiasis development, the first stage involves freshwater snails and the second involves humans or other mammals) (CDC, 2019) **(Figure 1.3).** *Schistosoma* eggs are released by the human host into fresh water where they hatch into miracidia that can survive up to 1-3 weeks in freshwater before infecting snails for survival and development into adult sporocysts and then forked-tailed free swimming cercariae **(Figure 1.3(5))** (Shebel, 2012). Humans acquire schistosomiasis through skin penetration by cercariae that are released by freshwater snails (intermediate host) (Weerakoon, 2015). Cercariae that infect humans mature into schistosomes inside the infected host (von Braun et al., 2019). Adult male and female schistosomes live in the human veins where they mate and produce fertilised eggs that can either be shed into the environment via faeces or urine or stay in the human host, initiate inflammation and die **(Figure 1.3(10))** (Colley et al., 2014).

1.4 Clinical Features of STHs and Schistosomiasis

Clinical features of STHs can either be acute or chronic, but those that are chronic in nature may lead to dire consequences such as poor school performance, growth retardation and lack of school attendance (Molvik et al., 2017a). Moreover, STHs in Nigeria cause anaemia, malnutrition, inefficiency in learning and school achievement due poor physical and cognitive development (Yaro et al., 2018). Other clinical features of chronic infection include abdominal pain and diarrhoea (Muller et al., 2016), intestinal obstruction by ascaris (Siviero, 2024) as well as iron deficiency anaemia in hookworm and heavy *T. trichiura* infections (Caldrer, 2022). Acute symptoms of a STHs infection are mostly due to their concurrent infection with *Ascaris* and or hookworm, causing eosinophilic pneumonia (Loeffler syndrome) due to larvae migrating in the pulmonary system, while the hookworm infestation causes a pruritic, papular rash known as 'ground itch' following skin penetration (Jourdan et al., 2018). Clinical features of *S. stercoralis* includes acute, hyper infection and chronic features, acute features usually result from auto-infection during its life cycle leading to loeffler-like syndrome, heartburn, bloating, diarrhea and asthma like symptoms (Czeresnia, 2022). Hyper infection syndrome usually occurs in people with immunosuppression and has symptoms such as; shock, meningitis, renal failure, respiratory failure, acute abdomen and disseminated intravascular coagulopathy (Karanam L, 2021). Chronic strongloidiasis is usually asymptomatic; however, the symptomatic patient's presents with vomiting, constipation, weight loss, urticarial (Czeresnia, 2022).

Clinical features of schistosomiasis can also be acute or chronic, with acute schistosomiasis occurring mostly among travellers. It is also referred to as Katayama syndrome and has clinical features including, fever, body weakness, joint pains, headache and abdominal pains (Colley et al., 2014). Chronic schistosomiasis generally results from a host reacting to deposited eggs in the intestinal wall and bladder wall causing granulomatous reaction that leads to several signs and symptoms like; hepato-splenomegaly and ascites, periportal fibrosis, anaemia, haematuria, renal failure and bladder cancer (Bethony et al., 2006).

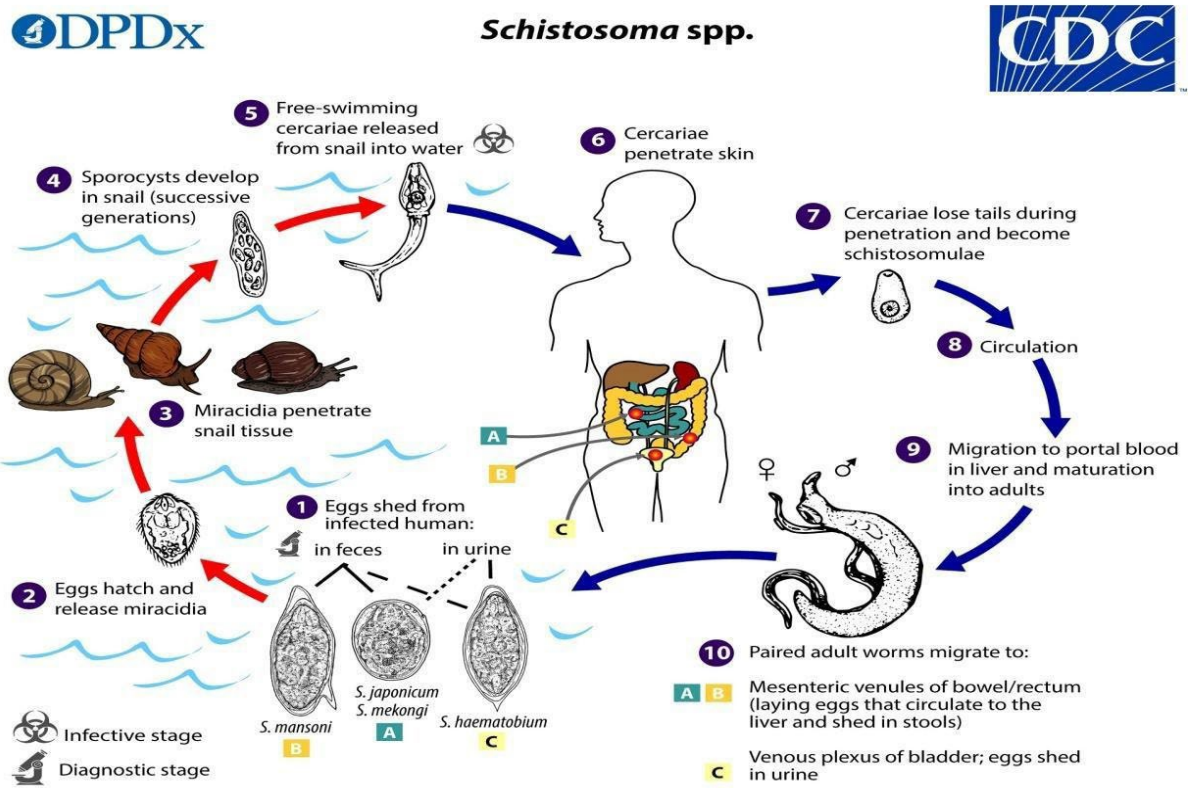

Figure 1.3: Life cycle of schistosomiasis (CDC, 2019). *Schistosoma* eggs are eliminated in faeces or urine, depending on species (**1**). Under appropriate conditions the eggs hatch and release miracidia (**2**), which swim and penetrate specific snail intermediate hosts (**3**). The stages in the snail include two generations of sporocysts (**4**) and the production of cercariae (**5**). Upon release from the snail, the infective cercariae swim, penetrate the skin of the human host (**6**), and shed their forked tails, becoming schistosomula (**7**). The schistosomulae migrate via venous circulation to lungs, then to the heart, and then develop in the liver, exiting the liver via the portal vein system when mature (**8,9**). Male and female adult worms copulate and reside in the mesenteric venules, with *S. japonicum* in the superior mesenteric veins associated with the small intestine (**10A**), and *S. mansoni* in the inferior mesenteric veins of the large

intestine (**10B**). The eggs are moved progressively toward the lumen of the intestine (*S. mansoni*, *S. japonicum, S. mekongi, S. intercalatum/guineensis*) and of the bladder and ureters (*S. haematobium*), and are eliminated with faeces or urine, respectively (**1**).

1.5 Helminthic Infection and Associated Co-Morbidities

Helminthic infections have existed in humans through evolution, however there are several infections and co-morbidities associated with helminths infection such as human immunodeficiency virus (HIV), tuberculosis, asthma and malaria (Lebu et al., 2023).

1.5.1 Helminths and HIV

Some studies have shown that people living in sub-Saharan Africa, Asia, Caribbean and Latin America that are infected with HIV-1 have a high risk of being co-infected with a helminthic infection (Akanksha, 2023). Deworming of individuals co-infected with HIV have been shown to be beneficial in terms of decreasing disease progression, and HIV viral load, while increasing the CD4+ count (Sangare et al., 2011). Similarly, it has been shown in prospective clinical trial conducted in Zimbabwe that mass drug administrations with praziquantel can reduce HIV-1 RNA in seminal fluid of infected individuals with HIV/uro-genital schistosomiasis co-infection (Midzi et al., 2017). Helminthic infections induce host Th2-type immune responses with associated down regulation of the individual's antiviral Th1-type response, thereby increasing individual's susceptibility to HIV (Downs and Fitzgerald, 2016; Mulu et al., 2015; Becker et al., 2018). Furthermore, there are several studies that suggest that increased susceptibility to HIV in women with female genital schistosomiasis is due to mucosal barrier damage of the cervix and vagina by *Schistosoma* lesions (O'Brien et al., 2019). Helminths increase the progression of the HIV infection as there are alteration in the distribution of immune-mediated cells, eosinophilia, anergy and down-regulation of type-one cytokine response (Mkhize-Kwitshana et al., 2014). Despite the unwanted effects that are caused by co-infection of helminths with HIV, the anthelmintics used in the treatment of STHs and schistosomiasis remains the same with no specific dosage modifications (Evans and Siedner, 2017).

1.5.2 Helminths and Tuberculosis

Tuberculosis is caused by acid-fast bacillus *Mycobacterium tuberculosis* that is a major global public health problem resulting in substantial morbidity and mortality (Babu and Nutman, 2016). Tuberculosis-helminth co-infection overlap significantly especially in some low socioeconomic sub-Saharan countries where poverty continues to exist and several diseases such as

malnutrition, diabetes and malignancies are known to increase the risk of tuberculosis progression from the latent to active form (Mhimbira et al., 2017). There are three possible ways in which helminthic infections increase the risk of acquiring tuberculosis; firstly, chronic maternal helminthic infection can lead to *in utero* helminth antigens sensitisation affecting newborn response to Bacillus Calmette-Guerin (BCG) vaccine and tuberculosis-specific immunity. Secondly, an increase in exposure of adults to helminthic infections can lead to an increased rate of acquiring tuberculosis. Lastly, in endemic areas, people with chronic helminth infections show impaired immunity to latent tuberculosis infections that can lead to an active disease (Chatterjee and Nutman, 2015). This is due to induction of opposing Th2 immunity as a result of chronic helminthic infection (Cadmus, 2020). Helminthic infections have also been shown to interfere with the diagnosis of tuberculosis (Simon, 2016). It has been reported that *in utero* exposure of the foetus to helminths can predispose the infant to a tuberculosis infection (Gebreegziabiher et al., 2014). A systematic review and meta-analysis conducted by Taghipour et al. (2019) showed a 26% prevalence of helminthic infections in tuberculosis patients in all the 20 cross sectional and case control studies reviewed, which suggested the need for stool sample analysis in all cases of tuberculosis.

1.5.3 Helminths and Malaria

Globally infections caused by malaria and helminths have been reported to be the most prevalent infections that affect humans in the tropics with the majority in sub-Saharan Africa (Shittu et al., 2017). It is estimated that more than 25% of pre-school aged children in sub-Saharan Africa are at risk of co-infection with malaria and hookworm leading to several interactions between the organisms including competition for nutritional resources and direct interference (Degarege et al., 2016). Some studies have shown that co-infection of STHs with malaria increases the intensity of malarial infection, while some suggest the co-infection has a protective effect (Specht and Hoerauf, 2007). Additionally, there is evidence that suggests co-infection of helminth with malaria worsens anaemia in pregnancy leading to premature delivery and maternal mortality (Mwangi et al., 2006). However, evidence also suggests that helminths have a protective effect against the development of acute renal failure, cerebral malaria and jaundice in malaria-infected patients (Tuasha et al., 2019). In a mechanism that is not yet understood, *S. mansoni* infections are thought to increase the incidence of malaria infections in children, possibly by driving an imbalance between Th1 and Th2 type immune response (Mbah et al., 2014). Helminthic infections are thought to pose a significant risk in the development of vaccines against malaria due to the induction of a Th1 immune response to malaria vaccine. Therefore, wide spread deworming programs against helminthic infections might go a long way in the success of malaria vaccination programmes (Hartgers and

Yazdanbakhsh, 2006). Diagnosis

There is a wide range of tools and techniques that are employed globally for the diagnosis of helminthic infections which includes parasitological, laboratory, serological, molecular and culture approaches. Common techniques used for the diagnosis of helminthiasis are the Kato-Katz technique (quantitative microscopic examination of faeces), the formol-ether sedimentation technique and flotation technique. Other techniques that are used for diagnosis of helminthiasis include polymerase chain reaction and serological tests (Utzinger et al., 2012). However, these latter two tests are difficult to perform, expensive and not readily available in the developing countries. The most common way of diagnosing STHs is the microscopic examination of the stool sample that involves the approximation of eggs per gram of the stool or presence of adults expelled in the stool (Rotejanaprasert et al., 2023). In developing countries, the most widely used technique to assess the occurrence of helminthic infection is the Kato-Katz technique, which is also recommended by the WHO (Knopp et al., 2008). However, the major drawback of the Kato-Katz technique is its low sensitivity in areas with light parasitic intensity (Glinz et al., 2010), it does not detect *S. stercoralis* infection and (Knopp, 2014) and hookworm eggs dissolves in the glycerol 30-60mins of preparation(Bosch, 2021).

1.6 Management of Helminthic Infection

Preventive chemotherapy (regular deworming) at intervals with benzimidazoles (mebendazole and albendazole) in populations at risk is the most important strategy recommended by the WHO in reducing morbidity and mortality of STHs (Savioli et al., 2018). Another important strategy is proper sanitation and health education, which focuses on lowering transmission and re-infection by encouraging healthy behaviours, such as use of pit latrines and hygienic behaviour that reduces soil contamination (Molvik et al., 2017b).

1.6.1 Vaccines against STHs and Schistosomiasis

The administration of a vaccine against human helminthic infections is an important strategy towards elimination of the global burden of SThs infections and schistosomiasis despite mass drug administration, deworming programs and environmental sanitation being the mainstay of elimination of the disease (Keiser et al., 2024). The human hookworm vaccine is currently under development by Sabin Vaccine Institute Product Development Partnership. It comprises of two antigens: *N. americanus* GST-1 (Na GST-1) and *N. americanus* APR-1 (Na APR-1) (Tsuji, 2020). Some of the vaccine schistosome antigens that have entered both clinical and experimental trials

include; Sm23, Smp80, glucose transporter protein and *S. mansoni* 29 kDa protein (Al-Naseri et al., 2021). The WHO recommends the use of Cysvax™, a vaccine that was developed by University of Melbourne (Melbourne, 2016), to prevent epilepsy in human neurocystercercosis.

1.6.2 Preventive Chemotherapy

Preventive chemotherapy of anthelmintic drugs to pre-school and school-aged children periodically is the main strategy adapted globally to combat the burden of helminthic infections (Andrews et al., 2017). Benzimidazoles (albendazole and mebendazole) are the drugs of choice recommended by the WHO for over 10 years for the regular deworming of preschool aged children and population at risk (WHO 2023). Preventive chemotherapy (deworming), using annual or biannual single-dose albendazole (400 mg) or mebendazole (500 mg), is recommended as a public health intervention where the baseline prevalence of any soil-transmitted infection is ≥ 20% among school-age children (SAC), treat young children (12-23 months), preschool (24-59 months) & SAC (5-12 yrs), where the baseline prevalence of any soil-transmitted infection is ≥ 20% among adolescent (10-19 yrs old) girls & women of reproductive age (WRA; 15-49 yrs), treat those non-pregnant adolescent girls and non-pregnant women of reproductive age, where the baseline prevalence of hookworm and/or *T trichiura* infection is ≥ 20% among pregnant women, and (ii) where anaemia is a severe public health problem (prevalence of 240% among pregnant women), treat pregnant women in the second or third trimester, but not in the first trimester (WHO, 2017). In view of disability-adjusted-life-years lost by helminth infections, in 2012 the WHO committed to eradicate eliminate neglected tropical diseases by the year 2020 with the goal of treating all children at risk by 75% in all endemic countries (Becker, 2018; Clarke et al., 2017). However, this target has not been achieved to date by many countries still being impacted by high case numbers. This was supported by the study undertaken by Hicks et al. (2015) on the importance of deworming preschool children in rural Kenya, where it was shown that deworming reduced helminth transmission in both treated and untreated children along with improving school attendance in untreated and treated children, though it did not improve academic performance in the same age group. However, the general impact of deworming programs is complex to assess because of several confounding factors such as, co-infection with other diseases that can produce similar health outcomes as helminthic infections. In addition, it usually takes five years with several rounds of successful preventive chemotherapy and regular follow-ups to observe the impact (Schulz et al., 2018). As a result of the schistosomiasis control initiatives to lower morbidity and mortality in six African countries using praziquantel as the only

chemotherapeutic drug, the WHO recommended praziquantel as the only drug of choice for preventive chemotherapy in both pre-school and school aged children in all areas that are endemic for schistosomiasis (Kuevi et al., 2023). In endemic communities with prevalence of *Schistosoma* spp. . infection ≥ 10%, WHO recommends annual preventive chemotherapy with a single dose of praziquantel at ≥ 75% treatment coverage in all age groups from 2 years old, including adults, pregnant women after the first trimester and lactating women, to control schistosomiasis morbidity and advance towards eliminating the disease as a public health problem (WHO, 2022).

Although there is an acknowledged need for preventative chemotherapy in Nigeria, no such programme exists. In contrast, the South African government through the Department of Basic Education and Department of Health introduced STHs deworming programs in line with World Health Education recommendation to deworm over 6 million school children from Grade R to 7, with the aim of improving quality education and improving children health. All the provinces were targeted to address the high prevalence of infection in disadvantaged children living in densely-populated and under-serviced areas (informal settlements) (Education, 2021)

1.6.3 Drug Treatment of Helminthic Infection

Anthelmintic drugs can be categorised into three groups depending on their mechanism of action: (1): Beta-tubulin binders that consist of benzimidazoles (albendazole and mebendazole) (2); spastic paralytic agents that include mainly pyrantel pamoate and levamisole, and (3); flaccid paralytic agents with piperazine the most prominent drug **(Table 1.1)** (Bharti et al., 2018b). Increased reporting of helminth drug resistance coupled with co-endemicity with different helminths and co-infection with malaria, tuberculosis or HIV, has led to the recommendation that combination therapy rather than monotherapy be used to eradicate helminthiasis and to improve drug efficacy (Becker et al., 2018). In the treatment of STHs and schistosomiasis, the WHO recommended drugs are albendazole (400 mg); mebendazole (500 mg); levamisole (2.5 mg/kg); pyrantel pamoate (10 mg/kg) and praziquantel (40-60 mg/kg in one or two divided doses) as these drugs have been shown to be effective against a wide range of helminths, including ascariasis, hookworm, trichuriasis, enterobiasis, lymphatic filariasis and schistosomiasis **(Table 1.1)** (WHO 2023).

1.6.3.1 Benzimidazoles

Albendazole and mebendazole are broad spectrum oral benzimidazoles that are used to treat

both intra and extra-luminal parasites. With mebendazole very effective in the treatment of *A. lumbricoides*, hookworms, and trichuriasis, while albendazole has a wider spectrum of activity including all the latter infections and strongyloidiasis, liver flukes (clonorchiasis and opisthorchiasis) together with taeniasis ((Pawluk et al., 2015); Keiser et al., 2024). Thiabendazole is another prominent benzimidazole that is active against numerous nematode, however its clinical use has been limited due to toxicity particularly to the liver, central nervous system and other side effects, such as hypersensitivity and visual effects (Keiser et al., 2024). The mechanism of action of benzimidazole includes the binding of the drug to the $\beta\beta$-tubulins in the cytoskeleton of the parasite, thereby inhibiting the polymerization of tubulin into microtubules, leading to disruption of essential absorption (glucose) in the parasite leading to its death. The benzimidazoles are ovicidal, larvicidal and vermicidal, where the activity against adult parasites is inferior to its activity against the developing parasites (Vinaud and Junior, 2017).

Table 1.1: WHO recommended anthelmintic drugs and their mode of action.

Class	Drug	Mode of action	Effect on parasite	Reference
Benzimidazole	Albendazole, Mebendazole	Binding to $\beta\beta$-tubulin thereby inhibiting polymerization of tubulin into microtubule	Disruption of essential absorption of the parasite leading to death	(Dayan, 2003); Keiser et al., 2024
Tetrahydro-pyrimidines	Pyrantel pamoate, Levamisole	Binding to Acetylcholine receptors of the autonomic ganglia	Spastic paralysis and expulsion of the parasite	Urbani and Albonico, 2003; Keiser et al., 2024
Avermectin	Ivermectin	Potentiation of neuro-transmission by disruption of glutamate-chloride channel	Paralysis of somatic muscles of the parasite leading to death	Sainas et al., 2018b;; Keiser et al., 2024
Salicyclanilde	Niclosamide	Inhibition of mitochondrial oxidative phosphorylation process thereby inhibiting uptake of oxygen and glucose by the organism	Death of the parasite	Taman and Azab, 2014; Keiser et al., 2024
Pyrazinoiso-quinoline	Praziquantel	Calcium influx into the whole parasite causing contraction of the parasite muscle	Death of the parasite	Vale et al., 2017; Cioli et al., 2014;; Keiser et al., 2024

Intestinal parasites are more sensitive than tissue parasites in the blood vessels and the interstitial parasites (Dayan, 2003). Albendazole and mebendazole are poorly absorbed from the GIT in humans, but absorption is increased more than five times when taken with a fatty meal (Pawluk et al., 2015). Benzimidazoles are extensively metabolised in the liver by cytochrome p450 enzymes and albendazole undergoes subsequent rapid oxidation into its active metabolites, namely albendazole sulphoxide and albendazole amino sulfone that are found in the systemic circulation (Ceballos et al., 2018). Excretion of albendazole occurs largely as metabolites in the bile, while mebendazole is excreted in the urine with some excreted in faeces as an unchanged drug (Dayan, 2003). Due to the teratogenicity and embryotoxicity that was reported in experimental rats, benzimidazoles has been recommended not to be administered to young children less than 1 year old or in pregnant women (Bharti et al., 2018b). A single dose of albendazole (400 mg) and mebendazole (500 mg) have shown to have excellent efficacy against *A. lumbricoides,* but are less efficacious against hookworm infestations and *T. trichiura* (Geary et al., 2010; Turner et al., 2016). Therefore, a combination albendazole or mebendazole together with ivermectin is used in the treatment of trichuriasis (Hotez, 2009; Turner et al., 2016). Despite being very effective against STHs, there are several reports on emergence of benzimidazole resistance in Africa and Asia (Lubis et al., 2012; Furtado et al., 2016). This is of concern as the drug discovery research into new anthelmintic agents is not as active as other first world pathologies. As such cautious use of these drugs should be instilled in healthcare providers and the general public.

