Prevalence of Soil Transmitted Helminths Among Children Aged 1-4 in Yabo District Sokoto State, Nigeria

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Abstract
Pre-school-aged children are always excluded in mass intervention policies for control of soil-transmitted helminths in rural sittings in Nigeria. An epidemiological study was conducted to access the prevalence of soil transmitted helminthiasis among children of 1-4years in Yabo district Sokoto State, with an aim to determine the area and age group with the highest prevalence of soil transmitted helminthes among the children of various communities in Yabo district. A cross-sectional survey was administered to obtain 490 study participants which were randomly selected and stool samples were collected in standard procedure and were also diagnosed using Con Method (FEM) to obtain the presence of egg/ovum, larva and adult parasites. The study revealed overall prevalence of soil transmitted helminthes among children in Yabo district Sokoto state to be (70.25%) which is high. Four (4) species of soil transmitted helminthes were identified and the highest prevalence was seen in Ascaris lumbricoides 132 (33.00%), followed by Trichuris trichiura 75 (18.75%), hookworms (Ancylostoma duodenale/Necator americanus) 47 (11.75%) and Strongyloides stercoralis 25 (6.25%).An overall prevalence of (70.25%) was obtained in Yabo district which Ruggar Iya had the highest prevalence, the infection intensity was very high in male children than in female and the subjects aged between 21- 30 and 31- 40months were much more infected than the rest. Ascaris lumbricoides had the highest prevalence than other species of STHs among the subjects in the study area.

Keywords*: children of 1-4 years, Yabo District Sokoto, prevalence, soil transmitted helminths,*

Introduction

Soil-transmitted helminths (STHs), also referred to as geohelminths, are intestinal parasitic nematodes transmitted through contact with contaminated soil. They are categorised as neglected tropical diseases (NTDs) and continue to be a serious public health issue, especially in low- and middle-income nations with inadequate sanitation and hygiene (WHO, 2023). The primary methods of transmission are eating of infectious eggs or skin penetration of infectious larvae when human excrement contaminates soil (Jourdan et al., 2018; Ngwese et al., 2021). Ascaris lumbricoides, Trichuris trichiura, Necator americanus, Ancylostoma duodenale, and

Strongyloides stercoralis are the main species that infect humans (Hotez et al., 2020). These parasites don't need intermediate hosts since they have a straight life cycle. In tropical areas like north-west Nigeria, warm, humid soil is ideal for the development of infectious stages (WHO, 2022). Over 1.5 billion people are thought to be infected with soil-transmitted helminths worldwide, with children having the highest illness burden (WHO, 2023). Iron-deficiency anaemia, malnourishment, stunted physical growth, diminished cognitive development, and subpar academic performance are all strongly associated with STH infections (Bain et al., 2019; Hotez et al., 2020). Morbidity is nevertheless significant and persistent even if death is comparatively low. STH infections are widespread in Nigeria and are strongly linked to poor personal hygiene, hazardous water sources, poor sanitation, and poverty (Awasthi & Hotez, 2019; Bala et al., 2019). Due to their frequent exposure to polluted settings and little understanding of cleanliness, school-aged children are especially susceptible (WHO, 2022). Despite mass drug administration (MDA) programmes using albendazole and mebendazole, reinfection remains common because chemotherapy alone does not prevent re-exposure to contaminated soil (Campbell *et al.*, 2019; WHO, 2021).

Due to inadequate hygiene practices, such as the careless disposal of human and animal waste, STHs are spread via contaminated soil, food, and drinking water (Bala et al., 2019). Through contact with their eggs or larvae, which flourish in warm, humid soils, especially in tropical regions, they may infect humans. Strongyloides stercoralis, the hookworms Ancylostoma duodenale, and Necator americanus, as well as Ascaris lumbricoides and Trichuris trichiura, are among the STHs that are acquired by larvae burrowing through intact skin (Bala et al., 2019). The STHs family of adult female worms generates between 100,000 and 200,000 eggs per day. Eggs expelled in faeces need time to mature in the soil. The embryo grows within the eggshell in a healthy environment with warm, humid soils. For the eggs to grow into infectious eggs, they must remain in the soil for two to many weeks. After being consumed in the jejunum, the larvae burst through the intestinal wall and go via the hepatic venules to the right side of the pulmonary circulation, where they undergo further moults and split into alveolar gaps. The 1.5 mm length larvae leave the alveoli, rise to the trachea, are swallowed, go through one last moult in the gut, and mature into adults. It takes eight to twelve weeks for mature adult worms to produce eggs after consuming infectious eggs. The mature worm may live for one to two years (Hotez et al., 2019). The existence or lack of sanitary facilities at home has been proven as a key driver of the occurrence of gastro-intestinal parasites (De Silva, 2012; Abossie and Seid, 2014; Mathewos et al., 2014). STHs can be linked to eosinophilia and/or persistent gastrointestinal symptoms, but they are frequently clinically asymptomatic and ignored until major complications or chronic clinical features manifest (Schulte et al., 2002; Gill et al., 2004; O'Brien et al., 2006; Becker et al., 2011; Naidu et al., 2013; Calderaro et al., 2014). These parasites may cause one or many infections. Heavy infections are linked to cognitive impairment, iron-deficiency anaemia, growth retardation, malabsorption, and malnourishment; children of school age and immunocompromised or immunosuppressed individuals are especially susceptible to these infections (Teklemariam et al., 2014). They seldom result in mortality, but they do induce varying degrees of tissue damage and illness in people (Stephenson et al., 2000; Stoltzfus et al., 2004). Along with their negative impacts on health, they also hamper children's physical and mental development, academic success, and economic progress (Drake et al., 2000; Guyatt, 2000). Additionally, consuming the ebryonated eggs that release larvae that burrow into the colonic epithelia upon reaching the cecum, where they mature into adult worms, is how STHs are transmitted to humans. By secreting pore-forming proteins, the adult parasite embeds its

anterior portion in epithelial tunnels (Drake et al., 2003). Macrophages and proinflammatory cytokines in the lamina propria, along with disruption of the normal colonic texture, cause inflammation at the site of attachment (MacDonald et al., 1994). The Trichuris worm may live for one to two years as an adult, and it takes 20 to 100 days for the infectious egg to mature. However, it takes eight to twelve weeks for an eaten egg to grow into an adult worm.

Depending on the species, STH infections have different pathologies and clinical signs. Furthermore, the severity of a STH infection is correlated with its clinical signs. The acute signs and symptoms of early larval migration via the epidermis and viscera and the persistent symptoms brought on by the adult worms' parasitism of the gastrointestinal system are the two categories of clinical aspects of STH infections. The most significant causes of STH worm infection, according to epidemiological investigations, are unhygienic circumstances such defecation and faecal pollution of water bodies. Personal hygiene is the cause of the spread. Ascariasis, trichuriasis, and hookworm have been identified as the main causes of helminthes infections in Nigeria, where there are an estimated 55 million, 34 million, and 38 million cases, respectively. One of the most significant causes of intellectual and physical development retardation worldwide is soil-transmitted helminthes. However, the medical and international community continues to mostly ignore them despite their significance in education, the economy, and public health. Many poor nations have not organised structures and resources to attain a high deworming coverage rate, despite the inexpensive cost of treatment (WHO, 2020). According to a WHO study (2020), for example, the nationwide coverage of treatment for school-age children in Bangladesh, India, Indonesia, and Thailand was less than 25%. In Thailand, the coverage was less than 1%. At least one-third of the world's population is thought to be chronically impacted by STHs, and the frequency of infections varies across nations and sometimes even within a single nation (WHO, 2021). Numerous prior studies have found significant correlations between STH infections and poor cognitive and educational performance, as well as malnutrition, particularly in children living in rural areas of developing nations, including Nigeria (Ahmed et al., 2012; Al-Mekhlafi et al., 2005a; Dreyfuss et al., 2000). Because soil-transmitted helminth infections deplete the host's nutrients or hinder nutrient absorption, they may cause malnutrition (Bain et al., 2013). The Nigeria Demographic and Health Survey (NDHS) 2008 found that 13.9% of children aged 6-59 months were wasted, 40.6% were stunted, and 23% were underweight. Ten years later, 22% of children in the same age group were underweight, 37% were stunted, and 7% were wasted, according to the NDHS 2018 (Osaro BO et al., 2023).

