ENVIRONMENTAL FACTORS AND CULTURAL PRACTICES INFLUENCING THE EPIDEMIOLOGY OF SOIL TRANSMITTED HELMINTHS IN IBADAN, NIGERIA

BY

David Anuoluwapo OYEBAMIJI

B. Sc., M. Sc. Zoology (Parasitology) (Ibadan)

Matric No: 146880

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CERTIFICATION

I certify that this work was carried out by Mr. D.A. Oyebamiji in the Department of Zoology, University of Ibadan.

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Supervisor

Adesola A. Hassan,
B.Sc. (Ibadan), M.Sc. (Jos), Ph.D. (Lagos)
Professor, Department of Zoology,
University of Ibadan,
Ibadan, Nigeria.

DEDICATION

This thesis is dedicated to the advancement of scientific research and improvement in the knowledge of Neglected Tropical Diseases.

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ABSTRACT

Soil-Transmitted Helminths (STHs) which affect approximately two billion people globally is a common public health concern in developing nations. Dynamics of host and environmental factors results in fluctuations in the parasite infectivity rate. Thus demographic information in endemic localities is necessary. Therefore, there is need to constantly update epidemiological data across geographic zones including remote endemic areas. Hence, this study was designed to evaluate the current knowledge, attitude, and practices, as well as environmental factors influencing the prevalence and intensity of STHs in Ibadan.

Soil samples (n=1980) were collected at a depth of 2-3 cm from five sampling sites (toilet areas, dumpsites, playgrounds, roadsides, and house vicinities) in the 11 Local Government Areas of Ibadan: South-East, South-West, North-East, North-West, Ibadan North, Akinyele, Ido, Lagelu, Egbeda, Oluyole and Ona-Ara, from January 2017 to December 2018. Faecal samples (n=1100) were also collected from consenting participants visiting Primary Health Centres. Parasite prevalence and intensity in soil and faecal samples were determined using standard methods, while temperature, rainfall, and Relative Humidity (RH) data were obtained from the Nigerian Meteorological Agency. Structured questionnaires were also administered to the consenting participants to obtain information on demographics (age, sex), and hygiene practices. Data were analysed using descriptive statistics, principal component analysis, and ANOVA at $\alpha_{0.05}$.

Soil contamination with at least one STH was recorded in 54.9% of samples examined. Soil parasite prevalence (%) were 39.9 (hookworm larvae), 26.8% (*Strongyloides* larvae), 19.9% (*Strongyloides* adult), and 13.4% (*Ascaris*). Prevalence (%) by location was 49.2 (South-East), 48.1 (South-West), 48.3 (North-East), 49.8 (North-West), 47.4 (Ibadan North), 51.1 (Akinyele), 52.2 (Ido), 55.1 (Lagelu), 53.6 (Egbeda), 51.8 (Oluyole), and 54.3 (Ona-Ara). Dumpsites had the highest mean parasite intensity (epg) of 216.2±211.5, 120.4±119.6 (toilet areas), 75.1±73.6 (roadsides), 13.7±11.8 (playgrounds), and 3.4±1.8 (house vicinities). Faecal samples had overall prevalence of 35.9% with *Ascaris* being the most frequently occurring (41.6%), hookworm (24.5%), *Trichuris* (23.4%), and *Strongyloides* (10.4%).

Highest parasite prevalence (%) in faecal samples was 38 from Ona-Ara, 36 (Lagelu), 35 (Ido), 34 (South-East), 32 (Egbeda), 31 (Akinyele), 30 (North-East), 29 (North-West), 28 (South-West), and 26 (Ibadan North). Overall intensity (epg) of faeces was 1043 (*Ascaris*), 771 (hookworm), 315 (*Trichuris*), and 210 (*Strongyloides*). Parasite prevalence (60.0%) was highest in November (mean temperature 30.9°C; rainfall: 39 mm; RH: 83%), while intensity (359) was highest in March (27.4°C; 67mm; 86%). Principal components 1, 2 and 3 accounted for 93.1% of total variations with RH (0.9) and rainfall (0.7) influencing STH prevalence (0.6) and intensity (0.7). Prevalence of infection was significantly higher in male (64.3%) than female (35.7%) participants. Prevalence was highest (23.4%) in 11-20 years and lowest (3.4%) in 51-60 years. Participants practicing open defaecation (22.4%) had a prevalence of 59.9%. However, participants that walk barefooted had STH prevalence of 60.7%.

Inadequate knowledge, open defaecation practices, and walking barefooted coupled with favourable climatic factors facilitated transmission of soil helminths in Ibadan.

Keywords: Climatic factors, Soil helminths, Hygiene status, Open defecation, Ibadan

Word counts: 472

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LIST OF ABBREVIATIONS

A:	Akinyele
DALYs:	Disability Adjusted Life Years
E:	Egbeda
EPG:	Egg Per Gram
IN:	Ibadan North
INE:	Ibadan North East
INW:	Ibadan North West
ISE:	Ibadan South East
ISW:	Ibadan South West
I:	Ido
JAPC:	Japan Association of Parasite Control
KAPE:	Korean Association for Parasite Eradication
L:	Lagelu
LGA:	Local Government Areas
MDA:	Mass Drug Administration
NGOs:	Non-Governmental Organisations
NTDs:	Neglected Tropical Diseases
OA:	Ona Ara
OD:	Open Deafecation
PCA:	Principal Component Analysis
PHC:	Public Health Centres
RH:	Relative Humidity
SAC:	School Aged Children
SSA:	Sub Saharan Africa
STH:	Soil-Transmitted Helminth
WASH:	Water, Sanitation and Hygiene
WHO:	World Health Organisation

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Soil-Transmitted Helminth (STH) parasites remain the primary cause of helminthiases, a disease condition that is currently amongst the foremost Neglected Tropical Diseases (NTDs) within populations in the low- and middle-income nations of the globe (Montresor *et al*., 2020). These diseases infect between 1.6 billion individuals or twenty-four percent of the entire world population and nearly 2.5 billion people, with children being the most affected population (Collender *et al.,* 2015; Oluwole *et al*., 2018). The vast majority of helminthic infections are caused by roundworms: *Ascaris lumbricoides* as well as *Strongyloides stercoralis*; whipworms: *Trichuris trichiura*; and hookworms: *Necator americanus* or maybe *Ancylostoma duodenale* (Strunz *et al*., 2014). Pullan *et al.* (2014) reported ascariasis in 891.6 million individuals, trichuriasis in 508.0 million individuals, and 480.2 million with hookworm.

Soil-transmitted helminthiases are present in most African regions and their public health significance had been stated in numerous studies reported from the country, Nigeria (Ojurongbe *et al.,* 2010; Auta *et al*., 2014; Bolaji *et al*., 2017; Fafunwa *et al*., 2017) and from other endemic nations as described by Scolari *et al.* (2000) and Clennon *et al*. (2004). The endemicity of soil helminthiasis can easily be observed in every rural and urban population, posing an outstanding risk to public health in most developing countries (WHO, 2000). The vast majority of STH infections could be observed in the tropical as well as the sub-tropical climate of the world wherever impoverishment is connected to poor hygienic conditions of individuals including their environments (Stolk *et al.,* 2016). The infections of STHs are mostly a result of the contamination of water, soil, and food by infected faecal substances (Stolk *et al.,* 2016).

Parasite life cycles involving *A. lumbricoides*, hookworms, and *T. trichiura* follow the normal general pattern of intestinal helminths. The adult stage of the parasite inhabits the gastrointestinal tract (hookworms and *A. lumbricoides* are found in the small intestine; *T. trichiura* is found in the large intestine), reproducing sexually, and producing eggs. Eggs are excreted with human faeces and dumped in the external environment. Soil-transmitted helminth infections are rarely fatal. Instead, the load of disease is less related to mortality than to the chronic and insidious effects on the health and nutritional status of the host (Collender *et al*., 2015).

1.2 Statement of the problem

Personal hygiene, dietary habits, level of education of people in the community; socio-economic standing and climate are among the common factors that influence the distribution and prevalence of parasitic infections (Alqarni *et al*., 2023). The over-all public health significance of STHs has been well documented and the projected number of Disability Adjusted Life Years (DALYs) loss to hookworm infection as a result of the sickness caused by these intestinal nematodes is 22.1 million, 10.5 million to *A. lumbricoides*, as well as 6.4 million to *T. trichiura*, giving a combined total of 39 million life-years (Hotez *et al*., 2006). Furthermore, the related and well-acknowledged disease burden is as significantly high with 34.7 million DALYs for tuberculosis or 46.5 million DALYs for malaria (Pullan and Brooker, 2012).

The World Health Organisation (WHO) came out with a plan to bring down the health and economic burden resulting from STHs via initiatives that fundamentally concentrate on drug therapy in the form of Mass Drug Administration (MDA) of anti-helminthic tablets to pre- and school-aged children, including those at risk groups in an endemic population (WHO, 2017). These campaigns have succeeded in reducing world morbidity emanating from helminth infections. Nonetheless, MDA is unlikely to interrupt cycles of STH transmission unless environmental measures are included to interrupt the acquisition of the new infections as discussed by Anderson *et al.* (2014) and Truscott *et al.* (2014). This is partly a result of STH ova being extraordinarily resistant to environmental stressors and survival can be for years in the soil's matrix (Nordin *et al*., 2009). This strength, combined with low infectious doses and high rates of excretion, contributes to the continuous transmission of STH in the presence of MDA (Collender *et al.,* 2015).

In Nigeria, there are sporadic de-worming programmes undertaken by the Federal and State Governments with the help of Non-Governmental Organisations (NGOs). These mass deworming targets mostly school-aged children, leaves out other age groups. Whereas the adult population does serve as what we call reservoir hosts for the transmission of STHs. When these groups are neglected for mass deworming, there will certainly be a continuation of STH transmission in such areas or at least there is the existence of economic development as well as better-quality sanitation practices which can thwart any on-going transmission (Schulz *et al*., 2018).

Finally, there is a mathematical model suggesting that the agenda of MDA which targets community participants of all ages could unavoidably interrupt STH transmission in the populations (Anderson *et al.,* 2017). There are no proper records of estimation of STH infections among all age groups in the metropolis, hence the study will determine STH infections among all ages as well as environmental contamination of soil by STH in the area.

1.3 Research questions

This study will provide answers to the following research questions;

i) What species of STH types are present in the area?

ii) Is there a focal restriction in the distribution?

iii) What is the level of knowledge and risk awareness of STHs with hygiene practices?

iv) Are there any relationships between personal hygiene, frequency of drug intervention climatic factors, and the reduction of STH?

v) Does effective antihelminthic drug usage have a great effect on the viability and intensity of parasite eggs in faeces?

1.4 Justification of the study

The soil-transmitted helminth infections are considered to be widely distributed in the tropical and subtropical areas of the globe, with the highest prevalence of infections coming from Asia, China, South America, and Sub-Saharan Africa (Khurana *et al*., 2021).

Guidelines for STH control by WHO have stipulated that there should be an annual or a biannual mass treatment for the entire population having a prevalence <50 or ≥ 50, respectively.

According to the report of Odinaka *et al*. (2015), the prevalence of helminthiases in Nigeria from one district to another district differs. Though several coordinated investigations were performed for the intestinal helminthiases occurrence in the country, unfortunately, according to scientific observations, epidemiologic data is still not readily obtainable in some community settings (Odinaka *et al*., 2015). In a finding performed on 720 soil samples collected from five Local Government Areas (Ibadan North West, Ibadan South East, Ibadan North, Ibadan North East, and Akinyele) in Ibadan, 67.1% of the collected soil samples had at least one species of STH, placing Ibadan metropolis as a major endemic setting for STH infections (Hassan *et al*., 2017).

In addition, there seems to be a lot of inconsistency in the prevalence as well as the intensity of *Trichuris* over the years in Nigeria and also there is no adequate documentation of the prevalence of *Strongyloides* in the Ibadan metropolis, even with the advent of MDA going on for the pre-and SAC.

The disease epidemiology indicates that cultural practices, hygiene, and conducive environmental variables are factors that enhance transmission. Environmental factors are dynamic and change with time, thus affecting distribution, hence the need to constantly update the epidemiological data across geographic zones including remote endemic areas like some in Ibadan. Hence, this study was designed to evaluate the current knowledge, attitude, and practice of respondents, and environmental factors on the status of STHs prevalence and intensity in the Ibadan metropolis.

1.5 Aim

This study was intended at determining the distribution patterns of STHs in the eleven Local Government Areas (LGAs) within Ibadan using standard methods. These included; Akinyele, Egbeda, Ibadan North, South East, South West, North East, North West, Ido, Lagelu, Oluyole, and Ona Ara

1.6 Specific objectives

The specific objectives of the study are to:

- determine species-specific prevalence and intensity of infection in both soil and faecal samples collected around Ibadan and the distribution of STH in the eleven local government areas using standard parasitological techniques
- relate drug usage in the study areas to the STH intensity as well as the viability of eggs/ova in the faecal samples.
- investigate the influence of intrinsic factors: human hygiene, diet behaviours, educational level of people, and socio-economic status on the current prevalence pattern of the STHs
- investigate the impact of climatic variations on the intensity and prevalence of STH infections with risk parameters

CHAPTER TWO

LITERATURE REVIEW

2.1 Global distribution of soil-transmitted helminths

Soil-transmitted helminths are parasites that cause the disease helminthiasis, which is among the foremost prevailing Neglected Tropical Diseases (NTDs) and they continue to exist within the poverty stinking populations in developing countries (Njiru *et al*., 2016; Oyebamiji *et al*., 2018). There are four main species (*A. lumbricoides, Ancylostoma duodenale, Necator americanus*, and *T. trichiura*) and one understudied species (*Strongyloides stercoralis*) of these parasites that constitute the most common global spread of NTDs, unfortunately, the broad analyses of the geographical distributions of the species are not easily accessible (Oyebamiji *et al*., 2018; Khurana *et al*., 2021). About 2 billion people were estimated to be infected worldwide with at least one species of intestinal nematode in 2019, thereby leading to 4.98 million Years Lived with Disability (YLD) and 5.18 million Disability Adjusted Life Years (DALYs) (Pullan *et al*., 2010; WHO, 2019). Soil helminth disease infections are more predominant in the SSA (Sub-Saharan Africa) and Southeast Asia compared to other areas of humanity as explained by Pullan *et al.* (2014) and Karagiannis-Voules *et al*. (2015). Sixty-seven percent of the overwhelming bulk of soil helminthic infections and their burden (68%) ensued in the Asia region, where invariably twenty-six percent of the total inhabitants were believed to host no less than one soil-transmitted helminth species (Pullan *et al*., 2010). Geostatistical models for sub-Saharan Africa and the available empirical data for all other regions are used to create Figure 2.1, which depicts the worldwide distribution and occurrence of soil-transmitted helminths per species as depictd by Pullan *et al*. (2014).

2.2 Diseases caused by soil-transmitted helminths in Nigeria

In the country, Nigeria, STH disease prevalence for hookworms, *T. trichiura,* and *A. lumbricoides* are still persistent among the population (Oluwole *et al.,* 2015; Oyebamiji *et al*., 2018).

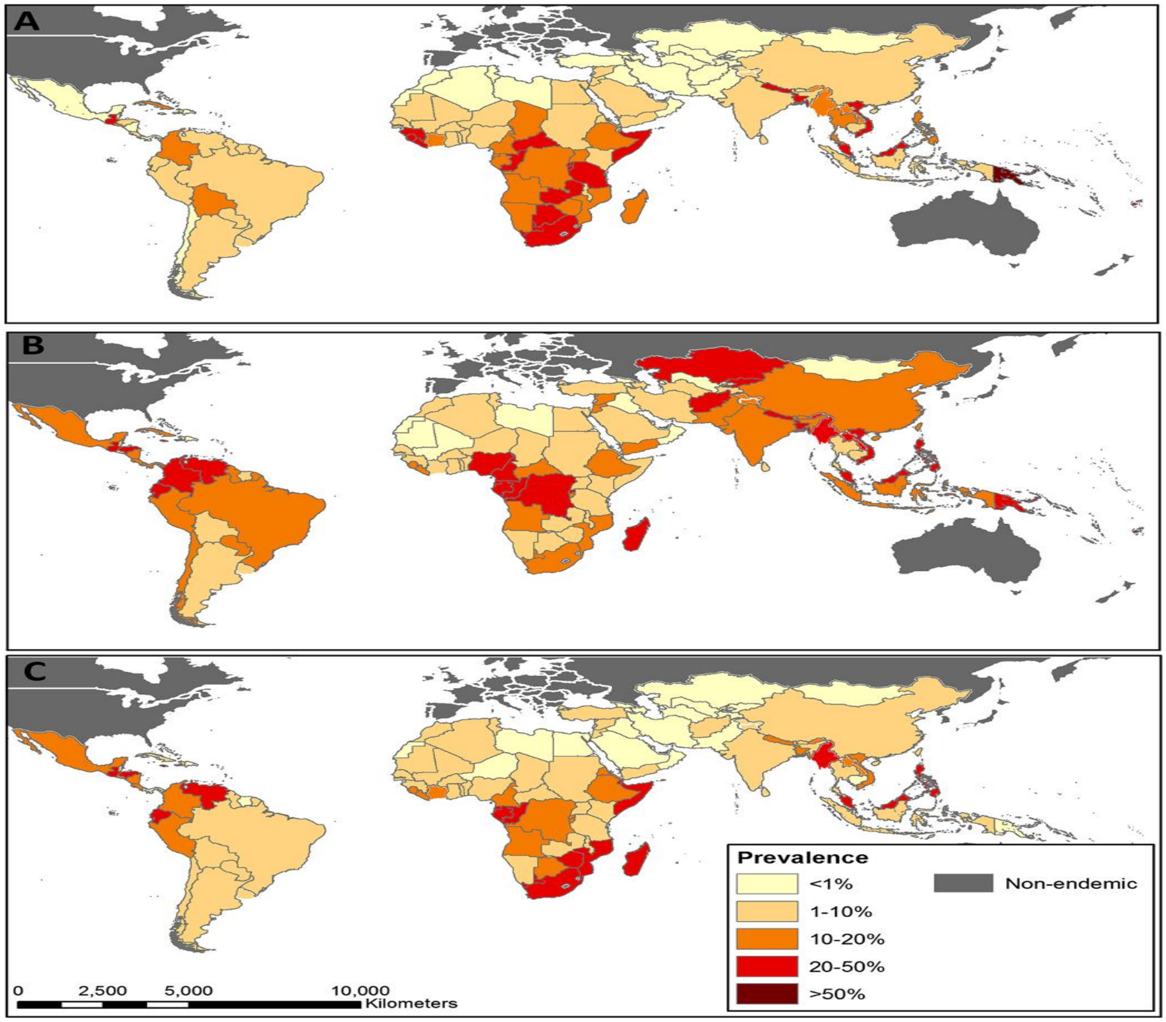


Figure 2.1: Distribution of the prevalence STH species infection. Hookworm (A*), A*. *lumbricoides* (B) and *T. trichiura* (C).

Source: Pullan *et al*. (2014).

According to reports by the Federal Ministry of Health (2013), STH infections in sub-Saharan Africa, Nigeria ranked highest in the total number of individuals infected. Young children between the ages of 5 and 14 years living in rural areas and urban slums are majorly affected by these infections (Arogundade *et al*., 2011; Oyebamiji *et al*., 2018). As a result, most STH studies and control measures are targeted at SAC based on the high-level prevalence often recorded among members of this group (Oyebamiji *et al*., 2018).

Many studies on STH infections are done usually using human faecal samples compared to soil samples to know the prevalence level in the population. Although studies carried out in humans may give the prevalence rate of the infection, they definitely cannot provide the extent to which the residents are at risk of the infection (Ogbolu *et al*., 2011). Only environmental studies (especially the ones done to monitor the level and ways of soil contamination with STH) give a succinct description of the rate at which individuals are at risk of the disease. In other to have a general outlook about the distribution of STH in Nigeria, Oluwole *et al*. (2015) collated Bayesian Geostatistical model-based estimations of the infections in the stool of SAC investigated in twenty out of the thirty-six states, together with Abuja, the Federal Capital Territory. Of all the school-aged children of approximately 41.5 million enrolled in the study, 5.7 million were projected to have been diseased with at least one STH parasite present (Oluwole *et al*., 2015). In addition to from the result, STH infection containing hookworm had the widest geographic spreading, because it was reported in 482 places across twenty states, having occurrence at the unit of the states ranging between 1.7% and 51.7% (Oluwole *et al*., 2015). *Ascaris lumbricoides* were present in three hundred and five (55.0%) settings in sixteen states, and the frequency of occurrence at the unit of the state fluctuated between 1.6% and 77.8%. While *T. trichiura* had the lowest distribution as it was found in fifty-five (9.9%) localities in twelve states with state-frequency of occurrence varying from 1.0% to 25.5% (Oluwole *et al*., 2015).

Ogun, Ondo, Kwara, Kogi, Anambra, and Taraba states were areas predicted with a high disease infection rate of >50% for *A. lumbricoides.* On the other hand, Benue, Taraba, Oyo, Kebbi, Kwara, Zamfara, Katsina, and Sokoto states were predicted with a high infection risk for hookworm while states with a high rate of *Trichuris* infection included Ogun, Ondo, Anambra, Enugu, and Taraba states (Oluwole *et al*., 2015). The spatial parasite spreading of the observed and predicted STHs in Nigeria which is the three main species in the country is shown in Figure 2.2 (Oluwole *et al*., 2015).

2.3 Effects of soil-transmitted helminths on children

Infection with soil helminthiasis is the main cause of disease and malnutrition among pre-SAC and SAC. Where the infected children tend to be physically not fit, have low weight compared to healthy ones, and are found as much as four (4) times more likely to be stunted. They often do suffer from learning disabilities and have educational challenges according to WHO (2010). The majority of these children in low-income settings are underachievers and may never realise their full capability owing to the fact that STH infection might have a detrimental effect on both intellectual and physical development as stated by Drake and Bundy (2001). The clinical consequences of iron deficiency anaemia and other nutritional deficiencies are the limitation on normal physical maturity leading to children failing to attain their capability for growth as expected (Drake and Bundy, 2001).

Heavy burdens of individual infection with *T. trichiura* and *A. lumbricoides* are associated with protein-energy malnutrition (Al-Mekhlai *et al.*, 2005). *Trichuris* dysentery syndrome is a result of intense trichuriasis in children that causes growth retardation and anemia (Li, 1990). The key root of childhood iron deficient anaemia is the infection of moderate to heavy hookworm burdens (Al-Mekhlai *et al.*, 2007). The deficits in growth among primary school children are associated with ascariasis (Mahendra *et al.*, 1997). Furthermore, from the increasing confirmation, these infections could have a negative effect on cognition and educational achievement in children (Sternberg *et al.*, 1997; Ahmed *et al.*, 2003). Helminthiases frequently result in undernutrition in children, which is linked to poor performance on cognitive and academic achievement assessments (Lozoff *et al.*, 1998). More severely infected people missed school twice as often as their uninfected colleagues, according to a cross-sectional study by Nokes and Bundy (1993), missing out on the chance to fully take advantage of the education provided by schools.