1.6.3.2 Praziquantel

Praziquantel is a synthetic pyrazino-isoquinoline derivative (Sinxadi and Maartens, 2009) that occurs as a racemic mixture of (R)- and (S)-isomers with the (R)-praziquantel possessing activity against schistosomes (tegumental damage and muscular paralytic contraction), whereas (S)-praziquantel is inactive against schistosomes (Sun et al., 2016). Despite praziquantel being used for over 40 years as the only drug in the treatment of all forms of schistosomiasis, its molecular targets and mechanism of action remain unclear. However, the proposed mechanisms by which praziquantel exerts its effect on schistosome parasites include: (1) inhibiting calcium influx into the whole parasite, resulting in the contraction of parasite muscle resulting in parasite death; and (2) Modifications of the surface of the parasite exposing underlying antigens to increase immune recognition of the schistosome infection to facilitate clearance (Nogueira et al., 2022;

Keiser et al., 2024). More than 80% of praziquantel is absorbed following oral ingestion but has low bioavailability range in that depends on different individuals with a reported half-life of 2.2 hrs to 8 hrs (Olliaro et al., 2014). Bioavailability of praziquantel is increased when co-administered with cimetidine and food but is decreased when co-administered with chloroquine and pre-administered with carbamazepine and phenytoin (Alsaqabi and Lotfy, 2014). After oral administration of praziquantel to children of 4 years and older with a dosage of 40-60 mg/kg of body weight, it undergoes extensive metabolism in the liver by CYP3AD and CYPC19 (Bustinduy et al., 2016). Praziquantel is primarily eliminated via the urine and faeces with more than 80% of the drug cleared within 24 hours (Cioli and Pica-Mattoccia, 2003). Praziquantel is the only drug indicated for the treatment of all forms of schistosomiasis. Other helminthic infections that can be treated with praziquantel includes; cysticercosis, taeniasis, fasciolosis and other diseases caused by cestodes and trematodes (Rezaizadeh and Olson, 2016). Although praziquantel is highly effective and safe in the treatment of schistosomiasis, it is associated with mild to moderate adverse effects that include abdominal pain, excessive sleep, headache, diarrhoea and dizziness which can be avoided by administering the drug at night (Chai, 2013; Keiser et al., 2024). Emerging problems associated with the use of praziquantel include the development of resistance by the helminths, which can be attributed to its continuous use as the only drug for the treatment of schistosomiasis for over 30 years. As well as the mass drug administration programs that could have contributed to the drug selection pressures on *Schistosoma* parasites with the subsequent emergence of resistant schistosomes (Ismail et al., 1999; Summers et al., 2022). Secondly, it is only effective against adult schistosome parasites; therefore, does not have a sterilizing effect to eradicate all stages from the human host to prevent the spread of the infection. Thirdly, reduced patient compliance occurs due to the unpleasant side effects and bitter taste, thereby affecting the sensitivity profile of the schistosomes (Rezaizadeh and Olson, 2016).

1.6.3.3 Niclosamide

Niclosamide is an anthelminthic drug that was discovered by Bayer in 1953 and was originally used as molluscicide to kill snails, the intermediate host of schistosomiasis, but was later discovered to be highly effective against cestodes (tapeworms) in 1960 (Chen et al., 2018). It is a halogenated salicylanilides derivative that possesses a mechanism of action of inhibiting the

mitochondrial oxidative phosphorylation process, thereby inhibiting the uptake of oxygen and glucose by the cestode (Taman and Azab, 2014). In the treatment of *T. solium* with niclosamide, a laxative must be administered 1-2 hours after dosage of niclosamide, to avoid development of cysticercosis that can be caused by the release of eggs from undigested dead segments of the tapeworm (Zhang et al., 2019). It is used as a second line drug to praziquantel for the treatment *Diphyllobothriidae* family tapeworms*, Rodentolepis (Hymenolepis) nana, T. saginata* and several other cestodes infection (Keiser et al., 2024). Niclosamide is the only molluscicide that has been recommended to be used commercially for the prevention of schistosomiasis (Liu et al., 2015). Although niclosamide is an anthelmintic drug, it has been found to be very effective in the suppression of many tumour cell lines of the lungs, breast, prostate, colon, pancreas, and ovary (Bhattacharyya et al., 2017).

1.6.3.4 Pyrantel Pamoate and Levamisole

Pyrantel pamoate is an imidazole-derived tetrahydropyridine derivative that was first developed in 1966 as a broad spectrum anthelmintic in both human and veterinary medicine and is used in the treatment of hookworm, roundworm and pinworm, as well as *Trichinella spiralis* and *Trichostrongylus* spp. . (Kopp and Keiser, 2017; Keiser et al., 2024). Pyrantel pamoate is a depolarizing neuromuscular blocking agents that open nonselective cation L-type channels and induce persistent activation of nicotinic acetylcholine receptors, resulting in the spastic paralysis of the parasite (Table 1.1) (Urbani and Albonico, 2003; Keiser et al., 2024). Pyrantel pamoate has also been found to inhibit cholinesterases in ascariasi*s* (Keiser et al., 2024). Following oral administration of pyrantel pamoate it is poorly absorbed from the GIT with about 85% of the drug excreted unchanged in the faeces (Becher, 2000; Porto, 2003). The dosage of pyrantel pamoate is 11 mg/kg orally for 3days (CDC, 2019); while high cure rates in the treatment of ascariasis and enterobiasis are achieved after a single oral dose of 11 mg/kg, to a maximum of 1 g for 3 days (CDC, 2019; Keiser et al., 2024). Pyrantel has mild and transient side effects that includes; nausea, vomiting, headache and abdominal pain (Ojha et al., 2014; Jain et al., 2006). Pyrantel pamoate is contraindicated in pregnancy, in patients with liver disease and known hypersensitivity to the drug (Rezaizadeh and Olson, 2016). Levamisole is a cholinergic anthelmintic similar to pyrantel pamoate in terms of its mechanism of action (Holden-Dye and Walker, 2007). It is a potent agonist of the L-type nematode nicotinic acetylcholine receptor. Activation of the receptor opens the central channel, producing

widely used as an anthelmintic agent in humans, but commonly used in veterinary medicine to treat several infestations of worms in sheep, pigs and cattle (Buchanan et al., 2010). Apart from its antiparasitic activity, levamisole is also used as an anticancer drug (Gholami et al., 2023). It has been medically approved in the USA as an adjunct for the treatment of colonic cancer and autoimmune disorders (nephritic syndrome and rheumatoid arthritis). Levamisole is rapidly absorbed from the GIT following oral administration with some evidence that suggests a more rapid absorption in females than males and it has a bioavailability of 60-70% with a half-life of 2-6 hours after undergoing extensive metabolism in the liver (Brunt et al., 2017). Side effects of levamisole include among others; irreversible neutropenia, necrotizing vasculitis and agranulocytosis in up to 20% of cases (Hess et al., 2014).

1.6.3.5 Ivermectin

Avermectin was discovered in 1967 in Japan and the new formulation of ivermectin released in 1981 and later approved to be used in the treatment of human onchocerciasis (river blindness) in 1988 (Ashour, 2019). Ivermectin is a broad spectrum antiparasitic (nematodes, arthropods) drug that is a derivative of avermectin which comes from a family of macrocyclic lactones produced by the filamentous soil bacterium *Streptomyces avermitilis* (Miyajima et al., 2016;). Ivermectin is used globally in both human and veterinary medicine for the treatment of several diseases that includes onchocerciasis, lymphatic filariasis, strongyloidiasis, ascariasis and some other ectoparasites like *Sarcoptes scabiei* (Laing et al., 2017). Ivermectin has been shown to be a very potent endectocide that is used in mass drug administration in multiple locations across West Africa by effective killing or disabling *An. gambiae* from host treated blood meals, thereby disrupting *P*. *falciparum* transmission in the field (Meyers et al., 2015; Kobylinski et al., 2023). In addition to its antiparasitic activity, ivermectin have been shown to have anti-inflammatory properties which could be used as a topical agent in the treatment of inflammatory skin conditions, such as papulopustular rosacea (Ventre et al., 2017; Del Rosso, 2017).

The mechanism of action of ivermectin is through potentiation of neurotransmission by disruption of glutamate-gated chloride channel causing neuronal hyperpolarization and paralysis of somatic muscles especially the pharyngeal pump leading to the death of the parasite. It is also proposed to have a minor effect on γ-amminobutyric acid (GABA) (Sainas et al., 2018a). Following oral administration ivermectin is readily absorbed in the GIT and has a half-life of 0.5 to 2.5hrs (Chaccour et al., 2017). Ivermectin is highly lipid soluble with a high protein binding and is widely distributed within the body and metabolised by hepatic CYP450 enzyme (Canga et al., 2008). Most

of the drug is excreted in the faeces with less than 1% being excreted unchanged in urine (Chaccour et al., 2017). Ivermectin is a well-tolerated drug with most of its side effects caused by inflammatory response to the death of microfilaria and includes; fever, malaise, pruritus, arthralgia, skin oedema, dyspnoea and hypotension, sympathetic signs associated with ivermectin toxicity includes; mydriasis, tremors, sialorrhea, motor in coordination and coma (Juarez et al., 2018). There are growing concerns globally to reduce efficacy of Ivermectin used in mass drug administration programs, which could be a sign of emergence of resistance to the drug (Doyle et al., 2018). Some studies have shown a wide spread of resistance to ivermectin in some countries in the treatment of scabies (Chosidow and Gendrel, 2016).

1.6.3.6 Combination therapy (albendazole + ivermectin)

WHO has included combination therapy of albendazole and ivermection to the list of essential medicines for the treatment of intestinal heminths and the goals of combination therapy are as follows; 1) Improved clearance of STH. 2) Reduce worm burden to a point where the infection is no longer clinically problematic and the host will not excrete large number of eggs or larvae which may infect others 3) efficacy of anthelmintic therapy may be measured by reduced faecal egg counts (Keller, 2021).

1.6.3.7 Water Sanitation and Hygiene (WASH) and personal prevention of STHs

Improved WASH is directly associated with decrease infection with STHs by reducing the contact of individuals with the eggs of helminthes in the environment (Vaz Nery, 2019). Safe and sufficient WASH plays a key role in the prevention of STHs, schistomiasis and other neglected tropical diseases (WHO, 2024). However, in Nigeria there is low implementation of preventive chemotherapy of STHs in pre-school and school aged children, it is therefore necessary to include WASH program in order to reduce the burden of STHs in the country (Oyeyemi, 2023). Other factors that prevent STHs infections are; improved personal hygiene, use of footwear, avoidance of open defecation, washing of vegetables and fruits before eating and proper waste disposal (Kurniyawan, 2024).

1.6.3.8 Rational for the Study

According to the WHO Nigeria has the highest burden of human helminthic infection sub-Saharan Africa, with estimated cases of 48,681,440 children requiring preventive chemotherapy (WHO, 2022). The northern part of Nigeria of which Kebbi State is part of, has the highest prevalence of

helminthic infection in Nigeria (63%) (Funso-Aina, 2020). The WHO reported that over 1.5 billion people still do not have basic sanitation services such as toilets and latrines leading to transmission of diarrhoeal diseases, helminthic infections and its burden as well as exacerbation of stunting of children especially those under 5 years of age (WHO 2023). Despite the huge burden of helminthic infections and proven positive benefits, the utilisation of deworming programmes among pre-school age children in sub-Saharan Africa is less than half (Belay et al., 2022). Deworming programmes in Nigeria have failed to reach 75% set by WHO, and this may be due to the public and care givers not being aware of such programmes and as such impacted on deworming programmes and targets (Eze et al., 2020). There have been increasing reports of the development of resistance by helminths to anthelmintic drugs, like albendazole and ascribed to largely be due to under dosing, patient non-compliance and frequent treatment of an infection through self-medication (Fissiha and Kinde, 2021). Minimal research has been undertaken on helminthic infections in the Birnin Kebbi metropolis. As such it is necessary to determine the extent of helminthic infections in the Birnin Kebbi metropolis and assess the knowledge and personal practices of the general public and healthcare providers in reporting and managing helminth infections.

1.7 Study Aims and Objectives

1.7.1 Aims

To determine the occurrence of helminthic infections and to assesses the knowledge of anthelmintic management and reporting among healthcare providers and the general public in Birnin Kebbi Metropolis, Nigeria.

1.7.2 Objectives

1. To determine the trend in annual and overall prevalence of helminth infections in two hospitals in the Birnin Kebbi metropolis, Nigeria from 2014-2020.
2. To determine the most common helminth that affects children and adults in Birnin Kebbi, Nigeria and to evaluate associated socio-demographic and clinical characteristics that may affect this occurrence.
3. To describe the outcome of helminthic infections in children and adults in Birnin Kebbi, Nigeria.
4. To determine the knowledge of healthcare providers on the management of helminthiasis

in Birnin Kebbi, Nigeria.

5. To determine the health practices among the public in Birnin Kebbi, Nigeria.

CHAPTER TWO:

RESEARCH METHODOLOGY

2.1 Study site and population cohort

The study was carried out in Birnin Kebbi, which is the capital city of Kebbi state in the north-western region of Nigeria **(Figure 2.1)**. It has an estimated population of 429,000 (Macrotrends, 2024). Lies between latitude 12° 27' 57.8808'' N and longitude 4° 11' 58.2864'' E, along the Sokoto-Kebbi River at the intersection of roads from Argungu, Jega, and Bunza (Yahaya et al., 2019). The study was conducted at the only two public Hospitals in Birnin Kebbi, namely the Sir Yahaya Memorial Hospital and Federal Medical Centre in Birnin Kebbi. Permission to undertake the project was obtained from the relevant authorities and chief executive officers of the selected hospitals (Section 2.4). On average 80% of Birnin Kebbi metropolis patients go to either of these hospitals for treatment when they are sick.

Figure 2.1: Location of Birnin Kebbi, the capital city of Kebbi state, Nigeria (Brinkhoff, 2022).

2.1.1 Federal Medical Centre

Federal Medical Centre is the largest hospital in Birnin Kebbi with approximately 400 beds and 1783 staff members and is located along Dukku barracks area of Birnin Kebbi (Kebbi, 2024). Federal medical center is a teaching hospital as well as referral center that is owned by federal government of Nigeria, patients come from all the local government of kebbi state.

2.1.2 Sir Yahaya Memorial Hospital

Sir Yahaya Memorial Hospital is a public hospital that is located along Haliru Abdu road Birnin Kebbi; it has 500 beds and 840 staff (Apie Project, 2023). It is the largest state-owned hospital in Kebbi state and is visited mainly by the local population in Birnin Kebbi. It also serves as a referral center for the other local hospitals owned by Kebbi state government.

2.2 Study design and population

This study consists of three parts:

2.2.1 Part one: Retrospective cross-sectional study

The first part of this study was a retrospective cross-sectional study of hospital records of patients diagnosed with helminthiasis over a seven-year period (2014-2020). A data extraction sheet (Appendix A) was used to collect information including amongst others, gender, age and occupation, symptoms and co-morbidities from the medical records of laboratory confirmed helminthiasis. The cases were obtained from the Medical Laboratory Science Department of Federal Medical Centre and Sir Yahaya Memorial hospitals, following appropriate approvals from the respective head of their microbiology units (Section 2.4). Both the hospitals use direct saline method as the method of helminthic diagnosis, it has low sensitivity in the diagnosis of helminths, both the hospitals test only one sample per patient. For each relevant case report, the laboratory records were reviewed to obtain information such as the year and month of the infection/treatment, type of helminthiasis. To calculate prevalence of helminths in stool samples, the total annual stool specimen number that was handled by the laboratory was obtained.

2.2.2 Part Two and Three: Questionnaire survey

The second part of the study entailed the recruitment of consenting healthcare providers, and the general public, including those who visited the two hospitals during the 2020-2021. The semi-structured self-administered questionnaire adopted from similar studies was administered to

healthcare providers (doctors, nurses, pharmacists and laboratory scientists) and the general public in order to assess their knowledge on the management of helminthic infections (Nasr et al., 2013c). The questionnaire for the healthcare providers (Appendix B) included three sections with (Aula, McManus et al.) Personal information: (demography) (4 questions); (Moser, Bärenbold et al.) Assessment of health workers knowledge about helminths (8 questions); (C.) further information (2 questions) which on average took 15-20 minutes to complete. The questionnaire for the general public (Appendix C) included seven sections with (Aula, McManus et al.) Personal information: (demography) (10 questions); (Moser, Bärenbold et al.) source of water, environment and sanitation conditions (4 questions); (C.) personal practices (7 questions); (D.) knowledge about intestinal worms infections (10 questions); (E.) treatment and treatment-seeking behavior (3 questions); (F.) worm management of children (10 questions); (Moser, Bärenbold et al.) Further information (1 questions), which on average took 15-20 minutes to complete. The context validity of the instrument was checked by a group of experts which includes doctors, pharmacologists, parasitologists and nurses. Questionnaires were administered using pen/paper.

Participation was voluntary and confidentiality of the participant identity was ensured as only the student and supervisors had access to the participant information. All the participants were given an information sheet (Appendix D1 (general public), and D2 (healthcare providers)) to explain the purpose of the study and asked to sign the consent form (Appendix E) before being allowed to complete the questionnaire.

2.3 Sample Size

A minimum sample size of 384 participants were recruited based on the sample size formula for cross sectional studies as recommended by Pourhoseingholi et al. (2013); $n = \frac{ZZ^2\,(1-pp)}{dd^2}$; where n= sample size, Z= normal static variant at 95% confidence interval and 80% power (=1.96 from Tables), P = expected proportion in the population which is unknown. Since it is unknown, 50% was assumed, d = absolute error or precision, which is assumed to be 5%. An attrition rate of 5% was assumed. The sample size of 384 was obtained using the Raosoft calculator with a <20,000 population at a 95% confidence interval and 5% margin of error.

2.4 Ethics

The protocol was approved by the WITS Postgraduate Office (Appendix F1). Ethical clearance to conduct the study was obtained from the University of Witwatersrand Human Research Ethics

Committee (Number: M190713 on 25/06/2020) (Appendix F2). Ethical approval to conduct the study in Birnin Kebbi metropolis was also obtained from the relevant authorities (Kebbi State Ministry of Health (Number: 105:012/2020 on 17/02/23) (Appendix G), Sir Yahaya Memorial Hospital (Number: SYMH/SUB/17/VOL. 111/96 on 10/08/2020) (Appendix H1) and Federal Medical Centre (FMC/BK/045/P/517/VIII 8/07/2020) (Appendix H1).

2.5 Data Collection

For the first Part of the study (retrospective study), a data extraction sheet was used to collect information under three main headings: demographic information, clinical symptoms of helminthiasis, diagnosis and therapeutic intervention (Appendix A) from the medical records of laboratory-confirmed helminthiasis infected patients. To calculate prevalence of the various helminth infections, the total annual number of stool specimens processed in the seven-year period (2014-2020) by the respective diagnostic Laboratory was used with the respective number of helminth species infections.

For Part Two and Three of the study, data collections were done using two separate questionnaires that were distributed to consenting healthcare providers and public. The questionnaire for healthcare providers (Appendix B) included data on demographic profiles such as: ward working in, job description, years of experience and gender and assessment of healthcare provider's knowledge about helminthic infection clinical features, common helminths that infect humans, method of diagnosis, and preventative and treatment measures. While the questionnaire for general public (Appendix C), included data on demographic profiles of the study participants such as: age gender, ethnicity, level of education, average monthly income and occupation and sources of water, environment and sanitary conditions, personal practices of the study participants, knowledge about intestinal worm infections and management of worm infections in children.

2.6 Statistical Analysis

Data was entered into the Statistical Package for the Social Sciences (SPSS) version 28.0 for analysis. Socio-demographic and clinical characteristics of the patients with and without STHs were presented. Categorical variables were presented as frequency, percentages, and charts, while the continuous variables that were normally distributed were presented as mean and standard deviation, while non-normally distributed variables were presented as median and

interquartile range. Socio-demographic characteristics were compared among stool specimens positive for STHs versus those negative for the presence of a helminth. Pearson's chi-square analysis was used for the association between categorical variables (such as gender) and helminthiasis status. Bivariate logistic regression was conducted to determine factors associated with helminthic status. An odds ratio and 95% confidence interval were calculated.

CHAPTER THREE:

RESULTS

In this chapter the analysis of the data obtained from the retrospective study of helminth infections in the two study sites, as well as the cross-sectional study with public and healthcare providers were presented.

3.1 Part One: Retrospective Study of Helminth Infections

This part presents the findings obtained from a seven years (2014-2020) retrospective data review of stool culture from two public hospitals in Birnin Kebbi metropolis, Nigeria.

3.1.1 Socio-demographic Characteristics of Patients and Helminth Prevalence

In overall, 4,082 stool samples were analysed between year 2014 to 2020, out of which 2268 were from Federal Medical Centre, and 1814 from Sir Yahaya Memorial Hospital (**Figure 3.1).** Out of 4082 stool samples that were analysed for helminthic infection, only 1% (n=39) were positive resulting in a 1.0% prevalence of helminthic infection in the Birnin Kebbi metropolis from 2014 to 2020 **(Figure 3.1).**

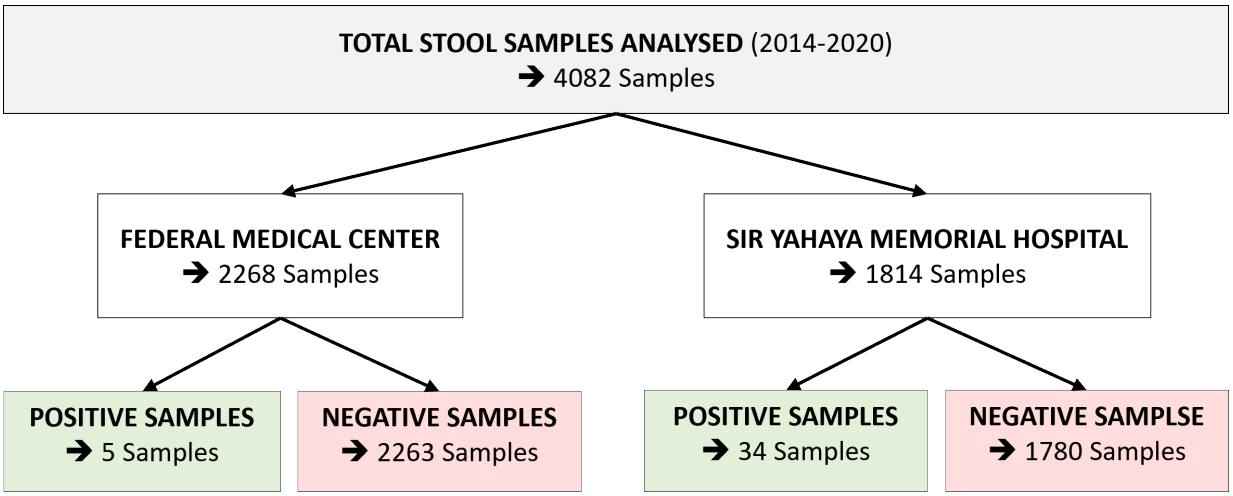

Figure 3.1: Stool samples numbers analysed for helminth infections from the Federal Medical Centre, and Sir Yahaya Memorial Hospital.