Mass medicine delivery is the primary method of preventing, treating, and controlling these parasites. Chemotherapy by itself, however, is insufficient to address the issues and additional strategies like hygiene and health education should also be taken into account. Man's behavioural attitudes and practices may be the primary determinant of control measures' success or failure. As a result, community involvement in active programmes aimed at raising their quality of life and health is crucial (WHO, 2021). For mass medication administration, a single dosage of albendazole tablets twice a year is advised (WHO, 2020). The primary obstacles to this approach, however, are that chemotherapy cannot eradicate young worms and cannot stop re-infection, which may happen shortly after treatment (Campbell et al., 2019; Jia et al., 2018).

The frequency of intestinal helminth infections in Almajiri schools and orphanages remains unknown, however there have been researches in Sokoto State. Studies in the area have mainly concentrated on three populations: newborns infected with geo-helminths (Iduh et al., 2015), children in school (Ibrahim et al., 2000), and Almajiris (Muhammad et al., 2018). Students at Government Day Secondary School in the Gidan Igwe Area were found to have a prevalence

rate of 60.0% of soil-transmitted helminthiasis, according to Bala et al. (2019). Primary school students in Wamakko Local Government had a prevalence of 33.50% of intestinal helminthiasis, according to research by Muhammad et al. (2018). A prevalence rate of 74.00% was reported by Singh and Idris (2014) in their study of Sokoto boarding school students. Primary school students had a frequency of 74.8 percent, according to Ibrahim et al. (2000), and among Almajiris in Sokoto city, 74.5 percent, according to Iduh et al. (2015). The prevalence of geo-helminth infections in babies was shown to be 1.40 percent by Isyaku et al. (2015), which is much lower.

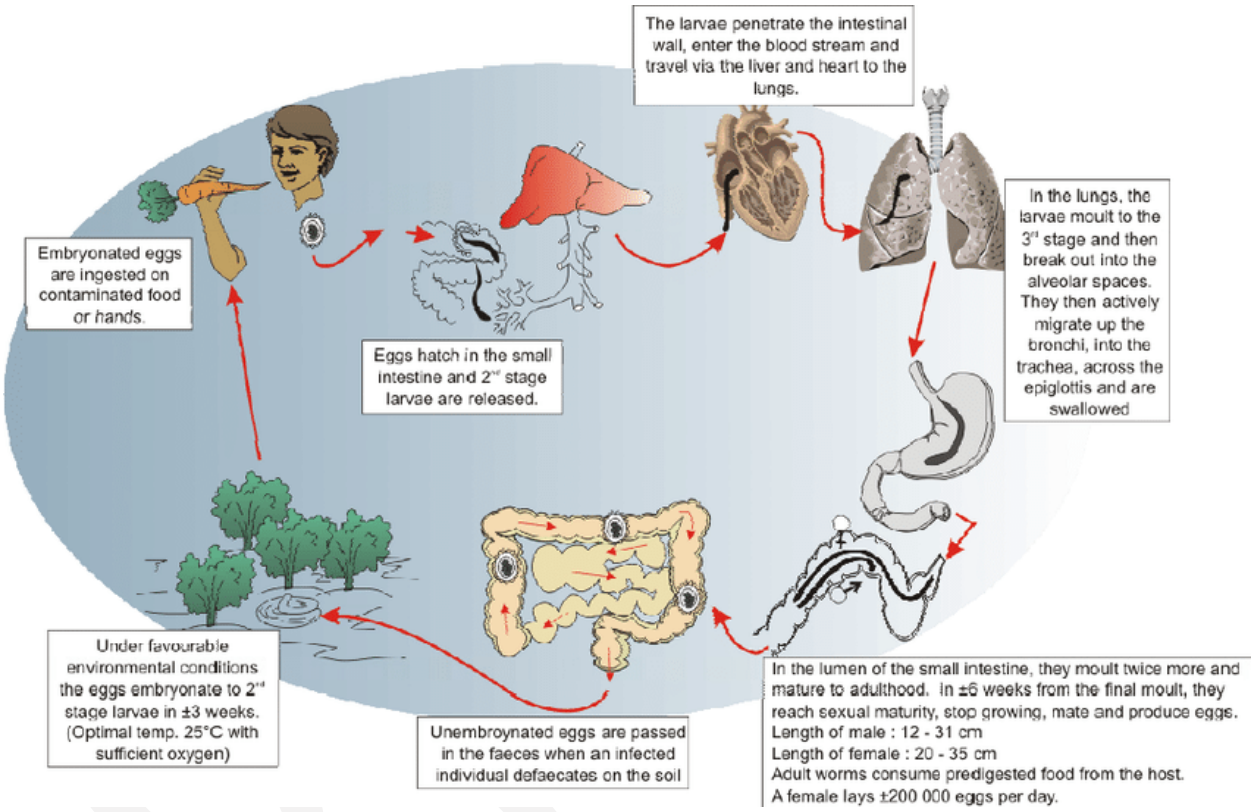

Figure1. Life cycle of *A. lumbricoides*, (Source: http//www.researchgate.net/profile/Colleen-Archer).

Indiscriminate defecation, low hygiene standards, and insufficient facilities for water supply and sanitation all increase the risk of contamination with A. lumbricoides eggs (Asaolu & Ofoezie, 2003). The parasitic illness known as trichuriasis is brought on by the worm Trichuris trichiura, which is a member of the Trichuroidea family. The mature worm has a pinkish-white hue. Its posterior portion, which houses the parasite's gut and reproductive organs, is referred described as having a whip-like form. The female is 5 mm longer than the male and measures between 35 and 50 mm. Up to 20,000 eggs are produced daily by the mature female (Cooper, 1995). The large intestine's best location for invasion is the cecum, and in cases of severe illness, the infection spreads to the rectum (Hotez, 2000).

Humans get the disease by consuming the embryonated eggs, which release larvae that burrow into the colonic epithelia until they reach the cecum, where they mature into adult worms. By secreting pore-forming proteins, the adult parasite embeds its anterior portion in epithelial tunnels (Drake et al., 1994). Macrophages and proinflammatory cytokines in the lamina propria, as well as disruption of the normal colonic texture, cause inflammation at the site of attachment

(MacDonald et al., 1994). The Trichuir worm may live for one to two years as an adult, and it takes 20 to 100 days for the infectious egg to hatch. However, it takes eight to twelve weeks for an eaten egg to grow into an adult worm. Below is an illustration of the life cycle.