STH causes enormous disability-adjusted life years lost in comparison to other infections as described by Chan (1997). DALYs are linked to the associations between stunting and wasting and ascariasis, hookworm infection and anaemia, trichuriasis, and poor academic

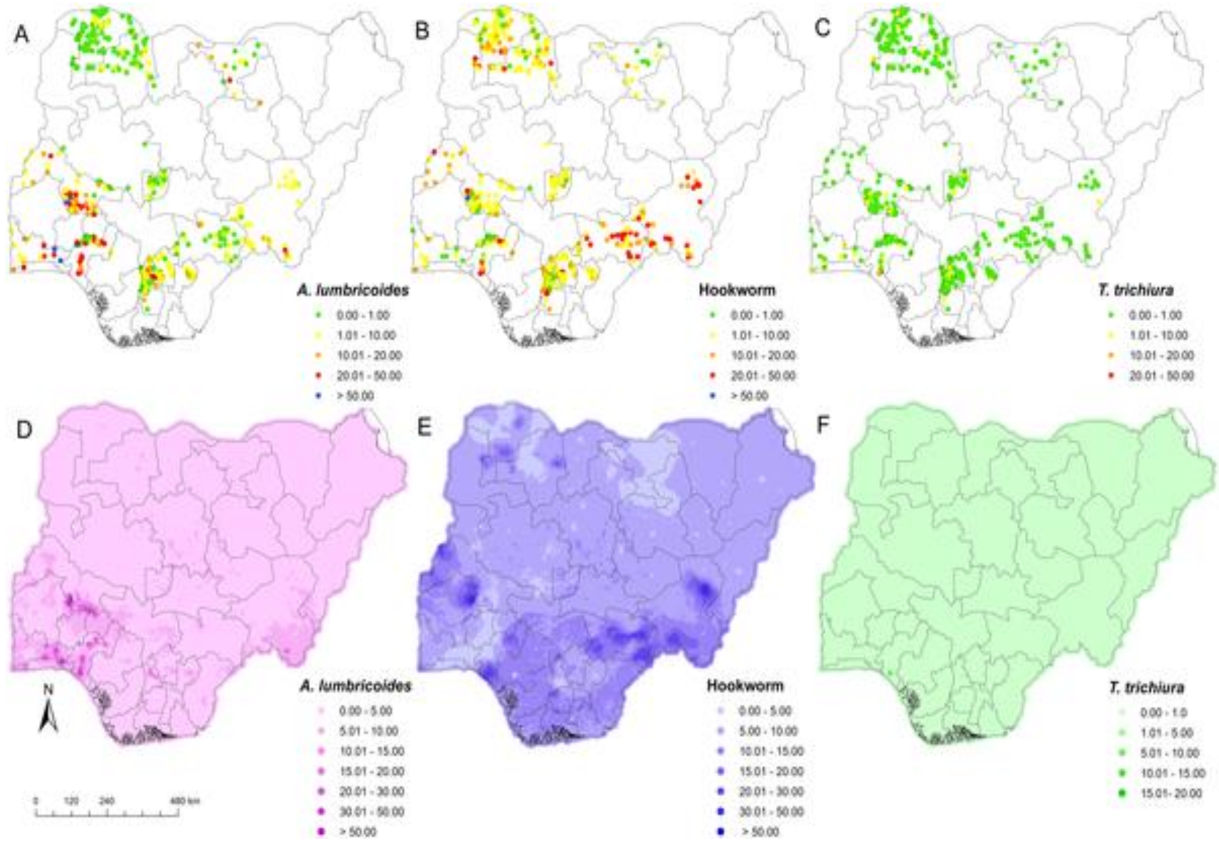


Figure 2.2: Soil-transmitted helminth infections spatial distribution in Nigeria. Observed prevalence of *A. lumbricoides* (A), Hookworm (B) and *T. trichiura* (C). Prevalence of *A. lumbricoides* prediction (D), hookworm (E), *T. trichiura* (F)

Source: Oluwole *et al*. (2015)

accomplishment as explained by Nokes *et al.* (1992) and Savioli *et al.* (2004).

2.4 Environmental pollution and the risk of spread of soil-transmitted helminths

Resulting from the fact that humans are constantly in contact with soil through their food, water, and air, as well as other means, the soil may contain and be a source of serious disease-causing chemicals that affect humans. Furthermore, enteric pathogens in high concentrations from solid wastes may find their way into the soil (Santamaria and Toranzos, 2003). Transmission of parasites in the environment plays a key role in the epidemiology of faecal-oral pathogens and also the conceptual epidemiological triad model includes the environment in addition to the host and pathogen as key indices to disease transmission (Hogan, 2012). The contamination of soil looks to be the most direct indicator of the risk of infection (Uga *et al*., 1997).

Several studies have established that STHs are dominant in rural and suburban areas with a low standard of living, and poor hygiene and sanitation (Oluwole *et al*., 2015; Oyebamiji *et al*., 2018). This is often because the soil has been found to be the foremost reservoir for helminth infections, and also the state of sanitation in an area determines to a large extent, the chance of infection since humans always come in contact with the infective stages of the parasites in their surroundings. The rate at which eggs of soil-transmitted nematodes are passed out with faeces is significant to the epidemiology of transmission; as a result of indiscriminate disposal of faeces, soil that is contaminated with STH eggs becomes a potential source of infection. The infected persons do excrete helminth eggs in their faeces, and humans accidentally pick up the infective stages of helminth eggs in regions where indiscriminate defaecation is practiced. When consuming raw, unwashed vegetables or failing to wash their hands after coming into contact with contaminated soil, people might contract roundworm or whipworm illnesses after the eggs have matured in the environment (a typical transmission route often seen in children) (Oluwole *et al*., 2015). Looking at hookworm infection, individuals sometimes turn out to be infected by walking barefoot on contaminated soil, because the infective stages of the worm emerge within the soil and thus make a way into the human skin.

In addition, the use of human and animal faeces as manure and also the inadequate disposal of human faeces are major habits that unarguably favour the entry of sizeable amounts of intestinal pathogens into the soil environment (Santamaria and Toranzos, 2003). Untreated excreta are shown to cause significant infections with enteric nematodes in consumers and field workers (Blum and Feachem, 1985). Vegetables and fruits often come in contact with soil post-harvest and so could become contaminated with soil enteric pathogens that may be present in sewage sludge or manure spread according to Santamaria and Toranzos (2003). *Ascaris* eggs have apparently been discovered adhering to furniture, door handles, money, and fingers in some endemic places (Kagel, 1983). Helminth parasite eggs have been found in water that has been preserved for drinking and/or cooking, according to Jonnalagadda and Bhat (1995).

Furthermore, the increase in the global tendency to eat raw or partially cooked vegetables must be considered one of the major routes of STH infections (Rostami *et al*., 2016). There is evidence that the majority of vegetables contaminated by STH eggs are leafy vegetables like spinach, parsley, and lettuce (Rostami *et al.*, 2016). A potent description can be that vegetables like lettuce have broad leaves and large surface areas, resulting in additional contact with sewage-contaminated soil surfaces (Adamu *et al*., 2012). Sewage effluent or water supplies contaminated with sewage are sometimes used to irrigate vegetables when there is a shortage of water, and this is responsible for the contamination of the vegetables. In addition, disposing of night soil on the open field means harvesting the helminth parasite since the soil is good habitation for the soil helminths which continue to remain viable for a long period of time (Gyawali *et al*., 2013). Inadequate sanitation will increase the possibility of contamination and also the risk of helminth infection (Ziegelbauer *et al.*, 2012). Weather events like rainfall will wash off parasitic eggs from soil to waterways which then increase the chance of infection through the water within the community (Gyawali *et al*., 2013). Additionally, the act of disposing of night soil and faeces at the bank of the river might contaminate the water sources during flooding once parasites are washed off from the soils to waterways (Gyawali *et al*., 2013). It is obvious that environmental control of STH through proper sanitation and hygienic practices could be a major step in reducing the spread of STH infections. Moreover, Ziegelbauer *et al.* (2012) noted that sanitary facilities are connected to a decrease in the incidence of infection with soil helminths when they are accessible and used.

Emerging research interest is the control of soil helminth contamination of the surroundings (Gyoten *et al*., 2010). Results of previous study showed that soil contaminated with soil helminths in both rural and urban settings had a prevalence that ranged from eleven percent to eighty-two percent indicating significant geographic variability (Horiuchi *et al*., 2013). Nonetheless, very little work has been done in order to monitor the environmental levels of worm eggs in settings with current mass drug administration programmes to control soil-transmitted helminths (Steinbaum *et al*., 2016). The situation of not monitoring the environmental level of worm eggs is not helpful and as a result, it is necessary to identify the hot spots of STH eggs contamination within the domestic surroundings to design interventions targeted toward reducing the transmission of STH (Steinbaum *et al*., 2016). The dynamic processes concerned in STH transmissions, like non-parasitic infective stage development including survival, rely upon the abounding environmental conditions according to Anderson (1982). For instance, free-living species present within the environment progress which usually die at temperature-dependent rates (Udonsi and Atata, 1987). The development of *T. trichiura* and *A. lumbricoides* is inactive below 5 ^{o}C and above 38^{o}C, whereas that of hookworm larvae can be stopped at 40^{o}C, which, according to Udonsi and Atata (1987) and Smith and Schad (1989), show that the temperatures between 28^{0}C and 32^{0}C are those at which free-living infectious stages proliferate at their fastest rates.

Both the soil moisture as well as relative atmospherical humidness have also been found to influence the development and survival of ova and larvae: higher humidities are associated with faster ova development; while ova of *T. trichiura* and *A. lumbricoides* do not embryonate at low humidities (less than 50%) (Otto, 1929). According to Nwosu and Anya (1980) and Udonsi *et al.* (1980), ambient humidity and the number of hookworm larvae are inversely correlated. Though seasonal dynamics in the parasite transmission could take place, such changeability is also of very little consequence to the overall parasite equilibrium within community settings for the reason that the life-span of adult worms is usually much longer (1 to 10 years) than the periods within the year throughout that the average number of matured females is produced by one adult female parasite (Brooker *et al.,* 2006). The number of matured females produced can on the ordinary be greater than one, thereby upholding the overall endemicity (Oyebamiji *et al*., 2018).

Nevertheless, a doubtless important issue to contemplate is the prolonged existence of the mature parasite, ever since the situation within the parasite's host is to protect from the external high temperatures (Brooker *et al.,* 2006). Hookworms have an extended lifetime (3–4 years) than what we have for *T. trichiura* or *A. lumbricoides* (between one and two years). This only means that hookworms will be protected from external temperatures for over twice as long as other parasite types, meritoriously shielded from high temperatures over between three and four years' periods under suitable developmental conditions (Brooker *et al.,* 2006). This greatly will increase the possibility of hookworm transmission stages being put down and the development of an unsuitable thermal condition (Brooker *et al.,* 2006).

Effective environmental control strategies are enforced by obstructing the routes of transmission within the environment through proper sanitation, provision of good toilet facilities, and adoption of improved hygienic habits like washing hands with soap and water after defaecating. In the year 2001, WHO certified the use of preventive chemotherapy as the global strategy for controlling soil helminthiasis (Ziegelbauer *et al.,* 2012), and the crucial element of this scheme is a steady doling out of antihelminthic medications to vulnerable groups, includes children, women of reproduction age, as well as high-risk occupations like engagement in night-soil reuse including farming (Ziegelbauer *et al.,* 2012). Though this strategy reduces ill health caused by soil-transmitted helminths, it does not forestall rapid re-infection (Ziegelbauer *et al.,* 2012). In order to interrupt transmission as well as attain community-based elimination of helminthiasis, integrated control tactics that embody access to high-quality sanitation facilities as well as different harmonizing intervention strategies of a primary deterrence quality are required (Ziegelbauer *et al.*, 2012). The latter confirmed that providing adequate access to sanitary facilities and encouraging their use is an effective control strategy for STH infections.

2.5 Life cycles and pathogenesis of soil-transmitted helminths

Helminthiases often evolve at multiple levels, therefore the appearance of helminth infections vary depending on the infecting STH species, the host's apparent age, the existence of associated risk factors, the host's immune condition, and the presence of a low or severe parasite burden.

2.5.1 Ascariasis

Adult *A. lumbricoides* are expected to live between one and two years. The worldwide frequency of ascariasis is high for two reasons running. To begin with, adult females of the *A. lumbricoides* worm have an incredible ability to reproduce. During an infection, one worm is thought to release up to twenty-seven million eggs. Second, *A. lumbricoides* eggs are fairly sturdy, with a thick egg wall and an exterior proteinaceous shell, making them exceptionally elastic to severe conditions over time.

After ingesting an infectious egg, the larvae stage produces in the small intestine, invade the blood vessels lying on the intestinal wall of the stomach, and subsequently mature after cardiopulmonary migration (Figure 2.3). The larvae grow into adults and mature sexually in 6-10 weeks. Different from the hookworms or whipworms, the adult stage of the roundworms however does not attack the gastrointestinal mucosa. As they veer into the biliary tree or get twisted and matted into a bolus of worms, in its place, they can cause mechanical harm as well as luminal obstruction. Ascariasis-related growth retardation could be due to dietary factors (Ojha *et al.,* 2014). The cause may be that the parasite causes malabsorption during the process of villous atrophy and interferes with the host's nutrition. Nevertheless, these peptide inhibitors are typically generated by parasites. The Ascaris worm produces a variety of peptide serine protease inhibitors that may decrease the activity of pancreatic trypsin, chymotrypsin, and elastase in vitro. It is uncertain whether they exist and what role they play in the parasite-host connection (Ziegelbauer *et al.*, 2012). When the worms are plentiful, ascariasis can be harmful to the host. Migrating larvae and adult parasites are two major types of clinical consequences.

Effects resulting from migrating larvae: Dry cough, fever, minor chest discomfort, dyspnea, pulmonary infiltrations, and shortness of exertion are all symptoms of Loeffler's pneumonitis. Hypersensitive humans can develop hypersensitivity reactions such

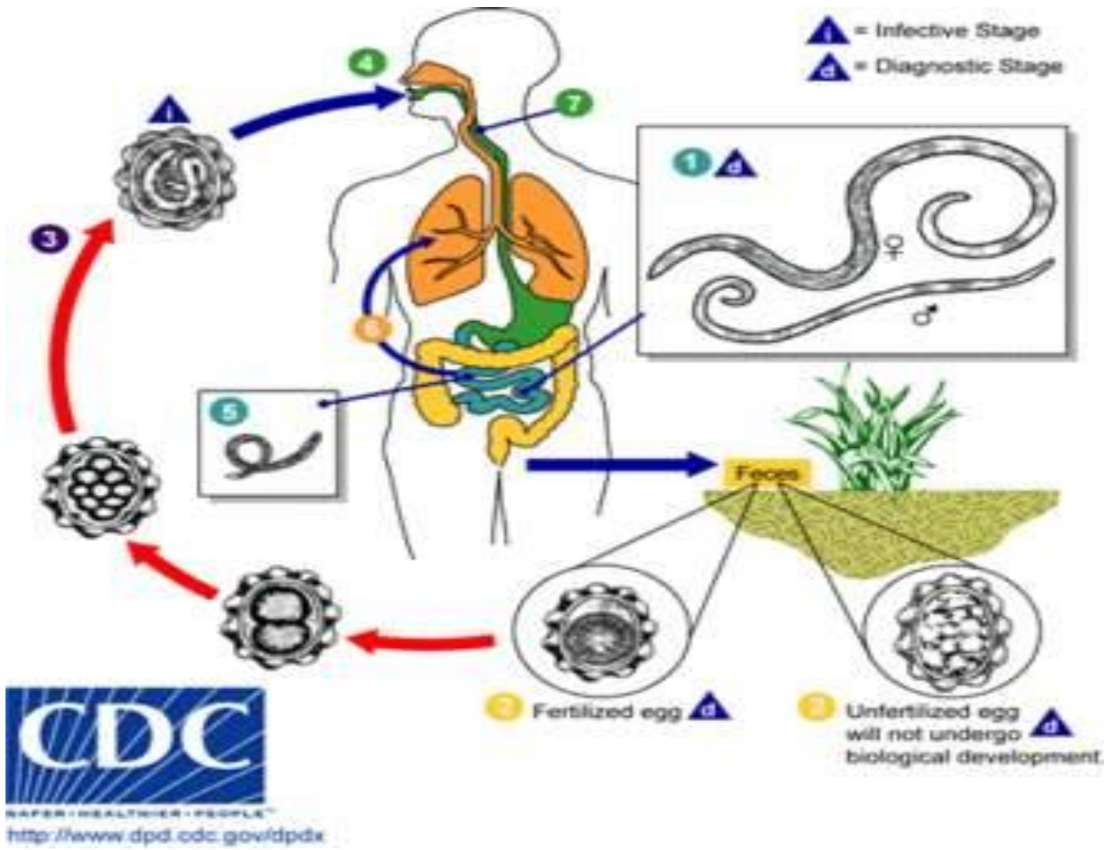


Figure 2.3: Life cycle of *Ascaris lumbricoides* (CDC, 2012)

as asthma and urticaria. A minimal harm is created through larval intestinal offensive, despite the fact that a few hepatic irritation and granulomata formations were described by Hotez (2011). The extraintestinal migrations within side the lungs are related to an energetic host inflammatory reaction that consists of extended serum IgE stages including eosinophilia as described by Hotez (2011).

Effects resulting from adult worms: The majority of the infections are found to be mild and asymptomatic, but then even the occurrence of a small number of *A. lumbricoides* could be hypothetically pathogenic. Adult intestinal parasites can induce vomiting, nausea, abdominal pain, steatorrhea, and epigastric pain in some situations. Dyspepsia (indigestion) and malabsorption of proteins, lactose, and several fat-soluble vitamins can result from moderate to severe infections. (Hotez, 2011; Ojha *et al*., 2014).

The largest intestinal nematode is *A. lumbrocoides*. It has a length of 15-45 cm and a diameter of 2-6 mm (Table 2.1). When absorbed by the blood, the body fluids of Ascaris cause toxic effects and cause fever like typhoid fever. Worm masses can cause intestinal obstruction and perforation, especially in children, and obstruct the pancreatic duct (Ojha *et al.,* 2014). Cholecystitis results from the transfer of worms to the common bile duct. Here, worms can directly cause obstruction of the cystic duct or act as a hub for stone formation. The movement of the worm can cause liver abscesses and appendicitis, sometimes in the stomach, and vomiting (Ojha *et al.,* 2014).

2.5.2 Hookworm diseases (Ancylostomiasis and Necatoriasis)

The nematode parasites *A. duodenale* and *N. americanus* cause human hookworm infections, and both species life cycles are found to be identical (Figure 2.4). Larval transmission is usually accomplished through direct skin penetration, foot penetration, or the fecal-oral route (Hotez, 2011). Once in the gastrointestinal tract, the larvae molt twice (more than two months) to become a mature adult parasite. Adults' anterior ends are buried deep beneath the distal duodenum and proximal jejunum mucosa. The active peptides which may reduce host inflammation, stop blood clotting, prevent platelet aggregation, and destroy connective tissue components are released after attachment (Hotez *et al.,* 2010). It causes capillaries and arterioles to leak blood continuously. Female hookworms lay up-to 10, 000 to 30, 000 ova every day, and their lifespan is predicted to be five

Table 2.1: Physical characteristics and the impact of STH

Infection	Agent parasites	Size (mm)	Burden of infections (millions)	DALYs (millions)	Death (annual)
Ascariasis	*A. lumbricoides*	150-450	807 - 1221	1.8 - 10.5	60,000
Trichuriasis	*T. trichiura*	30 - 50	604 - 795	1.8 - 6.4	10,000
Hookworm	*N. americanus*	7-13	576-740	1.5-22.1	65,000

(Adapted from Ojha *et al*., 2014)

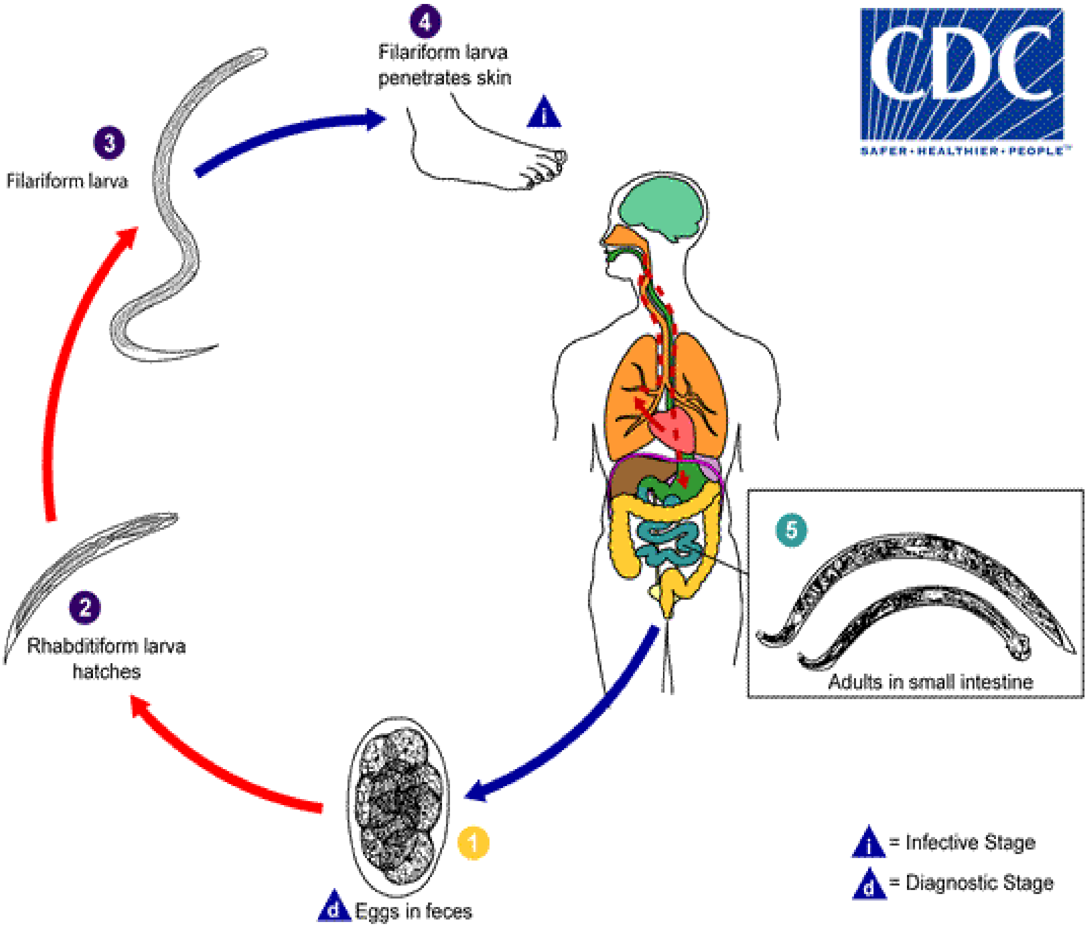


Figure 2.4: Life cycle of hookworm (CDC, 2012)

to seven years (Bethony *et al.,* 2006). Stomach pain, vomiting, nausea, anorexia, lethargy, dyspnaea, koilonychia, fading sclera, pallor, chlorosis, melena, and poor concentration are all symptoms of the disease infection. Each adult hookworm can cause up to 0.2mL of blood loss per day during heavy infections, depleting the host's protein and iron supplies and resulting in iron deficiency anaemia and protein malnutrition. Many children have a kwashiorkor-like appearance as a result of plasma protein depletion. Growth retardation, concentration problems, and delayed intellectual development are typically brought on by the emergence of a clinical iron deficiency over the course of significant chronic hookworm infections in teenagers. In addition to producing iron-containing metalloenzymes and monoamine oxidase, iron is necessary for the biosynthesis of dopaminergic neurons (Hotez, 2011). At birth, infectious *A. duodanale* larvae that have been trapped in pregnant women get into the colostrum and breast milk, where they cause an infantile hookworm infection (Ojha *et al.,* 2014).