One third (33.1%; n= 359) of the samples were within the age range of 1-10 years while the least 10.7% (n=438) were found to be within the age range of 11-20 years **(Figure 3.2A).** The majority of the patients (57.1%; n=2330) that were sent to the laboratory for stool analyses for the years 2014-2020 were males **(Figure 3.2B).**

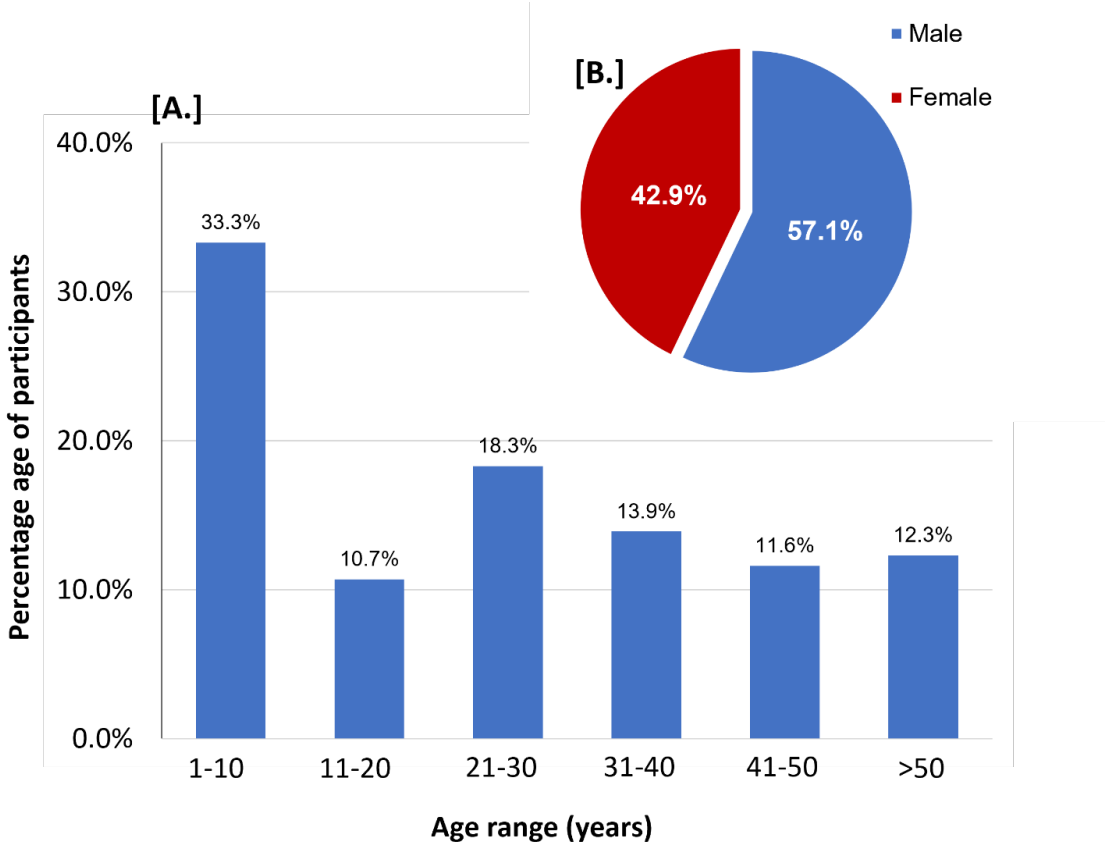

Figure 3.2: Distribution of the patient's age range (Aula, McManus et al.) and gender (Moser, Bärenbold et al.) for the stool samples analysed from both Sir Yahaya Memorial Hospital and Federal Medical Centre.

3.1.2 Annual distribution of stool analyses and isolates identified

Within the seven years of the study period, the 32.3% of the stool cultures were performed in the year 2015, while the least (1.0%; n=40) stool analyses were performed in 2018 **(Figure 3.3).** For the period of study, the majority (70.6%) of the stool analyses that were analysed yielded no growth; whilst the major microbial isolates diagnosed were *Escherichia coli* (10.6%; n=431) and *Salmonella* spp. . (9.5%; n=389) **(Table 3.1).**

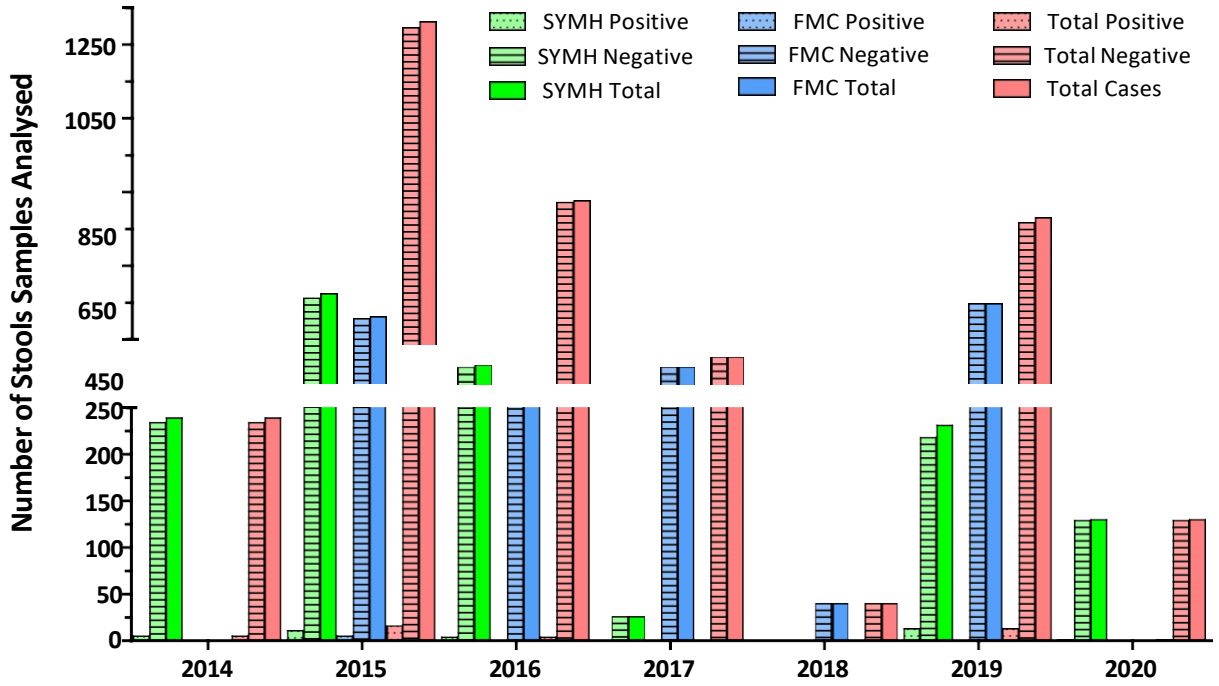

Figure 3.3: Annual distribution of stool analysed over the study period of 2014 to 2020. Total number of positive (dotted bar) cultures identified with the negative samples (stripped bar) from the Sir Yahaya Memorial Hospital (SYMH; green bars), Federal Medical Centre (FMC; blue bars) and total number of stool samples from both hospitals (red bars) submitted for diagnosis for helminth infections**.** (Raw data to be found in Table I.1).

3.1.3 Prevalence of Helminthic Infections

Out of the 39 positive helminthic samples recorded, 87.2% (n=34) were from Sir Yahaya Memorial Hospital where a statistically significant difference ($p<0.01$) was recorded between the study hospitals and diagnosis of helminths. There were more males (53.8%; n=21) with positive helminth stool samples than females (46.2%; n=18) ($p = 0.682$). Many of the helminths isolated were reported to be hookworm (59.0%; n=23) with no species identified; while *T. trichiura* and *Taenia* spp. . (2.6%; n=1) were rarely reported **(Figure 3.4)**. The majority (41.0%; n=16) of the positive helminthic stool samples were recorded in the year 2015, while no positive helminthic stool samples were recorded in the years 2017 and 2018 where a statistically significant difference ($p<0.01$) was recorded between the years of study and occurrence of a helminthic infection ($p=0.023$).

Table 3.1: Distribution of microorganism isolated within the period of the study of 2014 to 2020 as described in the laboratory diagnostic sheet (n=4074).

Isolate	Class of Microorganism	Frequency (n)	Percentage (%)
No growth	-	2881	70.6
Escherichia. coli	Bacteria	431	10.6
Salmonella spp. .	Bacteria	389	9.5
Shigella spp. .	Bacteria	222	5.4
Staphylococcus spp. .	Bacteria	40	1.0
Klebsiella spp. .	Bacteria	27	0.7
Hookworm	Nematode	23	0.6
Candida spp. .	Fungus	17	0.4
Proteus spp. .	Bacteria	11	0.3
Giardia duodenalis	Protozoa	9	0.2
Pseudomonas spp.	Bacteria	8	0.2
Enterobius vermicularis	Nematode	5	0.1
Strongyloides sterocoralis	Nematode	4	0.1
Ascaris lumbricoides	Nematode	3	0.1
Enterobacter spp.	Bacteria	3	0.1
Citrobacter spp.	Bacteria	2	0.05
Rodentolepis nana	Cestode	2	0.05
Entamoeba histolytica complex	Protozoa	1	0.02
Streptococcus spp.	Bacteria	1	0.02
Trichuris trichiura	Nematode	1	0.02
Taenia spp.	Cestode	1	0.02
Acinetobacter spp.	Bacteria	1	0.02

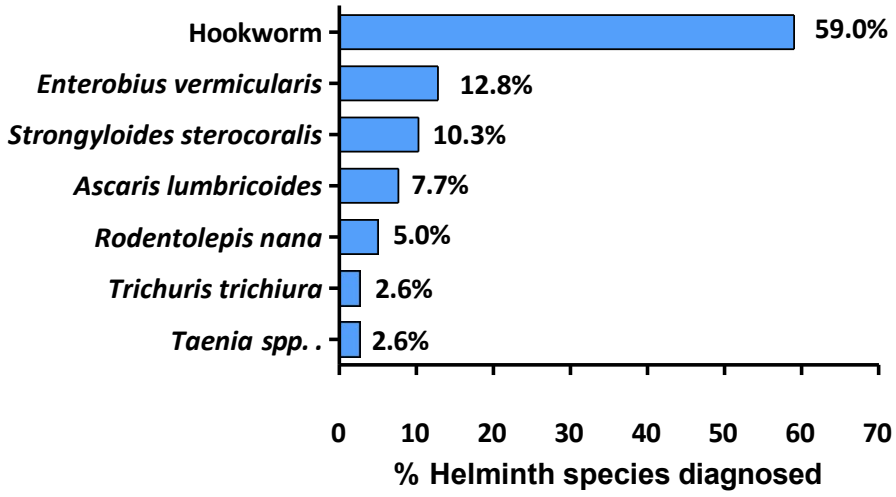

Figure 3.4: The diagnostic prevalence of isolated and diagnosed helminths in two major public hospitals in Birnin Kebbi metropolis from 2014-2020.

3.2 Part Two: Cross-sectional study: Healthcare providers

3.2.1 Socio-demographic Characteristics of Healthcare Providers

This was a cross-sectional study conducted using a structured questionnaire distributed to healthcare providers in two major public hospitals in Birnin Kebbi metropolis. The total return response was 71.3% (n=107) out of 150 questionnaires distributed (Table 3.2).

Table 3.2 Socio-demographic characteristics of 107 healthcare providers who participated in Part two of the study.

Item	Response	Frequency	Percentage
Ward working in (n=107)	- Outpatient Department	48.0	44.9
	- Obstetrics	22.0	20.6
	- Female Surgical Word	7.0	6.5
	- Diagnostic laboratory	6.0	5.6
	- Emergency	6.0	5.6
	- Male Medical Ward	5.0	4.7
	- Female Medical	5.0	4.7
	- Male Surgical Ward	2.0	1.9
	- Paediatrics	2.0	1.9
	- Amenity	2.0	1.9
	- National Healthcare Insurance Scheme	1.0	0.9
	- Pharmacy	1.0	0.9
Job description (n=107)	- Nurses	64.0	59.8
	- Doctors	27.0	25.2
	- Pharmacists	10.0	9.3
	- Laboratory scientists	6.0	5.6
Years of experience (n=107)	- 1-10 years	78.0	72.9
	- 11-20 years	24.0	22.4
	- > 20 years	5.0	4.7
Gender (n=107)	- Female	62.0	57.9
	- Male	45.0	42.1

Out of the total of 107 healthcare participants, the majority were nurses (59.8%; n=64) with only 5.5% of the respondents qualified as laboratory scientists (**Table 3.2**). A statistically significant difference was noted between the gender and occupations of the study participants ($p<0.001$), where the majority were females 57.9% (n=62). The majority of the doctors were male (74.1%; n=20), while only 29.7% (n=19) of the nurses were male. The median years of experience of the study participants was 9.0 (IQR=.0-21.8), with the majority of the healthcare providers had 1-10

years of work experience (72.98%; n=78). The healthcare participants (44.9%; n=48) were from the Outpatient Department, while only 1 (0.9%) each were from National Healthcare Insurance Scheme and Pharmacy.

3.2.2 Knowledge of Helminthic Infections

The most frequently mentioned helminths among the respondents were hookworm (50.6%; n=56) and *Ascaris* (37.3%*;* n=41); while *R. nana* and *Fasciola hepatica* (2.7%; n=3) were the least mentioned by the healthcare providers (**Table 3.3)**. The responses included both the scientific name and the common name, and once grouped accordingly the same helminths (hookworm and *Ascaris*) were mostly identified, whilst *Strongyloides* (1.6%) was overall the least mentioned (**Table 3.3)**.

Table 3.3: Healthcare provider's knowledge on helminths according to common or scientific names supplied (n=318).

Reported Helminths	Healthcare provider responses		Grouped Helminths	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Hookworm	54	50.5	77	24.2
Ancylostoma	12	11.2		
Necator americanus	11	10.3		
Ascaris	40	37.4	76	23.9
Roundworm	36	33.6		
Tapeworm	36	33.6	64	20.1
Taenia solium	14	13.1		
Taenia saginata	11	10.3		
Rodentolepis (Hymenolepis) nana	3	2.8		
Trichuris	20	18.	35	11.0
Whipworm	15	14.0		
Filariasis	7	6.5	21	6.6
Fluke worm	11	10.3		
Fasciola hepatica	3	2.8		
Pinworm*	13	12.1	20	6.3
Threadworm *	7	6.5		
Schistosomiasis	20	18.7	20	6.3
Strongyloides	5	4.7	5	1.6

** Enterobius vermicularis*

3.2.3 Knowledge of Symptoms Associated with Helminthic Infections

The three commonly mentioned symptoms by study participants were abdominal pain (56.1%), diarrhoea (48.6%) and nausea (22.4%), while the three least mentioned were skin rashes (2.8%), cognitive problems (1.9%) and restlessness (0.9%) (**Table 3.4)**.

Table 3.4: Distributions of healthcare provider's knowledge on symptoms of helminthic infections (n=277).

Symptoms	Frequency (n)	Percentage (%)
Abdominal pain	60	56.1
Diarrhoea	52	48.6
Nausea	24	22.4
Fever	23	21.5
Anaemia	19	17.8
Growth retardation	21	19.6
Loss of appetite	14	13.1
Rectal prolapse	14	13.1
Weakness	11	10.3
Blood loss	10	9.3
Fatigue	8	7.5
Abdominal discomfort	6	5.6
Blood in stool	5	4.6
Haematuria	4	3.7
Skin rashes	3	2.8
Cognitive problems	2	1.9
Restlessness	1	0.9

3.2.4 Knowledge on Diagnosis of Helminthic Infections

The majority of the respondents (76.6%) indicated that culturing of the stools is the best method to diagnose helminthic infection, while only 10.3% mentioned urine m/c/s and skin test (**Table 3.5)**. The majority of the healthcare providers mentioned environmental sanitation (82.2%) as the best way to prevent helminthic infections, while only 59.8% mentioned reduction of overcrowding.

Table 3.5: Distributions of healthcare provider's knowledge on methods of diagnosis and prevention of helminthic infection.

Item	Response	Frequency (n)	Percentage (%)
What is the best method to diagnose Helminthic infection? (n=107)	- Stool culture	82	76.6
	- Blood culture	27	25.2
	- Serological Test	15	14.0
	- Urine M/C/S	12	11.2
	- Skin test	12	11.2
What are the ways to prevent helminthic Infection? (n=107)	- Environmental Sanitation	88	82.2
	- Proper Health Education	87	81.3
	- Provision of Adequate water supply	84	78.5
	- Reduction of Overcrowding	64	59.8
	- All of the above	0	0.0

3.2.5 Knowledge on Management of Helminthic Infections

Vermox® and Combiworm® (12.1%; n=13) were the two most mentioned trade names of anthelmintic drugs by the study participants, while Alben G® and Retrax® were the least mentioned (1.9%; n=2) **(Table 3.6)**. Based on the active ingredients in the anthelmintic drugs reported, albendazole was the most common (42%) drug mentioned **(Figure 3.5)**. In contrast, when asked about the active ingredient, mebendazole (50.5%) was predominantly identified as the active ingredient of the provided drugs, with levamisole the least mentioned **(Table 3.7)**. Only 22.4% of the healthcare providers correctly identified the regimen of management for helminthic infections, namely albendazole 400 mg once daily orally **(Table 3.7)**. However, there were some misconceptions by the study participants on the management regimen involving levamisole 150 mg stat 1 (0.9%). Only 5.6% of the healthcare providers reported a previous encounter with a patient that had used herbal medication to treat helminthic infection.

Table 3.6: Distribution of knowledge of trade names of anthelmintic drugs identified by healthcare providers.

Trade names	Active ingredient/s	Frequency (n)	Percentage (%)
Vermox®	Mebendazole	13	12.1
Combiworm®	Albendazole	13	12.1
Zentel®	Albendazole	11	10.3
Ketrax®	Levamisole	8	7.5
Pyrantin®	Pyrantel pamoate	6	5.6
Zolat®	Albendazole	6	5.6
Egaten®	Triclabendazole	5	4.7
Wormin®	Mebendazole	4	3.7
Ascarel®	Pyrantel	3	2.8
Biltricide®	Praziquantel	3	2.8
Alben G®	Albendazole	2	1.9
Retrax®	Levamisole	2	1.9

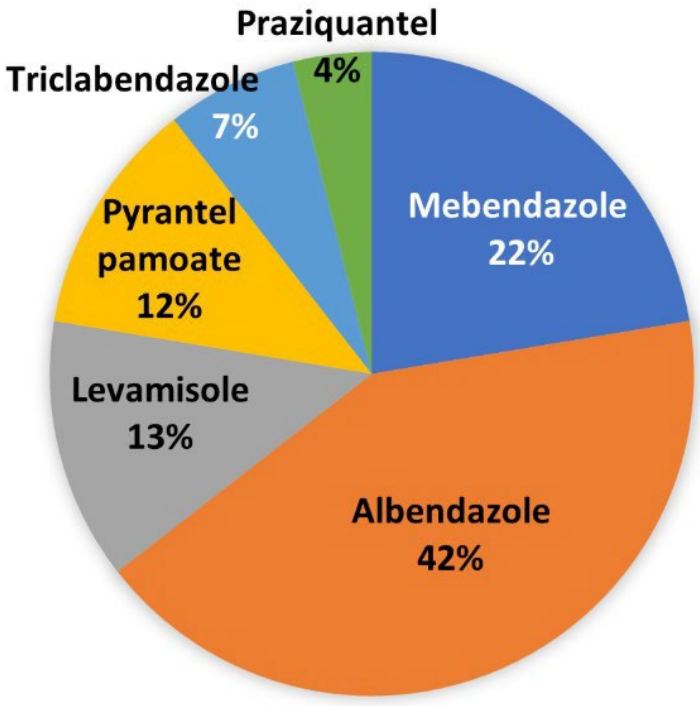

Figure 3.5: Active ingredients of the anthelmintic drugs reported by healthcare professionals.

Table 3.7: Knowledge of Healthcare Providers on Active Ingredients of the Listed Trade Names, drugs administered including dosage for children and use of herbal medication to treat helminth.

Item	Response	Frequency (n=)	Percentage (%)	Correct Response (%)
Can you list the active ingredients in the drugs you listed in the previous question? (n=107)	- Albendazole	61	57.0	32
	- Mebendazole	55	51.4	54.5
	- Praziquantel	37	34.6	8.1
	- Ivermectin	21	19.6	-
	- Pyrantel pamoate	14	13.1	42.9
	- Levamisole	8	7.5	100
How are prophylactic drugs administered including dosage for children and adults? (n=107)	- Albendazole 400 mg once daily	24	22.4	
	- Albendazole 200 mg start	10	9.3	
	- Mebendazole 100mg twice daily	1	0.9	
		1	0.9	
	- Levamisole 150 mg start	1	0.9	
	- Praziquantel 40 mg/kg/dose			

3.2.6 Healthcare Providers Overall Knowledge Score on the Management of Helminthic Infection

The overall knowledge score on the management of helminthic infection is not normally distributed, hence median knowledge core (13.0) was used to categorise knowledge of healthcare providers on management of helminthic infection (Laerd, 2018)). Those who had a score of ≤13.0 were categorised as possessing poor knowledge, while a score of ≥14 was categorised as possessing good knowledge. Kolmogorov-Smirnov test showed statistically significant difference on the distribution participant's knowledge score ($p<0.001$). Out of the 107 healthcare providers, the majority had poor knowledge (60.7%; n=65) on management of helminthic infection (**Table 3.8**). There was a statically significant difference between the overall knowledge category of the study participants and ward in which they worked ($p= 0.024$) (**Table 3.8)**. With the highest number of participants with good knowledge being found in the Outpatient Department (58.3%; n=28),

while interestingly all the participants from laboratory, paediatrics, men surgical ward, amenity and pharmacy recorded poor knowledge on helminthic infection management.

Pharmacists 90% were more informed on the management of helminthic infections, with doctors (55.6%) also possessing good knowledge. In contrast, 71.9% of nurses had poor knowledge (p<0.001) (**Table 3.8**). The majority (60.3%) of those respondents with poor knowledge had between 1-10 years of working experience (P=1.000).

Table 3.8: Distribution of overall knowledge on the helminthic management across different demography.

Characteristics	Good knowledge % (n)	Poor knowledge % (n)	P value
Ward			< 0.001
Outpatient	58.3 (n=28)	41.7 (n=20)	
Male Medical Ward	40.0 (n=2)	60.0 (n=3)	
Emergency	33.3 (n=2)	66.7 (n=4)	
Obstetric	31.8 (n=7)	15.0 (68.2)	
Female Medical Ward	20.0 (n=1)	80.0 (n=4)	
Female Surgical Ward	14.3 (n=1)	85.7 (n=6)	
Male Surgical Ward	0.05 (n=0)	100.0 (n=2)	
Laboratory	0.0 (n=0)	100.0 (n=6)	
Paediatric	0.0 (n=0)	100.0 (n=2)	
Amenity	0.0 (n=0)	100.0 (n=2)	
Pharmacy	0.0 (n=0)	100.0 (n=1)	
Gender			0.231
Female	33.5 (n=22)	64.5 (n=40)	
Male	44.4 (n=20)	55.6 (n=25)	
Years of experience category			1.000
>20	40.0 (n=2)	60.0 (n=3)	
1-10	39.7 (n=31)	60.3 (n=47)	
11-20	37.5 (n=9)	62.5 (n=15)	
Job description			<0.001
Pharmacist	90.0 (n=9)	10.0 (n=1)	
Doctors	55.5 (n=15)	44.4 (n=12)	
Nurses	28.1 (n=18)	71.9 (n=46)	
Laboratory scientist	0.0 (n=0)	100.0 (n=6)	

3.2.7 Further Education of Healthcare Providers

The majority of the participants 50.9% (n=54) indicated that they were not ready to complete an additional questionnaire on helminth management, with 26.4% (n=28) indicating they would be prepared to complete another paper questionnaire and 21.7% (n=23) preferring it be emailed to them. Only 30.0% (n=30) of the healthcare providers indicated an interest to receive additional information on helminthic infections email, 16.8% (n=17) wanted to attend a workshop on helminthic infection compared to the 2% (n=2) who preferred to receive an information brochure.