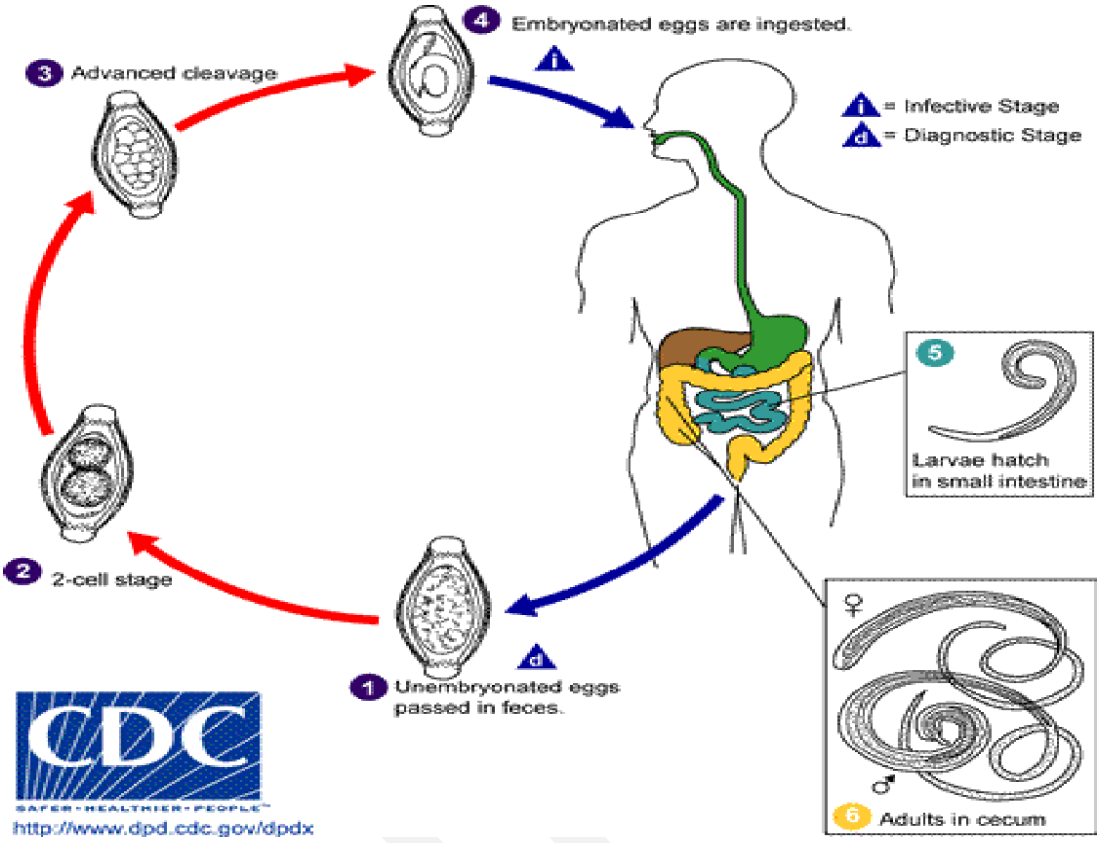

Figure 2: *Trichuris trichiura* life cycle
(Source: CDC)

Hookworms

Nematodes known as hookworms are members of the Ancylostomatidae family, which is a subfamily of the Strongyloidea superfamily. The two main genera that infect humans are Necator and Ancylostoma, which are distinguished in their adult stages by the presence of oral cutting organs (teeth or cutting plates) (Hotez, 1995a). Either N. americanus or A. duodenale may infect humans with hookworms. The mature worm is cylindrical, tiny, and greyish in colour; the female is bigger than the male, measuring 10–13 mm and 8–11 mm, respectively. After being discharged in faeces, the eggs hatch into rhabditiform or non-infectious stages in the soil within 24 to 48 hours. These stages then develop into infectious filariform larvae (L3 larvae), which may live in the soil for up to two weeks without finding a host.

The larvae may enter the body via the skin of the foot. Once inside, they go through the blood circulation to the lungs, then up to the trachea, where they are swallowed and develop into adults in the small intestine. The time between skin penetration and the growth of an adult worm is around five to nine weeks. According to Booker et al. (2006), a mature worm may live for three to four years. The two primary hookworm genera vary significantly in both biology and bio-pathology. N. americanus contains two cutting plates in the buccal capsule, while A. duodenale has two pairs of sharp teeth. It has been observed that A. duodenale is spread by oral

consumption of the larvae, in contrast to N. americanus, which can only complete its life cycle in humans following skin penetration (Hotez et al., 2005). Additionally, compared to N. americanus, A. duodenale is longer, produces more eggs (25,000–30,000 eggs per day against 9,000–10,000 eggs per day), and is more virulent due to its increased blood loss (Albonico et al., 1998). Figure 2.3 depicts the life cycle of hookworms.

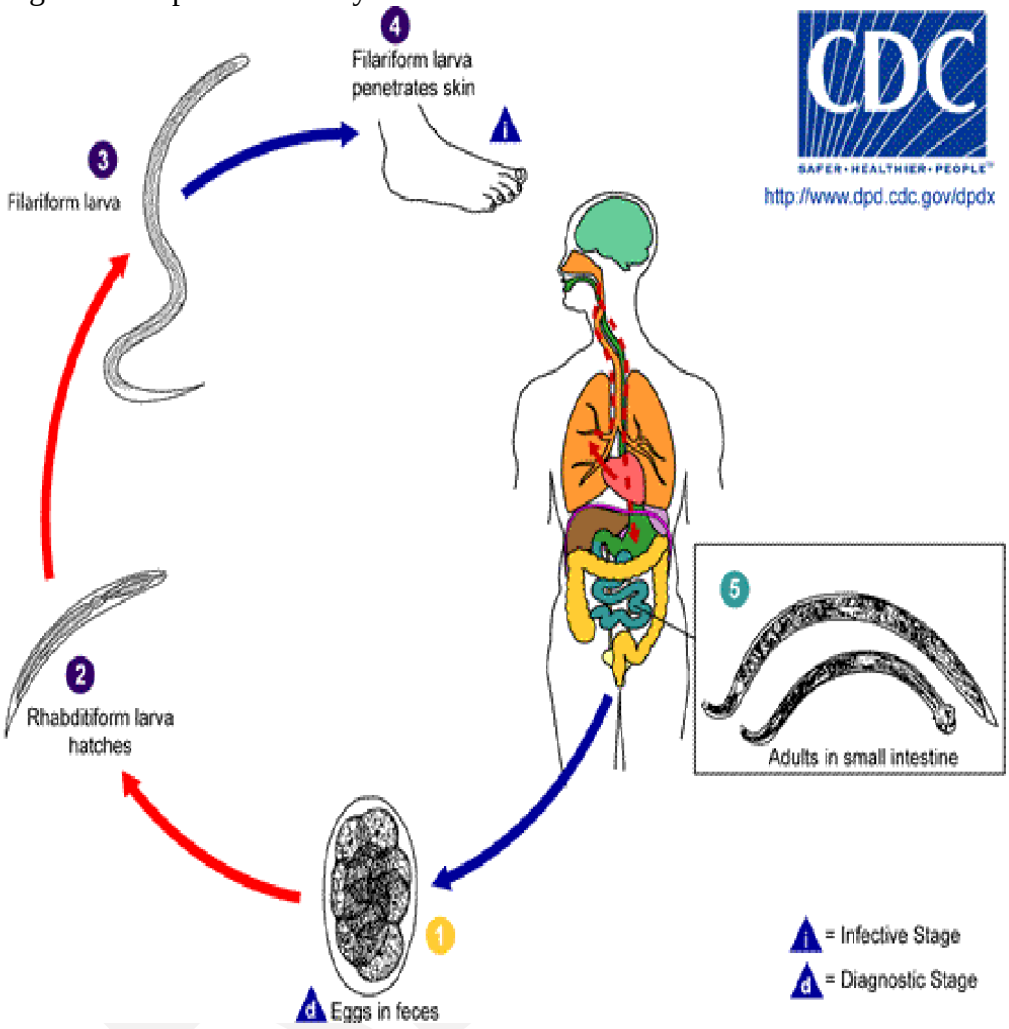

Figure 3: Hookworm life cycle
Source:(CDC Georgia, USA)