2.5.3 Trichuriasis

When *T. trichiura* first instar larvae enter the small intestine, they are freed from the eggs. It then goes through a series of molting cycles before reaching maturity (Figure 2.5). The adult stage emerges 30-90 days following infection and is primarily found in the caecum. The worm's anterior section burrows into the mucosal epithelium of the caecum. Adult *T. trichiura* worms have a lifespan of one to two years, and females lay 2,000 to 30,000 eggs every day (Ojha *et al*., 2014). Adult worms could be found all through the gut, from the caecum to the rectum, in severe infections. It then stays in the colon and forms epithelial tunnels to survive during the presence of the parasite. In response to secretory proteins produced by the parasite, host cell fusion results in the formation of tunnels (Pullan *et al*., 2014). Over time, the worm's enlarged posterior portion emerges from the epithelial tunnel and into the lumen (Ojha *et al*., 2014). Adult parasite worms have the power to disrupt the colonic mucosa's natural structure, which is already compromised by host inflammation. At the site of ulceration and parasite adhesion, there is also direct blood injury. A considerable number of Trichuriasis infected persons, particularly children with long-term, large-scale infections, experience chronic mucous diarrhaea, rectal prolapse, chronic malnutrition, and

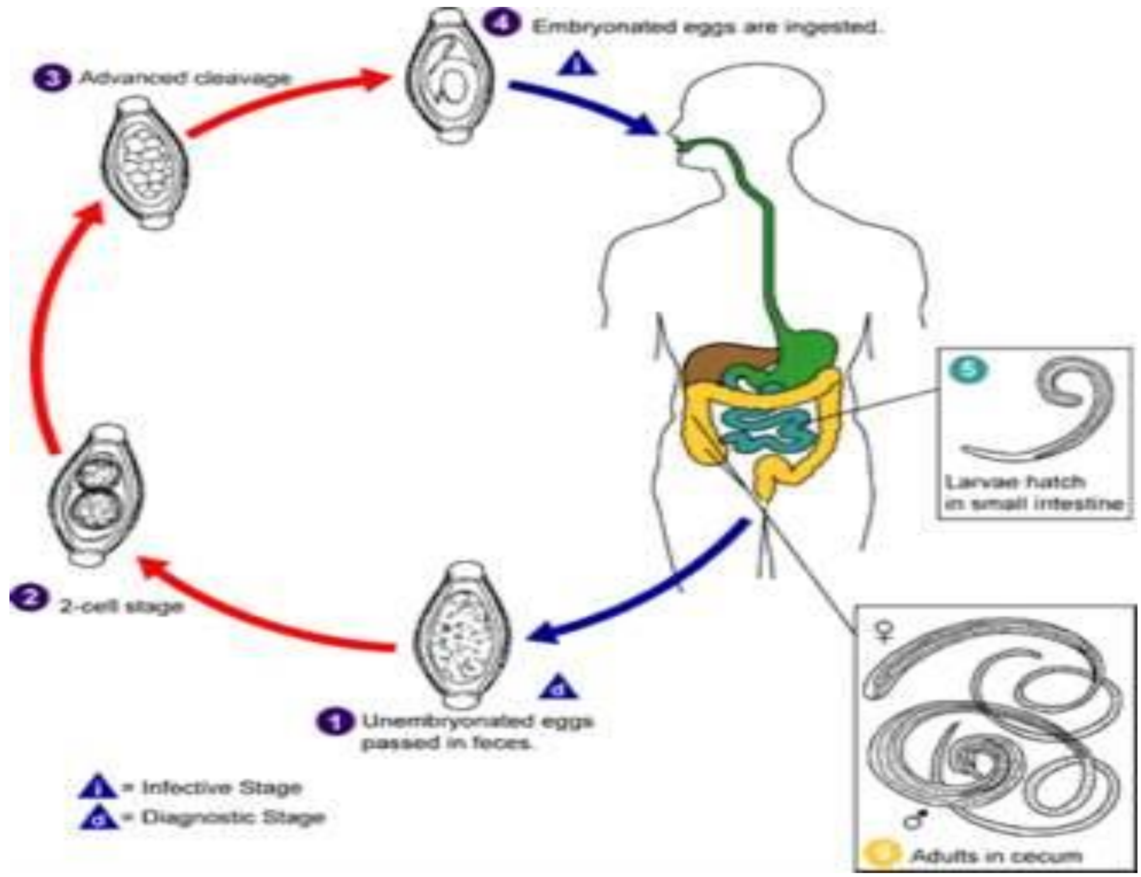


Figure 2.5: Life cycle of *Trichuris* (CDC, 2012)

anaemia related to iron deficiency, protein-energy malnutrition, and growth retardation as described by Stephenson *et al.* (2000).

2.5.4 Strongyloidiasis

The genus *Strongyloides* is a common nematode parasite of terrestrial vertebrates with fascinating biology (Viney, 2017). They produce a WHO-recognized NTD in humans, one of the soil-transmitted helminth infections. Strongyloidiasis, which is probably underappreciated, is a weak relative of the other STH parasites including hookworm, *Ascaris*, and *Trichuris*.

In contrast to most other parasitic nematodes, *Strongyloides* have two (2) adult generations, one inside the host and the other in the environment (Figure 2.6). Parthenogenesis, a genetically mitotic process, is used to replicate the adult parasite generation, which is exclusively female. Male and female eggs are genetically laid by parasitic females.

The first instar larvae (L1) that hatch from the ova leave faeces on the host, where they grow, mature, and molt. The developmental paths of males and females differ. Before becoming free-living adult male worms, male larvae (eggs) go all through a four stages of development (L1–L4). In terms of development, female larvae (eggs) have a preference. In one scenario, they can mature in the same way as men (molting via four larval parasite stages) before molting into free-living non-parasitic adult female worms. Female larvae, on the other hand, can molt through three larval instars to become third-instar larvae (L3), which are commonly infective to a new host (Viney, 2017).

Living in the open, females and males reproduce sexually, after which the female then lays ova. The resulting larvae molt into third-stage larvae via the L2 stage after these eggs hatch. What's more, all offspring of free-living females evolve into contagious L3s that infect the host, and there is only one free-living adult generation overall (Grant *et al.*, 2006). As shown in Figure 2.6, the homogonic (or direct) and heterogonic (or indirect) developmental pathways used by the free-living life cycle to produce the infectious third-stage larvae. The infective larvae instar, on the other hand, is developmentally stopped and will only resume development if they have successfully penetrated the skin of an appropriate animal host. These larvae travel round the host, molting through a L4 instar prior to entering the

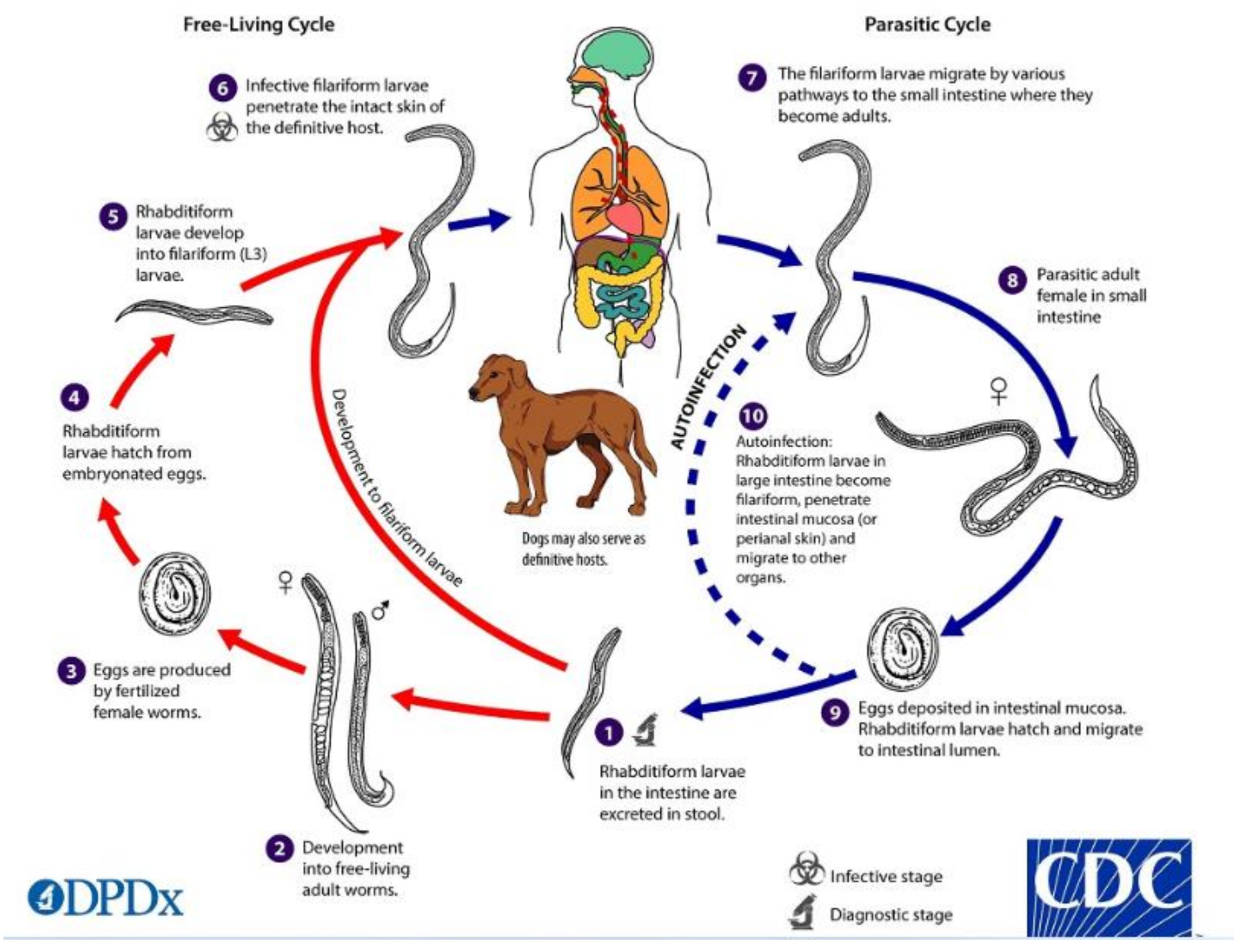


Figure 2.6: Life cycle of *Strongyloides* (CDC, Global Health, Division of Parasitic Diseases and Malaria, 2019)

stomach of a living host, where they further moult into the parasitic females to finish the parasite's life cycle. One of the notable species-precise features in the life cycle of *Strongyloides stercoralis* in man is that the infective L3 could intelligently attain development in the host intestine which causes an internal auto-infection, and these make human infections chronic (Viney, 2017).

There are many similarities between the two adult generations. They differ morphologically in that one is parthenogenetic and parasitic, while the other is sexual and free-living. This may be seen in the oesophageal morphology of the parasitic females, which is filariform in form and makes up almost a third of their entire body length, as opposed to the rhabditiform style and a ten percent portion of the length of the free-living adults. A rhabditiform oesophagus can be seen in all free-living parasite larval stages, with the exception of infective L3, which have a filariform oesophagus since they will eventually develop into parasitic females. The free-living non-parasitic adult stages are particularly susceptible to experimentation and have proved used in the genetic research of *Strongyloides* and the development of transgenesis (Viney, 2017).

2.6 Socio-economic and medical importance of STH infections

De Silva *et al.* (2003) updated atlases of worm infections using the methods pioneered by Chan *et al*. (1994) and based on applications of geographic information systems. De Silva and colleagues utilised data from 1990 onwards to reflect current changes in infection epidemiology. These findings demonstrate that soil helminthic infections are the utmost common human infections, putting a huge proportion of the globe's population at risk.

Each year, 27,000 persons often die from soil helminthiasis (case fatality rate of 0.0014 percent), according to the World Health Organisation (2002). Several scientists feel that this figure is an underestimate, although the number of people who die each year is significantly more. Crompton (1999) estimated that these diseases cause 155,000 fatalities per year (having a case fatality rate of about 0.08 percent).

Soil-transmitted helminths seldom kill their human hosts, and reporting mortality rates just scratches the surface of their health consequences. Instead, illness burden assessments such as Disability-Adjusted Life Years (DALYs) and some other related techniques produce numerous accurate pictures of disease helminths load. With an estimated two billion people infected with STH (Collender *et al*., 2015), even slight changes in disability weight can result in huge changes in DALY and other disease burden measures. This has helped to explain why, for example, the illness burden of STH infections was estimated to be eighteen million DALYs in 1990 but merely 4.7 million DALYs in 2001. It was discovered that there were just 2.6 million DALYs during those eleven years. Given that helminths are thought to be present surrounding key diseases like tuberculosis, measles, and malaria, these distinctions are significant. The lowest estimates from the 1990s, on the other hand, place helminthiasis on par with sexually transmitted diseases (gonorrhoea), otitis media, and iodine insufficiency. Because WHO global load of STH disease estimations are found to be low, the helminth working group of the Disease Control Priorities Project determined that they, however, does however not include the complete clinical range of helminth-associated disease as well as the chronic disability, such as exercise intolerance, chronic pain, anaemia, diarrhaea, including malnutrition (King *et al.*, 2005). Some of the various controversies surrounding helminthic infections are described here.

2.6.1 Infections with T. trichiura and A. lumbricoides

The age-associated epidemiology of *T. trichiura* and *A. lumbricoides* infectivity has placed consideration on sick school-age children in emerging nations since these worm burdens have the greatest impact on physical and intellectual development disturbances (Bundy, 1995). De Silva *et al.* (1997) reported that, of the 1.2 billion diseased individuals (comprising fifty-one million children under the age of fifteen), 59 million were found to be at risk of stunted growth, due to parasite infections, there may be a decline in physical fitness or both. This was based on an updated prediction of the global prevalence of roundworm infections and a more accurate classification of the morbidity. They estimated that despite receiving treatment, around 1.5 million juveniles would never catch up with their growth. They projected that 11.5 million people (almost exclusively youngsters) were at risk of developing more severe clinical illnesses in addition to lingering, subtle impacts. According to the data, at least 10,500 people die each year as a result of one of the major effects of ascariasis, with youngsters accounting for almost ninety percent of those who die. Because of the nonlinear relationship between pathogenesis and parasite load, the precise threshold at which *T. trichiura* and *A. lumbricoides* worm burdens set off childhood morbidity is uncertain, and because it is challenging to measure and attribute morbidity in people with low immunity and other underlying conditions, there is disagreement about this threshold (Bundy, 1995).

2.6.2 Hookworm infection

In contrast to lymphatic filariasis, hookworm infection is the helminthiasis that results in the most DALYs. Regardless of these DALY estimates, the true illness burden of protein malnutrition brought on by hookworm disease and iron-deficiency anaemia could well be undervalued. Each year, about twelve million DALYs are lost due to iron deficiency anaemia, making it the world's most imperative dietary problem. According to research, hookworms play a substantial role in iron deficiency anaemia epidemiology in the eastern Africa and around the world (Brooker *et al*., 2004). There is a connection between the quantity of blood shed by hosts and the number of mature hookworms present in the intestine in Tanzania, whereby hosts' iron levels are frequently low (Brooker *et al*., 2004). Nonetheless, it is questionable if the current disability weights adequately account for host protein losses and malnutrition, or whether they properly account for the hookworm's total contribution to severe anaemia from iron deficiency in iron-deficient societies. In Africa, where newborns and preschoolers are incredibly susceptible to the behavioural and developmental issues brought on by iron deficiency anaemia, there is growing interested in the significance of hookworm anaemia in preschoolers, as reported by Stephenson *et al*. (2000) and Brooker *et al*. (2004). Current DALY estimates could be greatly improved by taking a closer look at the effects of hookworm on women of reproductive age, another big iron-deficient population. Hookworms are present in around forty-four million of these women (WHO, 2020). Furthermore, severe anemia during pregnancy is linked to neonatal preterm, low birth weight, and lactation problems (Christian *et al.*, 2004).

2.6.3 Strongyloides infection

The disability-adjusted life year system is an inaccurate reflection of the true burden and morbidity of STH in general (Becker *et al*., 2012). Strongyloidiasis is thought to afflict between ten and forty percent of the population in numerous subtropical and tropical nations, however, infection with *S. stercoralis* is extremely under-reported, notably in SSA and Southeast Asia according to Schär *et al.* (2013). Strongyloidiasis could be found to be asymptomatic or cause skin rashes, abdominal pain, and irregular wheezing, among other symptoms (Siddiqui and Berk, 2001; Knopp *et al*., 2012). Importantly, a hyper infectious disease can be lethal in immune-compromised patients (Segarra-Newnham, 2007; Utzinger *et al.,* 2012; Schroeder and Banaei, 2013). Arising from the difficulty in correctly diagnosing this parasite, it is frequently overlooked in epidemiological mapping and burden estimates, because *S. stercoralis* infection does not result in anaemia and lacks a clinical indicator that is simple to identify and track, thus clinical follow-up for this infection is complicated. The difficulties of accurately identifying uninfected control groups by using standards required of poorly specific direct disease diagnosis, such as stool examinations, further complicate attempts to demonstrate the modest morbidity associated with *S. stercoralis* diseases. Through questionnaires and stool examinations, Steinmann (2008) was able to determine that people infected with *S. stercoralis* were more prone to complain of stomach aches.

The vast majority of infections do not have mucosal lesions, which are only visible in severe infections, according to pathology examinations of the gastrointestinal system. Even though many people do not have acute intestinal symptoms, these alterations include an inflammatory response that varies from congestive catarrhal enteritis to edematous and ulcerative enteritis, replicating the wide spectrum of symptoms recorded in endemic areas (Grove, 1994). Although non-specific urticarial is a common indicator (up to a hundred percent in one study of fifty-two cases), it is rarely reported impulsively by infected patients as stated by Bethony *et al*. (2006). More data on the impact of these infections on people's quality of life, especially in endemic populations rather than just travelers (Steinmann, 2008), should be the foundation for controlling strongyloidiasis with the goal of reducing related morbidity rather than just lowering the risk of hyperinflation (Steinmann, 2008).

2.7 Epidemiology of soil-transmitted helminth infections

Aggregated dispersals in human neighborhoods, specific susceptibility to heavily loaded or light infection, accelerated subsequent re-infection after treatment such as chemotherapy, and the age-intensity profiles which are characteristically convex with the exception of hookworm infection are the most striking epidemiological characteristics of human helminth infections (Hotez *et al.,* 2007a).

2.7.1 Influence of distribution pattern

Worm loads are substantially aggregated (over-dispersed) in all major human STH infections examined soo far, with most individuals harbouring only a few worms in their intestines, whereas a few hosts have abnormally enormous worm burdens (Hotez *et al.*, 2007b). Just about eighty percent of the worm population is usually found in 20% of the host population (Hotez *et al.*, 2007b). For greatly infected persons are both considered to be at risk of sickness and a large basis of environmental pollution, this over-dispersion has a number of ramifications, both in terms of helminth population biology and public well-being implications for the animal host. Individual persons are more susceptible to severe or minor diseases, which could explain the over-dispersion. The fundamental source of this propensity is still unknown. Conversely, having an amalgamation of heterogeneity in infection exposure or susceptibility to infection, as well as the ability to build effective immunity (genetic and dietary variables), is likely to have a role in the susceptibility of infection (Hotez *et al*., 2007a).

2.7.2 Age-Intensity influence

Following therapy, people of all ages quickly re-infect (Hotez *et al*., 2005). The concentration of transmission within the same population, the efficacy and coverage of therapy, the species' life expectancy (short-lived intestinal parasite reinfection more promptly), and the rate of transmission are all factors that affect the rate of reinfection. Infection prevalence patterns for the major helminth species are similar, with an increase in childhood and a generally consistent asymptom in maturity. The highest incidence of *T. trichiura* as well as *A. lumbricoides* infections occurs before the age of five, while the highest prevalence of hookworm infections occurs during adolescence or early adulthood (Figure 2.7). As a result of the nonlinear relationship between the intensity and prevalence, there is no evidence in the observed age-prevalence reports of the fundamental characteristics of age with respect to worm load. The age-intensity reports make available a greater knowledge of which populations are sensitive to certain helminths because parasite load is associated to morbidity. The age-intensity profiles for *A. lumbricoides* and *T. trichiura* infections are typically convex in shape, with the highest intensities in children aged 5 to 15 (Bundy, 1995).

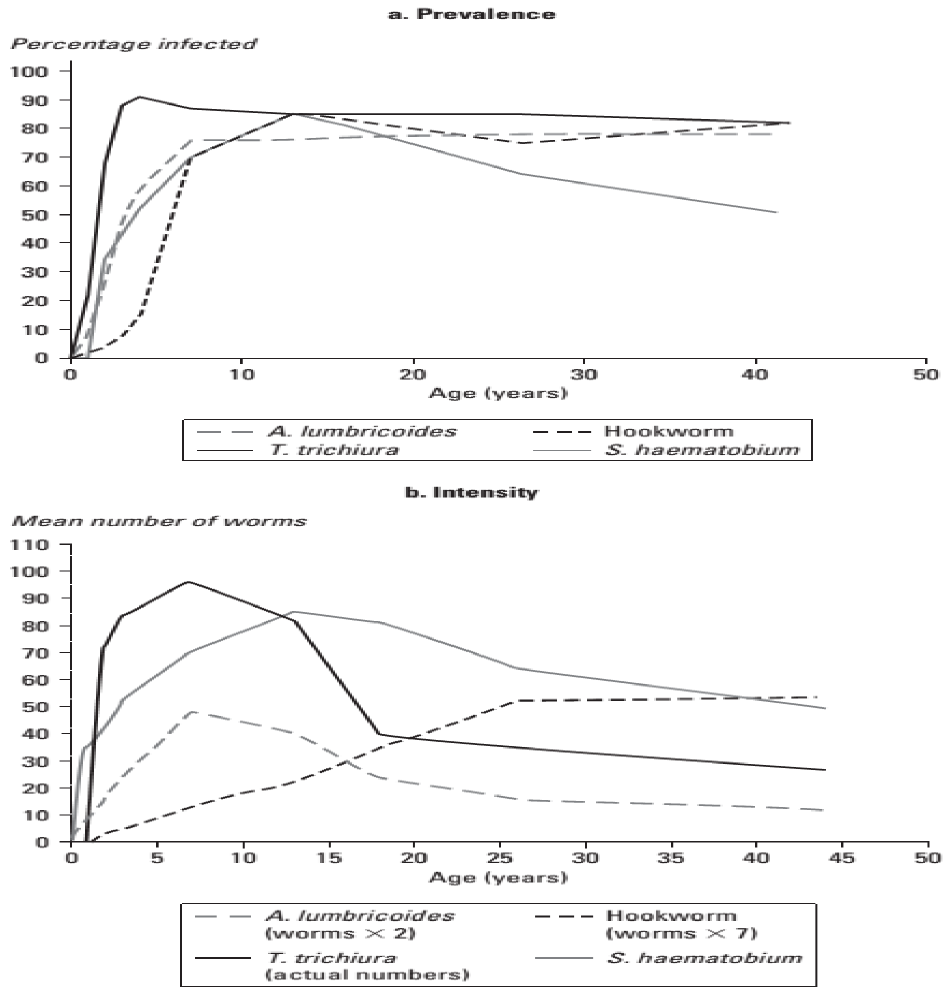


Figure 2.7: The age-associated prevalence and intensity profiles of helminths

Source: Hotez *et al*. (2005)

Hookworm, on the other hand, has a wide range of age-intensity profiles, though intensity normally multiplies with age until attainment of adulthood which then obviously plateaus as described by Brooker *et al.* (2004). The elderly in East Asia are likewise known to have the highest intensities. Children and young adults, on the other hand, are considered to be at a higher risk of both harbouring higher levels of parasitic infection (and consequently more morbidity) and becoming re-infected more quickly. Both can happen at critical times in a child's cognitive and physical development.