3.3 Part Three: Cross sectional study (General public)

This part describes the questionnaires that were distributed to the general public in Birnin Kebbi metropolis including patients that visited the two biggest hospitals in Birnin Kebbi metropolis, namely Sir Yahaya Memorial Hospital and Federal Medical Centre. Of the 360 questionnaires distributed, 70% (n=277) were completed.

3.3.1 Socio-demographic Characteristics of the General Public

The majority of the study participants from the general public were females 60.6% (n=168), with the remaining 39.4% (n=109) male. The majority of the participants (86.6%; n=240) were between the ages of 19-39 years, while the remainder (13.4%; n=37) were more than forty years of age. The participants (42.2%; n=117) had some form of tertiary education, while only 9.4% (n=26) had no form of education (**Table 3.9)**. The average family monthly income of the study participants is not normally distributed with the median income was thirty thousand naira (₦30,000); where the majority (85.6%) of the study participants earned an average monthly family income between 1000-59000 naira. The number of residents living in the same house ranged between 6-10 (45.1%) with 7.6% of the participants reporting more than 15 people living in the same house (**Table 3.9)**.

3.3.2 Source of Water, Environment and Sanitation Conditions

The majority of the participants (62.8%) reported that they had access to piped water as their major source of water for drinking, while only 1.1% used rain as their main source of water for drinking (**Table 3.10)**. The majority of the general public (65.0%) in this study used flush toilets at home or residency, with 11.6% using a communal pit toilet. However, one person (1%)

mentioned plastic bag and nylon as his toilet at home **(Table 3.10).** The majority of the study participants (44.4%) used sewer pipes connected to their toilet for waste disposal, while only 1.8% used other means of toilet waste disposal. Disposal of household garbage waste included burning (40.1%) and disposal in open fields (20.6%) (**Table 3.10)**.

Table 3.9: Socio-demographic characteristics of the general public (n=277) living in Birnin Kebbi.

Item	Response	Frequency (n=277)	Percentage (%)
Ethnic group (n=277)	- Hausa	216	78.0
	- Fulani	33	11.9
	- Others	28	10.1
The highest level of education (n=277)	- Tertiary/University	117	42.2
	- Secondary	112	40.4
	- Never went to School	26	9.4
	- Primary	22	7.9
	- Others (please specify)	0	0.0
Occupation (n=277)	- Business	102	36.8
	- Student	92	33.2
	- House wife	42	15.2
	- Civil servant	37	13.4
	- No occupation	4	1.4
Average Family Income (n=277)	- 1,000 - 59,000	237	85.6
	- 60,000 - 99,000	18	6.5
	- 100,000 - 200,000	12	4.0
	- > 200,000	10	3.6
Number of Residents in the Same House Category (n=274)	- 6-10	125	45.1
	- 1-5	95	34.7
	- 11-15	33	12.0
	- >15	21	7.6

3.3.3 Personal practices of the general public participants

With regards to the personal practices by the general public participants, the majority 142 (51.3%) had good personal practices, while 48.7% (135) reportedly had poor personal practices**.**

3.3.4 Overall knowledge on helminth infections by the general public participants

Results of the general public participants' knowledge on helminth infections revealed that 66.4% (n=184) of the respondents had good knowledge about intestinal worm infections, while about 33.6% (n=93) have poor knowledge**.**

Table 3.10: Source of water, environment and sanitation conditions in the general public's houses.

Item	Response	Frequency (n)	Percentage (%)
What is the main source of water used for drinking? (n=277)	- Pipe water	174	62.8
	- Well	54	19.5
	- Others	22	8.7
	- River	24	7.9
	- Rain	3	1.1
What sort of toilet do you have at your home of residency? (n=277)	- Have a flush toilet in own home	180	65.0
	- Pit toilet – communal	32	11.6
	- No flush toilet in the house	26	9.4
	- Pit toilet on own property	22	7.9
	- No toilet in the house	15	5.4
	- Chemical toilet on own property	1	4.0
	- Other (please specify)	1	4.0
	- Chemical toilet in house	0	0.0
	- Chemical toilet – communal	0	0.0
How is the toilet waste disposed of? (n=277)	- Septic tank	123	44.4
	- Sewer pipes	109	39.4
	- Other places	40	14.4
	- Others	5	1.8
How do you dispose of household garbage waste? (n=277)	- Burning	111	40.1
	- Dispose of in open field	57	20.6
	- Disposal at city dump	44	15.9
	- Burying	37	13.4
	- Dispose of in a river	15	5.4
	- Municipality removal & disposal	11	4.0
	- Others (please specify)	2	7.0

3.3.5 Overall, Knowledge on Helminth Infections by the General Public Participants

There was no statistically significant difference (p=0.7) between the knowledge on helminth infections and gender, although the female participants had a better knowledge (67.3%) than the male participants (34.9%) (**Table 3.11)**.

Table 3.11: Distribution of overall knowledge category among the general public across different demographics.

Characteristics	Good knowledge n (%)	Poor knowledge n (%)	Chi-square value	P value
Toilet disposal			**10.227**	**0.007**
Septic tank	91 (49.5%)	32 (34.4%)		
Sewer pipes	60 (32.6%)	49 (52.7%)		
Other places	28 (15.2%)	12 (12.9%)		
Others	5 (2.7%)	0 (0.0%)		
Source of water			**12.236**	**0.037**
Pipe water	113 (61.4%)	61 (65.6%)		
Well	34 (18.5%)	20 (21.5%)		
Others	22 (12.0%)	2 (2.2%)		
River	12 (6.5%)	10 (10.8%)		
Rain	3 (1.6%)	0 (0.0%)		
Occupation			**23.577**	**<0.001**
Business	68 (66.7%)	34 (33.3%)		
Students	49 (53.3%)	43 (46.7%)		
Civil servants	37 (97.3%)	1 (2.7%)		
Housewives	29 (69.0%)	13 (31.0%)		
No occupation	2 (50.0%)	2 (50.0%)		
Garbage disposal			**35.586**	**<0.001**
Burning	66 (35.9%)	4 5(48.4%)		
Burying	36 (19.6%)	1 (1.1%)		
Dispose at city dump	34 (18.5%)	10 (10.8%)		
Disposed of in open field	26 (14.1%)	31 (33.3%)		
Dispose in a river	10 (5.4%)	5 (5.4%)		
Municipality removal and disposal	10 (5.4%)	1 (1.1%)		
Others	2 (1.1%)	0 (0.0%)		

However, there was a statistically significant difference between knowledge and occupation ($p<0.001$), with the majority of the civil servant (97.3%) possessed good knowledge in contrast to those with no occupation possessing poorer knowledge (50.0%). Another cross tabulation showed a statistically significant difference ($p=0.037$) between the knowledge of the study participants and their source of water, where 61.5% had good knowledge when using pipe water as their main water source. Similarly, there was statistically significant differences ($p<0.001$) between the knowledge and method of waste disposable, the majority (49.5%) of the study participants who had access to a septic tank for toilet waste disposal had good knowledge (**Table 3.11)**.

3.3.6 Treatment and treatment seeking behaviour by the General Public Participants

Out of the 277 general public participants, 65.3% said they have never been treated for worm infection, while 20.8% reported they had received treatment for worm infections in the past 1-5 years (**Table 3.12)**. There was a strong association between treatment seeking behaviour and knowledge of worm infections by the general public participants, where 81.9% of those with poor knowledge on helminth treatment had not been treated for intestinal worm infections ($p<0.001$).

Table 3.12: Treatment and treatment seeking behaviour.

Item	Response	Frequency (n)	Percentage (%)
Have you been on treatment for intestinal worm infections over the following? (n=277)	- <6 months	15	5.4
	- 6 – 12 months	14	5.1
	- 1 – 5 years	54	24.5
	- > 5 years	13	4.7
	- Not been treated	181	65.3
What medication did you take to eradicate worm infection? (n=277)	- Mebendazole - (Vermox®)	27	13.8
	- Albendazole - (Zentel®, Bendex®)	123	60.0
	- Piperazine – (Padax®)	3	1.5
	- Niclosamide - (Yomesan®)	16	7.8
	- Praziquantel – (Biltricide®, Cysticide®)	3	1.5
	- Cannot remember	33	16.1
	- Other (please specify):	0	0.0
If you suffer from diarrhoea or abdominal pain, what do you do? (n=277)	- Nothing	9	3.3
	- Take Traditional Medicinal plants	17	6.2
	- Go to traditional healer	50	1.8
	- Go to clinic or doctor	182	66.4
	- Go to clinic or pharmacist	61	22.3
	- Other (please specify)	0	0.0

3.3.7 Helmth incidence and management in children of the General Public Participants

The majority of the study participants 52.3% said they do not have children (**Figure 3.6**; **Table J.1)**. Out of 132 participants that mentioned they have children, 60.8% reported that their children had never had a helminth infection, while 39.2% said their children had had a helminth infection in the past. Of these, 21.4% of the children that had the infection were between 1-6 years of age; with only 3.6% of those between ages of >6-11 years (**Figure 3.6)**.

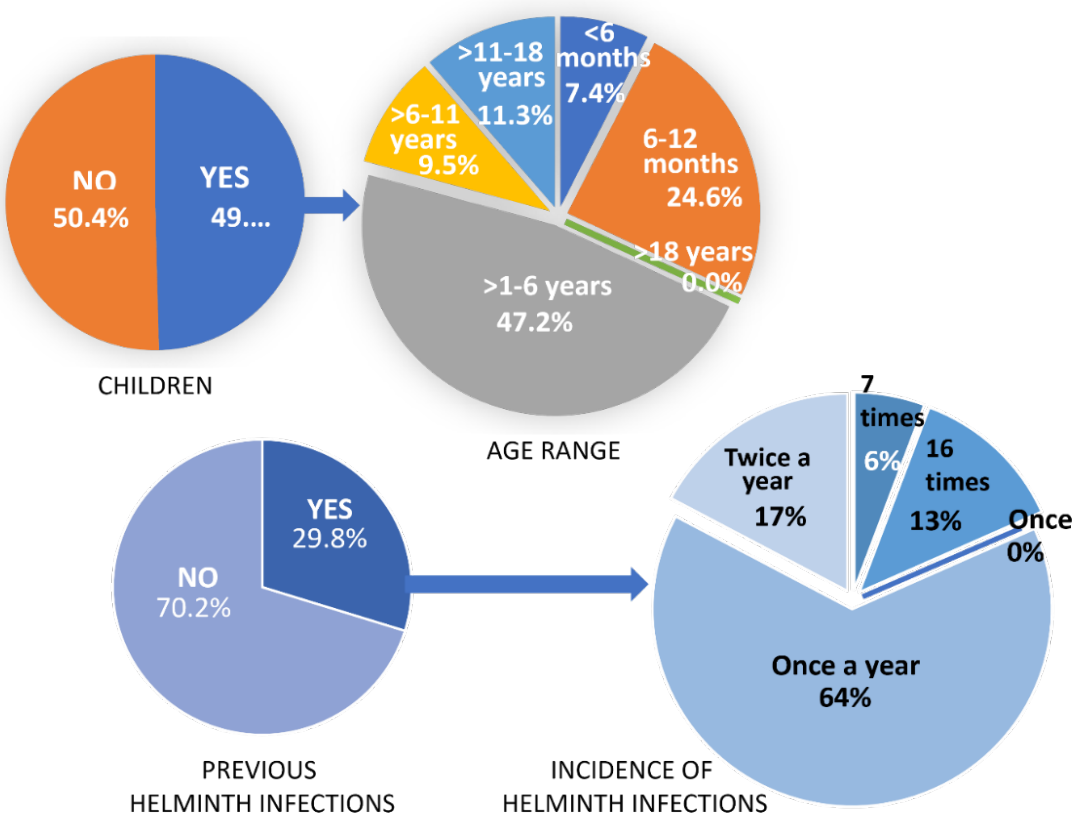

Figure 3.6: The demographics of the general public participants' children and incidence of helminth infections.

Hookworm (20.5%) was the most frequently mentioned helminth that was diagnosed (**Table 3.13)**. The 39.2% of those that reported that they have children mentioned that their children always wash their hands after defecation, while only 1.5% said their children rarely washed hands after defecation. Overall, 57.8% of those that have children prophylactically treat their children for helminth infections, with 14.1% reporting that they do not prophylactically treat their children. The majority of the parents (24.5%) only treat their children for worm infection when they recognize symptoms; whilst others only treat their children once diagnosed by a healthcare provider (13.4%) (**Table 3.13)**.

Table 3.13: Helminth diagnosis and management in the general public participant's children.

Item	Response	Frequency (n)	Percentage (%)
Who diagnosed the infection? (n=53)	- Self	10	15.1
	- Nurse	8	11.3
	- General practitioner	6	26.4
	- Clinic	14	1.9
	- Specialist	1	5.7
	- Family member	3	20.8
	- I don't remember	11	0.0
	- Other (please specify):	0	
What worm was diagnosed? (n=53)	- I don't know	8	15.1
	- Hookworm	15	28.3
	- Roundworm	8	15.1
	- Tapeworm	11	20.8
	- Pinworm	7	13.2
	- Mixed	3	5.7
	- Bilharzia	1	1.9
	- Other (please specify):	0	0.0
Do your children wash their hands after defecation? (n=132)	- Always	81	61.4
	- Sometimes	43	32.6
	- Rarely	5	3.8
	- Never	3	2.3
Do you prophylactically treat your children to prevent an infection? (n=132)	- No	30	22.7
	- Yes	102	77.3
How often do you prophylactically treat your children? (n=102)	- Every six months	72	70.6
	- Once a year	30	29.4
	- Other (please specify)	0	0.0
	- No response	0	0.0
When do you treat your child? (n=102)	- When I recognise the symptoms	47	46.1
	- Diagnosed by Healthcare Provider	28	27.5
	- When I see worms in the stool	15	14.7
	- Class mates/close relatives are infected	12	11
	- Other (please specify)	0	0.0

CHAPTER FOUR:

DISCUSSION

This study presents the prevalence of helminthic infection as well as basic knowledge of human helminthic infection among healthcare providers and the general public in Birnin Kebbi metropolis. Data from a retrospective study was complemented by the information on helminthic infection among general public as well as knowledge of helminthic reporting among healthcare providers in Birnin Kebbi metropolis.

4.1 Part One: Diagnosed helminth infections at two study sites

Overall, only 39 of the 4082 stool samples analysed were found to be positive for helminthic infection, which gave a 1% prevalence of helminthic infection the Birnin Kebbi metropolis **(Figure 3.5).** According to a meta-analysis conducted in Nigeria, there was low prevalence of helminthic infection reported in the northwestern part of the country (Kebbi state included) compared to other parts of the country (Karshima, 2018a). This may have been due to the difference in environmental condition like rainfall, temperature, humidity moisture of the soil, that encourage the development of parasitic eggs (Oyeyemi and Okunlola, 2023). However, the rate of intestinal parasitic infection is high (85%) in sub-Saharan Africa affecting mostly school age children (6-12 years) (Zeynudin et al., 2022). The findings from this study of the low 1% prevalence of helminths **(Figure 3.5)** could be attributed to: firstly, poor record keeping from the study hospitals, secondly variable techniques and skill set/training used to culture the stool resulting in inaccurate diagnosis and thirdly, once the patient has visited a clinic or healthcare provider outside of the two study sites and a diagnosis made, a laboratory test may not have been requested (Khurana and Sethi, 2017). Another factor that may influence the low prevalence of helminthic infection in this study is the fact that STHs thrive less in places with good personal practices (Akinsanya et al., 2021) which is what was obtained in part 3 of this study. Furthermore, direct saline technique was used to diagnosed helminthic infections in both the study hospitals, which is not the gold standard diagnostic technique according to WHO, it has low sensitivity especially in areas with low intensity infections which will lead to underdiagnosis of helminths (Jember, 2015).

The highest prevalence of helminth infection (32.3%) was recorded in 2015 **(Figure 3.4).** However, no government programme was implemented, in view of this it may have been due to a poor reporting system in the state, more over helminthic infections are not a notifiable disease

in the Kebbi state. Year 2020 recorded low analysis stool for helminthic infection (3.2%) **(Figure 3.4)**, where the COVID-19 pandemic present during this period resulted in the closure of some parts of the hospital, low turnover of the patients visiting the hospitals which negatively impacted on the healthcare of individuals including helminthic infection reporting (Akinsanya et al., 2021). The majority of hospital resources that were meant to go for other diseases were diverted to manage the COVID-19 pandemic, which could have adversely affected the protocol followed with non-COVID-19 infected patients.

In this study, hookworms were the most frequently (59.0%) isolated helminth from the stool samples (Table 3.1). Hookworm name was gotten from the participant's records/file, as all the other species were written in Latin names. This is similar to that reported by the general public participants in Part 3 of this study when the helminths were diagnosed in their children (Table 3.12). Similarly, hookworm was more prominent (1.8-fold) over roundworm infections (18.8%) as reported in a retrospective study on prevalence of intestinal parasitic infection in Tanzania and Ghana (Table 3.1) (Mazigo et al., 2010; Adu-Gyasi et al., 2018). However, this differs from the studies conducted in southwest Ethiopia and India where Ascaris lumbricoides (roundworm) was found to be the most prevalent STHs among school aged children (Tefera et al., 2017; Salam and Azam, 2017). Hookworm infection is a major cause of morbidity around the world and is associated with 246,000 lives (Akinsanya, 2021; Byrne et al., 2021). The most serious effect of hookworm infections is the iron deficiency anaemia that is caused by blood loss as the helminth feeds from its human host, along with malnutrition and impaired physical growth (WHO, 2023e). According to the WHO, taeniasis is the leading cause of death from food-borne diseases leading to 2.8 million disability adjusted life years (WHO, 2022). Neurocysticercosis caused by *T. solium* is the most common cause of adult-onset epilepsy, as well as the common cause of preventable parasitic infection of the nervous system in humans (WHO, 2022). Although there is low prevalence of helminthic infection in this study, the government needs to do more to prevent the devastating effect of human helminthic infection caused by hookworm and taeniasis.

The majority of the patient's stool samples that were analysed across the two hospitals were from males, this is similar to the findings in Karachi Pakistan **(Figure 3.2)** (Arshad et al., 2019). However, research done in Guyana on prevalence of helminthic infection showed female were more infected than males (Wrights et al., 2015). The incidence of helminth infections in the different gender groups may be due to the fact that males are more engaged in outdoor activities such as fishing and go to the rivers bare footed where they are more prone to be infected with helminthic infection (Kache et al., 2020). Alternatively, females did not seek medical assistance

and self-managed those infections affected genital parts like STHs and sexually transmitted infections. It is therefore recommended to engage more female healthcare providers to attend to the diseases that affect females to increase the number of women attending the hospital to obtain appropriate therapy and education on how to prevent and manage these infections (Wharton-Smith, 2019). The occurrence of more infections in the youngest age group of 1-10 years **(Figure 3.3)** matches most literature from other countries and warnings from the WHO to protect this group of sensitive group (Gebreyohanns et al., 2018;WHO, 2023).

4.2 Cross-sectional studies (Healthcare providers).

4.2.1: Socio-demographic characteristics

There was a high return response of 71.3% of the distributed questionnaires, which afforded statistical analysis of the collected data (Ali et al., 2021). The majority of respondents were from the Federal Medical Centre as this is largely due to more healthcare providers employed at the Federal Medical Centre as it has a larger bed capacity compared to the Sir Yahaya Memorial Hospital. The majority of the respondents were females, this may be due to: firstly, there are more female nurses than male nurses **(Table 3.1)** and secondly, there are more female healthcare workers than male in both of these study sites (Personal communication: Matrons). Although not always the trend in reported studies and the working environment, the norm is that there is a larger number of female nurses on staff (Acka et al., 2010; Nasr et al., 2013a). Furthermore, there was a statistically significant difference between the gender and occupations of the study participants, where the majority were male doctors (74.1%), while only 29.7% of the nurses were male ($p<0.001$) **(Table 3.2)**.

4.2.1 Knowledge of the participants on common symptoms of helminths, preventive measures and treatment of helminths

Even though there was a low prevalence of hookworm in this study **(Figure 3.4),** hookworm (50.6%) and *Ascaris* (37.3%) were the most frequently mentioned helminths among the healthcare providers **(Table 3.3).** Hence future research should not focus on prevalence, but rather on the socio-ecological and exposure to risk factors associated with helminthic infection. Many of the healthcare providers mentioned abdominal pain (56.1%) and diarrhoea (48.6%) as the main symptoms of helminthic infection, this is similar to the study conducted in Burundi on the capacity gaps in healthcare facilities for the management of helminthic infection and schistosomiasis (Bizimana et al., 2018). Most of the participants (82.2%) mentioned

environmental sanitation as the best way to prevent helminthic infection. However, there is poor knowledge of the correct regimen of prophylactic treatment of helminth among study participants, with only 22.4% of the respondents having good knowledge about management of helminths. This is similar to the study on knowledge attitude and practice of women and healthcare workers regarding routine deworming (Dayananda et al., 2020). WHO published a guideline in 2017 regarding preventive chemotherapy of helminths, the guideline stated that there should be mass drug administration to all individuals at risk of morbidity caused by helminthic infection (Savioli et al., 2018). It is therefore imperative for healthcare providers to know the correct regimen of prophylactic treatment of helminths.

4.2.2 Overall knowledge of healthcare providers on helminths

Overall, 67.9% of the healthcare providers that participated in the study had poor knowledge of management of helminthic infections **(Figure 3.7)**. This is in line with that was reported in Ibadan, Nigeria that showed healthcare workers had poor knowledge of helminthic infection (37%) (Emeto, 2021). This decreased knowledge may be attributed to the low prevalence of helminthic infection in Northwestern Nigeria, though the overall prevalence remains high in Nigeria (Karshima, 2018). Pharmacists (90s%) and doctors (55.6%) had good knowledge on the management of helminthic infections, while 71.9% and 100% of nurses and laboratory scientists, respectively, had poor knowledge ($p<0.001$) (**Table 3.9**). Good knowledge recorded for doctors and pharmacists was as a result of doctors being the ones that usually diagnosed and prescribed anthelminthic medications for the patient in the hospital, while pharmacists are the ones that usually dispense the anthelminthic drugs to the patient and it is imperative that they know how to diagnose infection and the appropriate management regimens. This is in line with the study conducted in other countries with high helminth infections such as Brazil, where the regimens in the Brazilian Family Health Strategy and management of intestinal parasitic infections was investigated. The poor knowledge recorded for the nurses is as result of most of the nurses that participated in the study were in the Obstetric Ward **(Table 3.9)** where it is not likely for patients with helminthic infection to be admitted. The majority of the nurses with good knowledge were in Outpatient Department **(Table 3.9),** where most of the patient that visited the hospital with suspected helminthic infection are seen and given medications.