Pathology/Clinical manifestations of STH infections

Depending on the species, STH infections might present with different clinical signs. Furthermore, the severity of a STH infection is correlated with its clinical signs. While moderate-to-heavy infections are linked to serious consequences, light intensity infections are often asymptomatic (Neva and Brown, 1994). The acute signs and symptoms of early larval migration via the epidermis and viscera and the persistent symptoms brought on by the adult worms' parasitism of the gastrointestinal system are the two categories of clinical aspects of STH infections.

i. Early Larva Migration

Early Ascaris and hookworm larval migration to the lungs might result in a variety of tissue responses. The larvae may cause an inflammatory response that includes fever, a non-productive cough, wheezing, dyspnea, and blood in the sputum produced during a severe sickness. Eosinophilic granuloma is an aggregation of eosinophils in the lung in response to an Ascaris infection. These symptoms are referred to as Loffler's syndrome, with Ascaris continuing to be the most prevalent cause globally, especially in youngsters (Joob and Wiwanitkit, 2012). Regarding hookworm infections, recurrent contact with N. americanus and A. duodenale filariform larvae causes pruritus on the hands and feet, ground itch, and a common rash in the area (Hotez et al., 2004). Third-stage larvae travel to the lungs and create Loeffler's syndrome, which is similar to Ascaris infection but results in less severe pneumonitis (Neva and Brown, 1994). Wakana syndrome, which is characterised by pharyngeal irritation, cough, vomiting, and dyspnea, may also be brought on by oral consumption of A. duodenale larvae (Brooker et al., 2004; Hotez et al., 2004).

ii. Intestinal Parasitism by Adult Worm

Because there are many adult Ascaris in the small intestine, gastrointestinal symptoms may arise during the intestinal late phase of Ascaris infection. These include lactose intolerance, distension and discomfort in the abdomen, and vitamin A malabsorption (Taren et al., 1987). When it comes to Trichuris, the mature worm is often discovered with its rear end free in the large intestine's lumen and its anterior end slightly lodged in the mucosa. When there are severe infections, these adult worms may be observed in the colon and rectum and can result in colitis. It results in a clinical picture that is similar to inflammatory bowel disease, including fatigue, diarrhoea (occasionally bloody diarrhoea), and persistent stomach discomfort (Bundy and Cooper, 1989). The symptoms of hookworm are linked to intestinal inflammation caused by feeding the worms, which puncture the intestinal mucosa and suck blood voraciously while making anticoagulant, allowing bleeding to persist (Blanton, 2007). The symptoms range from nausea, stomach discomfort, and sporadic diarrhoea that may include blood to progressive anaemia in chronic instances, depending on the severity of the infection (Hotez, 2004). Furthermore, severe chronic infections linked to severe intestinal blood loss and hypoproteinemia might result in palpitations, mucous membrane pallor, exhaustion and weakness, dyspnea, bleeding, and oedema. Anaemia and a drop in host haemoglobin concentration below 11 g/dl are thot to be caused by the presence of more than 40 mature worms in the small intestine (Albonico et al., 2004). According to Nallam and Gnanamani (1998), hookworm infections may drain over 50 millilitres of blood per day when the egg per gramme (epg) faeces is around 250. This lowers the red blood cell count, haemoglobin, and serum proteins.

Laboratory Diagnosis of STH Infections

STH infections are diagnosed in laboratories by looking for their distinctive eggs and/or larvae in stool samples taken from affected people. In order to find STH eggs and larvae in faeces, the following methods are often employed:

I. Direct Smear Technique: This method needs to be used to each stool sample that the laboratory receives. Both the eggs of other species and the motile larvae of Strongyloides or hookworm may be found.

ii. Formalin-Ether Sedimentation Technique: For all intestinal parasite infections, including STH, this is the preferred approach, particularly for mild infections. Formalin, a fixative reagent used in the procedure, stops the stages from developing further.

iii. Kato-Katz Technique: The WHO recommends this method as the gold standard for diagnosing STH infections. Egg counting is a great way to assess the severity of illnesses (WHO, 2002). This method uses cellophane tape soaked in a solution of malachite green as a cleaning agent (Odongo-Aginya et al., 2007). The eggs on the whole slide are to be counted using faecal material of a defined size.

iv. McMaster Technique: This method counts and identifies STH eggs in faecal samples. A counting chamber that allows for the microscopic examination of a known amount of faecal solution is used to count eggs (Barda et al., 2014).

v. Flotac Technique: This novel direct approach for diagnosing intestinal parasite infections was developed lately. Up to 1 g of faeces may be prepared for microscopic inspection using this procedure, which uses a cylindrical device with two 5-ml flotation chambers (FLOTAC equipment). Because it may be used to both fresh and stored faecal samples, this method is beneficial (Knopp et al., 2009).

Vi. Harada Mori Culture: To cultivate and retrieve hookworm and Strongyloides nematode larvae, a little quantity of excrement is cultured on a filter paper strip in a test tube filled with water. Light hookworm infections may be found using this technique (Jozefzoon and Oostburg, 1994).

Intervention and Control Measures.
These days, albendazole and mebendazole are the most often used medications for treating STH infections. These medications are inexpensive, safe, and effective against these parasites; however, pregnant women and children under the age of two should be treated with caution (WHO, 2005). The most popular medications are:

i. Albendazole: This broad-spectrum anthelmintic medication is used as a single dosage of 400 mg, which is lowered to 200 mg for infants less than 24 months. While Strongyloides and Trichuris infections may need further doses, such as a three-day course of therapy, this single dosage is quite successful against Ascariasis and hookworm infections (WHO, 1999; Al-Mekhlafi et al., 2008b). Albendazole essentially stops microtubule synthesis by attaching to worm β-tubulin and inhibiting parasite microtubule polymerisation, which kills mature worms in a matter of days (Bethony et al., 2006). The majority of the drug's anthelminthic effect occurs immediately in the stomach, and the host absorbs it poorly. As a result, albendazole and other benzimidazole derivatives are unable to eradicate young worms or stop re-infection, which may happen shortly after therapy (Jia et al., 2012).

ii. Mebendazole: This benzimidazole derivative is also offered as an oral solution (100 mg/5 ml) and flavoured chewable tablets (100 and 500 mg). While trichuriasis requires a three-day course of therapy, mebendazole, like albendazole, is administered as a single dosage that is effective against Ascaris and hookworm infections (Stuckler et al., 2011). The medication only affects the

worms in the stomach since it is poorly absorbed from the gastrointestinal system and very insoluble in water.

iii. Other Medications: A single dosage of pyrantel pamoate and levamisole is also administered. They work well against infections caused by STH. Pyrantel pamoate is very efficient against trichuriasis but less effective against hookworm infections (WHO, 2022).
Low effectiveness against anthelmintics has been reported in several investigations. For example, albendazole (400 mg) as a single dosage has a high cure rate for hookworm and Ascaris infections, while it has a poor cure rate for Trichuris infections (Al-Mekhlafi et al., 2008a; Horton, 2000; Norhayati et al., 1997b). The mature worms' embedding in the large intestine's mucosa may be the cause of the treatment's poor effectiveness against Trichuris. According to prior research conducted in Mexico, albendazole was 100% effective against Ascaris but only 35% effective against Trichuris (Rodriguez-Perez, 2011). According to different research conducted in Lao PDR, 36% of hookworm infections were cured with albendazole and 18% with mebendazole (Soukhathammavong et al., 2012). Pyrantel-oxantel therapy for trichuriasis has been linked to similar issues, with a 32% cure rate (Albonico et al., 2002). Similarly, a research conducted in Zanzibar, Tanzania, revealed that mebendazole or albendazole alone had extremely low efficiency against trichuriasis, with cure rates of 19% and 10%, respectively (Knopp et al., 2010). The national mass deworming project was discontinued in Malaysia in the 1970s due to reports of hookworm infections being resistant to pyrantel pamoate (Ahmed et al., 2011). Similar poor effectiveness of albendazole pills in treating trichuriasis in Orang Asli populations has been documented in another research (Al-Mekhlafi et al., 2008a; Norhayati et al., 1997).