2.8 Consequences of the change in climate and behaviour of human in helminthiases

To aid in successful management in highly endemic areas, further research is needed into novel therapeutic choices and a better knowledge of the health implications of STH infections (Hotez *et al*., 2008). Additionally, there is growing support for an integrated and comprehensive approach to STH control in order to obtain outcomes that are not dependent exclusively on anthelmintics and that could provide long-term protection through improved sanitation and education. It is also necessary to acknowledge that STHs will increase the danger of illness brought on by other diseases like HIV/AIDS, malaria, and tuberculosis (Hotez and Molyneux, 2008). The transmission of HIV/AIDS and malaria will be greatly reduced if there is a great control in the health impacts of STHs (Weaver *et al.*, 2010).

There is a substantial remonstrance in the grasp of the complexness of association within and between infections within single hosts and people as a result of co-endemicity of those disease infections in many of the poor localities of sub-Saharan Africa (Weaver *et al*., 2010). There can be a new trend and serious problem to the control of STHs due to changes in the climatic conditions (Weaver *et al*., 2010).

There are significant linkages between the developments of parasite, behaviour of human in terms of hygiene with foreseen climate changes in relevance to STH infections and ways for identifying how the environment affects parasites, such as a predicted climate change associated with helminth prevalence (Weaver *et al.*, 2010).

2.8.1 Regional climate change and soil-transmitted helminths

The Intergovernmental Panel on Climate Change (IPCC) released a predicted assessment report for future purposes under the regime of accelerated climatic changes. This report involved predictions of a 1.1^0C – 6.4^0C rise in the world mean surface temperature by 21^0C, having the most effective estimates at 1.0^0C–4.0^0C (Weaver *et al*., 2010). However, the report given by Weaver *et al.* (2010) was explained to be essentially conventional with estimations of the rates as well as magnitudes of modification (Richardson *et al.,* 2009; Weaver *et al*., 2010). The current inadequacy of operational limits on future greenhouse gas emissions can contribute to further warming, and there is a growing recognition that at this time anticipated scenarios may fall short of expectations, as well as the degree of environmental transformation catching us off guard (Weaver *et al*., 2010). Global changes in the climatic condition alone, regardless of germs and helminthiasis, have been seen as the biggest challenges to international health in this current century (Costello *et al.,* 2009; Weaver *et al*., 2010).

Because of limited facilities and resources, as well as a lack of climate data, the expected implications of global climate change for Africa and Asia remain unknown (Boko *et al.*, 2007). Climate change, as a determinant of soil temperature and humidity, always do have a direct impact on parasites (for example, by promoting the expansion and/or relocation of helminths infection outside their existing ranges or their extinction in some areas). Indirectly, parasite prevalence and abundance can be influenced by the weather (e.g. as a result of socioeconomic developments like altered agricultural routines or abridged food accessibility).

Regardless of the apparent amount of ambiguity surrounding the rate as well as projected after-effects of global climate change, imperative inquiries about the consequences for human health arise (Patz *et al.,* 2007). Complications and complexness of parasite transmissions and environmental impact analysis mean of different forms of micro-and macroparasites are going to be vulnerable to varied gradation to stable climatic changes (Polley, 2005; Weaver *et al*., 2010). The fact that hosts are both directly and indirectly influenced by global climate change adds to the complexity of the interactions. So, how would climate change effect STHs and their hosts?

2.8.2 Knowledge of the relationship between parasitism and climate

The study of the underlying relations between climate change, climate, as well as STH ecology has gotten a lot of interest (Van Dijk *et al.,* 2010). There is a need for the understanding of how the global climatic changes will affect STHs by examining the interactions between the parasites' life cycles and ecology and the climatic conditions (Figure 2.8). Several factors such as suitable host, environmental soil for parasite development, and flexibility, guided by lower and upper survival tolerances are liable for the distribution, prevalence, and abundance of a parasite (Weaver *et al*., 2010). Moreover, narrative variables like however stages of free-living are handed out within the surroundings and therefore the potential for arrested development may interconnect with short-term weather and climate patterns to sway dissemination (Mas-Coma *et al.,* 2008; Weaver *et al*., 2010). As a consequence, climatic factors significantly affect the realised or actual spread of helminths in time and space. The ecological circumstances that affect parasite survival and transmission are likewise influenced by these factors. Indirectly (via hosts) or directly (through free-living stages), changes in environmental condition variables have an impact on parasite environmental science by altering host and geographic spreading, prevalence, infection pressure, as well as the intensity of parasites (Figure 2.9) (Mas-Coma *et al.,* 2008).

Changes in the distribution, prevalence, including the severity of STHs and other parasites will be intimately related to those of their hosts, and will be influenced by a variety of circumstances (Polley and Thompson, 2009). The proportions of increasing landscape level to regional perturbation may result in enterprising ecological relationships, new contact Eco zones and zones, movement of the host, as well as emerging new animal (zoonotic) infections (Brooks and Hoberg, 2007; Weaver *et al*., 2010). As a result of the chaotic movement of human populations, the failure of control mechanisms will coincide with the appearance of both recognised and novel infections. Despite the lack of data for soil-transmitted helminths, the empirical evidence of climate-driven change have arisen from findings of high-latitude systems in the Northern Hemisphere, especially involving ungulates (Van Dijk *et al*., 2010).

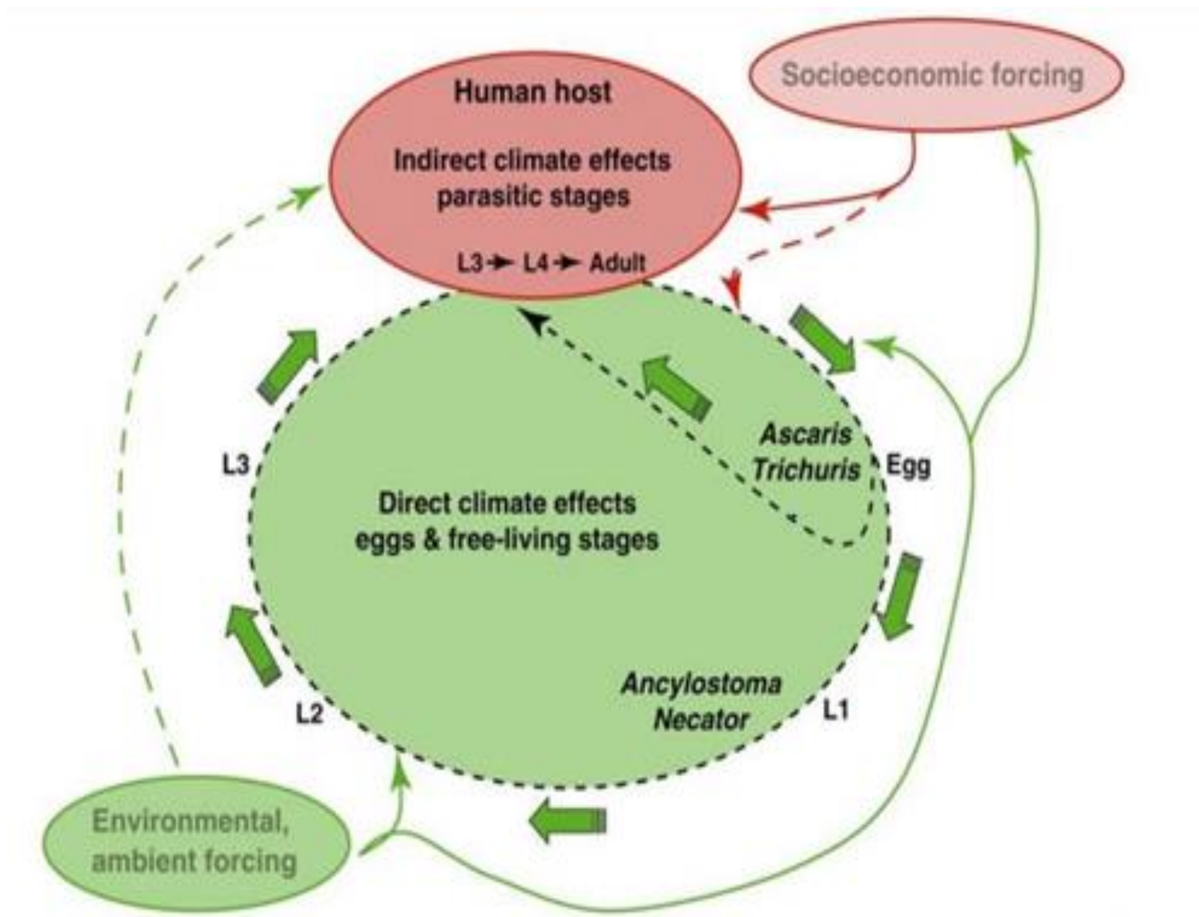


Figure 2.8: Overall life cycle pathways of *Ascaris*, *Trichuris* and hookworms (*Ancylostoma* and *Necator*) Source: Weaver *et al*. (2010)

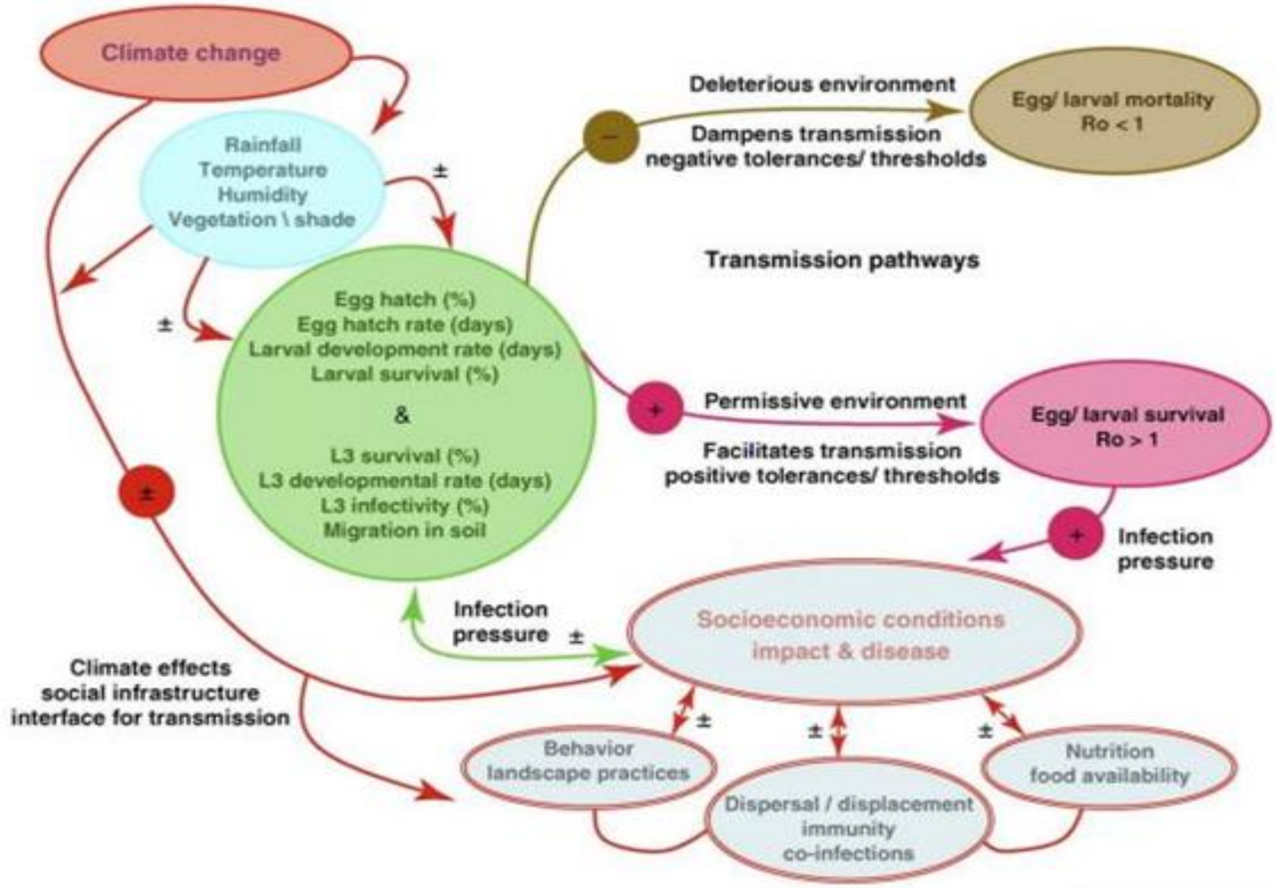


Figure 2.9: The complexity of interactions between potential climatic and Socioeconomic factors that will serve as determinants of distribution and Disease. Source: Weaver *et al*. (2010)

In these investigations, both the long-term accumulative shifts (also known as tipping points) and short-term ephemeral (or severe) occurrences were found as factors influencing helminth-related disorder distribution and onset patterns according to Weaver *et al*. (2010). The correlation between gradual climate change and habitat disturbance and finer changes in epidemiology is becoming clearer. On the other hand, discrete phenomena such as temperature, precipitation, and humidity extremes may be associated to rapid change and explosive emergence.

2.8.3 Biological developments of STHs and change in climate change

There are factors that enhance the prevalence and distribution of STHs, the important ones are human behaviour and the physical surroundings according to Weaver *et al*. (2010) (Figure 2.9). The transmission patterns of hookworms, for example, are studied in great depth in numerous tropical and subtropical locales, emphasizing these interactions (Brooker *et al.,* 2006; Weaver *et al*., 2010). Understanding the environmental boundaries and foreseeing or projecting different shifts allows us to develop more effective responses to shifting climatic regimes, parasite prevalence, and human exposure patterns (Weaver *et al*., 2010).

Like all other infectious diseases, STH infection life cycles, efficient transmission, and population preservation are frequently expressed by the necessary reproductive number (R0). A number of 1 or above suggests that there is a strong likelihood that an infection will persist in the community (Weaver et al., 2010). R0 values for *A. lumbricoides*, *T. trichiura*, and hookworm are currently accepted to be 1 to 5, 4 to 6, and 2 to 3, respectively (Brooker *et al.,* 2006). STHs' infectious stages (*A. lumbricoides* and *T. trichiura* eggs, and hookworm's motile L3 larvae) are all found to be reliant on the external environment, notably the soil. Every one of those stages has climatic growth as well as development levels. Circumstances outside of them might have a favourable or negative impact on transmissibility. It is therefore worth noting, though, that these special clouts may not all be negative and do result in a decrease in spreading. Desiccation (and death) rates for *T. trichiura* and *A. lumbricoides* eggs, as well as hookworm egg hatching success, can be affected by interactions between climatic conditions. Overall survival and infective L3 development may be harmed. Brooker *et al.* (2006) found that the 2 (two) different species of hookworms do have different developmental forbearances and ecological parameter thresholds, with ninety percent of eggs hatching between 15–25^{0}C for *A. duodenale* and having 20–35^{0}C for *Necator americanus* (Weaver *et al.,* 2010). Because *N. americanus* is mainly a tropical parasite with low resilience, its range may not extend in comparison to *A. duodenale*. *A. duodenale*, on the other hand, is less vulnerable to dryness and can be found in cooler, drier, and 'marginal' habitats. It is definitely a bigger disadvantage because it is more virulent and could arguably pose numerous significant obstacles under a development regime.

In some parts of Central Africa, drought intensification and rising temperatures may assist in severely limit STH spreading over time (Intergovernmental Panel on Climate Change, 2007). Hookworms have greater survival thresholds in Central Africa, exceeding 40°C–47°C, whereas *A. lumbricoides* and *T. trichiura* do not exist whereby the mean land surface temperatures exceed 37°C–40°C (Weaver *et al.,* 2010). In Cameroon, rainfall above 1500mm per year giving rise to a predominance of *T. trichiura* and *A. lumbricoides* of more than fifty percent (Weaver *et al.,* 2010). These findings show that each species is more vulnerable to rising temperatures, while hookworms appear to be more vulnerable to rising desiccation (Brooker *et al*., 2006). To compensate for unfavourable ground conditions, hookworm L3 can seek out suitable soil microhabitat in deeper layers of the soil. Furthermore, *A. duodenale* propensity to halt development in a host after infection (Weaver *et al*., 2010), allowing it to' sit out' harsh seasonal situations, might therefore further confound the image of changing distribution models. Even though there is a lot of laboratory-derived data about STH developmental constraints, linking the dots from these thresholds as well as patience to complete ambient environmental circumstances is difficult. As a result, transmission dynamics on native scales are a complex mosaic that are linked to both climatic and socioeconomic factors. STH distribution is likely to fluctuate within and around endemic localities, with an increase in the transmission and dispersal in newly discovered areas being accompanied by corresponding declines in other areas. The geographical mosaic of rising and falling STH prevalence comparative to current levels of endemicity must be understood for a variety of possible future climate change scenarios in order to be effectively controlled.

2.9 Diagnosis and prevention

2.9.1 Diagnosis

Clinical

To better understand the epidemiology of the disease and to develop and evaluate infection control strategies, diagnostic approaches for identifying the helminth-caused diarrhaea/underlying dysentery's aetiology are useful. Helminthiasis symptoms include perianal itching, fever, intermittent abdominal pain, and loss of appetite, nausea, diarrhaea, and vomiting. The diarrhaeal stage of the infection, on the other hand, is difficult to identify from other bacterial, viral, and protozoan infections (Ojha *et al.*, 2014).

Laboratory

Even though clinical signs might raise suspicion of helminthiasis, helminth isolation and identification from faeces are still required for diagnosis (Ojha *et al*., 2014). When an adult roundworm is passed in faeces or vomit, it can be seen when observed under a microscope; the use of an anthelminthic medication may cause the worm to be ejected. The decisive approach for identifying helminth eggs from faeces preparations is microscopic identification using smears or after concentration.

Microscopy, requires trained professionals, is less sensitive to detecting mild and moderate infections, can lead to misdiagnosis, and can lead to delayed or inadequate treatment (Goodman *et al*., 2007). Numerous concentration as well as floatation methods are obtainable including Kato-Katz technology (Collender *et al*., 2015), ethyl formolacetate sedimentation, modified ethyl acetate floatation and modified Wisconsin flotation (Ojha *et al.*, 2014), simple gravity sedimentation (Goodman *et al*., 2007), McMaster salt flotation (Collender *et al*., 2015), a centrifugal-flotation technique in Sodium nitrate and Zinc sulphate solutions (Ogbolu *et al*., 2011), and using the Harada-Mori filter paper strip procedure for helminth ova discovery in the faecal assays (Collendar *et al*., 2015). On epidemiological grounds, these filter paper strip procedures or the charcoal refinement technique are the methods of preference for distinguishing *A. duodanale* and *N. americanus* larvae. On the other hand, the practicality of these procedures might be limited as a result of their time-consuming disposition, low sensitivity as well as labour intensiveness. The World Health Organisation endorses the utilisation of Kato-Katz quantitative procedure for detecting helminth eggs (Keller *et al*., 2020), which is most widely used in human helminth surveys. Nonetheless, the Kato-Katz procedure's utility in detecting infections in children may be restricted, as breast-fed infants' faeces have a tendency to be waterier and have lower egg counts. The Kato-Katz test, according to Keller *et al*. (2020), can only detect around half of all low-intensity infections, whereas the sedimentation or concentration test is substantially more sensitive.

Molecular biology, proteomics, and data from genome-sequencing projects have all advanced our understanding of parasitology (Ojha *et al.*, 2014). The ability to apply these important tools could invariably pilot an improve diagnosis as well as control of many important pathogens globally. There has been development of antibodies in the identification of helminth eggs, circulating antigen complexes (Ojha *et al.*, 2014), and parasite antigens (copro-antigens) released in host faeces. The helminth copro-antigens may be identified via an enzyme-linked immunoassays and as a result coproantigen ELISA (Enzyme-Linked Immunosorbent Assays) do have some crucial benefits over the established serum antibodies analyses (Ojha *et al.*, 2014). The antibody-based procedures critical of helminth antigens could also be expended in detecting human immunoglobulins (IgE) (McSorley and Maizels, 2012). For some STH infections, commercially available antibody detection tests are available, however their limited sensitivity and specificity render them inappropriate for field use for discriminating between current and previous infections. More current opportunity procedures consist of detection of antigen and antibodies via the means of ELISA, the Indirect Haem-Agglutination test (IHA), the latex agglutination test, Polymerase Chain Reaction (PCR), and the intradermal test (Ojha *et al.*, 2014) based on detection methodologies. The use of PCR-based techniques allows infection to be resolved down to the genotype level, bringing clarity to some asymptomatic helminthiasis investigations. Several conventional real-time PCRs for the recognition of microbial causes, including intestinal pathogens, were however created and demonstrated to be very sensitive and specific (Verweij *et al*., 2004). Molecular approaches like Luminex PCR and real-time PCR have proven to be extremely specific, sensitive, and repeatable diagnostic procedures (Collendar *et al*., 2015). Due to increasing costs, equipment, and the necessity for specialists to administer the tests, they are challenging to implement in low and middle income nations (Ojha *et al.*, 2014).

Soil helminthiasis infections are also associated with eosinophilia and mild to moderate anaemia. The presence of Charcot-Leyden crystals in a patient's feces or sputum samples can aid in the diagnosis of an illness (Hotez *et al*., 2008). An occult blood test (benzidine) may yield a positive result during a persistent infection. The clinical symptoms of STH infections vary depending on the larvae's location. Whipworms in the rectum can be detected with colon endoscopy, whereas capsule endoscopy can help with therapeutic examinations of STH infections in the management of any inflammatory disorder (Ojha *et al.,* 2014).

2.9.2 Prevention

The public health control processes are considered as best long-range strategic intervention for controlling helminthiasis in sub-tropical and tropical nations of the world. The most operational intervention strategies in preventing STH re-infection as well as minimising the potential for the drug resistance development (Ojha *et al*., 2014) in the long term are non-chemotherapeutic-based possibilities. The ambition of curing alone is almost impractical in squashing out helminthic infections for the reason that the patient could easily get infections as a result of improper sanitation. Making sanitary facilities available and encouraging their use as opined by Ziegelbauer *et al.* (2012) systematic review findings, is a successful control strategy for soil helminthiasis. To have a long-term impact on increasing sanitation, the entire community population have got to be included in the development process (Ojha *et al*., 2014). Improved sanitation, as well as chemotherapy and health education, could help to drastically reduce the helminthiasis problem. These operations, on the other hand, would improve people's lives, especially children's lives (Ojha *et al.,* 2014). A shift in focus to community-specific information would complement existing helminthiasis programmes while also being more financially sustainable. It would also reduce susceptibility to other infections including schistosomiasis and trachoma, as well as minimize the rate of diarrhea. All of these would help to reduce child mortality rates (Ziegelbauer *et al.,* 2012).