The study showed poor knowledge of the healthcare providers (67.9%) in the management of helminthic infection, where many did not mention 50% of the symptoms of helminthic infections such as abdominal discomfort, anaemia and growth retardation **(Table 3.4);** whilst others did not

mention the correct ways of diagnosis of helminthic infections (Table 3.5). This is of concern as it is the responsibility of healthcare providers to educate the general public on how to recognise and manage a helminth infection implementing optimal non-pharmacological as well pharmacological treatment/prophylactic measure to ensure eradication of the infection as well as limit/prevent the spread of helminth infections. Lack of knowledge by healthcare providers can result in increased burden of disease, as well as the inappropriate administration of the drug resulting in adverse effects in the patient and the development of drug resistance by the helminth. This study clearly indicates the need for proper enlightenment and education of healthcare providers on the management of helmintic and other neglected tropical diseases. Despite some progress made in many low-income countries concerning helminthic infection eradication, lack of skills and knowledge to identify and manage human helminthic infections have contributed to the continued and rising numbers of helminth-infected people (Emeto, 2021). Therefore, periodic training and continued education on the parasitological and pharmacological knowledge of human helminthic infections is required for proper management of these diseases.

4.3. Part 3: Cross sectional (General public)

4.3.1 Socio-demographic characteristics

Two-thirds of the participants from the general public were female (60.6%) as it was observed that those who visited the study hospitals were in fact females (**Table 3.10**). Traditionally in Birnin Kebbi metropolis, females are the ones that visit hospitals more especially because they are the ones that take children to the hospital when they are sick, it may also be as a result of poor health seeking behaviour that is found in most African societies (Sacolo-Gwebu, 2019). This trend differs from a study conducted in Ibadan, Western Nigeria where 61.8% of the caregivers were males, (Oyebamiji et al., 2018). Almost half of the general public participants (42.2%) that participated in this study had a tertiary education as their highest level of education (**Table 3.10**), as this may be as a result of hospital visits being more common with people with higher level of education. Of the participants visiting these two study sites, 86.6% where within the age category of 18-39 years (**Table 3.10**). This may be due to the fact that those within this age range are of reproductive age group and therefore are the one that will take their children to hospital.

The WHO reports that certain living conditions can promote the occurrence and spread of helminth infections, includes low monthly income, people living in the house and method of sewage waste disposal (WHO, 2023; Bhutta et al., 2014). These conditions were met in this study i.e. a low average monthly income between ₦1000-₦59,000 which is just above the minimum

wage in Nigeria. On average 65.2% of the households had more than five people in a dwelling which can rapidly increase the rate at which an infection is spread (**Table 3.10**) (Tembo, 2019), especially if 34.3% of household do not have a flush or chemical based toilet to reduce the spread of eggs into the communal soil (**Table 3.11**) (Gebru, 2023). One of the ways forward to reduce the burden of helminthic infection globally is to improve the standard of living of the people (WHO 2023).

Although overall there was a low 1% incidence of helminths detected in the two study sites over the past 7 years (**Figure 3.4)**, This was not a good representative figure of the true number of infections that occurred in the Birnin Kebbi community. Parents or guardians who participated in this study indicated that 32.4% of their children had been infected more than one infection over the past five years, with 17.9% not seeking advice at a clinic/doctor/pharmacist, but home-diagnosing their infection (Table 3.13). Diagnosing an infection is routine for mothers or relatives who have had children or siblings with the same infection diagnosed by a clinic, and in order to save costs on traveling to the clinic and the healthcare professional, they obtain the anthelmintic drugs such albendazole (Zentel™) or mebendazole (Vermox®) from the pharmacy as it is scheduled as a S1, over-the-counter drug. A more accurate figure of infections could have been obtained if the number of anthelmintic drugs sold in the Birnin Kebbi metropolis was obtained to see how this correlates with the reported numbers. In South Africa in 2018, STHs infection became a notificable disease (NICD, 2021). Due to under-reporting of the disease by healthcare workers, STH disease burden has been proven difficult to quantify in Nigeria (Emeto, 2021). It will therefore be important if the Nigerian government classified helminthic infection as a notifiable disease in order to improve the accuracy of reporting of helminthic infection.

The majority of the healthcare provider's respondents had 1-10 years of work experience 78 (72.98%), further analysis shows that most of the respondents that have greater than 20 years of work experience were nurses 5 (7.8%) compared to other healthcare provider's cadre though not statistically significant (p=0.176) (Table 3.2).

4.3.2 Knowledge and Practices of General Public Participants on Helminthic Infection

When assessing the knowledge and personal practices of the general public participants on human helminthic infection, participants were asked about personal practices such as washing hands before eating, using soap when washing hands, using antiseptic soap when washing hands, washing fruits, vegetables before eating **(Table 3.12**). After computing the median score of

personal practice of the general public participants, just over half (51%) were found to have a good personal practice, as reported in a similar Bangladesh study (56.9%) (**Figure 3.19**) (Nath et al., 2018). However, this outcome differed from a Thailand study that reported 66.49% of the participants to have poor personal practices attributing to open defecation and nail-biting behaviours (Narkkul, 2022). There was a statistically significant difference between personal practice of the study participants and their level of education, with 73% of participants with no schooling having poor practice; while 49.3% of participants with tertiary education had good practice ($p=0.013$). This is in line with a similar Indonesian study that reported on an improvement in good personal practice as the level of education improved ($p<0.001$) (Lee, 2023). About 1% of the general public participants used municipality waste disposal which showed strong association between knowledge of helminth and garbage disposal ($p<0.001$) (**Table 3.10**). The high prevalence of helminths occurrence and infections is known to be associated with poor environmental and personal hygiene (Ramayanti and Ghiffari, 2019). The optimal way to decrease human helminthic infection is to; firstly, the government should do periodic preventive treatment with albendazole; secondly, health hygiene and education should be frequently provided to the general public and thirdly, there should be provision of clean drinking water and adequate sanitation (WHO 2023). More than 81% of the general public participants used either septic tank or sewer tank as means of toilet disposal **(Table 3.10),** which was a good personal practice according to the criteria set by the WHO (WHO 2023). More than 60% of the public participants used pipe water as their major source of water for drinking, there was a strong association between water source used for drinking and prevalence of helminthic infection, with those with using the river as their water source having a higher prevalence of infection compared to those with piped water (Benjamin, 2022). The high level of good personal practice recorded in this study may have contributed to the low prevalence of helminthic infections found in Birnin Kebbi metropolis. More than half of the general public participants (56.4%) reported that they have not been treated for helminthic infection **(Table 3.13)**, this is similar to the study that was conducted in eastern Cameroon that reported 57.1% not being treated (Ongbassomben, 2021). Although the majority of the general public participants reported having a helminth infection, most of them could not describe what intestinal helminths are and only a few could give examples of helminths **(Table 3.13**). The positive outcome was that the majority of the general public participants (81.2%) know that helminths are harmful to human beings, which can be used to further educate the community to increase awareness and reduce the infection occurrences. Interestingly 56.4% of the general public participants reported not ever being treated for a

helminth infection, it may be as a result of lack of symptoms and signs associated with helminthic infection or that they suffered from infections of light intensity that does not warrant them to report to the hospital. About two-thirds of the study participants from the general public mentioned albendazole as the medication they take when they have worm infestation **(Table 3.15).** This may be a serious problem in the management and elimination of helminthic infection in Nigeria, as it may cause resistance to the drug due to lack of knowledge about correct dosage as well as repeated exposure to the drug (Orr, 2019). From the current study, majority of the participants from the general public (73.5%) had good knowledge, followed by primary school (63.6%), then secondary school (61.6%); while most of the participants with poor knowledge (42.5%) had no schooling at all. However, these observations were not statistically significant ($p=0.19$). Overall, the majority of the study participants (66.4%) from the general public showed poor knowledge about the types of helminths, source of helminthic infection, names of helminths and ways of preventing helminths (**Table 3.12**). This outcome is similar to the rural Malaysian study in which participants were found to have a low level of awareness (29.3%) about symptoms, ways of prevention and transmission (Nasr et al., 2013b). However, in the latter study, it was found that those participants with a higher level of education had a better knowledge of helminths ($p<0.001$) (Nasr et al., 2013b). Similarly, a Brazilian study found that their participants had a high level of knowledge on symptoms of helminthic infections and preventive measures, where they reported the participants had a high school level of education (de Moraes Neto et al., 2010).

This may also have been due to follow up visits by the Brazilian Department of Health, non-governmental organisations and academic institutions on implementing the WHO guideline in health education programmes to reduce incidence of helminthic infections in areas with high prevalence of the disease (Celestino, 2021). Despite Nigeria being endemic for STHs (Oyeyemi, 2023), there is no national school based STHs or parasitic programme in place. There is not much data about the demography of helminthic infection to help guide the development of a school health programme that is necessary for the sustainable control of helminthic infection in school children (NCDC, 2017).

In the contrast, the study conducted in western Côte d'Ivoire there was no significant association between the level of education of the study participants and knowledge of helminthic infection (Acka et al., 2010). However, the location of the studies could have greatly impacted these contrasting findings, where the current study and Malaysian study were conducted in cities and western Côte d'Ivoire was undertaken in a rural setting.

Based on this it is apparent and widely accepted that by improving the level of education in the

community there should be a significant increase in the level of awareness about: ways of contracting helminths, preventing measures, signs and symptoms of helminthic infection. The current study also showed a significant association between knowledge of helminthic infections and average family monthly income of the study participants, majority (91.7%) with monthly income between ₦1000-₦59,000 have poor knowledge of helminthic infection while those with family monthly income of ≥₦200,000 have better knowledge of helminthic infection. Helminthic infection is one of the diseases associated with poverty (infectious disease of poverty) and it is reported to have high prevalence among poor people (WHO 2023). It has been estimated that helminthic infections affect 1 billion people globally, mostly in sub-Saharan Africa including Nigeria (Bhutta et al., 2014). According to Nigerian National Bureau of Statistics 2022 report, Kebbi state is among the top 10 poorest state in Nigeria with more than 82% of the population being poor (PUNCH, 2023) and this has a massive impact towards elimination of helminthic infection.

4.3.3 Treatment Seeking Behaviour of the General Public Participants

The WHO advocates for the use of anthelminthic drugs for the prevention and treatment of human helminthic infection in order to lower the burden of the disease in the community (WHO, 2023; Edelduok et al., 2013). Intermittent preventive therapy with albendazole is found to be effective and beneficial in the management of human helminthic infections (Olds, 2013). This method of therapeutics has its pros and cons. An advantage is that the occurrence of infections and economic benefits are favourable, however if the preventative drugs are taken inappropriately there is a risk of the development of resistance by the helminth which could jeopardise the community (Orr, 2019). In this study, 65.3% of the general public participants had never been treated for helminthic infection; however, for those who had been treated in the past 1-5 years, there was a strong correlation between the periodic helminth treatment and the participant's poor knowledge of helminthic infections ($p<0.001$) (**Table 3.15**).

A positive observation of this study was that 66.4% of the general public participants go to a clinic/medical doctor/pharmacist when they experience symptoms such as diarrhoea and abdominal pain **(Table 3.14**). this is in line with a similar study conducted in Kenya on KAP among parents of preschool aged children where the majority of the participants (four-fifths) preferred going to government health facility to seek for treatment of helminthic infection rather than taking traditional medication or going to a chemist (Masaku et al., 2017). Interestingly two thirds of the general public participants that had helminth infections treated, mentioned albendazole

as the drug they take to eradicate these helminths which is in line with the WHO recommendations (Tee et al., 2022; WHO, 2023). In contrast, mebendazole was only mentioned to be used by 13.8% of the general public participants (Table 3.12). The use of albendazole has been shown to have superior cure rates and egg reduction rates compared to mebendazole; where albendazole administered at a 6-monthly interval was more effective than various mebendazole regimens and may be the best choice in the control of the 3 geohelminths, *A. lumbricoides*, hookworm and *T. trichiura* (Muchiri, 2001).

4.3.4 Treatment of Helminths/Preventive chemotherapy

Albendazole (400mg) and mebendazole (500mg) are recommended drugs used for the treatment of STH infections (WHO 2023), with two-thirds of the study participants mentioning albendazole as the drug they took when they had worm infections **(Table 3.14)**. This is in line with a study conducted in Jos Nigeria that reported that more than 70% of the study participants knew about the correct drug regimen for treating helminthic infection (Jimam, 2013). This may be as a result of albendazole being an over-the-counter drug. Although the drug may be an appropriate effective medication for most of the helminths, it may however be a dangerous practice by public participants. Firstly, because albendazole may not be drug of choice for some helminthic infection such as *Strongloides stercoralis* in which ivermectin is the drug of choice (WHO 2023) and secondly there is high risk of resistance to albendazole which is an emerging trend due to in proper dosage or correct regimen (Furtado, 2016). In terms of preventive chemotherapy of the helminths 22% of the healthcare providers mentioned the correct regimens according to national guidelines for the preventive chemotherapy of the helminths **(Table 3.7)** (NCDC, 2017). This may be due to the absence of periodic trainings to healthcare providers on the management of helminthic diseases in Nigeria.

From this first study undertaken in Birnin Kebbi to determine the occurrence, knowledge, and management of human helminthic infections, the prevalence of helminthic infection was found to be low at 1% based on the stool samples from the two study sites, Sir Yahaya Memorial Hospital and Federal Medical Centre. The study showed that knowledge on how to manage intestinal helminths was generally poor among the healthcare providers across the two major hospitals in Birnin Kebbi metropolis. To compound this there was generally poor knowledge of common helminths among the general public, with low level of awareness of symptoms, poor practice and preventive measures.

CHAPTER FIVE:

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

Despite several challenges encountered to complete this study, it revealed inadequate knowledge of helminthic infections among the general public and healthcare providers. Poor knowledge of healthcare providers in management of helminthic infection is part of the challenges that made STH infections difficult to eliminate. These findings provide key evidence that there is need for proper health education and policy development on management of helminthic infection. Unfortunately, the governments' support towards elimination of neglected tropical diseases has been poor in the developing countries, such as Nigeria. According to the WHO all pre-school and school aged children, as well as pregnant adolescents and women of reproductive age groups in helminth endemic areas should receive regular anthelmintic prophylaxis with albendazole and/or mebendazole for STHs and praziquantel for schistosomiasis. However, as of 2019 only 23% of pregnant women from areas endemic for helminthic infection received tablets. The prevalence of helminthic infections reported in this study was low 39 (1%) at the two study sites in Birnin Kebbi metropolis in seven years, this may be due to techniques used and staff skill to diagnose accurately training in the developing countries to diagnose helminthic infection, which has always been a major challenge, that has relatively low sensitivity in some areas or as a result of WHO global programs on preventive chemotherapy that targets pre-school and school age children. The annual trend of the helminthic infections in Birnin Kebbi showed a 41% prevalence in the year 2015 with no positive sample recorded in the year 2017 and 2018, but increased in later years. Hookworms (*Ancylostoma duodenale*, *Necator americanus*) (59%) were the most isolated helminths from this study which is in line with the global trend of prevalence of helminthiasis (WHO 2023).

Both healthcare providers and the general public were recorded to have poor knowledge of helminthic infections in this study; The general public participants (51.3%) had good personal practices to avoid helminth infections, especially those participants who had a higher level of education (tertiary and secondary) compared to those who had no schooling, which may have contributed to the low prevalence of helminthic infection recorded in this study. It further

strengthens the need for proper health education as a means of reducing the burden of helminthic infection. Another high priority for the government is to fund similar and related research on human helminthic infection considering very little research was done on helminthic infection in this part of the country, it will further provide more knowledge about the prevalence of helminthic infection. Of concern is the repurposing of albendazole, mebendazole and ivermectin as anticancer drugs and mosquitocidal agents and the potential of expanding the resistance profile to the helminths for which they were initially intended (Chai, 2021; Furtado, 2016). In recent years there has been minimal drug discovery targeting helminths (Partridge, 2020). As such these drugs need to be passively guarded to eradicate helminths in the third world countries where they are desperately needed to ensure community health and to assist each household and the country's economic development (Ng'etich, 2024.)

5.1 Limitations of the study

5.1.1 Part One: Retrospective

The main limitation of the retrospective study was that both hospitals had poor record keeping; where all the records were not digitally stored, resulting in some data that are missing from the years captured in this study. The lack of standard reporting of the species of the infection affected accurate reporting to influence educational programmes needed. Method of diagnosis of helminths is a limitation that is common to both study hospitals, as both the hospitals are not using diagnostic technique (Kato-katz method) that was recommended by WHO, but rather uses direct saline method which has low sensitivity for helminth identification. PCR generally would have found more hookworm and Strongyloides infections than any microscopic method currently employed.

5.1.2 Part Two: Cross sectional (Healthcare Providers)

Distribution of the questionnaires to the healthcare providers was extremely difficult because of some restrictions in the study hospitals due COVID-19 pandemic. The question about diagnostic methods omitted microscopy, the usual way to detect stool parasites.

5.1.3 Part Three: Cross sectional (General Public)

For the general public, some of the study participants were not literate, therefore the questions

have to be translated to their local language, there are scientific words which are difficult to translate exactly into the local language. Another limitation is that the questionnaire used was adapted from a similar study in Malaysia, which may have some cultural differences with our community.

5.2 Recommendations for future research:

This is the first research on the occurrence knowledge and management of human helminthic infection in Birnin Kebbi metropolis; it is therefore recommended for any future research on helminths to focus on the control programmes available to eliminate helminthic infections in Birnin Kebbi metropolis. In addition, standard guidelines for the treatment of helminths need to be issued by the Nigerian Department of Health and the logistics of registering STHs infections as a notifiable disease. Another recommendation is to focus on introducing programmes that will educate the healthcare providers as well as the general public on the management of helminthic infections and to assess the impact of these programmes**.**

CHAPTER SIX:

REFERENCES

Acka, C. A., Raso, G., G'goran, E. K., Tschannen, A. B., Bogoch, I. I., Séraphin, E., Tanner, M., Obrist, B. & Utzinger, J. 2010. Parasitic Worms: Knowledge, Attitudes, and Practices in Western Côte d'Ivoire with Implications for Integrated Control. *Public Library of Science Neglected Tropical Diseases*, 4(12), p.e910

Adu-gyasi, D., Asante, K. P., Frempong, M. T., Gyasi, D. K., Iddrisu, l. F., Ankrah, l., Dosoo, D., Adeniji, E., Agyei, O. & Gyaase, S. 2018. Epidemiology of soil transmitted Helminth infections in the middle-belt of Ghana, Africa. *Parasite Epidemiology and Control*, 3(3), p.e00071.

Akinsanya, B., Taiwo, A., Adedamola, M. & Okonofua, C. 2021. An investigation on the epidemiology and risk factors associated with soil-transmitted helminth infections in Ijebu East Local Government Area, Ogun State, Nigeria. *Scientific African*, 12(1), p.e00757.

Ali, F., Ciftci, O., Nanu, l., Cobanoglu, C. & Ryu, K. 2021. Response rates in hospitality research: an overview of current practice and suggestions for future research. *Cornell Hospitality Quarterly,* 62**,** pp.105-120.

Al-Naseri, A., Al-Absi, S., El Ridi, R. & Mahana, N. 2021. A comprehensive and critical overview of schistosomiasis vaccine candidates. *Journal of Parasitic Diseases*, 45, pp.557-580

Aula, O. P., et al. (2021). "Schistosomiasis with a Focus on Africa." *Tropical Medicine and Infectious Disease **6**(3): 109.*

Becker, S.L., Liwanag, H.J., Snyder, J.S., Akogun, O., Belizario Jr, V., Freeman, M.C., Gyorkos, T.W., Imtiaz, R., Keiser, J., Krolewiecki, A. and Levecke, B., 2018. Toward the 2020 goal of soil-transmitted helminthiasis control and elimination. *Public Library of Science Neglected Tropical Diseases*, 12(8), p.e0006606.

Belay, D. G., Kibret, A. A., Diress, M., Gela, Y. Y., Sinamaw, D., Simegn, W., Andualem, A. A., Seid, A. M., Bitew, D. A., Seid, M. A., Eshetu, H. B., Jemere, T. D., Shiferaw, Y. F., Shibabaw, Y. Y. & CHILOT, D. 2022. Deworming among preschool age children in sub-Saharan Africa: pooled prevalence and multi-level analysis. *Tropical Medicine and Health,* 50 (1)**,** 74.

Buchanan, J. A., Oyer, R. J., Patel, N. R., Jacquet, G. A., Bornikova, L., Thienelt, C., Shriver, D. A., Shockley, L. W., Wilson, M. L., Hurlbut, K. M. & Lavonas, E. J. 2010. A confirmed case of agranulocytosis after use of cocaine contaminated with levamisole. *Journal of Medical Toxicology,* 6(2) p.160-4.

Brinkhoff, T. 2022. City Population: Birnin Kebbi. Accessed 2 March 2024. 20https://www.citypopulation.de/en/nigeria/admin/kebbi/NGA022006 birnin kebbi/

Byrne, A., Manalo, G., Clarke, N. E. & Vaz Nery, S. 2021. Impact of *hookworm* infection and preventive chemotherapy on haemoglobin in non-pregnant populations. *Tropical Medicine & International Health*, 26(12), pp.1568-1592.

Canga, A. G., Prieto, A. M. S., Liébana, M. J. D., Martínez, N. F., Vega, M. S. & Vieitez, j. J. G. 2008. The pharmacokinetics and interactions of ivermectin in humans—a mini-review. *The American Association of Pharmaceutical Scientists Journal*, 10, p.42-46.

CDC. 2022. Parasite- Soil-transmitted helminths [Online]. CDC. Available: https://www.cdc.gov/parasites/sth/ [Accessed 03/02/ 2024].

CDC. 2019. Life cycle of schistosomiasis [Online]. Available: https://www.cdc.gov/dpdx/schistosomiasis/modules/Schistomes_LifeCycle_lg.jpg [Accessed 28/04/ 2019].

Ceballos, l., Krolewiecki, A., Juárez, M., Moreno, l., Schaer, F., Alvarez, l. I., Cimino, R., Walson, J. & Lanusse, C. E. 2018. Assessment of serum pharmacokinetics and urinary excretion of albendazole and its metabolites in human volunteers. *Public Library of Science Neglected Tropical Diseases*, 12, p.e0005945.

Chaccour, C., Hammann, F. & Rabinovich, N. R. 2017. Ivermectin to reduce malaria transmission I. Pharmacokinetic and pharmacodynamic considerations regarding efficacy and safety. *Malaria Journal,* 16(1), p.161.

Chai, J.-Y. 2013. Praziquantel treatment in trematode and cestode infections: an update. *Infection & Chemotherapy*, 45(1), p.32-43.

Chala, B. 2013. A retrospective analysis of the results of a five-year (2005–2009) parasitological examination for common intestinal parasites from bale-Robe Health Centre, Robe Town, Southeastern Ethiopia. *International Scholarly Research Notices*, 2013, p.694731.

Chatterjee, S. & Nutman, T. B. 2015. Helminth-Induced Immune Regulation: Implications for Immune Responses to Tuberculosis. *Public Library of Science Pathogens*, 11(1), p.e1004582.

Chen, W., Mook, R. A., Premont, R. T. & Wang, J. 2018. Niclosamide: Beyond an antihelminthic drug. *Cellular Signalling*, 41, pp.89-96.