Risk Factors of STH Infections

Numerous risk factors have been linked to the high frequency and severity of STH in a number of prior investigations. These include a variety of behavioural, environmental, socioeconomic, and demographic elements that create a chain of causation for STH infections (Figure 2.5). Therefore, in order to adopt effective control measures, a better knowledge of the link between risk factors and the dynamics of STH transmission is crucial. According to de Silva et al. (2003), the risk factors for STH infections might vary by location and sometimes within the population or nation as a whole.

Methodology

Study Area

Yabo Local Government Area in Sokoto State, Nigeria, was the site of the research. Yabo is located in a semi-arid region of Nigeria. It is located at 12°43'51.6"N (12.6476700°), 5°04'18.4"E (5.0717800°), and has a tropical climate with temperatures between 38°C and 42°C from March to May. Kilgori, Binji, Bakale, Bingaje, Birnin Ruwa, Fakka, Ruggar Iya, Yabo I, II, and Torankawa make up its area council. There is very little rainfall, which begins late in April and ends early in September (FOH, 2005). Since Sokoto, Kebbi, and Zamfara were formerly known as Sokoto, Yabo Local Government is one of the earliest local governments in Sokoto State, with its headquarters located in the town of Yabo. At that point, Tambuwal, Shagari, and Yabo were all referred to as Yabo. Tambuwal, Wamakko, Shagari, Bodinga, and Silame LGAs are all next to Yabo. With an area of 789 km² and a population of 115,302 (NPC/FRN, 2007), Yabo is expected to increase exponentially at a pace of 2.78% to 144,020 by 2013. Yabo is

located north of the equator and has a typical savanna environment with distinct dry and rainy seasons that last around six months each. The majority of the population are Fulanis and Hausas, who practice Islam as their primary religion (NPC/FRN 2007 and WHS 2006).



Source: Arc GIS Lab. Department of Geography UDUS 2017(artificially enhanced for better visualization)

Sample Size Determination

The following procedure was used to calculate the sample size based on 95% confidence limits and 5% sampling errors (Trushfield, 2005). The cross-sectional survey formula was used to determine the sample size.

$N= [Z^2 -P (Q)] / D^2$

N= Number of sample size

Z= Standard normal deviation at 95% confidence interval 1.96 (confidence interval)

P = Prevalence from previous study in the area (Bala *et al.*2019.) (No=620, 60.2%) = 0.620

D = Degree of confidence at 0.05

Q= 1-P= 1- 0.620 = 0.380

Q = 0.380

N= 3.8416 – 0.62 (0.38) /0.0025

N= 3.2326(0.38)/0.0025

N= 1.228388/0.0025
N = 490.3552 = 490.

Study Design

Kilgori, Binji, Torankawa, and other nearby villages make up the Yabo District, where the research was carried out. A total of 490 subjects were given questionnaires and 490 stool samples were taken. The study used a cross-sectional study design to examine the district's children's soil-transmitted helminthiasis.

Community sensitization was carried out prior to data collection with the assistance of staff from the Primary Health Care (PHC) personales within the study area. Household sampling was performed through random selection of houses within the communities. From each selected household, a maximum of three or a minimum of one eligible child aged 1–4 years was recruited into the study following parental consent.

Parents or caregivers of eligible children were provided with sterile stool containers and applicator sticks and were educated on proper stool sample collection procedures on the day of the visit. Stool samples were taken from each participant and sent to a central site, often the home of the village leader (Hakimi or ward leader).

A systematic questionnaire was used to interview parents or caregivers whose children gave sufficient stool specimens. The questionnaire was used to record details about each child's age and gender, family cleanliness, and personal hygiene habits. On the day of collection, every stool sample was analyzed at the research area's central health institution.

Population Sampling

The study was carried out among children in Yabo district, which involve under aged male and female children of 12- 48 months or 1- 4 years old and were randomly selected in the study area. A total number of 261 male and 229 females were captured in this study.

Methods of Data Collection

In order to evaluate the nutritional status and the main sociodemographic risk factors for human helminthes among children in the research region, questionnaires were created and printed.

Administration of Questionnaires

Details about the subject's age, gender, and sociodemographic characteristics, such as where they get their drinking water from (protected or unprotected), how they handle water, whether or not their home has latrines, what kind of latrines they use, whether they wash their fruits or vegetables before eating, whether they eat raw vegetables, the condition of their fingernails, and whether they swim A systematic questionnaire that was pre-tested outside the research region was used to collect data on the study participants' nutritional condition, interaction with animals, shoe wearing habits, and environmental cleanliness. The team members translated the English-language questionnaire into the native tongue. In this case, the guardians or caregivers of the research participants were interviewed since they were too young to complete the questionnaire. All of them were carried out with the Head of Ward's (Hakimi) approval. Following the collection of the stool sample container, questionnaires were distributed in the research region. The feces sample container's serial numbers were kept the same.

Inclusion and Exclusion Criteria

Any ward participants who satisfied the requirements and willingly consented to provide informed permission for sample collection were included in the research. However, even with the interpretation and assistance of their guardians or caregivers, individuals from the wards who refused to grant informed permission for sample collection and who would not be able to provide correct answers during questionnaire administration were omitted.

Stool Sample Collection

A period of two to three days was used for community visitation and sensitization activities. The first day was dedicated to visitation and awareness creation among the ward heads (Hakimi) and parents or guardians of the study participants. During this visit, questionnaires and stool sample containers were distributed to the respective parents or caregivers in each ward to enable proper preparation for stool collection and questionnaire administration scheduled for the following day. Stool samples were collected and, if needed, questionnaires were given out on the third day. Every parent or guardian of the research participants received instruction on how to properly collect their children's feces samples in the early morning (Bala et al., 2019).

On the second and third days, the research team visited the wards early in the morning to collect stool samples, administer questionnaires, and assess the nutritional status of the children accordingly. All collected stool samples were properly labeled and arranged serially in containers before being transported to the diagnostic Centre at the Local Government health facility for laboratory examination on the same day of collection after each ward visitation within the district.