2.10 Mass drug administration for soil-transmitted helminthiasis

The Global Network for Neglected Tropical Diseases (GNNTD) was formed in 2006 by a group of organisations dedicated to MDA control. Its objective is to develop a bundle of pharmaceuticals that can instantaneously target the six (6) highly frequent human helminthiases in order to boost efficiency and create economies of scale (hookworm diseases, trichuriasis, ascariasis, schistosomiasis, lymphatic filariasis, and onchocerciasis). Integrated helminth control has caught the attention of both international policymakers and drug donors because to its affordability and effectiveness (Hotez *et al.*, 2008).

People were routinely treated regardless of whether they were actively infected with the disease-causing parasitic worm during MDA in resource-poor communities with a high incidence of helminthiasis. The mixed nature of depending on medications to treat or eradicate common infectious diseases like malaria has raised apprehensions that emerging resistance mechanisms or other associated difficulties could stall global struggles in implementing MDA, both of which can be integrated and otherwise (Hotez *et al*., 2007a). These concerns, combined with a growing need for a better understanding of a number of central clinical as well as epidemiological facets of human helminths infection, including their interfaces with geographically overlapping co-infections (such as HIV/AIDS and malaria), have heightened the need for increased clinical research activities related to large-scale helminth control (Hotez *et al.*, 2008). Firstly, the effects of human helminthic diseases on health have been reexamined, with an emphasis on the special impacts of mono- and polyparasitism on child growth and development as well as their validities on pregnancy and delivering complications (Ajanga *et al.,* 2006; Larocque *et al*., 2006; Friedman *et al.*, 2007). Third, the development of an advance tools in the control of helminth infections, such as treatments, diagnostics, and vaccinations; secondly, extensive intensive care as well as the MDA evaluation and integrated control; third, functioning research aimed at increasing population access to anthelminthic medications and monitoring drug resistance; and fourth (Hotez *et al.*, 2008).

The present synthesis of existing research data has climaxed in a recently announced set of WHO guiding principle for MDA and integrated control efforts (WHO, 2006). In parallel investigations, the effects of micronutrient supplementation are being investigated, particularly in the treatment of anemia caused by hookworm and schistosomiasis (Hall, 2007). Other investigations are focusing on the impact of infection on pregnant women and women of child-bearing age, who are frequently exempted from MDA due to concerns about faetal toxicity (Gyorkos *et al.,* 2006), or on the early developmental influences of soil helminthic infections in the pre-school children (Stothard and Gabrielli, 2007).

2.10.1 The draw-backs of drug administration

Despite the clear success of MDA, restrictions in treatment efficacy have been seen in various field settings, and serious concern had been expressed regarding the possibility of the occurrence of resistance to the mainstay medications of MDA plans, such as the benzimidazole anthelminthic, which is primarily used to treat soil helminthic infections, as well as ivermectin, which is utilised for treating filarial infections (Flohr *et al.,* 2007). Only -tubulin, maybe ABC transporters and -tubulin, are valid biomarkers for nematode resistance to benzimidazoles and albendazole, as well as other macrocyclic lactones such as ivermectin. These are the only anthelminthic medications to which nematodes are resistant (Prichard and Roulet, 2007).

In the face of the incredible attainments of MDA plans, parasitic disease eradication is not always possible in areas with high endemicity, necessitating new drug development (as well as strategies for their successful use). In the coming decade, new antihelminthic drugs should be discovered with the help of the mining of recently completed helminth genomes (Hotez *et al.*, 2008). In the meanwhile, animal clinical trials have demonstrated the effectiveness of tribendimidine, a novel broad-spectrum medication, in treating soil-transmitted helminth infections and artemether compounds in treating the early stages of schistosome infection (Utzinger *et al.,* 2007). However, new families of cysteine protease inhibitors are currently being investigated as anthelminthic and antiprotozoal medications (Abdulla *et al.,* 2007).

Antihelmintic medications are currently used for more than just treating symptomatic soil helminthiasis infections; they are also being used to reduce morbidity in endemic areas on a broad scale. Childhood stunted growth as well as low physical fitness and nutritional condition has been linked to chronic infection with soil-transmitted helminths. The improvement in these traits following deworming is used to infer a causal relationship between chronic infection and delayed childhood development (Krautz-Peterson *et al.,* 2007). Although there is little particular evidence to support this idea, the mechanisms underlying these relationships are assumed to include nutritional deficiency (Krautz-Peterson *et al.,* 2007).

In school-aged children, regular therapy with benzimidazole anthelmintic medicines decreases and sustains the worm load below the parasitic infection limit (Brooker, 2007). Regular deworming has been shown to boost iron reserves, development, and physical fitness in this age group, as well as cognitive function and school attendance (Hotez *et al.,* 2008). Nutritional deficiencies for instance malnutrition, wasting, stunting, and appetite have all been encountered in younger children, according to studies (Krautz-Peterson *et al.*, 2007; Hotez *et al*., 2008), and these enquiries further found that children that are treated, do score higher on motor and verbal milestones during their early development, while some researchers disagree on these proposals. In light of these discoveries, anthelmintic medications can now be given to children as young as three-year-old who are infected with soil-transmitted helminths (Krautz-Peterson *et al.,* 2007).

The patents on WHO-recommended anthelmintic medications have expired, and generic manufacturers can now make the drugs at a lower cost. The cost of medicine distribution is also minimal because teachers could participate in deworming following a little training (Hotez *et al.,* 2008). If women in the endemic regions are therefore treated once or twice during pregnancy, maternal anaemia, birth weight as well as infant mortality at six months improve significantly (Hotez *et al.*, 2008). Antihelmintic medication is suggested during pregnancy in locations where hookworm infections are common, except during the first trimester (Krautz-Peterson *et al.,* 2007). Reinfection is a significant issue in treatment. After community-wide treatment, hookworm infection rates reach eighty percent of pre-treatment levels in 30–36 months (Hotez *et al.,* 2008), *A. lumbricoides* infection rates reach fifty-five of pre-treatment levels in eleven months (Li *et al*., 2006), and *T trichiura* infection rates reach forty-four percent of pre-treatment levels in seventeen months (Hotez *et al*., 2008). Despite reinfection, ongoing treatment to lower the worm burden over time may be able to avert a number of the consequences of chronic infection. By means of repeated treatment of animals kept in close proximity and with little gene flow, drug resistance to front-line anthelmintics is well-known in livestock nematodes (Hotez *et al.,* 2008). Drug resistance would emerge quickly if such settings were recreated in human nematodes.

Human nematodes reproduce more slowly, are treated less frequently (the treatment period is greater than the parasites' generation time), and are only administered to certain groups, releasing a certain pool of sensitive alleles. As a result, selection pressure should be lessened (Hotez *et al.,* 2008). Nonetheless, treatment efficacy must be continuously checked, particularly in locations somewhere drug pressure is considerable, for instance in areas where mass anthelmintic chemotherapy is also used to eradicate lymphatic filariasis. The research agenda includes the development of delicate devices for an early identification of anthelmintic resistance, with a focus on in-vitro tests and molecular biology approaches that might be tailored to field situations (Hotez *et al.*, 2008). For no new anthelmintic medications are currently in late-stage development, the efficacy of existing drug therapy must be conserved.

Concerns concerning the long-term effectiveness of benzimidazole anthelmintic medicines, as well as the establishment of resistance, have driven initiatives to develop and test other control measures. Nitazoxanide, a nitroimidazole chemical used to treat giardiasis and cryptosporidiosis in children, is also being studied as a broad-spectrum antiparasitic with anthelmintic characteristics (Morales *et al.*, 2007). Tribendimidine found to have a very low toxicity, nonetheless broad-spectrum activity against various soil helminthiasis had been mentioned (Kines *et al*., 2006). Tribendimidine was found to be similar to mebendazole and albendazole in randomized studies in China for the treatment of hookworm, *T. trichiura*, and *A. lumbricoides* infections, and better than these medications for the treatment of *Necator americanus* infection (Kines *et al*., 2006). In Africa, researchers are evaluating tribendimidine and albendazole for the treatment of hookworm. Combination therapy, which uses medications with different mechanisms of action, is another way to boost efficacy and reduce the chance of resistance (Hotez *et al.*, 2008). The combinations of levamisole and mebendazole, and pyrantel and oxantel, for example, are found to be more efficacious than any single medicine (Braschi *et al.*, 2006).

2.11 Elimination of soil-transmitted helminths

Several of the Sustainable Development Goals (SDGs) of the United Nations must be achieved in order for STH solutions to be effective (WHO, 2019), so controlling or eliminating these parasites should be a top concern. In different parts of the globe, the aggregation of STHs has been demonstrably controlled or eradicated. Despite the obvious possibility for broader and more effective control, the question must be asked: why are over a billion people still suffering from STH-related diseases? Anthelmintics have traditionally been used to control helminths in humans since the 1970s (Pham *et al.*, 2023).

Even though mass drug management plans combined with parasite and hygiene education have been effective in controlling STH infections, lack of knowledge on the variables affecting the distribution, prevalence, and severity of STH infections appears to be the greatest barrier to complete control (Schaafsma *et al.*, 2015).

Cambodia story

Cambodia is the first country to reach the WHO's 75% MDA target by regularly providing anthelminthic drugs to 84% of its SAC (WHO, 2014). Cambodia Ministry of Health launched a two-phase deworming programme in 2002 and established "the National Task Force for the control of STH infection, Schistosomiasis (SCH) and the elimination of lymphatic filariasis". Anthelminthic drug (mebendazole 500mg) and well-being education were delivered to 75% of its schoolchildren twice in the year 2002 (Sinuon *et al.*, 2005). Prior to this, prevalence was consistently high, 50%, and with large areas recording over 70%. Cambodia had a school population of approximately 2.8 million children at the time of intervention.

Phase one, which ran from December 2002 to March 2003, focused on more than a million students from eleven provinces, while phase two, which ran from July 2003 to January 2004, focused on all students, with an estimated 84% coverage where the second round of campaign was conducted in some locations and re-treatment took place (Sinuon *et al.*, 2005). The strong political commitment explains why a high coverage for a bi-annual deworming was achieved despite Cambodia's minimal resources. The deworming programme represents a successful model for other developing countries.

There was a repeated deworming campaign every 6-month interval and retraining of the teachers every 3 years. A total of over 2 million children were reached with deworming programme, should the retreatment trend continue as stipulated in the 2011-2020 strategic plan, in another 10 years, Cambodia expectedly should be able to break STH transmission and eliminate the disease as a public health problem (Sinuon *et al.,* 2005).

The Japan story

According to Hasegawa *et al*. (2020), the Japanese economy nearly collapsed after WWII, food supply decreased dramatically, and the environmental cleanliness waned significantly and remained bad for a couple of years. Similarly, in cities, all of the open spaces were constantly utilised for vegetable gardens, and night dirt was a typical fertilizer. The prevalence of *Trichuris* and, in particular, *Ascaris* infection increased dramatically as a result of the deterioration in cleanliness. To combat the increased incidence, the JAPC was created in 1949. There was some dispute earlier about whether to focus on either chemotherapy or environmental sanitation. Because of the high cost of contemporary sanitation, the JAPC chose to concentrate on chemotherapy rather than environmental and infrastructure upgrades, leaving them to the government.

The JAPC intervention strategy was to conduct biennial mass screening and treatment at schools. Because Japan's postwar health system was inadequate, schools provided a more stable and cost-effective infrastructure for deworming (Hasegawa *et al*., 2020). Due to seasonal fluctuations in incidence, Tokyo Health Service (Tokyo Health Service Association, 2015) conducted testing and treatment every June/July and November/December between 1967 and 2000. Researchers at Japan's Public Health Institutes devised the now-common cellophane thick smear (Kato-Katz) procedure for preparing as well as analysing faeces for soil helminthic eggs and Harada-culturing Mori's technique for hookworm larvae in the 1960s to efficiently test such a huge number of pupils (Pham *et al.,* 2023).

Santonin (50 mg) and conic acid (5.0 mg) were used together until the early 1980s, when pyrantel pamoate and some other broad-spectrum anthelmintic and benzimidazoles turned out to be accessible (Hong *et al.,* 2006). In Japan, the deworming programme was a huge success. Deworming began in 1949, and prevalence began to diminish immediately, dropping below one percent in 1973 and 0.05 percent in 1982 (Figure 2.10).

The percentage fell to 0.05 percent in the middle of the 1980s, indicating a strong success for the screening and treatment programme. Undoubtedly, the significant economic and sanitary infrastructure advancements made in the decades following the war contributed to the decline; but, it is difficult to determine how much longer, if at all, it would have taken without them. Despite rapid economic progress, it took around 30 years to eliminate the disease.

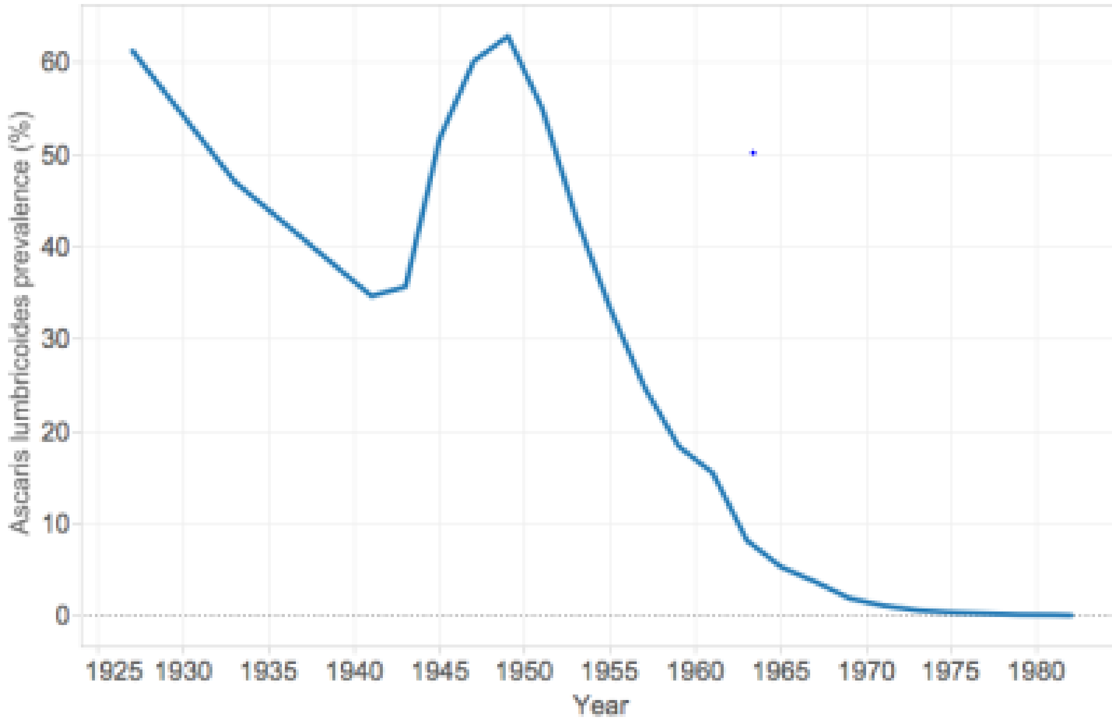


Figure 2.10: *Ascaris* prevalence in Japan, 1922-1980. Source: Schaafsma *et al.* (2015)

The rate was reported to be less than one percent in 2002, and there has been no mass stool examination for STH since then.

The Korea story

In the decades preceding extensive deworming, very high numbers of Koreans in all regions carried parasites. In a 1969 survey conducted across the country, it was discovered that 90.5% of the inhabitants had one or more STHs, including 58.2% of *Ascaris*, 74.2 % of *Trichuris*, and 9.1 % of hookworm (Schaafsma *et al.*, 2015). When the Japanese Overseas Technical Cooperation Agency started a three-year support agenda in the year 1969, the KAPE, which was founded in 1964 to address the issue, was finally able to undertake a statewide deworming campaign (Kim *et al.*, 2014).

The Korean Association for Parasite Eradication was founded with the intention of eliminating STH within ten years, however this goal proved to be far too ambitious. The intervention strategy was inspired by the successful JAPC strategy in Japan. A systematic, twice-yearly school-based mass screening and treatment program was put in place, involving all elementary, middle, and high schools nationwide. The KAPE used a variety of medications for therapy, which changed as new anthelmintics were introduced (Hasegawa *et al*. (2020):

- Conic acid and santonin and (1969-early 70s)
- Pyrantel pamoate (1973-88)
- Piperazine (1971-81)
- Mebendazole (1983- till date)
- Albendazole (1988- till date)

Since each soil helminthiasis incidence fell to less than 5% in 1987, KAPE decided that mass screening and treatment on a biannual basis were no longer essential. They switched to an annual autumn intervention schedule that year from a biannual spring and fall schedule. Before ending the programme in 1995, they ran it for a further eight years.

According to Hong and Yong (2020), KAPE conducted a public education crusade within the school scheme in addition to the screening and treatment procedures to raise awareness, stimulate participation, and support hygienic preventative behaviours. The health repercussions, infection channels and risk factors, as well as practical preventative behaviours like hand washing and vegetable washing, were all included in the educational materials. Posters, brochures, talks, videos, and even feature films were used to spread these messages.

The sanitation component of KAPE was restricted to small pilots, including evidence projects like septic tanks and composting toilets, while South Korea experienced rapid economic development, which is likely to have enhanced sanitary settings and accelerated the rate at which soil helminthic infections decreased (Hong and Yong, 2020).

2.12 Water, sanitation, and hygiene

The World Health Organisation's present objectives have a focus on morbidity control, and there are case studies of successful STH transmission interruption (Asbjornsdottir *et al.*, 2017). Prior to persistent control efforts by large-scale screening and MDA, soil-transmitted helminths were very common in the Southeast Japan, United States, and South Korea. However, transmission looked to have been stopped in these areas (Bleakley, 2007; Asbjornsdottir *et al*., 2017). It is crucial to remember that despite the fact that these effective initiatives mainly relied on mass chemotherapy, they all occurred at a time when the economy was experiencing rapid growth and access to WASH had improved. WASH improvements have been promoted as essential for the control or eradication of STH and are significant from the perspective of human rights (Hutton and Chase, 2016; Campbell *et al.,* 2017). Yet, there is conflicting information addressing how WASH services affect the prevalence and severity of STH infections (Strunz *et al*., 2014; Benjamin-Chung *et al*., 2015; Grimes *et al*., 2016; Campbell *et al.,* 2017; Oswald *et al*., 2017). The particular intervention(s) used will have an impact on WASH, as will other community members' actions like using WASH and contributing to the environmental reservoir (Oswald *et al*., 2017), agricultural activities (Amoah *et al*., 2016; Krause *et al*., 2016), and some environmental elements like precipitation and soil composition (Etewa *et al.,* 2016; Campbell *et al.,* 2017; Wardell *et al.,* 2017). WASH interventions are rarely offered at a sufficient scale since they are not only difficult in some structural ways but also expensive to implement as comparison to MDA; universal access is still a long way off (Hutton and Chase, 2016; Roche *et al.,* 2017). There is therefore, a limited high-quality trial confirmation on the impact of WASH interventions on STH prevalence or incidence, and the majority of data are from observational and/or cross-sectional research (Campbell *et al.*, 2016), even though numerous randomized studies are running or have results that are to be published (Roche *et al.*, 2017).

2.13 Geographic information system in epidemiological studies

The advent of geographical information systems as a new tool for graphical representation and spatial analysis of databases offers a new approach for planning and managing the control of tropical diseases (Ortu and Williams, 2017). Geographical Information System provides common ground for dialogue between Zoologists, Veterinarians, Medical Public Health Workers, Agriculturists, Geologists, Botanists, Engineers (Oladejo *et al*., 2014). In the past, epidemiologists, public health experts, and medical geographers have utilized maps to examine relationships between place, environment, and disease. As a result, spatial analysis and mapping have a long history with epidemiology (Bhatt *et al.*, 2017), and they can be used to understand how diseases spread as well as to monitor and control disease (Oladejo *et al.*, 2014).

Several factors determine the distribution of parasitic infections, these are food habit, cultural traditions, the environment, economic situations, social status, and so on. Each parasitic organism has a distinct social and natural habitat, and a hospitable environment is necessary for its growth (Tyoalumun, 2016). In terms of STH mapping, African nations have undertaken the majority of the operations (Brooker *et al.*, 2009). The risk maps are the end product of transmission models that integrate environmental data with epidemiology and vector biology data (Oladejo *et al.*, 2014). The use of mapping as a tool helps visualize differences, grouping, heterogeneity, and homogeneity in data. Symbols, maps, and colours could express feature or the comparative significance of different landscapes, allowing spatial patterns and connections to be observed (Oladejo *et al.*, 2014).

In order to assess and predict the temporal and spatial distribution of disease risk locations, risk mapping and geographic information system technology are now crucial methodologies. This has allowed for the development and implementation of sound control interventions as well as the advancement of epidemiological knowledge (Oladejo *et al.*, 2013). Spatio-temporal transmission models are aimed to speculate contacts between infectious and susceptible individuals and estimate the spread of the disease. These methods help to identify areas/locations and times at risk of the disease (Chammartin *et al*., 2014).

The geostatistical analyst uses sample points taken at different locations in the study area and creates (interpolates) a continuous surface using Kriging methods. These sample points are measurements of some parameters such as rainfall or parasites count found in the study area or environment. In order to predict values for each place in the research region, the analyst creates a surface using the values from the measured locations. There are two types of interpolation algorithms offered by Geostatistical Analyst: deterministic and geostatistical. For interpolation and uncertainty, deterministic approaches employ mathematical functions. Finally, in addition to numerous interpolation approaches, many supporting tools are provided. These tools allow one to study and better understand the data well in order to be able to construct good map surfaces based on the data available.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

Ibadan is a city situated in the southwestern geopolitical region of Nigeria, approximately 128 km away from Lagos which is the commercial capital of Nigeria, and about 530 km away from the Federal Capital Territory, Abuja. Ibadan is positioned in the south-eastern section of Oyo State, around 121 kilometers east of the Republic of Benin's border, in the forest zone, near the forest-savanna line (Ajayi *et al*., 2012; Oyebamiji *et al.*, 2018). Ibadan serves as a key crossing point between the northern regions and the coastal region. When Britain still controlled the region, Ibadan served as its administrative hub. The city is 3,080 square kilometers (1,190 square miles) in size, with an elevation that varies from 150 meters above sea level in the valley zone to about 275 meters above sea level on the main north-south ridge that cuts through the middle of the city (Ajayi *et al.,* 2012).

The climate in Ibadan is tropical wet and dry, with a long wet season and fairly stable temperatures throughout the year. The rainy season in Ibadan lasts from March to October, with a decrease in precipitation in August (Ajayi *et al.,* 2012). The wet season appears to be split into two distinct wet seasons because of this lull. The dry season, which lasts from November to February, is when Ibadan experiences the classic West African harmattan. Ibadan experiences a mean total rainfall of 1420.06 mm every 109 days. Rainfall has two maxima in June and September. The mean maximum and minimum temperatures are 26.46^{0}C and 21.42^{0}C respectively, and the relative humidity is 74.55% (Ajayi *et al.,* 2012). The soil in Ibadan belongs to the major soil group called ferruginous soil, which was formed from underlying rocks such as granite gneiss, quartz-schist, biotite gneiss, and schist (Ajayi *et al*., 2012). The soil is generally characterized by a sandy surface horizon overlying a weakly structured clay accumulation (Suits *et al.*, 2011). According to the Food and Agricultural Organisation (1966), the natural fertility of the soil is high. However, under traditional management practices, ferruginous soils are of low productivity and are sensitive to erosion. The soil has a low water-holding capacity (Suits *et al.*, 2011).