Chidi, O. J., Joseph, E. & Frank, O. I. 2023. Prevalence, Pattern and Risk Factors of Soil Transmitted Helminth Infections amongst Children in a Tertiary Institution in South East, Nigeria. *Open Journal of Gastroenterology*, 13(8), pp.267-277.

Chong, N.S., Hardwick, R.J., Smith, S.R., Truscott, J.E. and Anderson, R.M., 2022. A prevalence-based transmission model for the study of the epidemiology and control of soil-transmitted helminthiasis. *Public Library of Science One*, 17(8), p.e0272600.

Chosidow, A. & Gendrel, d. 2016. Tolérance de l'ivermectineorale chez l'enfant. *Archives de P Diatrie,* (23)2, pp.204-209.

Cioli, P. & Pica-Mattoccia, L. 2003. Praziquantel. *Parasitology Research* 90, p.S3–S9.

Cioli, D., Pica-Mattoccia, l., Basso, A. & Guidi, A. 2014. Schistosomiasis control: praziquantel forever? *Molecular and Biochemical Parasitology*, 195(1), pp.23-29.

Clarke, N. E., Clements, A. C., Doi, S. A., Wang, D., Campbell, S. J., Gray, D. & Nery, S. V. 2017. Differential effect of mass deworming and targeted deworming for soil-transmitted helminth control in children: a systematic review and meta-analysis. *The Lancet*, 389(10066), pp.287-297.

Colley, D. G., Bustinduy, A. L., Secor, W. E. & King, C. H. 2014. Human schistosomiasis. *The Lancet,* 383(9936), pp.2253-2264.

Coulibaly, T. T., Panic, G., Silué, K. D., Kovač, J., Hattendorf, J. & Keiser, J. 2017. Efficacy and safety of praziquantel in preschool-aged and school-aged children infected with *Schistosoma mansoni*: a randomised controlled, parallel-group, dose-ranging, phase 2 trial. *The Lancet Global Health,* 5(7), pp.688-698.

Dayan, A. D. 2003. Albendazole, mebendazole and praziquantel. Review of non-clinical toxicity and pharmacokinetics. *Acta Tropica,* 86(2-3)**,** pp.141-59.

De Moraes Neto, A. H., Pereira, A. P., Alencar Mde, F., Souza, P. R., Jr., Dias, R. C., Fonseca, J. G., Santos, C. P. & Almeida, J. C. 2010. Prevalence of intestinal parasites versus knowledge, attitudes, and practices of inhabitants of low-income communities of Campos dos Goytacazes, Rio de Janeiro State, Brazil. *Parasitology Research*, 107, pp.295-307.

Degarege, A., Veledar, E., Degarege, D., Erko, B., Nacher, M. & Madhivanan, P. 2016. *Plasmodium falciparum* and soil-transmitted helminth co-infections among children in sub-Saharan Africa: a systematic review and meta-analysis. *Parasites & Vectors*, 9, p.1-10.

Del Rosso, J. Q. 2017. Topical Ivermectin: Data Supporting Dual Modes of Action in Rosacea. *The Journal of Clinical and Aesthetic Dermatology*, 10(9), p.39-42.

Doenhoff, M. J., Cioli, D. & Utzinger, J. 2008. Praziquantel: mechanisms of action, resistance and new derivatives for schistosomiasis. *Current Opinion in Infectious Diseases*, 21(6), 659-667.

Downs, J. A. & Fitzgerald, D. W. 2016. No more neglect of helminths and HIV. *The Lancet*, 388(10054), pp.1857-1859.

Dowu, O. A., Babalola, A. S. & Olapegba, T. 2022. Prevalence of soil-transmitted helminth infection among children under 2 years from urban and rural settings in Ogun state, Nigeria: implication for control strategy. *Egyptian Paediatric Association Gazette*, 70, pp.1-7.

Draugalis, J. R., Coons, S. J. & Plaza, C. M. 2008. Best practices for survey research reports: a synopsis for authors and reviewers. *American Journal of Pharmaceutical Education*, 72(1), p.11.

Dunn, J.C., Turner, H.C., Tun, A., Anderson, R.M. 2016. Epidemiological surveys of, and research on, soil-transmitted helminths in Southeast Asia: a systematic review. *Parasites & Vectors*, 9(1), pp.1-13

Edelduok, E., Eke, F., Evelyn, N., Atama, C. & Eyo, J. 2013. Efficacy of a single dose albendazole chemotherapy on human intestinal helminthiasis among school children in selected rural tropical communities. *Annals of Tropical Medicine and Public Health*, 6(4), p.413.

Education, Department of Basic Education. 2021. National School Deworming Programme [Online]. South Africa: Department of Basic Education. Available: https://www.education.gov.za/Programmes/DewormingProgramme.aspx [Accessed 28/02/ 2024].

Ekelozie, I.S., Obeagu, E.I., Ochiabuto, O.M.T.B. and Udunma, O.C., 2018. *Hookworm* Infestation amongst Primary School Children in Enugu. *Annals of Clinical and Laboratory Research*, 6(1), p.227.

Evans, E. E. & Siedner, M. J. 2017. Tropical Parasitic Infections in Individuals Infected with HIV. *Current Tropical Medicine Reports*, 4, pp.268-280.

Fissiha, W. & Kinde, M. Z. 2021. Anthelmintic resistance and its mechanism: a review. *Infection and Drug Resistance,* 14**,** 5403-5410.

Eze, P., Agu, U. J., Aniebo, C. L., Agu, S. A. & Lawani, L. O. 2020. Perception and attitudinal factors contributing to periodic deworming of preschool children in an urban slum, Nigeria. *BMC Public Health,* 20**,** p.1-12.

Friedman, J. F., Olveda, R. M., Mirochnick, M. H., Bustinduy, A. L. & Elliott, A. M. 2018. Praziquantel for the treatment of schistosomiasis during human pregnancy. *Bulletin of the World Health Organization,* 96(1), p.59.

Furtado, l. F. V., De Paiva Bello, A. C. P. & Rabelo, É. M. L. 2016. Benzimidazole resistance in helminths: From problem to diagnosis. *Acta Tropica*, 162, p95-102.

Geary, T. G., Woo, K., Mccarthy, J. S., Mackenzie, C. D., Horton, J., Prichard, R. K., De Silva, N. R., Olliaro, P. L., Lazdins-helds, J. K., Engels, D. A. & Bundy, D. A. 2010. Unresolved issues in

anthelmintic pharmacology for helminthiases of humans. *International Journal for Parasitology,* 40(1), p.1-13.

Gebreegziabiher, D., Desta, K., Desalegn, G., Howe, R. & Abebe, M. 2014. The Effect of Maternal Helminth Infection on Maternal and Neonatal Immune Function and Immunity to Tuberculosis. *Public Library of Science One*, 9(4), p.e93429.

Gebreyohanns, A., Legese, M. H., Wolde, M., Leta, G. & Tasew, G. 2018. Prevalence of intestinal parasites versus knowledge, attitude and practices (KAPs) with special emphasis to *Schistosoma mansoni* among individuals who have river water contact in Addiremets town, Western Tigray, Ethiopia. *Public Library of Science One*, 13(9), p.e0204259.

Gholami, M. H., Rassouli, A., Mirzaei, S. & Hashemi, F. 2023. The potential immunomodulatory effect of levamisole in humans and farm animals. *Journal of Advanced Veterinary and Animal Research,* 10, p.620.

Glinz, D., Silué, K. D., Knopp, S., Lohourignon, l. K., Yao, K. P., Steinmann, P., Rinaldi, L., Cringoli, G., N'goran, E. K. & Utzinger, J. 2010. Comparing diagnostic accuracy of Kato-Katz, Koga agar plate, ether-concentration, and FLOTAC for *Schistosoma mansoni* and soil-transmitted helminths. *Public Library of Science Neglected Tropical Diseases*, 4(7), p.e754.

Gonzalez-Alcaide, G., Sosa, N., Shevy, l., Belinchon-Romero, I. & Ramos-Rincon, J.-M. 2023. Global research on cysticercosis and neurocysticercosis: A bibliometric analysis. *Frontiers in Veterinary Science,* 10, p.1156834.

Gordon, C.A., Kurscheid, J., Jones, M.K., Gray, D.J. and McManus, D.P., 2017. Soil-transmitted helminths in tropical Australia and Asia. *Tropical Medicine and Infectious Disease*, 2(4), p.56.

Hartgers, F. & Yazdanbakhsh, M. 2006. Co-infection of helminths and malaria: modulation of the immune responses to malaria. *Parasite Immunology*, 28(10), pp.497-506.

Hess, C., Ritke, N., Sydow, K., Mehling, l. M., Ruehs, H., Madea, B. & Musshoff, F. 2014. Determination of levamisole, aminorex, and pemoline in plasma by means of liquid chromatography-mass spectrometry and application to a pharmacokinetic study of levamisole. *Drug Testing and Analysis*, 6(10), pp.1049-1054.

Hicks, J. H., Kremer, M. & Miguel, E. 2015. The case for mass treatment of intestinal helminths in endemic areas. *Public Library of Science Neglected Tropical Diseases*, 9(10), p.e0004214.

Holden-Dye, l. & Walker, R. J. 2007. Anthelmintic Drugs. Worm Book, *National Library of Medicine*, p.1-13

Hotez, P. J. 2009. Mass Drug Administration and Integrated Control for the World's High-Prevalence Neglected Tropical Diseases. *Clinical Pharmacology & Therapeutics*, 85, pp.659-664.

Houweling, T. A., Karim-Kos, H. E., Kulik, M. C., Stolk, W. A., Haagsma, J. A., Lenk, E. J., Richardus, J. H. & De vlas, S. J. 2016. Socioeconomic inequalities in neglected tropical diseases: a systematic review. *Public Library of Science Neglected Tropical Diseases*, 10(5), p.e0004546.

Idowu, O. A., Babalola, A. S. & Olapegba, T. 2022. Prevalence of soil-transmitted helminth infection among children under 2 years from urban and rural settings in Ogun state, Nigeria: implication for control strategy*. Egyptian Pediatric Association Gazette*, 70, p.1-7.

Ignacio, C. F., De lima Barata, M. M. & De Moraes Neto, A. H. A. 2018. The Brazilian Family Health Strategy and the management of intestinal parasitic infections. *Primary Healthcare Research & Development*, 19(4), pp.333-343.

Indorato, F., Romano, G. & Barbera, N. 2016. Levamisole-adulterated cocaine: Two fatal case reports and evaluation of possible cocaine toxicity potentiation. *Forensic Science International,* 265, pp.103-106.

Jain, R., Jadon, N. & Radhapyari, K. 2006. Determination of antihelminthic drug pyrantel pamoate in bulk and pharmaceutical formulations using electro-analytical methods. *Talanta,* 70(2), pp.383-386.

Jourdan, P. M., Lamberton, P. H. L., Fenwick, A. & Addiss, D. G. 2018. Soil-transmitted helminth infections. *The Lancet*, 391(10117), pp.252-265.

Juarez, M., Schcolnik-Cabrera, A. & Dueñas-Gonzalez, A. 2018. The multitargeted drug ivermectin: from an antiparasitic agent to a repositioned cancer drug. *American Journal of Cancer Research,* 8(2), pp.317-331.

Kache, R., Phasuk, N., Viriyavejakul, P. & Punsawad, C. 2020. Prevalence of soil-transmitted helminth infections and associated risk factors among elderly individuals living in rural areas of southern Thailand. *BMC Public Health*, 20, p.1-9.

Karshima, S. N. 2018. Prevalence and distribution of soil-transmitted helminth infections in Nigerian children: a systematic review and meta-analysis. *Infectious Diseases of Poverty, 7(04),* pp.1-14.

Kebbi, F. B. 2024. Federal Medical Center [Online]. FMC Birnin kebbi. Available: https://fmcbirninkebbi.gov.ng/home [Accessed 26/02/ 2024].

Keiser, J., McCarthy, J., Hotez, P. J. 2024. Chemotherapy of Helminth Infections. In: Brunton LL, Hilal-Dandan R, Knollmann BC. eds. *Goodman & Gilman's: The Pharmacological Basis of*

Therapeutics, 13e. McGraw-Hill Education; 2017. Accessed March 22, 2024. https://accessmedicine.mhmedical.com/content.aspx?bookid=2189&sectionid=172484534.

Keiser, J. & Utzinger, J. 2008. Efficacy of current drugs against soil-transmitted helminth infections: systematic review and meta-analysis. *Jama,* 299(16)**,** pp.1937-48

Khurana, S. & Sethi, S. 2017. Laboratory diagnosis of soil transmitted helminthiasis. *Tropical Parasitology,* 7, p.86-91.

Knopp, S., Mgeni, A. F., Khamis, I. S., Steinmann, P., Stothard, J. R., Rollinson, D., Marti, H. & Utzinger, J. 2008. Diagnosis of soil-transmitted helminths in the era of preventive chemotherapy: effect of multiple stool sampling and use of different diagnostic techniques. *Public Library of Science Neglected Tropical Diseases*, 2(11), p.e331.

Kuevi, D. N. O., Acquah, F. A., Amuquandoh, A. & Abbey, A. P. 2023. Challenges and Proven Recommendations of Praziquantel Formulation. *Journal of Clinical Pharmacy and Therapeutics,* 2023, p.3976392

Laing, R., Gillan, V. & Devaney, E. 2017. Ivermectin – Old Drug, New Tricks? *Trends in Parasitology*, 33(6), pp.463-472.

Lebu, S., Kibone, W., Muoghalu, C. C., Ochaya, S., Salzberg, A., Bongomin, F. & Manga, M. 2023. Soil-transmitted helminths: A critical review of the impact of co-infections and implications for control and elimination. *Public Library of Science Neglected Tropical Diseases*, 17, p.e0011496.

Liu, Y., Ai, X., Wang, F., Suo, W., Yang, Q., Yang, H. & Xu, N. 2015. Determination of Niclosamide in Aquatic Animal Tissue by a Novel Extraction Procedure and High-Performance Liquid Chromatography–Heated Electrospray Ionization-Tandem Mass Spectrometry. *Analytical Letters,* 48(6), pp.929-943.

Lo, N. C., Snyder, J., Addiss, D. G., eft-neal, S., Andrews, J. R. & Bendavid, E. 2018. Deworming in pre-school age children: a global empirical analysis of health outcomes. *Public Library of Science Neglected Tropical Diseases,* 12(5), p.e0006500.

Lubis, I. N. D., Pasaribu, S. & Lubis, C. P. 2012. Current status of the efficacy and effectiveness of albendazole and mebendazole for the treatment of *Ascaris lumbricoides* in North-Western Indonesia. *Asian Pacific Journal of Tropical Medicine*, 5(8), pp.605-609.

Macrotrends. 2024. Birnin Kebbi, Nigeria Metro Area Population 1950-2024 [Online]. Macrotrends. Available: https://www.macrotrends.net/cities/206384/birnin-

kebbi/population#: ~:text=The%20current%20metro%20area%20population, a%203.94%25%20increase%20from%202021. [Accessed 26/2/ 2024].

Martin, R. J., Robertson, A. P., Buxton, S. K., Beech, R. N., Charvet, C. L. & Neveu, C. 2012. Levamisole receptors: A second awakening. *Trends in Parasitology,* 28(7)**,** pp.289-96.

Masaku, J., Mwende, F., Odhiambo, G., Musuva, R., Matey, E., Kihara, J. H., Thuita, I. G. & Njomo, D. W. 2017. Knowledge, practices and perceptions of geo-helminths infection among parents of pre-school age children of coastal region, Kenya. *Public Library of Science Neglected Tropical Diseases,* 11(13), p.e0005514.

Mazigo, H., Ambrose, E., Zinga, M., Bahemana, E., Mnyone, l., Kweka, E. & Heukelbach, J. 2010. Prevalence of intestinal parasitic infections among patients attending Bugando Medical Centre in Mwanza, north-western Tanzania: a retrospective study. *Tanzania Journal of Health Research*, 12(3), pp.178-182.

Melbourne, U. O. 2016. Pig Vaccine Cisvax™ prevents a form of epilepsy in humans [Online]. University of Melbourne. Available: https://research.unimelb.edu.au/strengths/updates/impact/pig-vaccine-cysvax-prevents-form-of-epilepsy [Accessed 25/02 2024].

Meyers, J.I., Gray, M., Kuklinski, W., Johnson, I.B., Snow, C.D., Black iv, W.C., Partin, K.M. and Foy, B.D., 2015. Characterization of the target of ivermectin, the glutamate-gated chloride channel, from Anopheles gambiae. *The Journal of Experimental Biology*, 218(10), pp.1478-1486.

Mhimbira, F., Hella, J., Said, K., Kamwela, L., Sasamalo, M., Maroa, T., Chiryamkubi, M., Mhalu, G., Schindler, C., Reither, K. And knopp, S., 2017. Prevalence and clinical relevance of helminth co-infections among tuberculosis patients in urban Tanzania. *Public Library of Science Neglected Tropical Diseases*, 11(2), p.e0005342.

Midzi, N., Mduluza, T., Chimbari, M.J., Tshuma, C., Charimari, l., Mhlanga, G., Manangazira, P., Munyati, S.M., Phiri, I., Mutambu, S.l. And midzi, S.S., 2014. Distribution of schistosomiasis and soil transmitted helminthiasis in Zimbabwe: towards a national plan of action for control and elimination. *Public Library of Science Neglected Tropical Diseases*, 8(8), p.e3014.

Midzi, N., Mduluza, T., Mudenge, B., foldager, l. & leutscher, P.D., 2017. Decrease in seminal HIV-1 RNA load after praziquantel treatment of urogenital schistosomiasis coinfection in HIV-positive men—an observational study. *In Open Forum Infectious Diseases*, 4(4), p.199

Midzi, N., Mtapuri-Zinyowera, S., Mapingure, M. P., Paul, N. H., Sangweme, D., Hlerema, G., Mutsaka, M. J., Tongogara, F., makware, G. & Chadukura, V. 2011. Knowledge attitudes and

practices of grade three primary schoolchildren in relation to schistosomiasis, soil transmitted helminthiasis and malaria in Zimbabwe. *BMC Infectious Diseases*, 11(1), pp.1-10.

Miyajima, A., Hirota, T., Sugioka, A., Fukuzawa, M., Sekine, M., Yamamoto, yY., Yoshimasu, T., Kigure, A., Anata, T. & Noguchi, W. 2016. Effect of high-fat meal intake on the pharmacokinetic profile of ivermectin in Japanese patients with scabies. *The Journal of Dermatology,* 43(9), pp.1030-1036.

Mkhize-Kwitshana, Z. L., Mabaso, M. L. & Walzl, G. 2014. Proliferative capacity and cytokine production by cells of HIV-infected and uninfected adults with different helminth infection phenotypes in South Africa. *BMC Infectious Diseases*, 14(1), pp.1-13.

Molvik, M., Heiland, E., Sulu, S. G., Kleppa, E., Lillebo, K., Gundersen, S. G., Kvalsvig, J. D., Taylor, M., Kjetland, E. F. & Vennervald, B. J. 2017a. Co-infection with *Schistosoma haematobium* and soil-transmitted helminths in rural South Africa. *South African Journal of Science*, 113(3-4), pp.1-6.1

Moser, W., et al. (2018). "Diagnostic comparison between FECPAKG2 and the Kato-Katz method for analyzing soil-transmitted helminth eggs in stool." PLoS Negl Trop Dis **12**(6): e0006562.

Muller, I., Yap, P., Steinmann, P., Damons, B. P., Schindler, C., Seelig, H., Htun, N. S., Probst-Hensch, N., Gerber, M., Du randt, R., Puhse, U., Walter, C. & Utzinger, J. 2016. Intestinal parasites, growth and physical fitness of schoolchildren in poor neighbourhoods of Port Elizabeth, South Africa: a cross-sectional survey. *Parasites and Vectors,* 9, p.1-13.

Mulu, A., Anagaw, B., Gelaw, A., Ota, F., Kassu, A. & Yifru, S. 2015. Effect of deworming on Th2 immune response during HIV-helminths co-infection. *Journal of Translational Medicine*, 13(1), p.236.

Mwangi, T. W., Bethony, J. & Brooker, S. 2006. Malaria and helminth interactions in humans: an epidemiological viewpoint. *Annals of Tropical Medicine & Parasitology*, 100(7), pp.551-570.

Nasr, N. A., Al-mekhlafi, H. M., Ahmed, A., Roslan, M. A. & Bulgiba, A. 2013a. Towards an effective control programme of soil-transmitted helminth infections among Orang Asli in rural Malaysia. Part 1: Prevalence and associated key factors. *Parasites & Vectors*, 6, pp.1-12.

Nasr, N. A., Al-mekhlafi, H. M., Ahmed, A., Roslan, M. A. & Bulgiba, A. 2013b. Towards an effective control programme of soil-transmitted helminth infections among Orang Asli in rural Malaysia. Part 2: Knowledge, attitude, and practices. *Parasites & Vectors*, 6, p.28.

Nath, T. C., Padmawati, R. S., Alam, M. S., Das, S. & Murhandarwati, E. H. 2018. Elimination of soil-transmitted helminthiasis infection in Bangladesh: knowledge, attitudes, and practices regarding mass drug administration. *Journal of Global Health Reports*, 2 p.e2018017.

Ndeffo Mbah, M. L., Skrip, l., Greenhalgh, S., Hotez, P. & Galvani, A. P. 2014. Impact of *Schistosoma mansoni* on malaria transmission in Sub-Saharan Africa. *Public Library of Science Neglected Tropical Diseases,* 8(10), p.e3234.

Nelwan, M. (2020). "Schistosoma japonicum." Available at SSRN 3695897.

Ng'etich, A.I., Amoah, I.D., Bux, F. and Kumari, S., 2024. Anthelmintic resistance in soil-transmitted helminths: One-Health considerations. *Parasitology Research*, *123*(1), pp.1-18.

Odinaka, KK., Nwolisa, E. C. N., Mbanefo, F., Iheakaram, A.C. and Okolo, S. 2015. Prevalence and Pattern of Soil-Transmitted Helminthic Infection among Primary School Children in a Rural Community in Imo State, Nigeria. *Journal of Tropical Medicine*, 2015, p.349439

Ojha, S. C., Jaide, C., Jinawath, N., Rotjanapan, P. & Baral, P. 2014. Geohelminths: public health significance. *The Journal of Infection in Developing Countries*, 8(01), pp.005-016.

Okello, A.l. and Thomas, L.F., 2017. Human taeniasis: current insights into prevention and management strategies in endemic countries. *Risk Management and Healthcare Policy,* 10, pp.107-116.

Olds, G. R. 2013. Deworming the world. *Transactions of the American Clinical and Climatological Association,* 124, p.265.

Olliaro, P., Delgado-Romero, P. & Keiser, J. 2014. The little we know about the pharmacokinetics and pharmacodynamics of praziquantel (racemate and R-enantiomer). *Journal of Antimicrobial Chemotherapy,* 69(4), pp.863-870.

Olusola Ojurongbe, F. A. A., Adekunle Olugbenga Olowe, Babatunde Meshach Okanlawon, & Adeyeba, O. A. 2010. Prevalence of Soil Transmitted Helminth Infections in a Tertiary Institution in Western Nigeria. *New York Science Journal*, 3(1) .12.