Laboratory Analysis of Stool Sample

According to WHO (2008), National Committee for Clinical Laboratory Standard (2018), Cheesbrough (2000), Arora and Arora (2005), Oyeyipo et al. (2013), and Demeke et al. (2021), the Formalin-Ether Concentration Technique (FECT) standard operating procedure was used to find the eggs/ova or larvae of the STHs in the fecal samples. A stool sample weighing around 1.0 g was suspended in 10 milliliters of a 10% formaldehyde solution and combined with an applicator stick. To eliminate debris, the suspension was transferred into a larger tube via a gauge-covered funnel. After measuring out around 3 milliliters of ether solution (diethyl ether), the tube was filled and sealed. After giving the suspension a good shake, the mixture was put into a 15 ml conical centrifuge tube and centrifuged for three minutes at 2000 rpm. The distinctive layer in the centrifuge tube was removed using an applicator stick. To get rid of the contents that left the sediments, the tube was swiftly and carefully reversed. Using a microscope set to 10× and 40× objectives, the sediments were then inspected for the presence of intestinal helminthes ova by placing a drop on a clean, grease-free glass slide covered with a cover slip (Taiwo et al., 2017; Demeke et al., 2021).

Data Analysis

After entering all of the collected data into a spreadsheet using Microsoft Excel 2013, SPSS (Statistical Package for the Social Sciences) version 26.0 was used to do statistical analysis. Chi-square (X2) tests and a simple distribution of the research variables were used; $P < 0.05$ was deemed statistically significant.

Using the formula (Number Infected/Number Examined) × 100, the prevalence of the STHs was determined and reported as a percentage. The formula: total number of individuals of a certain

parasite species in a sample of a host species / number of infected individuals of the host species in the sample was used to determine mean intensity (Nnatuanya et al., 2023).

The correlation between the risk variables for infection and the prevalence of infection across all wards was examined using the Chi-square (X2) test. The relationship between the wards, the individuals' age and gender, and the prevalence of infection was ascertained using the odds ratio (OR).

Results

Prevalence of Soil Transmitted Helminthes Species among the Total Communities of Yabo District

The frequency of soil-transmitted helminth (STH) infections among 490 children assessed in 10 Yabo District wards is shown in Table 4.1 below. The findings showed that 279 children had at least one STH species infection, resulting in a 56.94% total frequency. The distribution of STH infections differed considerably amongst the wards under investigation, according to a Chi-square test ($\chi^2 = 70.75$, DF = 9, $p < 0.001$). This suggests that the incidence of STH infections was strongly correlated with the ward of residency and that the frequency of infection was not consistent across the district. Variations in ambient cleanliness, personal hygiene habits, availability to clean drinking water, socioeconomic circumstances, health education, and the execution of deworming programs across the wards might all be responsible for the observed disparities. Among the helminth species identified, *Ascaris lumbricoides* was the most prevalent parasite, infecting 132 (26.94%) children. This was followed by *Trichuris trichiura*, which infected 75 (15.31%) children, while hookworms (*Ancylostoma duodenale*/*Necator americanus*) were detected in 47 (9.59%) children. *Strongyloides stercoralis* was the least prevalent parasite, occurring in 25 (5.10%) children. The predominance of *A. lumbricoides* suggests that environmental contamination with infective eggs and poor sanitation may be important factors influencing transmission within the study area.

Marked variations in infection prevalence were observed among the wards. The highest overall prevalence was recorded in RGR IYA, where 44 of 50 children (88.00%) were infected. This was followed by FKK with 37 of 48 children (77.08%), BNJ and KLGR, each with 33 infected children (67.35%), and BNGJ with 32 infected children (64.00%). In contrast, the lowest prevalence was observed in YB B, where only 14 of 49 children (28.57%) were infected, followed by BRN RW with 15 of 48 children (31.25%) and YB A with 17 of 47 children (36.17%).

With respect to individual parasite species, the highest prevalence of *A. lumbricoides* was observed in RGR IYA (40.00%), followed by KLGR (38.78%) and TRNKW (34.00%), whereas the lowest prevalence occurred in YB A (14.89%). For *T. trichiura*, the highest prevalence was recorded in RGR IYA (26.00%) and FKK (25.00%), while the lowest prevalence was observed in YB B (4.08%). Hookworm infections were most common in RGR IYA (18.00%), followed by FKK (16.67%) and BNJ (16.33%), whereas the lowest prevalence occurred in YB B (2.04%) and BRN RW (2.08%). The prevalence of *S. stercoralis* ranged from 0.00% in BRN RW to 8.33% in FKK, indicating relatively low occurrence throughout the study area.

Overall, the findings demonstrate that STH infections remain a major public health concern among children in Yabo District, with *A. lumbricoides* being the dominant parasite species. The significant variation in prevalence among wards highlights the need for targeted intervention strategies, particularly in highly affected wards such as RGR IYA, FKK, BNJ, KLGR, and BNGJ. Regular mass deworming, better sanitation facilities, clean water supply, and ongoing

health education targeted at lowering exposure to infectious stages of the parasites are also suggested control approaches.

Prevalence of Soil Transmitted Helminthes Species among the Total Communities of Yabo District

Key: YB A = Yabo A; YB B = Yabo B; BKL= Bakale; BRN RW =Birnin ruwa;

Wards	**No. Examined (N)**	***Ascaris lumbricoides* (%)**	***Trichuris trichiura* (%)**	**Hookworms (*Ancylostoma duodenale/ Necator americanus*) (%)**	***Strongyloidiasis stercoralis* (%)**	**Total Prevalence (%)**
YB A	47	07 (14.89)	04 (8.51)	03 (6.38)	03 (6.38)	17 (36.17)
YB B	49	08 (16.32)	02 (4.08)	01 (2.04)	03 (6.12)	14 (28.57)
BKL	50	10 (20.00)	08 (16.00)	04 (8.00)	04 (8.00)	26 (52.00)
BRN RW	48	11 (22.92)	03 (6.25)	01 (2.08)	00 (0.00)	15 (31.25)
BNGJ	50	15 (30.00)	10 (20.00)	05 (10.00)	02 (4.00)	32 (64.00)
BNJ	49	12 (24.49)	09	08 (16.33)	04 (8.16)	33 (67.34)
FKK	48	13 (27.08)	(18.35)	08 (16.67)	04 (8.33)	37 (77.08)
RGR	50	20 (40.00)	12	09(18.00)	02 (4.00)	44 (88.00)
IYA	49	19 (38.78)	(25.00)	04 (8.16)	02 (4.08)	33 (67.34)
KLGR	50	17 (34.00)	13	04 (8.00)	01 (2.00)	28 (56.00)
TRNKW			(26.00)			
			08 (16.33)			
			06 (12.00)			
Total	**490**	**132 (26.94)**	**75 (15.31)**	**47 (9.59)**	**25 (5.10)**	**279 (56.94)**

BNGJ=Bingaje; BNJ =Binji; FKK= Fakka; RGR IYA= Ruggar Iya; KLGR= Kilgori; TRNKW= Torankawa; N = Number Examined; % = Percentage; X^2 = Chi-Square; = 70.75, P-Value = 0.001 and df = 9

Prevalence of Soil Transmitted Helminthes in Relation to Gender among Children in Yabo District

Table 4.2 below reveals that, out of the 490 children examined across the study wards, 261 (53.27%) were males and 229 (46.73%) were females. 56.53% of people had helminth infections that were spread via the soil. Compared to female children (55.02%), male children had a slightly greater frequency of infection (57.85%).

With 28.35% of infections in men, Ascaris lumbricoides was the most common parasite, followed by Trichuris trichiura (15.33%), hookworms (10.73%), and Strongyloides stercoralis (3.45%). In a similar vein, the most common parasite among females was A. lumbricoides (25.33%), followed by hookworms (8.30%), T. trichiura (15.28%), and S. stercoralis (6.11%).