The Yoruba people make up the majority of the city's population. The city is a significant hub for trade in cassava, cocoa, cotton, lumber, and palm oil thanks to its advantageous location along the inactive railway line that connects Lagos and Kano. There are numerous cattle ranches, a dairy farm, as well as commercial abattoirs in Ibadan, and the area is rich in clay, kaolin, and aquamarine. Processing agricultural products is one of the key industries in the region, along with the manufacture of tobacco products and cigarettes, flour mills, leather goods, and furniture.

3.2 Study locations and sites

Ibadan metropolis, the largest city and the capital of Oyo State, has eleven (11) different Local Government Areas (LGAs). The LGAs are; Akinyele (A), Egbeda (E), Ibadan North (IbN), Ibadan North West (IbNW), Ibadan North East (IbNE), Ibadan South West (IbSW), Ibadan South East (IbSE), Ido (I), Lagelu (L) Oluyole (O), and Ona Ara (OA). One well-known location was purposively chosen from each LGA, these were; Akanran, OA; Alakia, E; Aleshinloye, IbSW; Bodija, IbN; Eleyele, IbNW; Iwo Road, IbNE; Molete, IbSE; Moniya, A; Olodo, L; Omi Adio, I and Podo, O (Figure 3.1). Different sample sites from each location were visited for soil collections, they were; Toilet Areas (TA), Refuse Dump Sites (RDS), Play Grounds (PG), Road Sides (RS), as well as House Vicinity (HV).

3.3 Study participants/population

The study populations were volunteers aged five years and above. Consenting individuals attending the Primary Health Centre (PHC) at each LGA were enrolled in the study.

3.4 Ethical considerations

Ethical approval was requested from the Ethical Board of the State Ministry of Health in Ibadan (Appendix I) and was obtained prior to the commencement of the study. Advocacy visits were organised for adequate familiarity with the environment, permission was obtained from the officers of the PHC. Informed consent was obtained from each participant and participants that were not interested in the study were able to withdraw at any time in the course of the study.

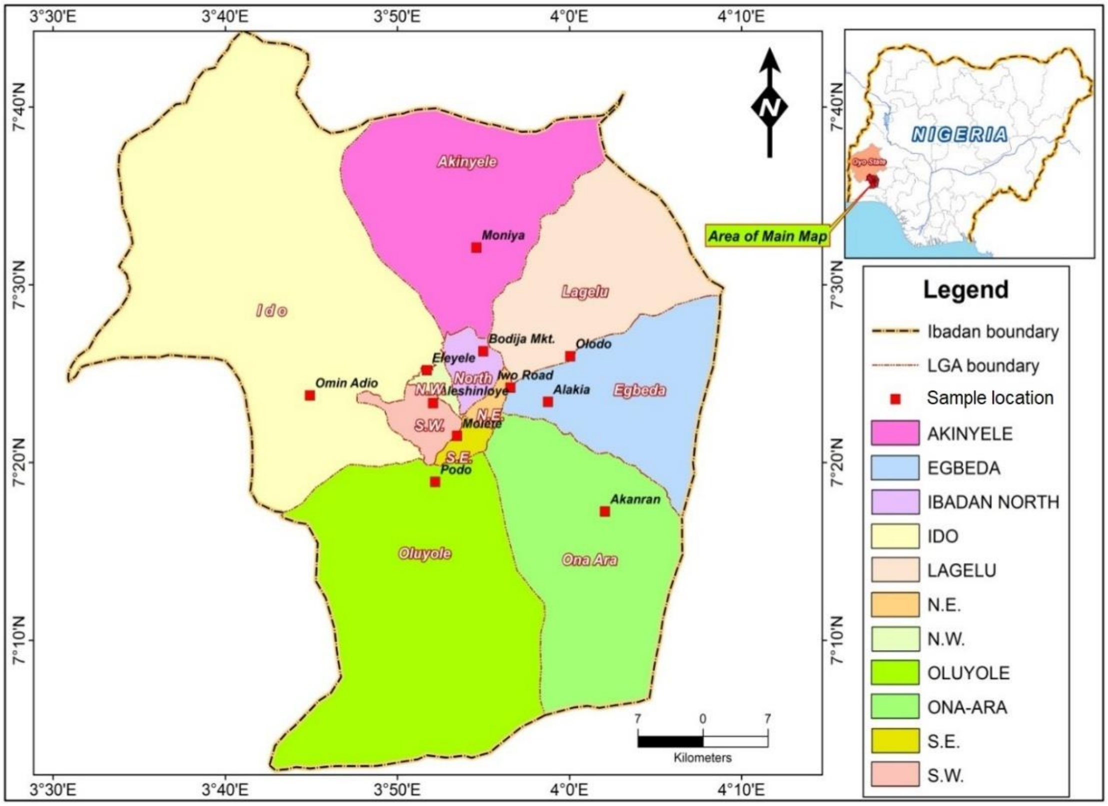


Figure 3.1: The eleven sampling locations around the Local Government Areas of Ibadan

3.5 Inclusion criteria

Healthy individuals living in each LGA who signed a written participation informed consent form and volunteered to participate in the study were incorporated into the study. Participants of various ages were enrolled in this study.

3.6 Exclusion criteria

Individuals with sick history and were on drug therapy during the one-month period before the study, individuals who did not sign the written consent form, and pregnant women were excluded from participating in this study.

3.7 Study design and sample size determination

This investigation was a cross-sectional study carried out between January 2017 and December 2018. Purposive random soil sampling was done every two months between the hours of 6 and 11 in the morning, at such locations where STHs seemly survive or the possibility of human exposure was high according to the methods described by Oyebamiji *et al*. (2018).

528 soil samples at least for the five sampling sites across the sampling locations according to the formula given by Oyebamiji *et al*. (2018):

$$N = \frac{[Z^2(P)(1-P)]}{(d^2)} \qquad \text{(Formula 3.1)}$$

N= Sample size, Z= 1.96, d= absolute error or precision, P= Previous prevalence studies obtained, P= 55.9% which was the value obtained earlier by Ogbolu *et al*. (2011).

Faecal sample size determination: a minimum of 320 samples was estimated using the prevalence value of 67.1% reported by Auta *et al*. (2014).

3.8 Sample collection

3.8.1 Soil sample collection

About 100 g of soil was collected randomly at depth of 2-3 cm (Odimkanoro *et al.,* 2013) from 4 different points at each of the sampling sites; TA (Figure 3.2), RDS (Figure 3.3), PG (Figure 3.4), RS (Figure 3.5), and HV (Figure 3.6). Each soil sample collected was kept in a properly marked and sealed polythene bag until needed for further studies.

Figure 3.2: Toilet area in Ibadan Northwest

Figure 3.3: Refuse dump site in New Bodija, Ibadan North LGA

Figure 3.4: Playground in Moniya, Akinyele LGA

Figure 3.5: Roadside area in Iwo Road, Ibadan Northeast

Figure 3.6: House vicinity in Egbeda LGA

3.8.2 Faecal sample collection

A clean, marked wide-mouth plastic sample bottle with covers was given to study participants who were appropriately instructed on how to collect the faecal sample which should be done early in the morning devoid of contamination using the applicator stick provided with the sample bottle. These were collected from the participants early morning of the following day. Some samples were examined immediately and other faecal samples were instantly preserved using 10% formalin and ultimately taken to the laboratory for further examination (Pham Duc *et al*., 2013; Auta *et al*., 2014).

3.9 Screening of soil and faeces samples for parasites

3.9.1 Parasites' ova or larvae recovery from the soil sample

3.9.1.1 Isolation, concentration, and identification of STH eggs: Soil-transmitted helminth egg extraction or isolation was carried out using Cobb's decanting and sieving methods (Cobb's, 1920). About 20.0g of soil sample was collected into a clean container and 1000 ml of water was added to ensure proper mixing when stirred. The mix was filtered through a 212µm mesh sieve into a second container, to leave behind any available heavy coax soil particles which might settle in the sieve. The resultant supernatant collected was mixed and allowed to stand for about thirty seconds, after which it was sieved through another mesh (180µm) into a clean container and allowed to stand overnight. Furthermore, any excess water was thereafter decanted and the sediment was thoroughly mixed.

Approximately 15 mL of the sediment was centrifuged at 2500 rpm for 10 minutes in order to separate STH eggs from the soil. After removing the produced supernatant, the sediment was added, violently agitated, and centrifuged once more at 2500 rpm for 10 minutes. The floatation solution (sucrose with 1.3 specific gravity) was then added to the sediment. In addition, a fresh cover slip was placed on the centrifuge tube after a few drops of sucrose solution were added to the solution in the tube until a meniscus formed (Ogbolu *et al.*, 2011; Oyebamiji *et al*., 2018). After 6 minutes, the coverslip was taken off, put on a microscope slide, and checked for the presence of STH eggs. The number of species of egg types found was counted and recorded and the slides were viewed under the microscope at a magnification of X40 and X10. The STH eggs were distinguished with the aid of keys and standard text (Otubanjo, 2008).

3.9.1.2 Soil parasites extraction

A modified Baermann procedure was employed for the extraction of the larvae of *Strongyloides* and hookworm (Collender *et al*., 2015). A well-modified funnel having short rubber tubing attached to the stem and closed by a clamp served as the device (Plate 3.1). The water-filled funnel was maintained upright and filled with water. On top of a wire screen, a two-layered paper serviette, and about 20g of dirt were added. The "enveloped" sampled soil was put into the Baermann funnel (that was filled with distilled water) in accordance with the procedure outlined by Oyebamiji *et al*. (2018). The soil larvae that were already present moved out of the paper serviette and the screen into the water in the funnel gravitationally sank to the bottom of the funnel and which were then collected after 48–72 hours. Under the automated light microscope, the lower 5ml of the suspension was examined for the presence of STH parasites.

3.9.1.3 Determination of prevalence and intensity of parasite in soil

The following formula was used to determine the parasite contamination:

$$\text{Prevalence} = \frac{\text{Number of parasite-positive samples}}{\text{Total samples of soil examined}} \times 100\% \qquad \text{(Formula 3.2)}$$

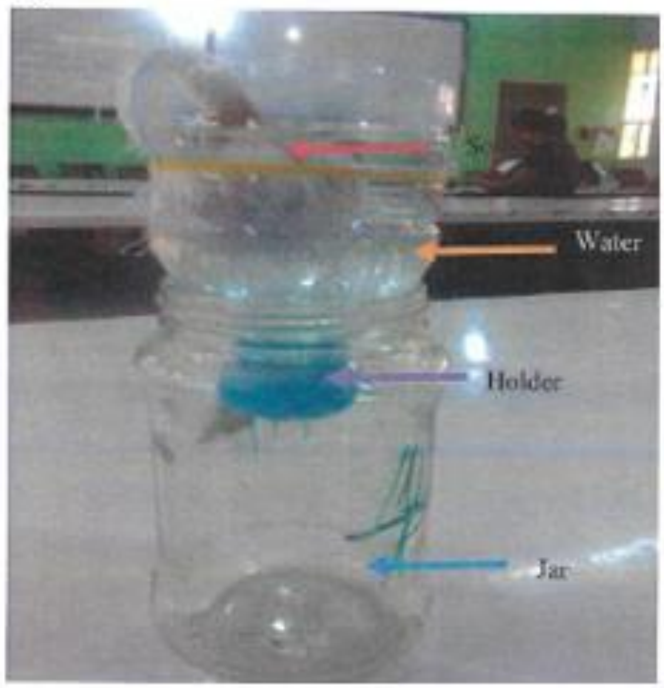
Parasite intensity (total mean larvae/egg per gram of sampled soil) was estimated by means of methods outlined by Paller and de Chavez (2014).

3.9.2 Faecal samples examination for STH eggs/larva: identification and counts

3.9.2.1 Assay of faecal samples

An assay of the faecal samples was prepared using sedimentation methods. Freshly collected faeces of 10.0g was thoroughly and very carefully mixed with 7mLs of 10% formalin in a glass beaker and then filtered through double-layered gauze into a centrifuge tube. The tubes had been loaded with 3mLs of ethyl acetate liquid and completely stirred with a solid wood rod, additionally, the tubes had been closed with a rubber stopper and agitated.

a



b

Plate 3.1: Modified Baermann method for culturing soil nematodes

a- soil wrapped in netting material lined with filter paper,

b- culture set-up using plastic bottle

vigorously (Fafunwa *et al*., 2017). The solution was centrifuged for five minutes at 2000 rpm. Following centrifugation, all layers except the sediment layer were removed making use of a suction pipette. The sediment was then examined and the Kato Katz method was used for egg examination and count (Kato *et al.*, 1972; WHO, 1985; Moncoya *et al.,* 2018).

3.9.2.2 Prevalence/intensity of STH in faecal samples

The overall prevalence of STH was determined using the standard method. The intensity of parasites' eggs per gram (epg) of faeces was estimated by multiplying the egg extracted via Kato Katz by twenty-four. The WHO guidelines for the distinction of participants into light, heavy and moderate infections with each parasite were utilised (WHO, 2002).

The investigation outcome was given to the medical personnel at the PHC. Participants whose samples were positive were given Mebendazole (Wormin 500).

3.9.2.3 Determination of egg viability of parasites in the soil

Due to its time-consuming nature, incubating to establish viability has limitations. As a result, stains are used to distinguish between non-viable and viable ova centred on the egg shells' porousness. Recovered eggs were smeared into a clean glass slide and stained with crystal violet to distinguish between living and dead helminth eggs and observation was made under automated image analysis (Collender *et al*., 2015). This process was repeated for every sample that had a parasite egg.

3.10 Determination of climatic factors

The ambient Temperature (T), Relative humidity (Rh), and Rainfall (R) data were obtained from the Nigeria Metrological Institute, Ibadan as they are the sole administrator of monitoring the environmental climatic variations from January 2017 to December 2018.

3.11 Questionnaires administration

A close-ended questionnaire pre-tested and standardized was administered in English and Yoruba languages. Interpretation was done to aid non-English speakers and data mined included; age, sex, dietary habits (i.e., variables related to the type of toilet used, hand washing, and shoe-wearing habits of the participants), socio-economic status, education, perception, and knowledge regarding parasitic infections. Some of the participants who could not fill out the questionnaire properly were assisted to complete the questionnaire when necessary. The confidentiality of the information submitted by study participants is properly protected in the completed questionnaire.

3.12 Mapping of STH in the LGAs

Using a hand-held Global Positioning System (GPS) device, the coordinates of the sampling places within the research region were collected (Garmin Corp, Kansas, USA). The GPS information was changed into East as well as the North points and incorporated into an image by using the GIS application (ArcGIS 9.3 software). The information with the parasites located at each place turns into the upcoming category.

The Kriging method of spatial interpolation was deployed for the development of risk maps. 10 (ten) classes of prevalence had been predicted from the outcome of Kriging for every parasite. These classes had been depending on the importance of counts of parasites for each place. The boundary of the study LGAs was picked as the scope of the kriging consequence. A thirty percent transparency was furthermore set to find out some other overlay layers. The outcome was additionally re-classified into 9 (nine) with different colour legends; deep blue (extremely low), light blue (very low), light green (low), faint green (below medium), yellow (medium), deep yellow/brown (above medium), wine (high), light red (very high), and deep red (extremely high), using the modified criterion given by Hassan *et al.* (2017).

3.13 Statistical analysis

Various STH data obtained from the 1980 soil samples and 1100 faecal samples were therefore computed into the Microsoft excel 2010 version, checked for entry errors that might exist, and analyses were done using the SPSS Inc.'s version 21 software for Windows (Chicago, IL, USA). Questionnaires were also coded and entered into the SPSS for further statistical analysis, with the significant difference of variables tested using Fischer's actual test as well as chi-square at a 5% level of significance. Demographic attributes of the respondents along with other categorical variables been provided as percentages and frequencies and examined with the Chi-square test. With $p < 0.05$, the substantial associations of certain parameters were determined, and cross-tabulations of very significant parametres of the questionnaire obtained. Furthermore, the Chi-square test was utilized to estimate the statistical significance of several variables. A one-way ANOVA was employed to test for the ways of intensity in addition to parasites prevalence within the sampling areas and a p-value of less than 0.05 was considered statistically significant. The connection between parasite prevalence and intensity, and then climatic and edaphic variables have been analyzed using regression co-efficient. Principal Component Analysis (PCA) was used the show the relationship that exists between the environmental factors and the epidemiology of STH parasites in the study area. Finally, a regression coefficient was used to determine the relationship between frequencies of drug use, intensity, and viability of STH ova/eggs.

CHAPTER FOUR

RESULTS

4.1 Prevalence and intensity of soil helminths

4.1.1 Parasite types found

The four stages of parasite species encountered were ova of *Ascaris* (Plate 4.1), *Strongyloides* larvae (Plate 4.2), *Strongyloides* adult (Plate 4.3), and larvae of hookworm (Plate 4.4).

4.1.2 Overall and species-specific occurrence(s)

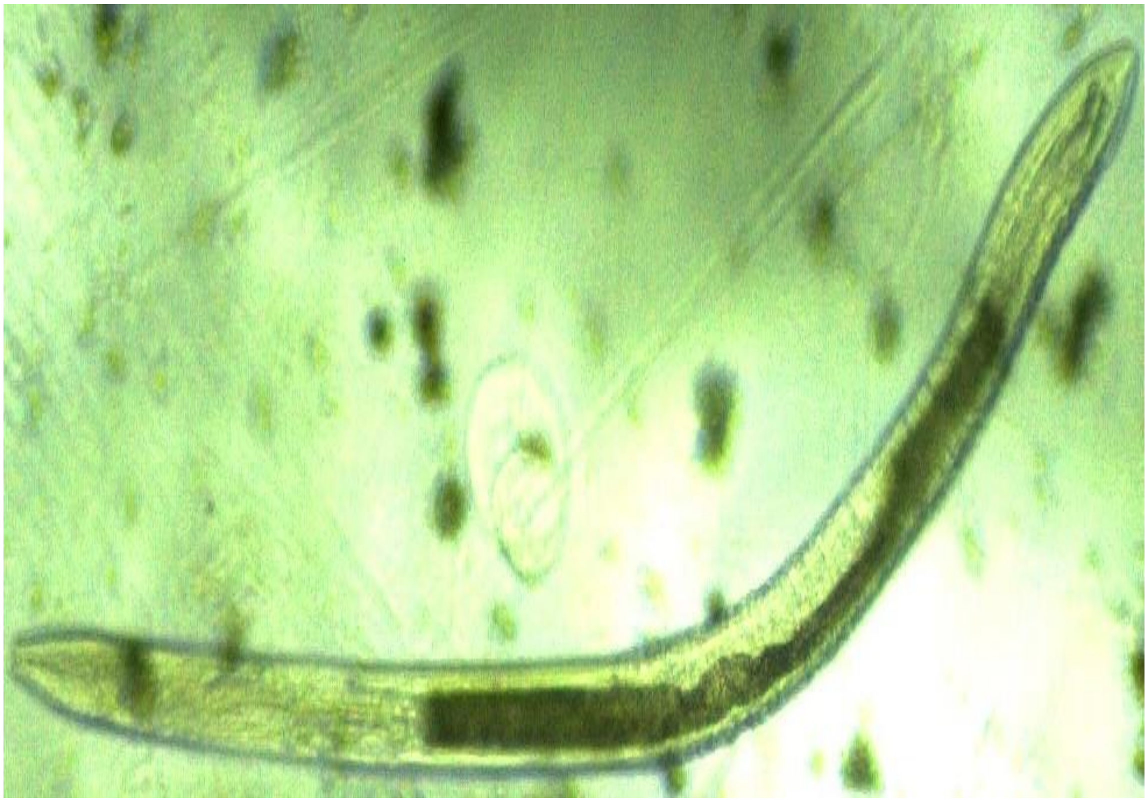
Out of a total of 1980 soil samples examined, at least one type of parasite was found in 1087 (54.9%) soil samples. Figure 4.1 shows the species-specific prevalence of parasites in soil samples. Hookworm larvae were the most common STH found in this study (39.8%), followed by larvae stage of *Strongyloides* (26.8%), adult *Strongyloides* (19.9%), and ova of *Ascaris* (13.4%). The differences in prevalence variation were significant ($p<0.05$).

4.1.3 Prevalence of STH with respect to sampling locations and sites

Figure 4.2 shows the prevalence of STHs across the sampling locations. Soil samples from the Olodo location had the highest prevalence of parasite (55.1%), followed by samples from Ona Ara (54.3%), Alakia (53.6%), Omi Adio (52.2%), Podo (51.8%), Moniya (51.1%), Eleyele (49.8%), Molete (49.2%), Iwo Road (48.3%), Aleshinloye (48.1%). Soil samples from the Bodija location had the least prevalence of 47.4%. The variation in the prevalence of STH parasites across sampled locations was significant ($p< 0.05$). In Figure 4.3, samples of soil from refuse dumpsites had the highest prevalence of 35%, followed by sites from toilet areas (33%), roadside (22%), and playgrounds (8%), and the least were the soil samples taken from house vicinities (2%). There was no significant difference in the prevalence of parasites between refuse dumpsites and toilet areas. However, there was a significant variation between the prevalence of STHs from soil samples from house vicinities and other sampled sites ($\chi^2 = 25.63$, $p\leq0.05$).