Omeragić, J., Alagić, D., Šerić-haračić, S. & Kapo, N. 2023. Epidemiology of Taeniosis/Cysticercosis in Humans and Animals. In, Taeniasis and Cycticercosis/Neurocysticercosis - Global Epidemiology, Pathogenesis, Diagnosis, and Management, Eds, El-Ashram, S., Alouffi, A., Tellez-Isaias, G., Manuel Madeira de Carvalho, L., & Al-Olayan, E. (Eds.). IntechOpen. doi: 10.5772/intechopen.10

Orish, V. N., Asumbono, M. A., Addei, I. B., Ayaaba, M. A., Kwadzokpui, P. K., Marinkovic, A., Prakash, S., Okorie, C., Izurieta, R. & Pandit, R. 2023. Knowledge, Attitude, and Practice

towards Prevention of Intestinal Helminth Infection among Residents of the Ho Municipality in the Volta Region of Ghana. *Journal of Parasitology Research*, 2023, p.5515603

Oyebamiji, D., Ebisike, A., Egede, J. & Hassan, A. 2018. Knowledge, attitude and practice with respect to soil contamination by Soil-Transmitted Helminths in Ibadan, Southwestern Nigeria. *Parasite Epidemiology and Control*, 3(4), p.e00075.

Oyeyemi, O. T. & Okunlola, O. A. 2023. Soil-transmitted helminthiasis (STH) endemicity and performance of preventive chemotherapy intervention programme in Nigeria (in year 2021). *Scientific Reports*, 13, p.10155.

Pawluk, S. A., Roels, C. A., Wilby, K. J. & Ensom, M. H. H. 2015. A Review of Pharmacokinetic Drug–Drug Interactions with the Anthelmintic Medications Albendazole and Mebendazole. *Clinical Pharmacokinetics*, 54, pp.371-383.

Picot, S., Beugnet, F., Leboucher, G. and Bienvenu, A.L., 2022. Drug resistant parasites and fungi from a one-health perspective: A global concern that needs transdisciplinary stewardship programs. *One Health*, 14, p.100368.

Porto, I. 2003. Antiparasitic drugs and lactation: focus on anthelmintics, scabicides, and pediculicides. *Journal of Human Lactation*, 19(4), pp.421-425.

Pourhoseingholi, M. A., Vahedi, M. & Rahimzadeh, M. 2013. Sample Size Calculation for Medical Studies. *Gastroenterology and Hepatology from Bed to Bench*, 6(1), pp.14-17.

Pullan, R. L. & Brooker, S. J. 2012. The global limits and population at risk of soil-transmitted helminth infections in 2010. Parasites & Vectors, 5(1), 1-14.

Pullan, R. L., Smith, J. L., Jasrasaria, R. & Brooker, S. J. 2014. Global numbers of infection and disease burden of soil transmitted helminth infections in 2010. *Parasites & vectors*, 7, pp.1-19.

Ramayanti, I. and Ghiffari, A., 2019. Factors of soil-transmitted helminths infections in children who live in the surrounding of the final disposal landfill of Sukawinatan, Palembang. In Journal of Physics: *Conference Series*, 246(1), p.012045

Raymon, l. P. & Isenschmid, D. S. 2009. The Possible Role of Levamisole in Illicit Cocaine Preparations. *Journal of Analytical Toxicology*, 33, pp.620-622.

Rezaizadeh, H. & Olson, E. 2016. Specific GI Microbial Infections. Pocket Handbook of GI Pharmacotherapeutics. *Springer*. pp.75-109

Ross, A. G., Chau, T. N., Inobaya, M. T., Olveda, R. M., li, Y. & Harn, D. A. 2017. A new global strategy for the elimination of schistosomiasis. *International Journal of Infectious Diseases*,

54 pp.130-137

Rotejanaprasert, C., Chuaicharoen, P., Prada, J. M., Thantithaveewat, T., Adisakwattana, P. & Pan-ngum, W. 2023. Evaluation of Kato-Katz and multiplex quantitative polymerase chain reaction performance for clinical helminth infections in Thailand using a latent class analysis. *Philosophical Transactions of the Royal Society B*, 378, p.20220281.

Saidu, U., Ibrahim, M. A., De koning, H. P., Mckerrow, J. H., Caffrey, C. R. & Balogun, E. O. 2023. Human schistosomiasis in Nigeria: present status, diagnosis, chemotherapy, and herbal medicines. *Parasitology Research*, 122(12), pp.2751-2772.

Sainas, S., Dosio, F., Boschi, D. & Lolli, M. L. 2018a. Chapter One - Targeting Human Onchocerciasis: Recent Advances Beyond Ivermectin. In: BOTTA, M. (ed.) *Annual Reports in Medicinal Chemistry*. 51, pp.1-38.

Sainas, S., Dosio, F., Boschi, D. & Lolli, M. L. 2018b. Targeting Human Onchocerciasis: Recent Advances Beyond Ivermectin. Neglected Diseases: *Extensive Space for Modern Drug Discovery,* 51, pp.1-38.

Salam, N. & Azam, S. 2017. Prevalence and distribution of soil-transmitted helminth infections in India. *BMC Public Health*, 17(1), p.201.

Sangare, l.R., Herrin, B. R., John-Stewart, G. & Walson, J. L. 2011. Species-specific treatment effects of helminth/HIV-1 co-infection: a systematic review and meta-analysis. *Parasitology*, 138(12), pp.1546-1558.

Sartorius, B., Cano, J., Simpson, H., Tusting, l. S., Marczak, l. B., Miller-petrie, M. K., kinvi, B., Zoure, H., Mwinzi, P. & Hay, S. I. 2021. Prevalence and intensity of soil-transmitted helminth infections of children in sub-Saharan Africa, 2000–18: a geospatial analysis. *The Lancet Global Health*, 9(1), pp. e52-e60.

Savioli, l., Albonico, M., Daumerie, D., Lo, N. C., Stothard, J. R., Asaolu, S., Tchuem Tchuenté, l. A. & Anderson, R. M. 2018. Review of the 2017 WHO Guideline: Preventive chemotherapy to control soil-transmitted helminth infections in at-risk population groups. An opportunity lost in translation. *Public Library of Science Neglected Tropical Disease*, 12(4), p.e0006296.

Schulz, J. D., Moser, W., Hürlimann, E. & Keiser, J. 2018. Preventive chemotherapy in the fight against soil-transmitted helminthiasis: achievements and limitations. *Trends in Parasitology,* 34(2), pp.590-602.

Shittu, O., Shittu, d. S., opeyemi, o. A., fakayode, o., danladi, y. K., fulani, s. A., olaleye, a. D., Adebo, P. O., Ibrahim, A. O. & Akor, S. J. 2017. Overlapping distribution of *Plasmodium falciparum* and soil transmitted helminths in a malaria hyper-endemic region, North-Central

Nigeria. *Asian Pacific Journal of Tropical Diseases*, 7(12), p.930-5.

Shumbej, T., Belay, T., Mekonnen, Z., Tefera, T. & Zemene, E. 2015. Soil-Transmitted Helminths and Associated Factors among Pre-School Children in Butajira Town, South-Central Ethiopia: A Community-Based Cross-Sectional Study. Public Library of Science One, 10(8), p.e0136342.

Simon, G. 2016. Impacts of neglected tropical disease on incidence and progression of HIV/AIDS, tuberculosis, and malaria: scientific links. *International Journal of Infectious Diseases*, 42, pp.54-57.

Sinxadi, P. & Maartens, G. 2009. Pharmacology of anthelmintics: albendazole, mebendazole and praziquantel: clinical pharmacology. *CME: Your SA Journal of CPD*, 27(6), pp.274-276.

Specht, S. & Hoerauf, A. 2007. Does helminth elimination promote or prevent malaria? T*he Lancet*, 369(9560), pp.446-447.

Steinbaum, l., Mboya, J., Mahoney, R., Njenga, S. M., Null, C. & Pickering, A. J. 2019. Effect of a sanitation intervention on soil-transmitted helminth prevalence and concentration in household soil: A cluster-randomized controlled trial and risk factor analysis. *Public Library of Science Neglected Tropical Disease*, 13(2), p.e0007180.

Sun, Q., Mao, R., Wang, D., Hu, C., Zheng, Y. & Sun, D. 2016. The cytotoxicity study of praziquantel enantiomers. *Drug Design, Development and Therapy*, 10, pp.2061-2068.

Taghipour, A., Mosadegh, M., Kheirollahzadeh, F., Olfatifar, M., Safari, H., Nasiri, M. J., Fathi, A., Badri, M., Piri Dogaheh, H. & Azimi, T. 2019. Are intestinal helminths playing a positive role in tuberculosis risk? A systematic review and meta-analysis. *Public Library of Science One*, 14(10), p.e0223722.

Taman, A. & Azab, M. 2014. Present-day anthelmintics and perspectives on future new targets. *Parasitology Research*, 113, pp.2425-2433.

Tchuem Tchuenté, l. A., Rollinson, D., Stothard, J. R. & Molyneux, D. 2017. Moving from control to elimination of schistosomiasis in sub-Saharan Africa: time to change and adapt strategies. *Infectious Diseases of Poverty*, 6(01), pp.12-25.

Tebeje, B. M., Harvie, M., You, H., Loukas, A. & Mcmanus, D. P. 2016. Schistosomiasis vaccines: where do we stand? *Parasites & Vectors*, 9, pp.1-15.

Tee, M. Z., Lee, S. C., ER, Y. X., YAP, N. J., Ngui, R., Easton, A. V., Siow, V. W. Y., NG, K. S., Boey, C. C. M. & Chua, K. H. 2022. Efficacy of triple dose albendazole treatment for soil-transmitted helminth infections. *Public Library of Science* One, 17(8), p.e0272821.

Tefera, E., Belay, T., Mekonnen, S. K., Zeynudin, A. & Belachew, T. 2017. Prevalence and intensity of soil transmitted helminths among school children of Mendera Elementary

School, Jimma, Southwest Ethiopia. *The Pan African Medical Journal*, 27, p.88

Tsuji, N., 2020. Schistosomiasis and hookworm infection in humans: Disease burden, pathobiology and anthelmintic vaccines. *Parasitology International*, *75*, p.102051.

Tuasha, N., Hailemeskel, E., Erko, B. & Petros, B. 2019. Comorbidity of intestinal helminthiases among malaria outpatients of Wondo Genet health centres, southern Ethiopia: implications for integrated control. *BMC Infectious Diseases*, 19(1), pp.1-8.

Turner, H. C., Truscott, J. E., Bettis, A. A., Hollingsworth, T. D., Brooker, S. J. & Anderson, R. M. 2016. Analysis of the population-level impact of co-administering ivermectin with albendazole or mebendazole for the control and elimination of *Trichuris trichiura*. *Parasite Epidemiology and Control,* 1(2), pp.177-187.

Urbani, C. & Albonico, M. 2003. Anthelminthic drug safety and drug administration in the control of soil-transmitted helminthiasis in community campaigns. *Acta Tropica*, 86(2-3), pp.215-221.

Utzinger, J., Becker, S. L., Knopp, S., Blum, J., Neumayr, A. L., Keiser, J. & Hatz, C. F. 2012. Neglected tropical diseases: diagnosis, clinical management, treatment and control. *Swiss Medical Weekly*, 142.

Vale, N., Gouveia, M. J., Rinaldi, G., Brindley, P. J., Gärtner, F. & Correia da Costa, J. M. 2017. Praziquantel for Schistosomiasis: Single-Drug Metabolism Revisited, Mode of Action, and Resistance. *Antimicrobial Agents and Chemotherapy*, 61(5), p.e02582-16.

Ventre, E., Rozières, A., Lenief, V., Albert, F., Rossio, P., Laoubi, l., Dombrowicz, D., Staels, B., Ulmann, l., Julia, V., Vial, E., Jomard, A., Hacini-rachinel, F., Nicolas, J.-F. & Vocanson, M. 2017. Topical ivermectin improves allergic skin inflammation. *Allergy,* 72(8), pp.1212-1221.

Vinaud, M. C. & Junior, R. D. S. L. 2017. Mode of action of the main anti-parasitic drugs. *Revista de Patologia Tropical/Journal of Tropical Pathology*, 46(2), pp.121-133.

Von Braun, A., Trawinski, H., Wendt, S. & Lübbert, C. 2019. Schistosoma and Other Relevant Helminth Infections in HIV-Positive Individuals—An Overview. *Tropical Medicine and Infectious Disease*, 4(2), 65.

Weerakoon, K.G., Gobert, G.N., Cai, P. and McManus, D.P., 2015. Advances in the diagnosis of human schistosomiasis. *Clinical Microbiology Reviews*, 28(4), pp.939-967.

WHO. 2012. Global disribution of schitosomiasis [Online]. WHO. Available: /www.who.int/schistosomiasis/Schistosomiasis_2012-01.png?ua=1 2014].

WHO. 2017. Soil Transmitted Helminthiasis [Online]. WHO. Available:

http://apps.who.int/neglected_diseases/ntddata/sth/sth.html [Accessed 8/11 2019].

WHO. 2019. WHO Model List of Essential Medicine (2019) [Online]. Available: https://apps.who.int/iris/bitstream/handle/10665/325771/WHO-MVP-EMP-IAU-2019.06-eng.pdf?ua=1 [Accessed 2/11/ 2019].

WHO. 2022. Taeniasis/cysticercosis [Online]. WHO. Available: https://www.who.int/news-room/fact-sheets/detail/taeniasis-cysticercosis [Accessed 03/02/ 2024].

WHO. 2023. Soil Transmitted Helminths [Online]. WHO. Available: https://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections [Accessed 05/03/ 2024].

WHO. 2023. Schistosomiasis [Online]. WHO. Available: https://www.who.int/news-room/fact-sheets/detail/schistosomiasis [Accessed 04/02/ 2024].

WHO (2023). "Schistosomiasis." Retrieved 25/09/, 2024, from https://www.who.int/news-room/fact-sheets/detail/schistosomiasis.

Wrights, J., Ansari, A.A. and Sukhraj, K. 2015. Prevalence and Association of Parasitic Helminths among the Cross Section of Male and Female Gender Groups at University of Guyana, Georgetown, Guyana. *Research Journal of Parasitology*, 10(2), pp.50-57.

Wright, J.E., Werkman, M., Dunn, J.C., Anderson, R.M. 2018. Current epidemiological evidence for predisposition to high or low intensity human helminth infection: a systematic review. *Parasites & Vectors*, 11(1), p.112

Yahaya, T., Doherty, V. F., Akinola, O. S. & Shamsudeen, A. 2019. Heavy metal profiles and microbial counts of selected sachet water brands in Birnin Kebbi Metropolis, Nigeria. *Journal of Science*, 21(1), pp.229-234

Zeynudin, A., Aegefa, T., Tesfaye, M., Suleman, S., Yesuf, E. A., Hajikelil, Z., Ali, S., Azam, K., Husen, A. & Yasin, J. 2022. Prevalence and intensity of soil-transmitted helminth infections and associated risk factors among household heads living in the peri-urban areas of Jimma town, Oromia, Ethiopia: A community-based cross-sectional study. *Public Library of Science One,* 17, p.e0274702.

Zhan, B., Beaumier, C. M., Briggs, N., Jones, K. M., Keegan, B. P., Bottazzi, M. E. & Hotez, P. J. 2014. Advancing a multivalent 'Pan-anthelmintic' vaccine against soil-transmitted nematode infections. *Expert Review of Vaccines*, 13(3), pp.321-331.

Zhang, H., Liu, C. & Zheng, Q. 2019. Development and application of anthelminthic drugs in China. *Acta Tropica,* 200, pp.105181.

APPENDIX A: Data collection instrument

DATA COLLECTION SHEET FOR RETROSPECTIVE HELMINTHIC STUDY						
Patient study ID#:						
Hospital ID#:						
-1	**DEMOGRAPHIC INFORMATION**					
1.1	Age					
1.2	Sex					
1.3	Race					
1.4	Residential area/town					
1.5	Occupation					
1.6	Date of admission					
1.7	Date of discharge					
1.8	Ward No					
-2	**CLINICAL SYMPTOMS OF HELMINTHIASIS**					
2.1	Diarrhoea					
2.2	Abdominal pain					
2.3	Constipation					
2.4	Rectal prolapsed					
2.5	Anal itching (pruiritus)					
2.6	Colic					
2.7	Weight loss					
2.8	Bloody stool					
2.9	Bloody urine					
2.1	Cough					
2.11	Lung infection					
2.12	Skin inflammation					
2.13	Seizures					
2.14	Tiredness/Lethargy					
2.15	Restlessness					
2.16	Hyperactivity					
2.17	Irritability/nervousness					
	Other					
2.18						
2.19						
2.2						
-3	**DIAGNOSIS**					
4.1	Methods of diagnosis					
	Species					
4.2	*Ascaris lumbricoides*					
4.3	*Ancy/stoma duodenale*					
4.4	*Necator americanus*					
4.5	*Trichuris triciura*					

4,6	*Enterobius vermicularis*				
4,7	*Toxocaracatis*				
4.4	*Toxocaracanis*				
4,1	*Ancy!ostomabrazi!iense*				
4.11	*Ancy!ostoma caninum*				
4.12	*Strong!oidesstercoro!is*				
4.13	*Schistosoma mansoni*				
4.14	*Schistosoma haemotobium*				
4.15	*Taenia saginata*				
4,16	*Diphyl!obothrium !atum*				
4.17	*Hymenolepis nana*				
4.18	*Taenia so!ium*				
4.19	*Echinococcus granu!osus*				
4,2	*Oncocerca vo!vu!us*				
4.21	*Wuchereriabancrofti*				
4.22	*Brugiama!ayi*				
4.23	*Loa Joa*				
4,24	*Dracuncu!us medinensis*				
4.25	*Protozoa!:*				
4.26	*Other:*				
4,27	*Other:*				

-4	**THERAPEUTIC INTERVENTION**				
		dose	*duration*	*trade name*	*generic*
4,1	Albendazole				
4,2	Mebendazole				
4,3	Piperazine				
4.4	Praziquantel				
4,5	Niclosamide				
4,6	Ivermectin				
4,7	Diethylca rbamazine				
4,8	Metronidazole				
4,9	Corticosteroid				
4,1	Antihistamine				
4.11	Iron				
4.12	Muiit-vitamin				
4.13	Minerals				
4.14	Doxycycline				
4.15	Laxative				
	Other				
4,16	Surgery				
4.17					
4.18					

Appendix B: Questionnaire Healthcare Providers

QUESTIONAIRRE HEALTH CARE PROVIDERS

OCCURRENCE, KNOWLEDGE AND MANAGEMENT OF HUMAN HELMINTHIC INFECTION

IN BIRNIN KEBBI, KEBBI STATE NIGERIA

PARTICIPANT NO.: HCP.A:

A	PERSONAL INFORAMATION: (DEMOGRAPHY)
1.	**Ward working in:**
2.	**Job description:**
3.	**How long have you worked as a health care professional?** Years:
4.	**Gender:** D1. Male 02.Female

B	ASSESMENT OF HEALTH WORKERS KNOWLEGDE ABOUT HELMINTHS
B.1	**What are the most common helminths that infect humans?** 1. 2. 3. 4. 5.
B.2	**What are the clinical symptoms of a helminths infection?** 1. 2. 3. 4. 5.
B.3	**What is the best method to diagnose Helminthic infection?** 1.D Blood Culture 2.0 Urine M/C/S 3.0 Stool Culture 4.0 Skin Test 5.0 Serological test 6.0 Other (Specify):
B.4	**What are the ways to prevent helminthic Infection?** 1D Provision of Adequate water supply 2. ☐ Proper Health education 3. ☐ Environmental Sanitation 4.0 Reduction of Overcrowding 5.0 All of the above

B.5	Can you list the trade names of the drugs used to manage helminthic infection? 1. 2. 3. 4. 5.
B.6	Can you list the active ingredients in the drugs listed in Question B.5? 1. 2. 3. 4. 5.
B.7	How are prophylactic drugs administered including dosage for children and adults?
B.8	Do know if your patients have used herbal medicine to treat a helminth infection? If so, please give the names of these products: 0 1. Yes 02. No 1. 2. 3. 4.
C	FURTHER INFORMATION
C.1	As a parent/guardian would you be prepared to complete an additional questionnaire on helminth management within your household? 01. No 0 2. Yes 03. Email address: For the link
C.2	Would you like additional information sent to you? 01. No 02. Workshop 03. Information brochure 04.Email address:
THANK YOU FOR TAKING TIME TO PARTICIPATE IN THIS STUDY	

Appendix C: Questionnaire general public

QUESTIONAIRRE GENERAL PUBLIC

OCCURRENCE, KNOWLEDGE AND MANAGEMENT OF HUMAN HELMINTHIC INFECTION IN BIRNIN KEBBI, KEBBI STATE NIGERIA

PARTICIPANT NO.: GP.A:

A.	**PERSONAL INFORAMATION: (DEMOGRAPHY)**
A.1	**Study number:**
A.2	**Ethnic group (Tribe):**
A.3	**Age:**
A.4	**Gender:** D1. Male D2. Female
A.S	**Address:** Town: District: Province:·
A.6	**The highest level of education?** D1. Never went to School D2. Primary 03. Secondary 04.Tertiary/University 06. Others (please specify):
A.7	**Occupation:**
A.8	**Average Family Month Income:** R
A.9	**Number of Residents in the same House:**
A.10	**Number of rooms in your House:**
B.	**SOURCE OF WATER, ENVIRONMENT AND SANITATION CONDITIONS:**
B.1	**What is the main source of Water used for drinking?** D1. River D2. Pipe water 03.Well 04. Rain Os. Others (please specify):
B.2	**What sort of toilet do you have at your home of residency?** D1. Have a flush toilet in own home D2. No flush toiled in the house 03. No toilet in the house 04. Pit toilet on own property Os. Pit toilet-communal 06. Chemical toilet in house 07. Chemical toilet on own property 08. Chemical toilet -communal 09. Other (please specify):
B.3	**How is the toilet waste disposed?** Toilets leads to..... D1. Sewer pipes D2. Septic tank 03. Other places 04. Others (please specify):

B.4	**How do you dispose of household Garbage waste?** D1. Municipality removal & disposal 03. Dispose of in a river 04. Burning Os. Others (please specify): D2. Dispose of in open field 03. Burying Os. Disposal at city dump
C.	**PERSONAL PRACTICIES**
C.1	**Do you wash your hands before eating?** D1. Never 03. Sometimes D2. Rarely 04. Always
C.2	**Do you use body soap when washing your hand?** Di.Never 03. Sometimes D2. Rarely 04. Always
C.3	**Do you use antiseptic soap when washing your hand?** D1. Never 03. Sometimes D2. Rarely 04. Always
C.4	**Do you wash fruits (grapes, apple, and mango) before eating them?** D1. Never 03. Sometimes D2. Rarely 04. Always
C.S	**Do you wash the vegetables before eating?** D1. Never 03. Sometimes D2. Rarely 04. Always
C.6	**Do you eat pork?** D1. Yes ☐2. No
C.7	**Do you know how to recognize worm infected meat?** D1. Yes ☐2. No
D	**KNOWLEDGE ABOUT INTESTINAL WORMS INFECTIONS**
D.1	**Did you ever hear about intestinal worms before this time?** D1. Yes 02.No
D.2	**Ifyes, where did you hear about intestinal worms?**