According to statistical research, male children were 1.12 times more likely than female children to be infected (OR = 1.12; 95% CI: 0.79–1.60). Nevertheless, there was no statistically significant correlation between gender and STH infection ($\chi^2 = 0.42$, P = 0.52), suggesting that there was no significant difference in the incidence of infection between male and female children in the research region. Consequently, among the children studied, gender was not shown to be a major risk factor for soil-transmitted helminth infection.

Table 4.2.1 Overall prevalence of STHs in relation to gender

Gender	No. Examined	*A. lumbricoides* n (%)	*T. trichiura* n (%)	Hookworms (*A. duodenale/N. americanus*) n (%)	*S. stercoralis* n (%)	Total Infected n (%)
Male	261	74 (28.35)	40 (15.33)	28 (10.73)	9 (3.45)	151 (57.85)
Female	229	58 (25.33)	35 (15.28)	19 (8.30)	14 (6.11)	126 (55.02)
Total	**490**	**132 (26.94)**	**75 (15.31)**	**47 (9.59)**	**23 (4.69)**	**277 (56.53)**

Odds Ratio (Male vs. Female) = 1.12
95% Confidence Interval = 0.79–1.60
P-value = 0.52
Chi square = 0.42

Table 4.2.2 Chi-square Analysis for Overall STH Infection by Gender

Gender	Examined	Infected (%)	Uninfected (%)	OR (95% CI)	χ^2	P-value
Male	261	151 (57.85)	110 (42.15)	1.12 (0.79–1.60)	0.42	0.515
Female (Reference)	229	126 (55.02)	103 (44.98)	1.00		

Prevalence of Soil Transmitted Helminthes in relation to Age among Children in Yabo District

The distribution of soil-transmitted helminth (STH) infections in children by age group in Yabo District is shown in Table 4.3. Four age groups—12–20 months, 21–30 months, 31–40 months, and 41–50 months—were created from the examination of 490 children. Children between the ages of 12 and 20 months had the greatest overall frequency of STH infection, with 60 out of 97 children (61.86%) having at least one helminth species infection. Children between the ages of 21 and 30 months came in second, with 97 out of 161 children (60.25%) having the infection. The overall incidence for children aged 31–40 months was 50.79% (96/189), while the prevalence for children aged 41–50 months was 51.16% (22/43). Ascaris lumbricoides was the

most common parasite species found in all age groups. Its frequency peaked in children between the ages of 12 and 20 months, when 30 children (30.93%) were infected. As children grew older, it progressively decreased, reaching 18.60% among those between the ages of 41 and 50 months. This pattern implies that younger kids were more prone than older kids to get A. lumbricoides. The prevalence of *Trichuris trichiura* was also highest among children aged 12–20 months (19.59%) and decreased to 12.16% among those aged 31–40 months. However, a slight increase to 18.60% was observed in the 41–50 months age group. With prevalence rates of 9.27%, 9.94%, 8.47%, and 6.98% in the 12–20, 21–30, 31–40, and 41–50 months age categories, respectively, hookworm infections were also more prevalent in younger children. The least common helminth species found in the research population was Strongyloides stercoralis. Children between the ages of 21 and 30 months had the greatest incidence of this parasite (6.82%), while children between the ages of 12 and 20 months had the lowest frequency (2.06%).

Age and the prevalence of soil-transmitted helminth infections among the children under study were significantly correlated, according to statistical analysis ($\chi^2 = 14.27$, $p = 0.002$). The null hypothesis that age has no effect on STH infection was rejected since the p-value fell below the 0.05 threshold of significance. This result suggests that the risk of STH infection in children in Yabo District is significantly influenced by age.

Inadequate hand washing techniques, frequent playtime contact with contaminated dirt, poor personal hygiene, and greater exposure to infectious stages of the parasites might all contribute to the higher incidence seen in younger children. As children grow older, improved hygiene behavior, better parental supervision and the gradual development of immunity may contribute to the reduction in infection prevalence observed in some age groups.

Overall, the findings demonstrate that younger children, particularly those aged 12–30 months, constitute the most vulnerable group to soil-transmitted helminth infections in Yabo District and should therefore be prioritized in deworming, health education, and sanitation intervention programmes.

Table 4.3.1: Prevalence of Soil-Transmitted Helminths According to Age among Children in Yabo District overall summary

Age Group (Months)	No. Examined	A. lumbricoides n (%)	T. trichiura n (%)	Hookworm's n (%)	S. stercoralis n (%)	Total Infected n (%)
12–20	97	30 (30.93)	19 (19.59)	9 (9.27)	2 (2.06)	60 (61.86)
21–30	161	45 (27.95)	25 (15.53)	16 (9.94)	11 (6.82)	97 (60.25)
31–40	189	48 (25.39)	23 (12.16)	16 (8.47)	9 (4.76)	96 (50.79)
41–50	43	8 (18.60)	8 (18.60)	3 (6.98)	3 (6.98)	22 (51.16)
Total	**490**	**131 (26.73)**	**75 (15.31)**	**44 (8.98)**	**25 (5.10)**	**275 (56.12)**

Table 4.3.2 Overall statistical analysis for age group using 41-50 as reference group

Age Group (Months)	No. Examined	Total Infected n (%)	OR (95% CI)	χ^2	P-value
12–20	97	60 (61.86)	1.55 (1.12–2.87)		
21–30	161	97 (60.25)	1.43 (1.05–2.54)		
31–40	189	96 (50.79)	1.28 (0.94–2.20)		
41–50 (Ref.)	43	22 (51.16)	1.00	14.27	0.002

X2= 14.27
P value = 0.002

Table 4.3.3 Statistical Analysis base on Ward Format

Ward	OR (95% CI)	χ^2	P-value	Interpretation
YB A	1.12 (0.63–1.98)	11.42	0.008	Significant
YB B	0.73 (0.49–1.09)	5.86	0.120	Not Significant
BKL	0.85 (0.58–1.26)	9.12	0.029	Significant
BRN RW	0.74 (0.29–1.87)	9.58	0.023	Significant
BNGJ	1.31 (0.84–2.03)	9.74	0.021	Significant
BNJ	1.21 (0.82–2.03)	8.91	0.031	Significant
FKK	1.21 (0.82–2.03)	11.86	0.009	Significant
RGR IYA	1.68 (1.11–2.54)	14.27	0.002	Significant
KLGR	1.57 (1.08–2.29)	12.83	0.005	Significant
TRNKW	1.34 (0.91–1.99)	9.41	0.024	Significant

Risk Factors that Significantly Contribute to the Transmission of Soil Transmitted Helminthes in the Study Area.

Chi-square (χ^2) statistics were used to analyze the association between several environmental, behavioral, and hygiene factors and soil-transmitted helminth (STH) infection among research participants. A confidence level of $p < 0.05$ was used to evaluate statistical significance.

Infection status and knowledge of soil-transmitted helminths were statistically substantially correlated ($\chi^2 = 0.003$, $p = 0.034$), suggesting that participants' or caregivers' awareness levels had a major impact on the incidence of infection. Similarly, a history of past STH infection diagnosis showed a significant correlation with infection status ($\chi^2 = 0.003$, $p = 0.039$), indicating that current infection patterns within the research group may be connected to prior exposure or diagnosis. Wearing shoes was substantially linked to STH infection ($\chi^2 = 0.002$, $p = 0.021$). Children who did not wear shoes on a regular basis were more likely to come into contact with polluted soil, which raised their risk of illness. In a similar vein, fingernail status demonstrated a statistically significant correlation with infection ($\chi^2 = 0.002$, $p = 0.022$), suggesting that untrimmed fingernails may promote transmission via ingestion of infectious eggs as a result of inadequate personal hygiene. Despite being near the significance level, there was no statistically

significant correlation between hand washing before or after meals and infection ($\chi^2 = 0.003$, p = 0.055). On the other hand, hand washing after feces demonstrated a statistically significant correlation with infection status ($\chi^2 = 0.022$, p = 0.032), underscoring the significance of good hygiene practices in avoiding transmission.