Mag: X40

Plate 4.1: Fertilized *Ascaris* eggs



Mag: X40

Plate 4.2: ***Strongyloides* larvae**

Mag: X40

Plate 4.3: Adult of *Strongyloides*

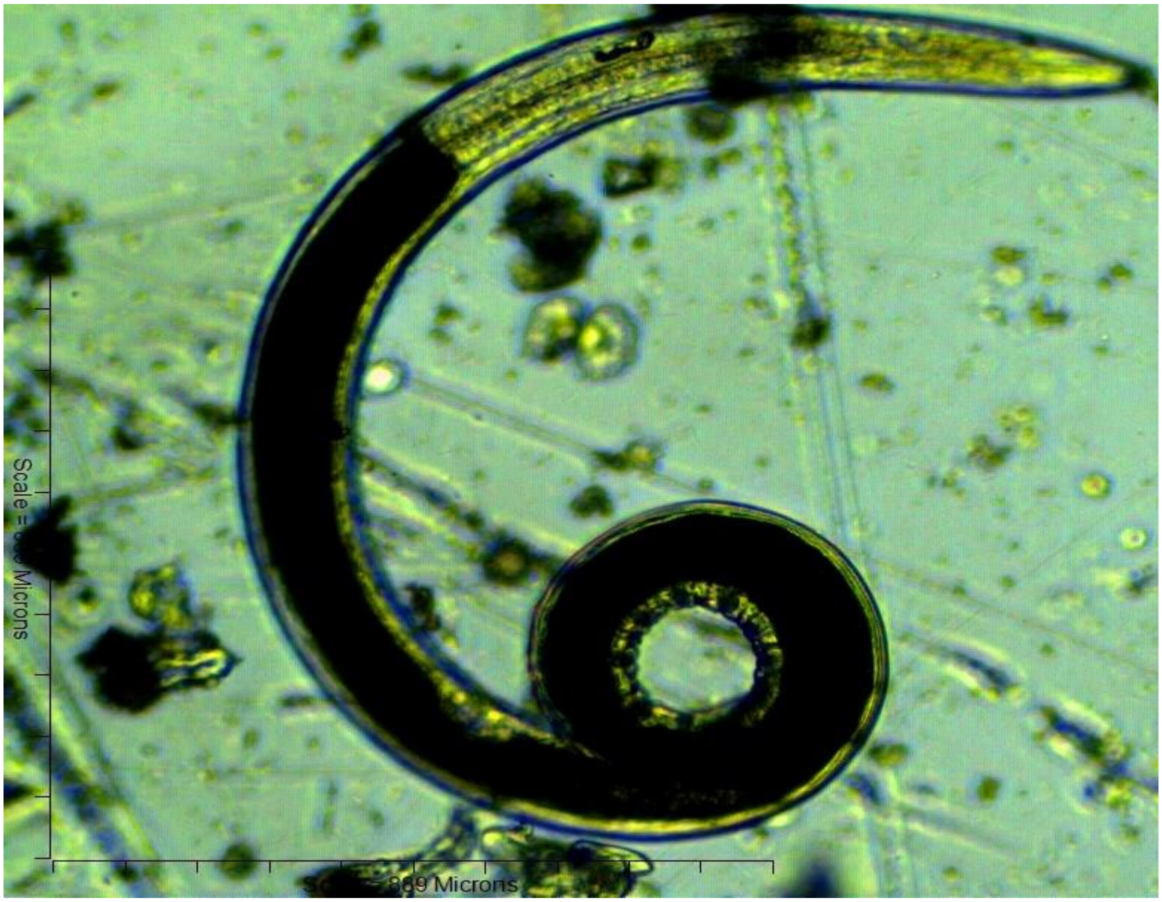


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Plate 4.4: Hookworm larvae

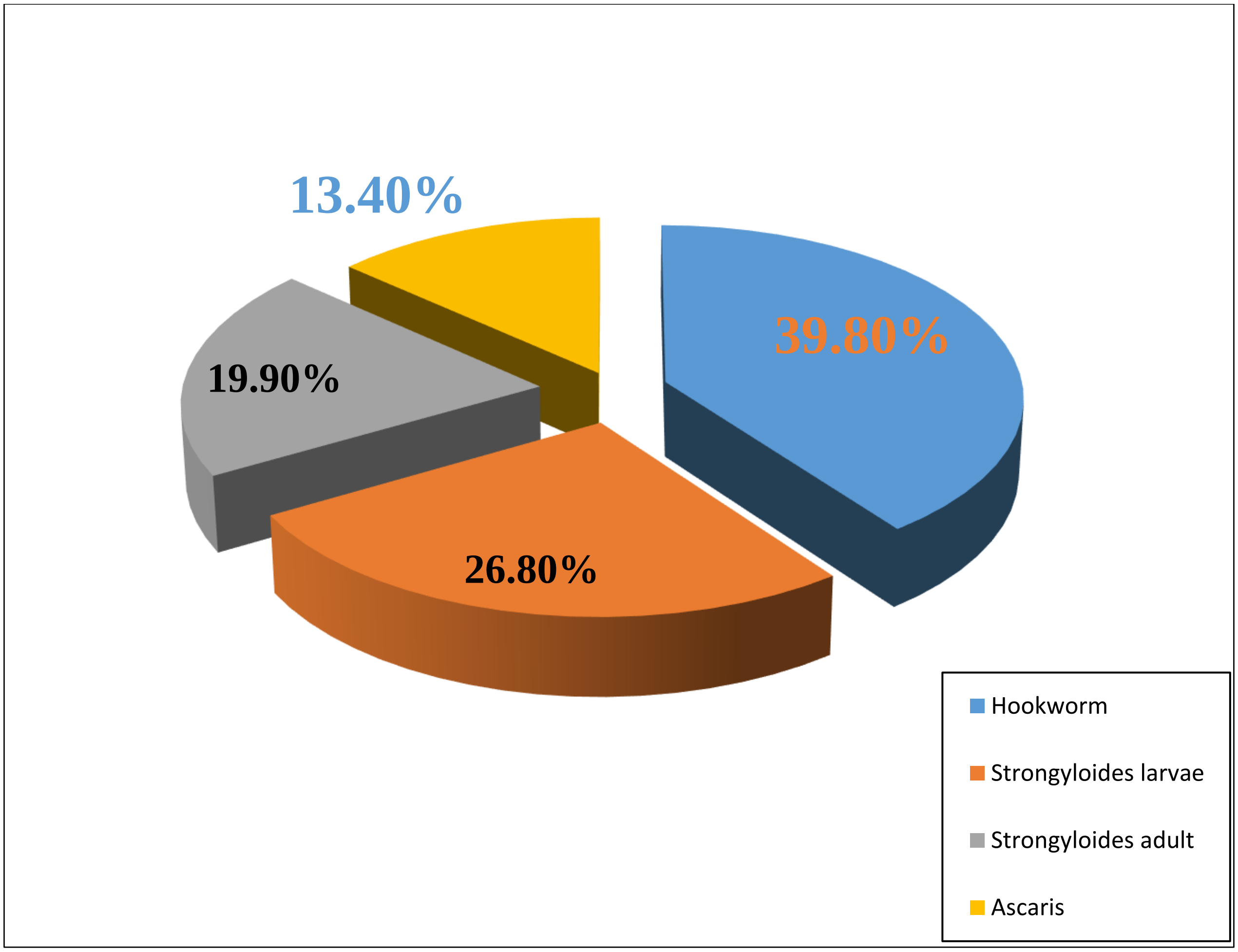

Figure 4.1: Overall species specific prevalence of STH in soil samples

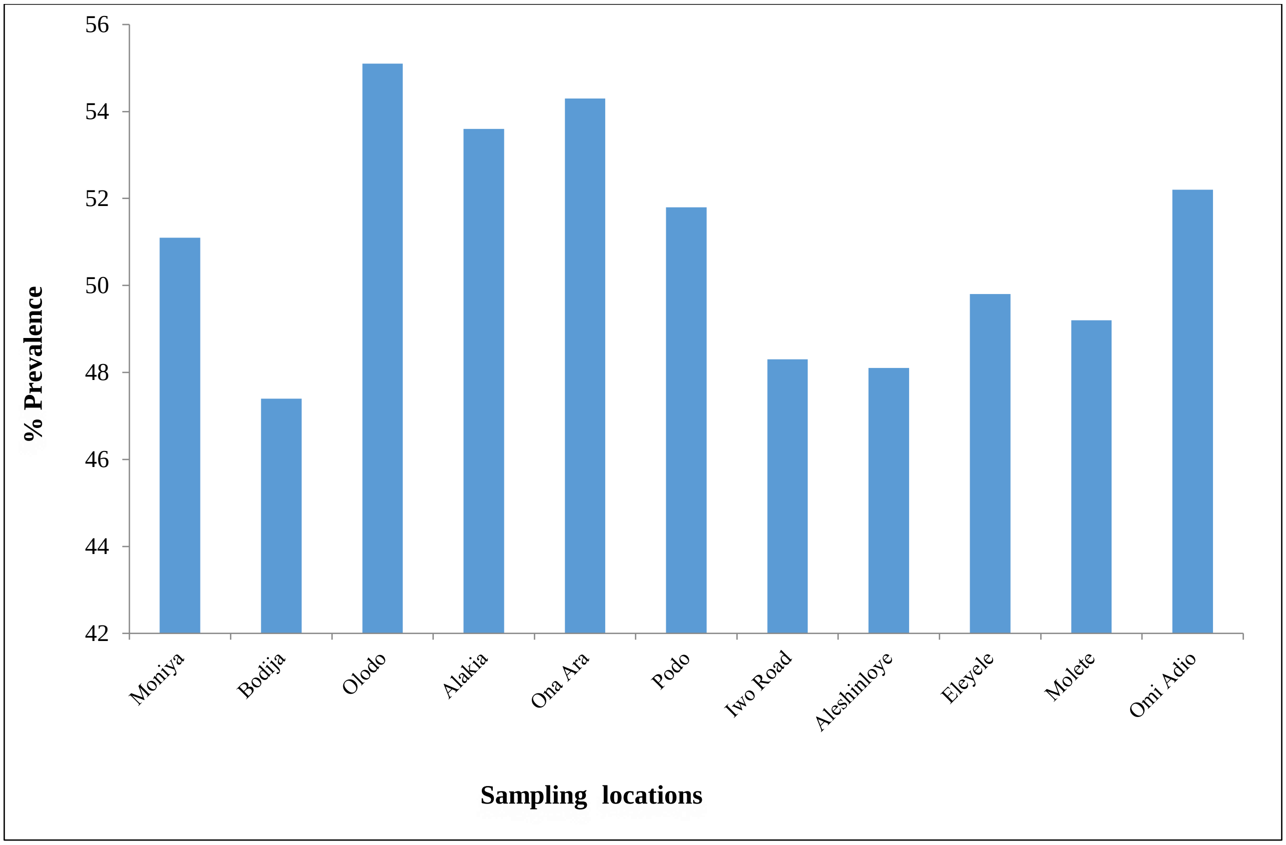

Figure 4.2: Contamination rate of STH with respect to sampling locations

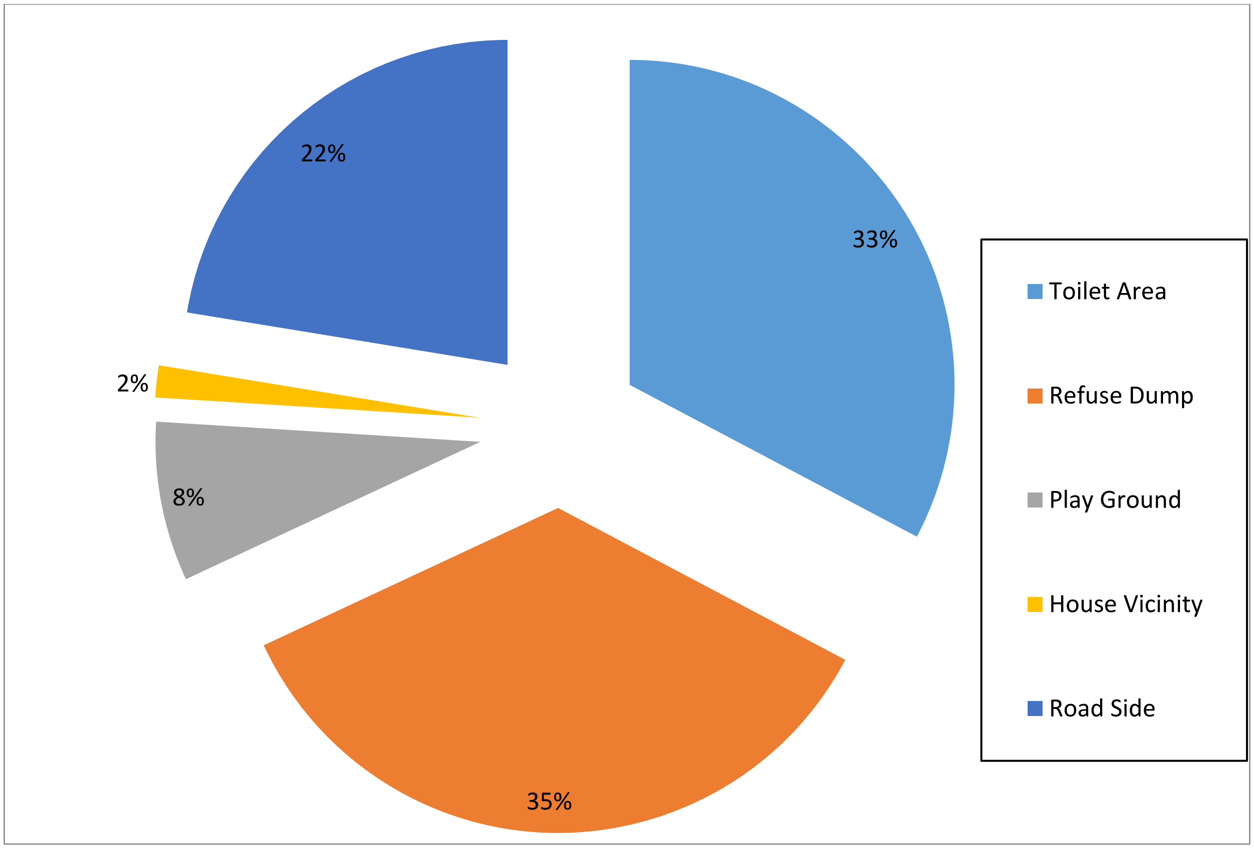

Figure 4.3: Prevalence of STH in relation to the sampling sites

4.1.4 Parasite species-specific prevalence by sampling location

Figure 4.4 shows the parasite-specific prevalence in each sampling location. The distribution pattern shows that for all the parasite species, there was a consistently decreasing occurrence from hookworm to *Strongyloides* larvae followed by *Strongyloides* adult and then *Ascaris,* except at Aleshinloye where *Strongyloides* adult worms were found more prevalent than *Strongyloides* larvae ($p \geq 0.05$).

4.1.5 Monthly occurrence

Monthly prevalence ranged from 60 % to 91%. November had the highest prevalence of STH parasites (91%), followed by March (89%), April (86%), February (84%), October (82%), June (81%), January (79%), December (77%), September (67%), May (63%), August (61%), and July had the least prevalence of 60% (Figure 4.5). There was a sharp decrease in parasite prevalence from June to July and the highest prevalence was observed in November. There was no significant difference in the prevalence between the studied months ($p \geq 0.05$), except for between July, August, March, and November ($\chi^2 = 25.43$, $p \leq 0.05$).

4.1.6 Overall and species-specific mean intensity

The overall mean intensity was 423.5 ± 60.2 (Table 4.1). Mean intensity ranged from 21.8 ± 6.1 egg/larvae/adults per gram to 309.1 ± 41.4 egg/larvae/adults per gram and the mean intensity in relation to species of STH is shown in Figure 4.6. Hookworm was the most prevalent STH (74.6%) in the soil samples examined, followed by the larva of *Strongyloides* (13.2%), adult *Strongyloides* (7.2%) and the least occurred parasite was *Ascaris* species (5.1%). The STH infection occurrence variation was significant ($\chi^2_{(16)} = 65.25$, $p<0.05$).

4.1.7 Parasite species-specific mean intensity with respect to sampling locations and sites

Figure 4.7 shows the species-specific mean intensity across the sampling locations. Hookworm contamination was highest in soil samples taken from various locations, followed by the larva of *Strongyloides*, and adult *Strongyloides* and the least occurred parasite was the *Ascaris* species. There was a significant difference in the variation of parasites' mean intensity across the sampling locations ($p \leq 0.05$, F= 837). Refuse dumpsite had the highest mean

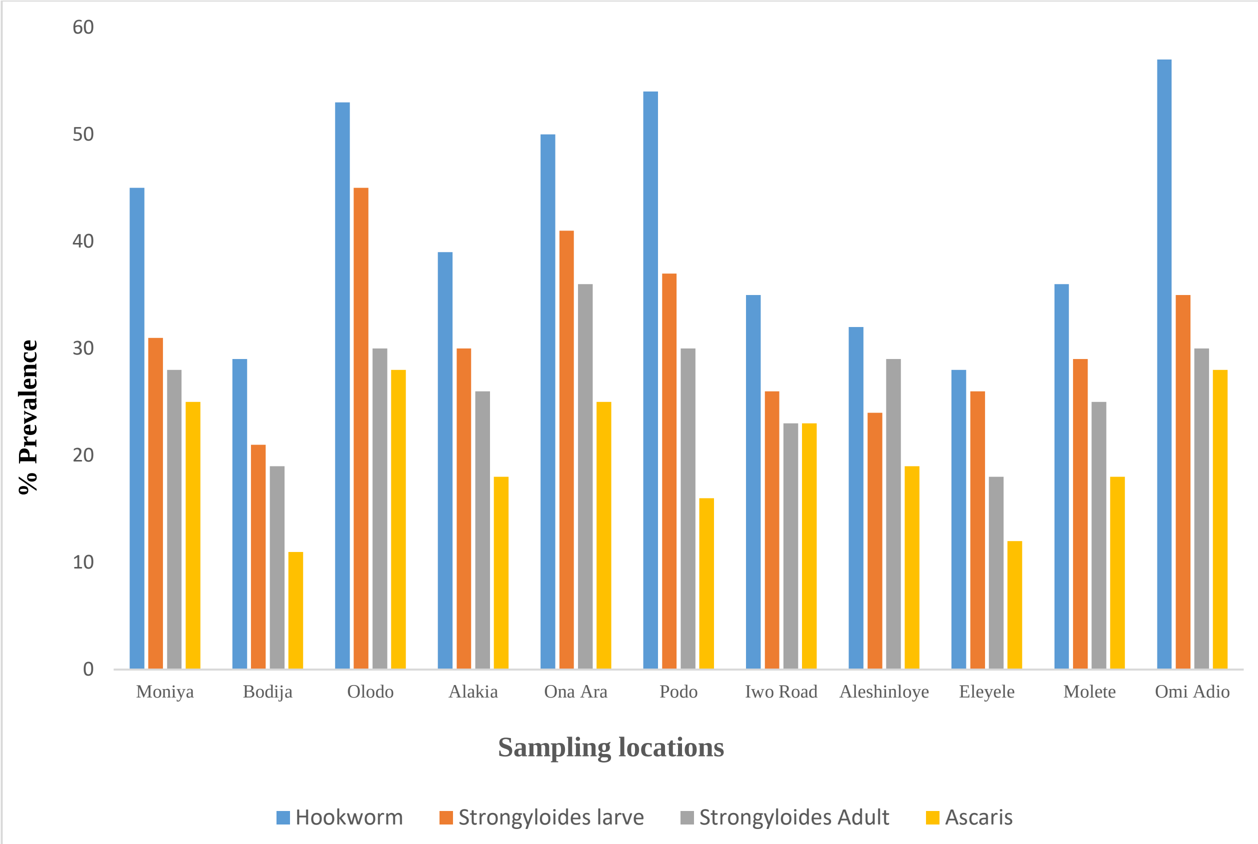

Figure 4.4: Occurrence of parasites within the sampling locations

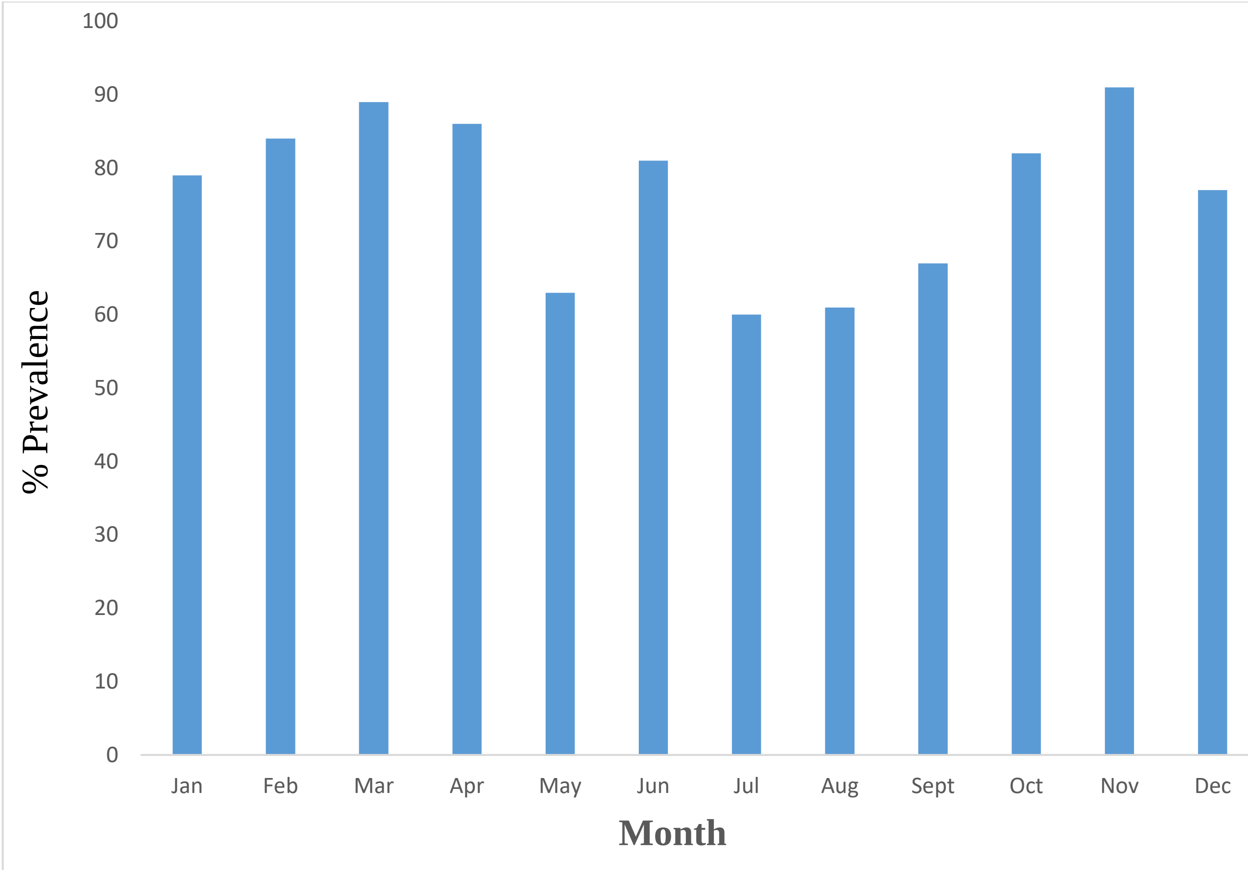

Figure 4.5: Monthly prevalence of STH parasites

Table 4.1: Species specific mean intensity

Parasite	Mean intensity
Hookworm	**309.1± 41.4**
Strongyloides larvae	56.6 ± 14.0
Strongyloides adult	29.7 ± 7.0
Ascaris	**21.8 ± 6.1**
TOTAL	**423.5 ± 60.2**