D.3	**What are intestinal worms?**
D.4	**Give types of names of intestinal worms you know.** 1. 2. 3. 4.
D.5	**Do you think that worms are good Or bad for people's health?** D1. I think worms are good for health D2. I think worms are harmless 03. I think worms are harmful 04. I do not know
D.6	**How do people get infected with worms?** 1. 2. 3.
D.7	**Have you had an intestinal parasite/worm infection?** D1. Yes 02.No
D.8	**Ifyes, when was the last time?** D1. Less than 3 months ago 03. One year ago Os. When I was a child D2. Six months ago 04. More than a year ago 06. I do not remember
D.9	**How can we prevent intestinal worms?** 1. 2. 3. 4. 5.
D.10	**Do you think human faeces can be source of worm infection?** D1. Yes 02.No 03. I don't know

E	**TREATMENT AND TREATMENT-SEEKING BEHAVIOUR**
E.I	**Have you been on treatment for intestinal worm infections over the following?** D1. <6 months D2. 6 -12 months 03. 1- 5 years 04. > 5 years Os. Not been treated
E.2	**What medication did you take to eradicate worm infection?** D1. Mebendazole - (Vermox) D2. Albendazole - (Zentel/Bendex) 03. Piperazine - (Padax) D2. Niclosamide - (Yomesan) 03. Praziquantel - (Biltricide/Cysticide) 04. Cannot remember Os. Other (please specify):
E.3	**If you suffer from diarrhoea or abdominal pain, what do you do?** D1. Nothing D2. Take Traditional Medicinal plants 03. Go to traditional healer 04. Go to clinic/doctor Os. Go to clinic/ pharmacist 06. Other (please specify)
F	**WORM MANAGEMENT OF CHILDREN**
F.I	**Do you have children?** D1. Yes 02.No
F.2	**Have your children had a worm infection?** D1. Yes 02.No
F.3	**What was the age range of the child/children when they had the infection?** D1. <6 months D2. 6-12 months 03. >1-6 years 04. >6-11 Os. >11-1s years 06. >18 years
F.4	**Did the child/children have multiple worm infections?** D1.1 ☐2. 2-5 03. 6-10 04. Once a year Os. Twice a year
F.5	**Who diagnosed the infection?** D1. Self D2.Nurse 03. General practitioner 04.Clinic Os. Specialist 06.Family member 07. I don't remember Os. Other (please specify):

F.6	**What worm was diagnosed?** ☐1. Roundworm ☐2. Hookworm ☐3. Pinworm ☐4. Mixed ☐5. Tapeworm ☐6. Bilharzia ☐7. I don't know ☐8. Other (please specify):
F.7	**Do your children wash their hands after defaecation?** ☐1. Never ☐2. Rarely ☐3. Sometimes ☐4. Always
F.8	**Do you prophylactically treat your children to prevent an infection?** ☐1. No ☐2.Yes
F.9	**How often do you prophylactically treat your children?** ☐1. Once a year ☐2. Every six months ☐3. Other (please specify):
F.10	**When do you treat your child?** ☐1. When I see worms in the stool ☐2. When I recognise the symptoms ☐3. Diagnosed by Healthcare Provider ☐4. Class mates/close relatives are infected ☐5. Other (please specify):
G	**FURTHER INFORMATION**
G.1	**Would you like additional information on worm and management sent to you?** ☐1. No ☐2. Information brochure ☐3. Workshop ☐4. Email:
	THANK YOU FOR TAKING TIME TO PARTICIPATE IN THIS STUDY

APPENDIX D1: Participant information sheet - general public

School of Therapeutic Sciences
Pharmacology Division
Department of Pharmacy and Pharmacology

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13 July 2021

Dear Potential Participant,

My name is Dr Isah Umar Mungadi a master's student from department of Pharmacy and Pharmacology, division of Pharmacology, Faculty of Health Sciences, University of the Witwatersrand Johannesburg, South Africa. I will be working on a project titled: *Occurrence, knowledge and management of human helminthic infection in Birnin Kebbi, Kebbi State Nigeria.* The aim of this research project is to determine the occurrence of worm infections, as well as assess the knowledge and management of worm infections in South Africa and Nigeria. As part of this project, I would like to invite you to complete a questionnaire designed to collate information about your knowledge of worm infections, how to prevent infections and to treat an infection. This activity will take around 15 - 20 minutes.

You will not receive any direct benefit from participating in this study. Participation is voluntary and there are no disadvantages or penalties for not participating. You may withdraw at any time or not answer any question if you do not want to. The survey will be completely confidential and anonymous as I will not be ask for your name or any identifying information, and the information you supply will be held securely and not disclosed to anyone else. The data from this questionnaire will be aggregated so that no single response will be identified. I may use a response to emphasize a particular result, however this will be anonymised.

If you have any questions afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a dissertation, which will be available online through the University library website. It may also be published in scientific journals and presented at academic meetings but your identity will not be revealed. If you wish to receive a summary of this report, I will be happy to send it to you upon request. If you have any queries, concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (medical), telephone: + 27(0)11-717-1408, email: hrec-medical.researchoffice@wits.ac.za.

Yours sincerely,

Dr Isah Umar Mungadi, 1475422@students.wits.ac.za, 0848525313 (Student)
Prof Robyn van Zyl, robyn.vanzyl@wits.ac.za, 083 312 0228 (Supervisor)

APPENDIX D2: Participant information sheet - healthcare providers

School of Therapeutic Sciences
Pharmacology Division
Department of Pharmacy and Pharmacology

WITS UNIVERSITY

Faculty of Health Sciences Private Bag 3, Wits, 2050, South Africa
Tel: +27 117172542 Fax: 0865534725 E-mail: 1475422@sludenls.ac.za www.wits.ac.za

13 July 20212019

Dear Potential Participant,

My name is Dr Isah Umar Mungadi a master's student from department of Pharmacy and Pharmacology, division Pharmacology, Faculty of Health Sciences, University of the Witwatersrand Johannesburg, South Africa. I will be working on a project titled: *Occurrence, knowledge and management of Human Helminthes infection in Binin Kebbi, Nigeria.* The aim of this research project is to determine the occurrence of helminthic infections, as well as assess the knowledge and management of helminthic infections in South Africa and Nigeria. As part of this project, I would like to invite you to complete a questionnaire designed to collate information about your knowledge of helminth infections and the appropriate management. This activity will take around 15 - 20 minutes.

You will not receive any direct benefit from participating in this study. Participation is voluntary and there are no disadvantages or penalties for not participating. You may withdraw at any time or not answer any question if you do not want to. The survey will be completely confidential and anonymous as I will not be ask for your name or any identifying information, and the information you supply will be held securely and not disclosed to anyone else. The data from this questionnaire will be aggregated so that no single response will be identified. I may use a response to emphasize a particular result, however this will be anonymised.

If you have any questions afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a dissertation, which will be available online through the University library website. It may also be published in scientific journals and presented at academic meetings but your identity will not be revealed. If you wish to receive a summary of this report, I will be happy to send it to you upon request. If you have any queries, concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (medical), telephone: + 27(0)11-717-1408, email: hrec-medical.researchoffice@wits.ac.za.

Yours sincerely,

Dr Isah Umar Mungadi, 1475422@students.wits.ac.za, 0848525313 (Student)

Prof Robyn van Zyl, robyn.vanzyl@wits.ac.za, 083 312 0228 (Supervisor)

APPENDIX E: Participant Consent Form

PARTICIPANT CONSENT SHEET

Project Title: *TITLE: Occurrence, knowledge and management of Human Helminthes infection in Binin Kebbi, Nigeria.*

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read **it,** or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Dr Isah Umar Mungadi, Principal Investigator, telephone no. 0848525313, or by e-mail at 0848525313,

Prof Robyn van Zyl, Supervisor, on telephone no. 011-717-2542, or by e-mail at robyn.vanzyl@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or bye-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Signature or mark _____

Witnessed by:

Name of Witness: _____

Signature: _____

Date: _____

APPENDIX F1: Protocol Approval

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

30 January 2024
Person No: 1475422
TAA

Dr IM Umar
Federal University
Birnin Kebbi
Kebbi State
1157
Nigeria

Dear Dr Isah Umar

Master of Science in Medicine: Change of title of research

I am pleased to inform you that the following change in the title of your Dissertation for the degree of **Master of Science in Medicine** has been approved:

From:	**Occurence, knowledge and management of human Helminthic infection in Johannesburg, South Africa and Nigeria.**
To:	**Occurrence, Knowledge and Management of Human Helminthic Infections in Birnin Kebbi Metropolis, Nigeria**

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

APPENDIX F2: WITS Research Ethics Committee approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R49 Dr IM Umar

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M190713

NAME: (Principal and Co-Investigators)	Dr IM Umar
DEPARTMENT:	School of Therapeutic Sciences Department of Pharmacy and Pharmacology Division of Pharmacology Medical School University
PROJECT TITLE:	*Occurence, knowledge and management of human helminthic infections in Birnin Kebbi Metropolis, Nigeria* Second change of study title noted on 9 January 2024
DATE CONSIDERED:	26 July 2019
DECISION:	Approved unconditionally
CONDITIONS:	Approval granted to Phases 1 and 2 on 2020/06/25 If contact information regarding student study participants is required, please contact the Registrar's office <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Profs R van Zyl, J Frean & S Schmollgruber
APPROVED BY:	Ms M van Niekerk, Co-Chairperson, HREC (Medical)
DATE OF APPROVAL:	27 February 2020 **EXPIRY DATE:** 26 February 2025

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report** in the format available at https://wits.ac.za/research/researcher-support/research-ethics/ethics-committees/. This report is due annually, for the duration of the Clearance Certificate, beginning on the first anniversary of Date of Approval above. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator

Date

APPENDIX G: Ethical approval Ministry of Health, Nigeria

KEBBI STATE MINISTRY OF HEALTH
(HEADQUARTERS)

MOH/KSREC/VOL I/56

17th February, 2023

KSHREC Registration umber: 105:021/2

Notice of full approval after full Ethical Committee Review

Re: Protocol full ti "Occurrence Knowledge and Management of Human Helminthic Infection in Birnin Kebbi Metropolis Nigeria".

Health Research Comm ttee Assigned Number: 105:012/2020

ame or Principal Investigator: Isah Umar Mungad

ame of C:O.Investlgators:

Address of Principal Investigator:• School of Therapeutic Sc ence, **Department** of Pharmacy and Pharmacology, Division of Pharmacology Medical School, University of Witwatersrand, **south Africa.**

Place of propose study/ nstitution: (1) Sir Yahaya Memorial Hospital **Bim n** Kebbl.

(2) Federal Medical Centre a min Kebbi

Date of ReceJpt of Valid Application: 24111June, 2020

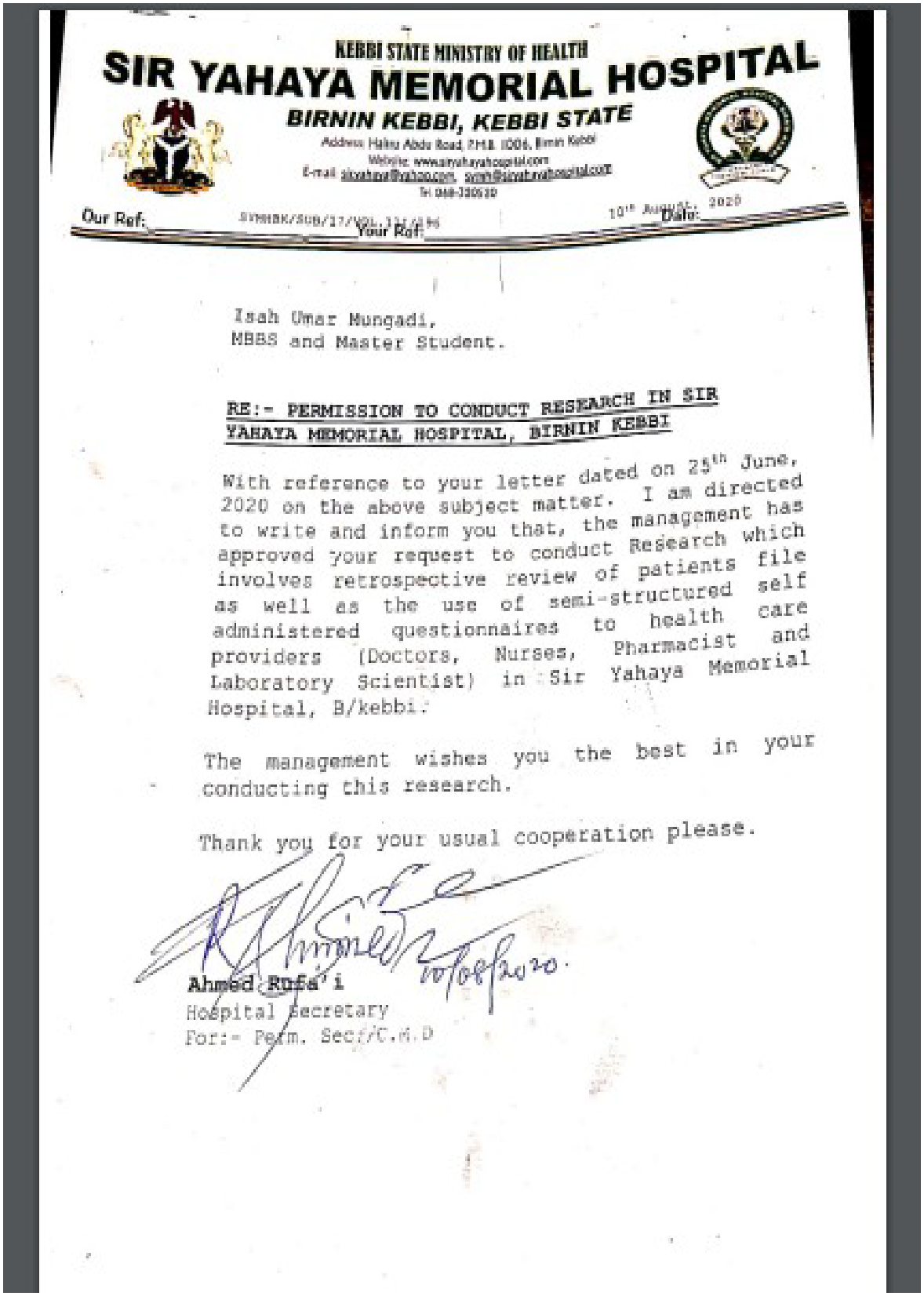
Date of Approval: 24t11 June, 1020

Approval exp ration date: 24t11 June, 2021

CRETARIAT COMPLEX, BIRNIN-KEBBI KEBBI STATE (NIGERIA)
Email: ministryofhealthkebbistate@gmail.com
@mohkebbistate official-ministryofhealthkebbistate

GWADANGAJI SE
P.M.8 1040
TEL: 08032 03601

APPENDIX H1: Ethics approval SIR YAHAYA MEMORIAL HOSPITAL Birnin Kebbi, Nigeria



KEBBI STATE MINISTRY OF HEALTH

SIR YAHAYA MEMORIAL HOSPITAL

BIRNIN KEBBI, KEBBI STATE

Address: Haliru Abdu Road, P.M.B. 1006, Birnin Kebbi
Website: www.siryahayahospital.com
E-mail: skyahaya@yahoo.com, smh@siryahayahospital.com
Tel: 068-330630

Our Ref: SYMMBK/SUB/17/VOL. II/[illegible] Your Ref: Date: 10th August, 2020

Isah Umar Mungadi,
MBBS and Master Student.

RE:- PERMISSION TO CONDUCT RESEARCH IN SIR YAHAYA MEMORIAL HOSPITAL, BIRNIN KEBBI

With reference to your letter dated on 25th June, 2020 on the above subject matter. I am directed to write and inform you that, the management has approved your request to conduct Research which involves retrospective review of patients file as well as the use of semi-structured self administered questionnaires to health care providers (Doctors, Nurses, Pharmacist and Laboratory Scientist) in Sir Yahaya Memorial Hospital, B/kebbi.

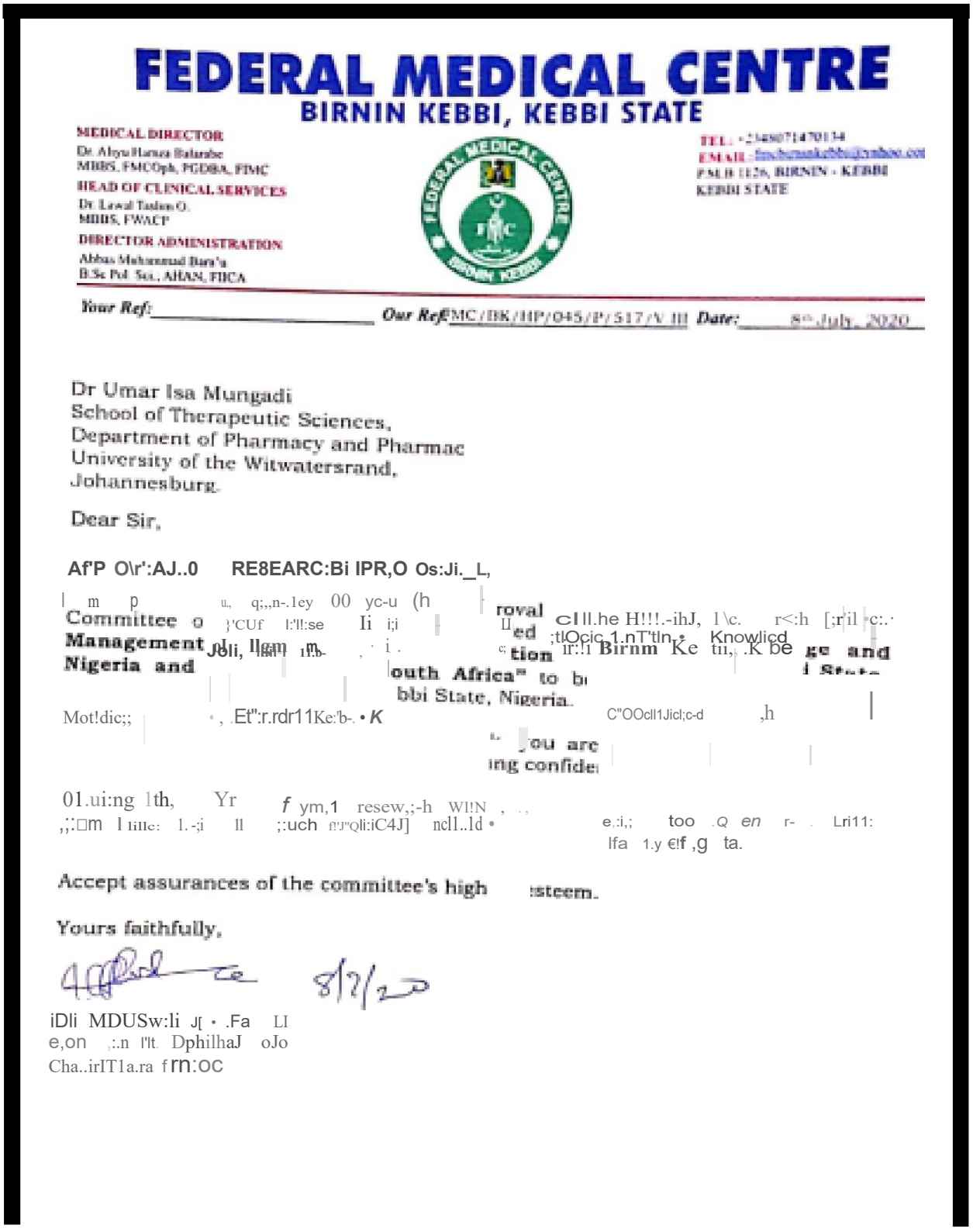
The management wishes you the best in your conducting this research.

Thank you for your usual cooperation please.

10/08/2020.

Ahmed Rufa'i
Hospital Secretary
For:- Perm. Sec/C.M.D

APPENDIX H2: Ethics approval Federal Medical Centre Birnin Kebbi, Nigeria



FEDERAL MEDICAL CENTRE
BIRNIN KEBBI, KEBBI STATE

MEDICAL DIRECTOR
Dr. Aliyu Haruna Balarabe
MBBS, FMCOph, PGDBA, FIMC
HEAD OF CLINICAL SERVICES
Dr. Lawal Taslim O.
MBBS, FWACP
DIRECTOR ADMINISTRATION
Abbas Muhammad Bara'u
B.Sc Pol. Sci., AIAN, FICA

TEL: +2348071470134
EMAIL: fmcbirninkebbi@yahoo.com
PMB 1126, BIRNIN - KEBBI
KEBBI STATE

Your Ref: _____ *Our Ref:* FMC/BK/HP/045/P/517/V.III *Date:* 8th July, 2020

Dr Umar Isa Mungadi
School of Therapeutic Sciences,
Department of Pharmacy and Pharmac
University of the Witwatersrand,
Johannesburg.

Dear Sir,

Af'P O\r':AJ..0 RE8EARC:Bi IPR,O Os:Ji._L,

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Accept assurances of the committee's high :steem.

Yours faithfully,

8/7/20

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APPENDIX I: Raw data of Part A: Helminth diagnoses per study site

Table I.1: Reported positive cases of helminths per study site and total helminths over study period.

SIR YAHAYA MEMORIAL HOSPITAL	2014	2015	2016	2017	2018	2019	2020
POSITIVE STOOL SAMPLES	5	11	4	0	0	13	1
NEGATIVE STOOL SAMPLES	234	679	493	26	0	218	129
TOTAL	239	690	497	26	0	231	130

TOTAL POSITIVE	34
TOTAL NEGATIVE	1779
GRAND TOTAL	1813

FEDERAL MEDICAL CENTRE	2014	2015	2016	2017	2018	2019	2020
POSITIVE STOOL SAMPLES	0	5	0	0	0	0	0
NEGATIVE STOOL SAMPLES	0	623	444	492	40	664	0
TOTAL	0	628	444	492	40	664	0

TOTAL POSITIVE	5
TOTAL NEGATIVE	2263
GRAND TOTAL	2268

SUM OF BOTH STUDY SITES	2014	2015	2016	2017	2018	2019	2020
POSITIVE STOOL SAMPLES	5	16	4	0	0	13	1
NEGATIVE STOOL SAMPLES	234	1302	937	518	40	882	129
TOTAL	239	1318	941	518	40	895	130

TOTAL POSITIVE	39
TOTAL NEGATIVE	4042
GRAND TOTAL	4081

APPENDIX J: Raw data of Part C: Children demographics

Table J.1: The demographics of the general public participants children and incidence of helminth infections.

Item	Response	Frequency (n)	Percentage (%)
Do you have children? (n=277)	- Yes	132	47.7
	- No	145	52.3
Have your children had a worm infection? (n=132)	- Yes	53	40.2
	- No	79	59.8
What was the age range of the child/children when they had the infection? (n=53)	- <6 months	15	28.3
	- 6-12 months	7	13.2
	- >1-6 years	24	45.2
	- >6-11	4	7.5
	- >11-18 years	3	5.7
	- >18 years	0	0.0
Did the child/children have multiple worm infections? (n=53)	- 1	0	0.0
	- 2-5	5	9.4
	- 6-10	6	11.3
	- Once a year	34	64.1
	- Twice a year	8	15.1