Important correlations were also found in factors linked to sanitation. STH infection was substantially correlated with the kind of latrine or toilet facility utilized ($\chi^2 = 0.004$, p = 0.049), indicating that better sanitation infrastructure lowers the risk of infection. Similarly, there was a statistically significant correlation ($\chi^2 = 0.004$, p = 0.044) between the availability of latrines and toilet facilities and environmental pollution and increased exposure. Additionally, there was a significant correlation between latrine/toilet use patterns and infection ($\chi^2 = 0.002$, p = 0.029), indicating that inconsistent or non-use of accessible sanitation facilities increased susceptibility to infection. Open defecation behaviors were shown to be significantly associated with STH infection ($\chi^2 = 0.002$, p = 0.024), confirming that it is a major transmission mechanism in the research region. Children's infection prevalence may be influenced by the frequency or consistency of anthelminthic therapy, as seen by the statistically significant correlation between deworming practices and infection status ($\chi^2 = 0.003$, p = 0.033). Furthermore, there was a significant correlation ($\chi^2 = 0.021$, p = 0.034) between contact with sewage or garbage and STH infection, suggesting a higher risk of exposure in polluted surroundings.

Overall, most behavioral and sanitation-related variables including awareness of STHs, history of diagnosis, shoe-wearing habits, fingernail status, hand washing after defecation, type and availability of latrine facilities, latrine usage, open defecation, deworming practices, and contact with refuse or sewage showed statistically significant associations with STH infection ($p < 0.05$). Only hand washing before or after meals did not show a statistically significant difference, although it approached significance

Table 4.4 Risk Factors that Significantly Contribute to the Transmission of Soil Transmitted Helminthes in the Study Area.

Variables	Categories	Frequency	Percentage (%)	X^2	P-Value
Awareness of STHs	Yes	98	98(24.50)	0.003	0.034
	No	392	392(98.00)		
History of diagnosis for STHs	Yes	100	100(25.00)	0.003	0.039
	No	390	390(97.50)		
Shoe Wearing Habits	Always	94	94(23.50)	0.002	0.021
	Sometimes	162	162(40.50)		
	Not at all	234	234(58.50)		
Status of Fingernails	Trimmed	191	191(47.75)	0.002	0.022
	Not trimmed	299	299(74.75)		
Hand Washing Before/After a Meal	Always	96	96(24.00)	0.003	0.055
	Sometimes	230	230(57.50)		
	Not at all	164	164(41.00)		
Hand Washing After Defecation	Always	103	103(25.75)	0.022	0.032
	Sometimes	216	216(54.00)		
	Not at all	171	171(42.75)		
Type of Latrine/Toilet	Water closet	48	48(12.00)	0.004	0.049
	Pit latrine	187	187(46.75)		
	Refuse dump	255	255(63.75)		
Latrine/Toilet Availability	Available	139	139(34.75)	0.004	0.044
	Not available	351	351(87.75)		
Latrine/Toilet Usage	Always	98	98(24.50)	0.002	0.029
	Sometimes	141	141(35.25)		
	Not at all	252	252(63.00)		
Open Defecation	Engaged	310	310(77.50)	0.002	0.024
	Not engaged	180	180(45.00)		
Taking Deworming	Monthly	68	68(17.00)	0.003	0.033
	Yearly	80	80(20.00)		
	Not at all	342	342(85.5)		
Contact with Refuse or Sewage	Yes	282	282(70.5)	0.021	0.034
	No	208	208(52.00)		

Summary, Conclusion and Recommendations

Summary

This research was carried out in Yabo District, Sokoto State, North-Western Nigeria, to evaluate the nutritional condition of children and the epidemiology of soil-transmitted helminthiasis. The study's objectives were to ascertain the prevalence of soil-transmitted helminths in children in various communities within the district, assess the nutritional status of the children in the study area, identify important risk factors contributing to transmission, and evaluate the intensity of infection based on age and gender. Male and female participants were chosen from the study communities, and the study was conducted among youngsters living in Yabo District. A cross-sectional survey with a descriptive design was used. Each of the district's wards—Ruggar Iya, Kilgori, Torankawa, Bingaje, Fakka, Binji, Birnin Ruwa, Bakale, Yabo B, and Yabo A—provided 49 samples. In order to gather demographic and socioeconomic data, including age, sex, use of sanitation facilities, hand washing habits before and after meals, nutritional status, and sources of drinking water, a structured questionnaire was given to each participant from whom samples were taken. Environmental and behavioral risk factors for infection were evaluated using these variables. Every participant supplied a stool sample in a sterile container with an applicator that was appropriately labeled. The sample was then sent to the central hospital laboratory in the study region for examination. Using the formol-ether concentration method, stool samples were microscopically inspected for the presence of geohelminth eggs, ova, or larvae. The Shakir tape was used to measure nutritional status as soon as the questionnaire was given out. The Statistical Package for the Social Sciences (SPSS) version 26.0 was used to analyze the data after it was inputted into Microsoft Excel 2014. Chi-square (X^2) tests and descriptive statistics were used, with $P < 0.05$ being the threshold for statistical significance. The results showed that children in Yabo District had an overall prevalence of soil-transmitted helminths of 56.94%, suggesting a high level of infection. The greatest incidence of four species of soil-transmitted helminths was found to be Ascaris lumbricoides (26.94%), followed by Trichuris trichiura (15.31%), hookworms (Ancylostoma duodenale and Necator americanus) (9.59%), and Strongyloides stercoralis (5.10%). Males had a greater infection rate (59.39%) than females (55.02%), according to gender-based study. Participants between the ages of 21 and 30 months had the greatest infection rate, closely followed by those between the ages of 31 and 40 months, according to age-related analysis. Ruggar Iya had the greatest prevalence of all the wards examined, according to the ward-based distribution.

Chi-square analysis revealed statistically significant correlations between soil-transmitted helminth infection and a number of risk variables, such as the use of deworming pills, shoe wearing habits, fingernail cleanliness, and the presence of latrines or toilet facilities ($P < 0.05$). According to a nutritional evaluation, children from Torankawa ward had the worst malnutrition, followed by those from Kilgori, Bingaje, Fakka, and Ruggar Iya. While normal nutritional status was highest in Bingaje, Yabo B, Yabo A, Ruggar Iya, Kilgori, Binji, Birnin Ruwa, and Bakale in decreasing order, moderate malnutrition was most prevalent in Fakka ward.

6.2 Conclusion

According to the research, Yabo District has a high occurrence of STHs infections, with Ruggar Iya having the highest infection rate. Children between the ages of 21 and 40 months were more impacted than other age groups, and male children had a greater frequency of infection than female children. The most common species in the research population was found to be Ascaris lumbricoides. The incidence of infections was shown to be significantly correlated with the

availability of sanitation, shoe wearing practices, fingernail cleanliness, and consistent use of deworming drugs. Children in the Torankawa ward have significant malnutrition, according to a nutritional examination. The results show that the persistence of soil-transmitted helminth infections in rural populations is mostly caused by poor sanitation, insufficient hygiene practices, and irregular deworming. Improving child-care practices and caregiver awareness can help reduce worm burden in rural settings. Regular deworming programs conducted at intervals of three to six months are essential for reducing infection prevalence among children in Yabo District.

RJPST

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