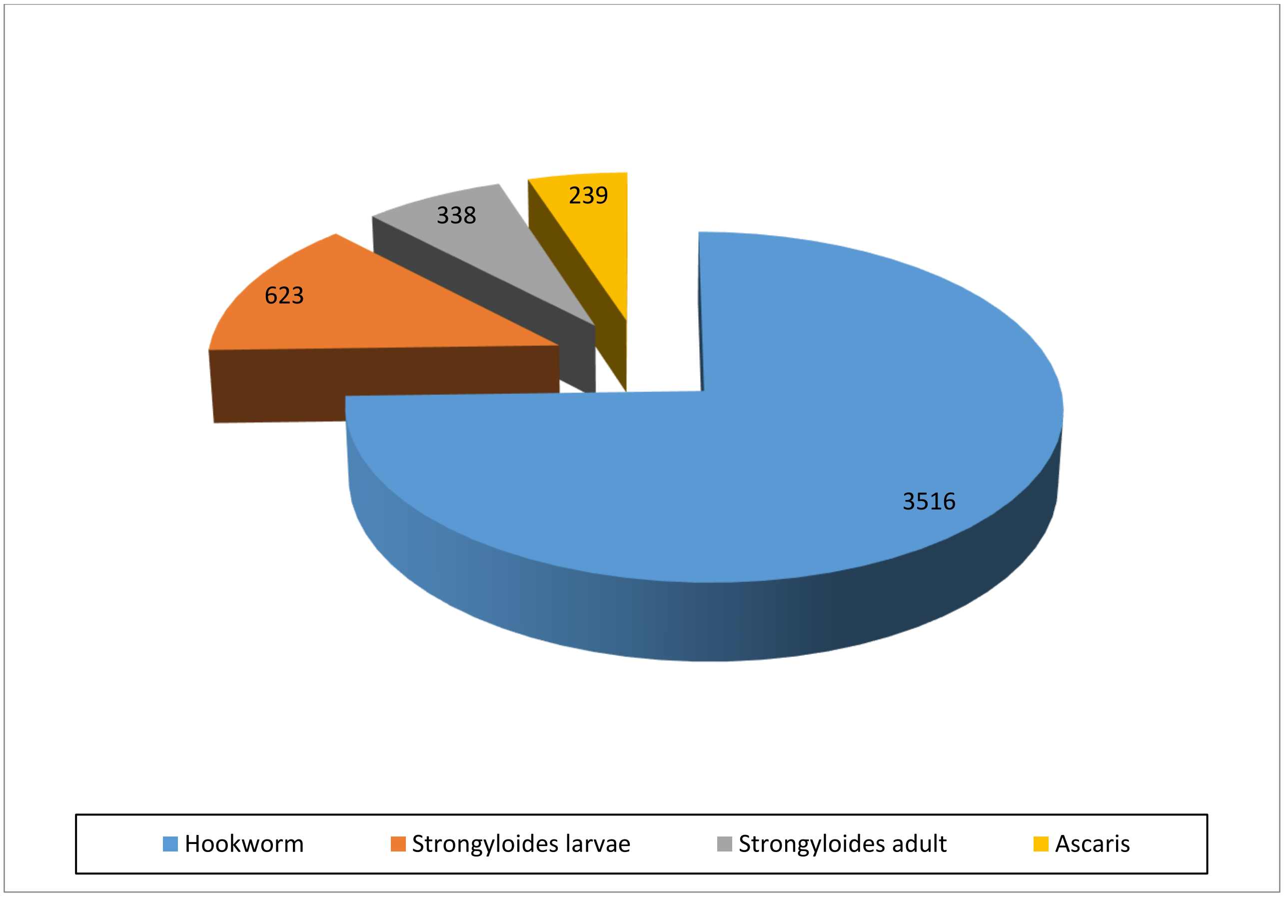

Figure 4.6: Species specific mean intensity of STH from soil samples

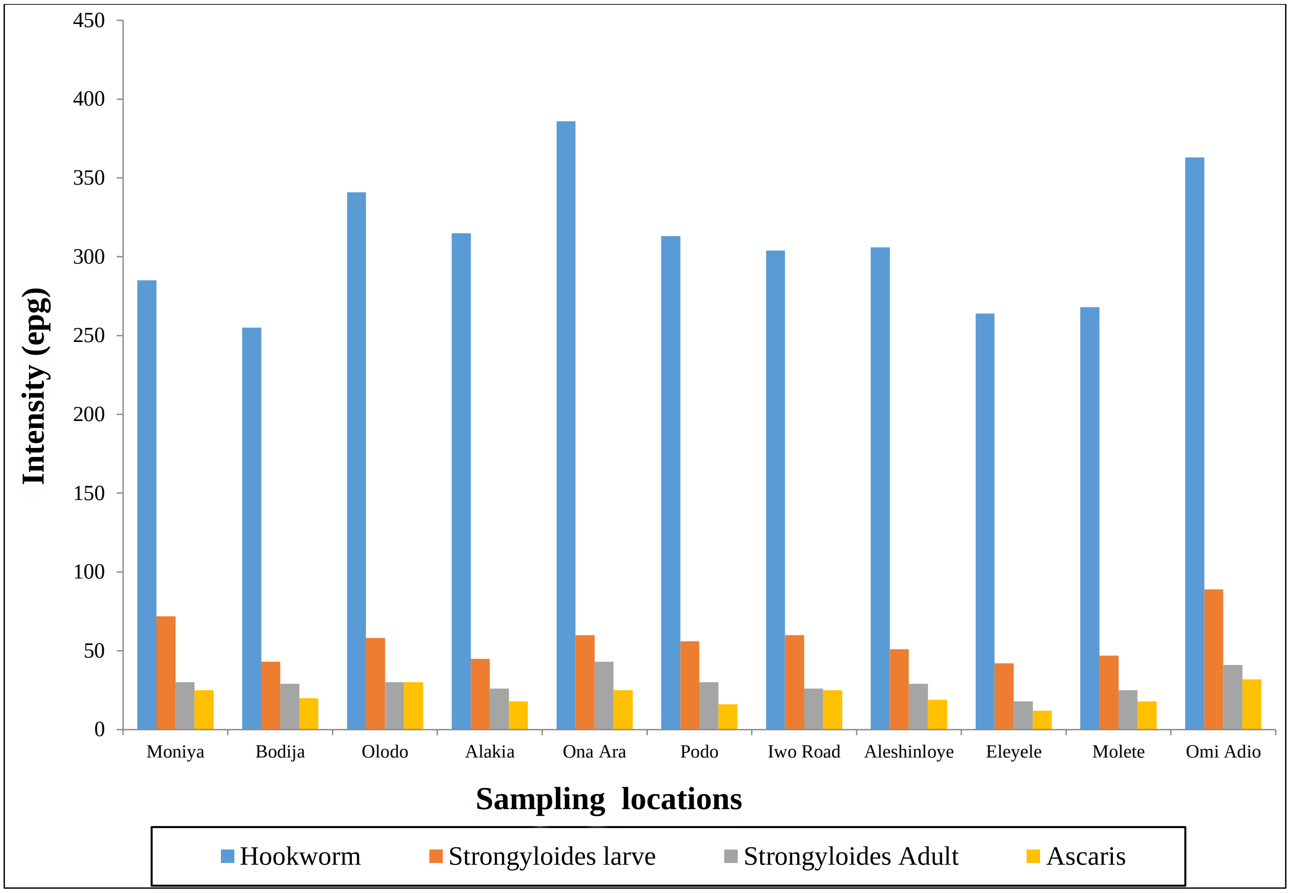

Figure 4.7: Species specific Intensity of STH in soil samples across the sampling locations

parasite intensity of 216.2±211.5 epg of soil, followed by the toilet area having a parasite intensity mean of 120.4±119.6 epg of soil, roadside (75.1±73.6), and playground (13.7±11.8), while the least intensity was recorded for samples from the house vicinity, 3.4±1.8 epg of soil (Figure 4.8). The mean STH intensity varied significantly between the sites (p 0.05). Figure 4.9 shows the species-specific mean intensity of parasites across the sampled sites. Hookworm larvae were the highest, followed also by *Strongyloides* larvae, adult *Strongyloides* and least the ova of *Ascaris*. When the means of parasite abundance was compared in relation to the sampled sites, there was a significant difference in the means of *Strongyloides* and *Ascaris* ($p \leq 0.05$, F= 165.189) amongst the sites, while there was no significant difference in means of hookworm.

4.1.8 Monthly intensity of STH parasites

March had the highest intensity of 15.7 epg of soil (Figure 4.10), closely followed by January (14.3), February (13.9), April (13.3), June (13.2), November (12.9), May (12.7), July (12.7), October (12.1), December (11.6), September (10.7) while the least intensity was in August (10.6). There was a decline in the intensity of parasites from July to August. At the onset of the rainy season in March, there was an increase in parasite intensity which was maintained till July. There was no statistical significant variation in the mean intensity of hookworm, *Strongyloides* and *Ascaris* found throughout the months ($p \geq 0.05$, F= 0.601).

4.2 Prevalence and intensity of faecal samples

4.2.1 Prevalence of helminths parasites infection

Out of a total of 1100 faecal samples, 395 (39.5%) were positive, and four species of parasites *Ascaris*, *Trichuris*, hookworm, and *Strongyloides* were found in the faecal samples examined. *Ascaris* were found to have the highest (41.6%) prevalence, followed by hookworm (24.5%), *Trichuris* (23.5%), and *Strongyloides* 10.4% (Figure 4.11). The variation in prevalence was significant. Figure 4.12 shows the prevalence of STH with respect to sampling locations where the prevalence ranged from 26% to 38%. The highest parasites prevalence in faecal samples was found in Ona Ara (38%), followed by Podo (37%), Olodo (36%), Omi Adio (35%), Molete (34%), Alakia (32%), Moniya (31%), Iwo Road (30%), Eleyele (29%), Aleshinloye (28%) and the least was found in samples

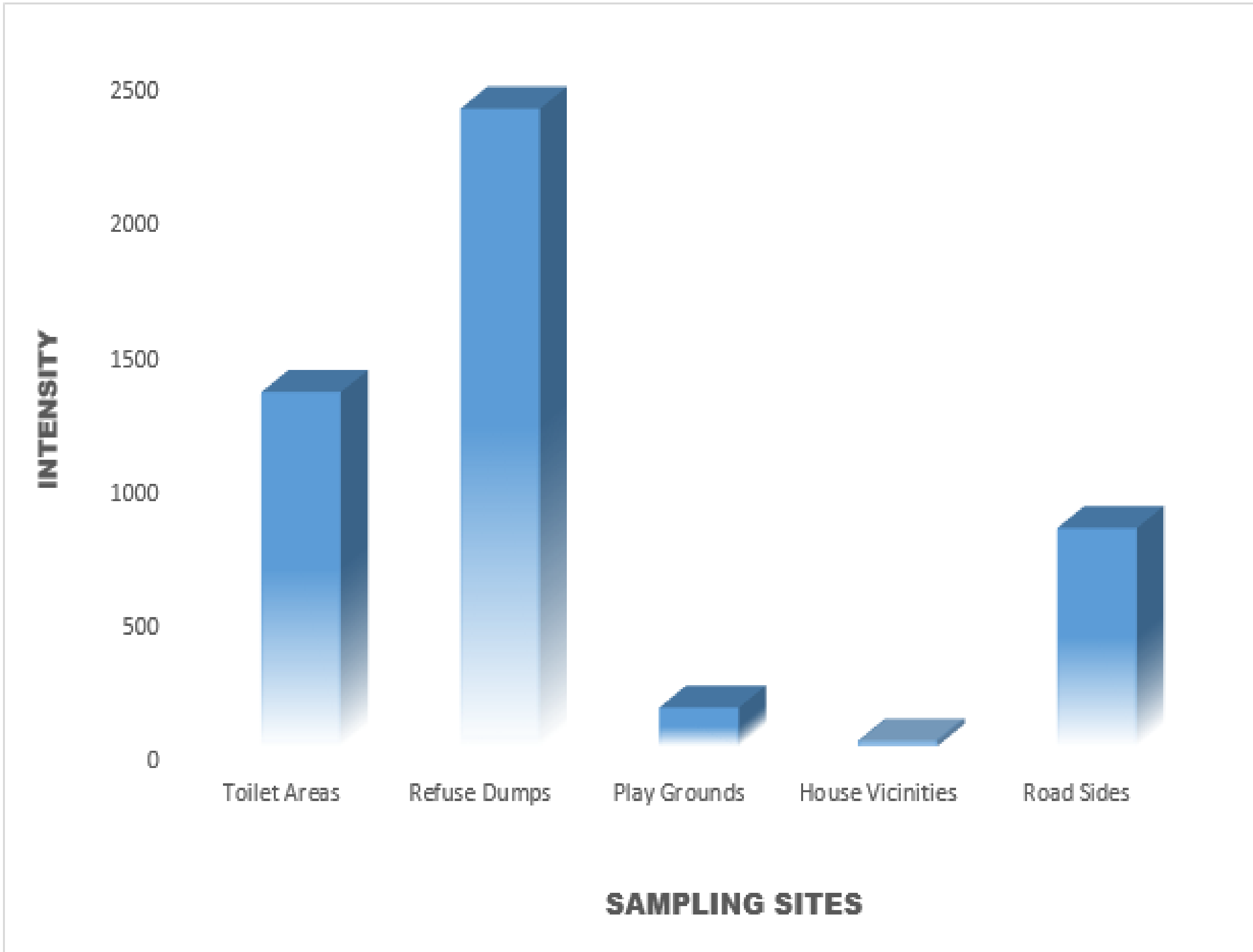

Figure 4.8: Overall mean intensity of STHs parasites in relation to sampled sites

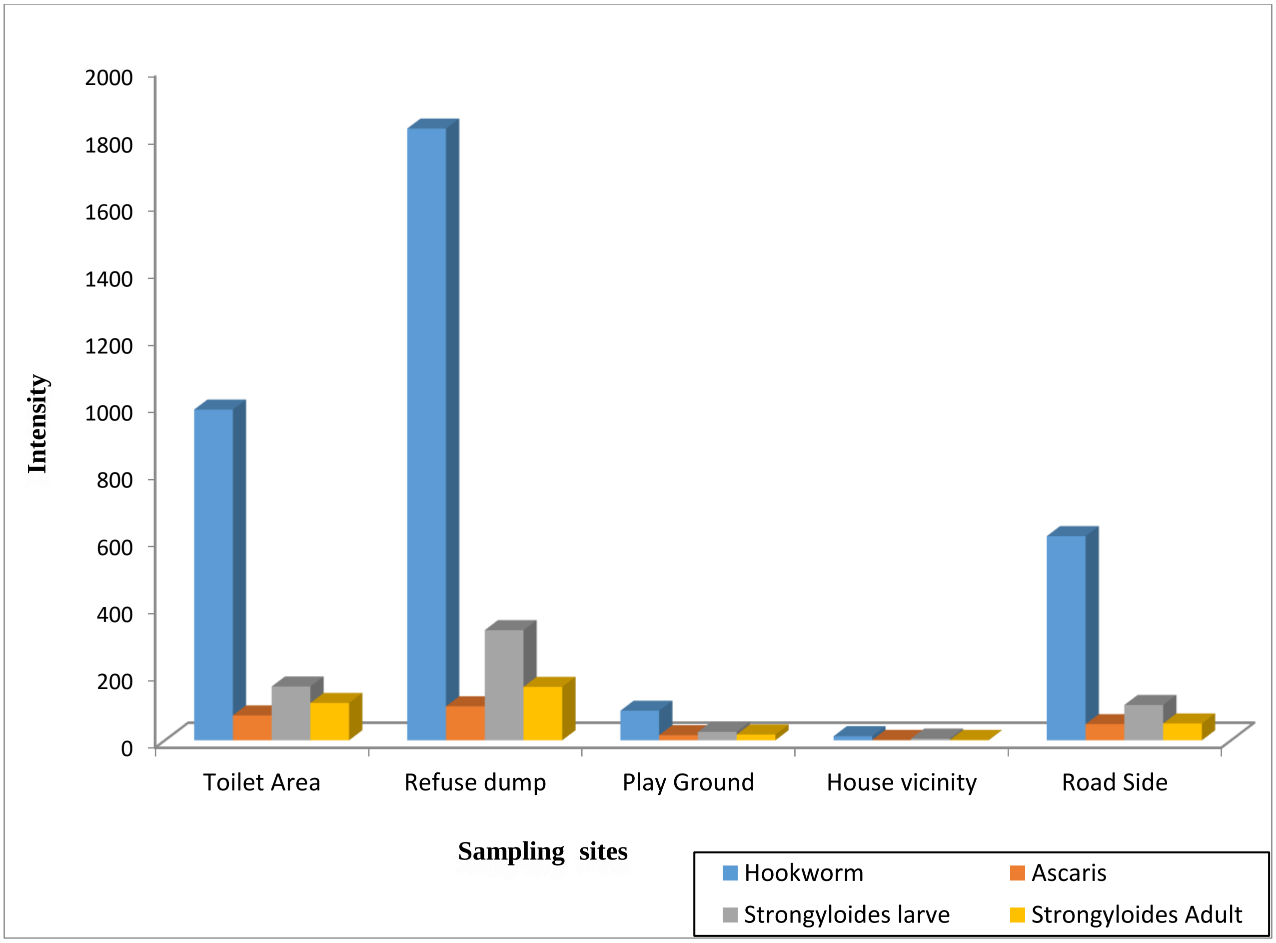

Figure 4.9: Species-specific intensity of STH in soil samples with respect to sampling sites.

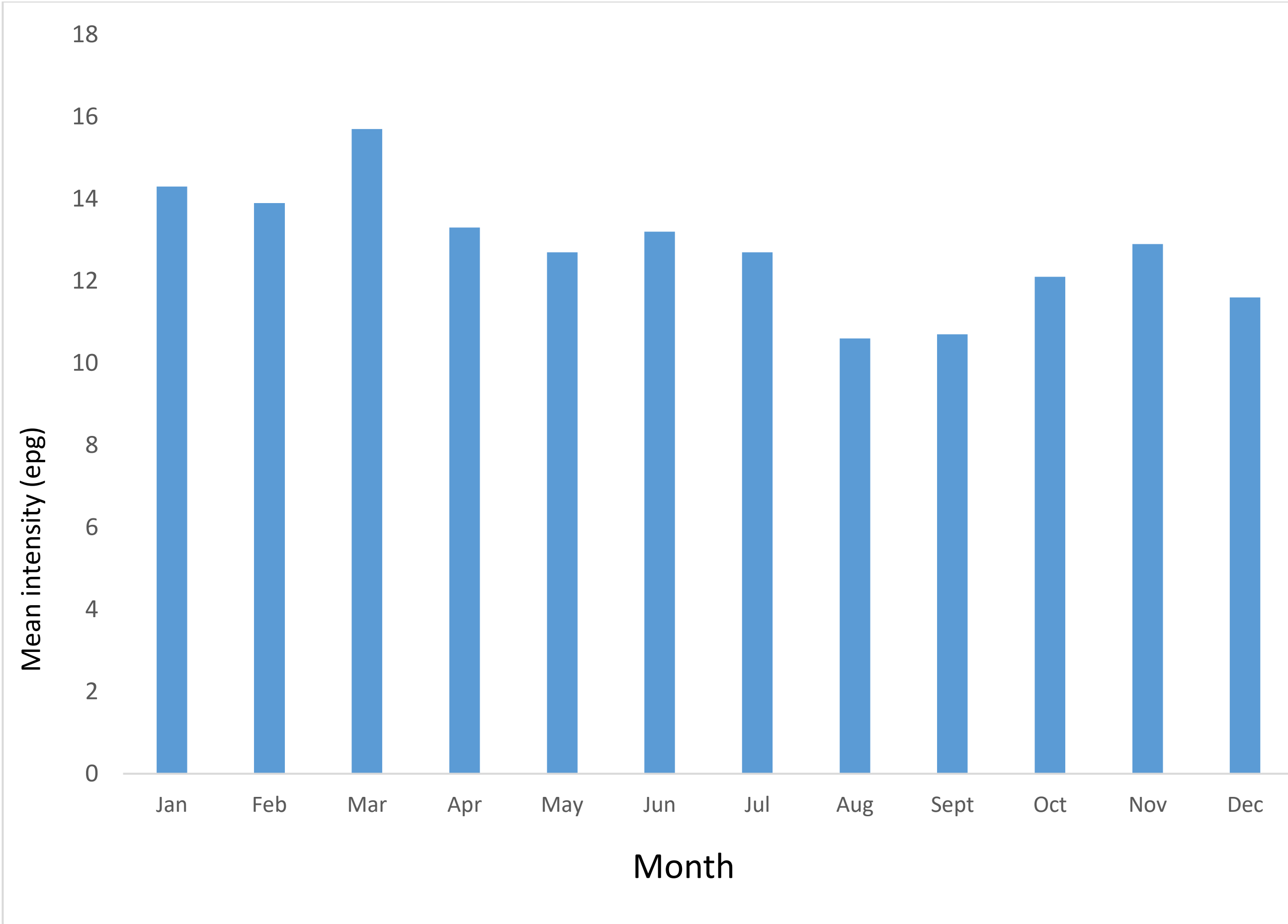

Figure 4.10: Mean intensity of STH in relation to the month of sampling

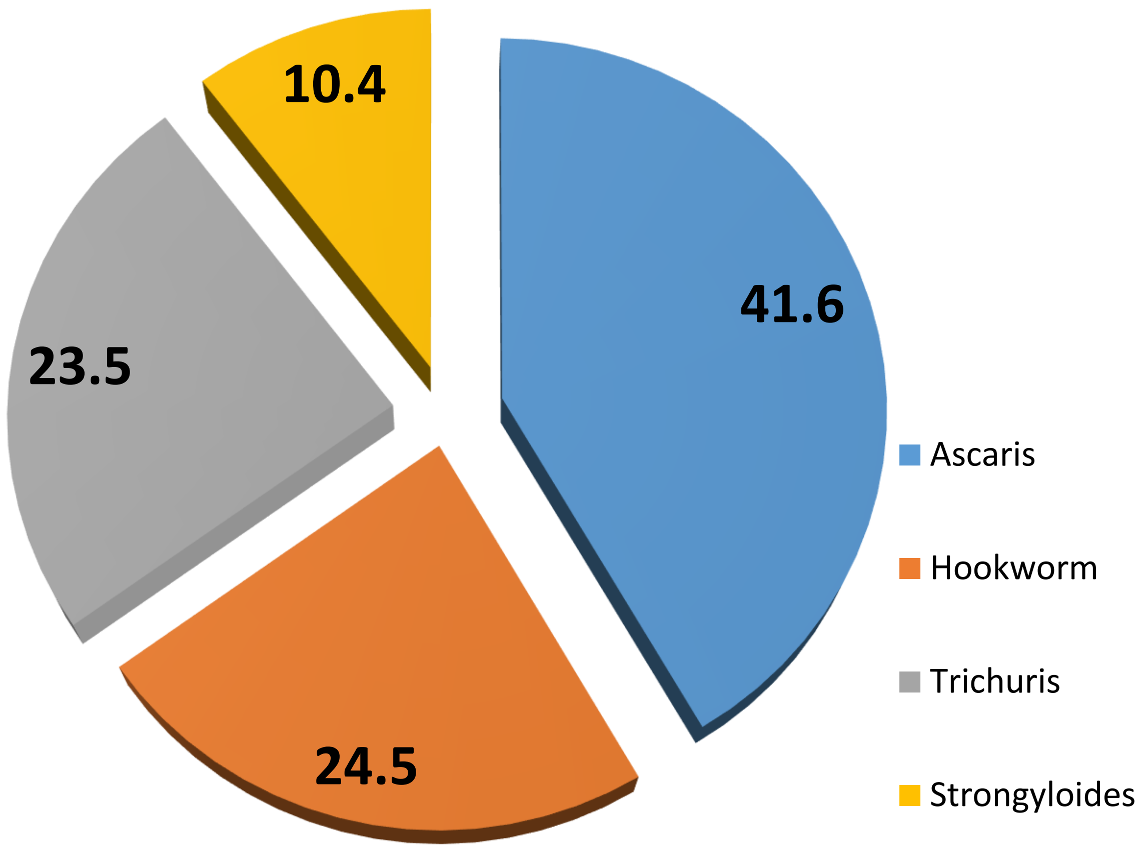

Figure 4.11: Overall prevalence (%) of STH types in faecal samples

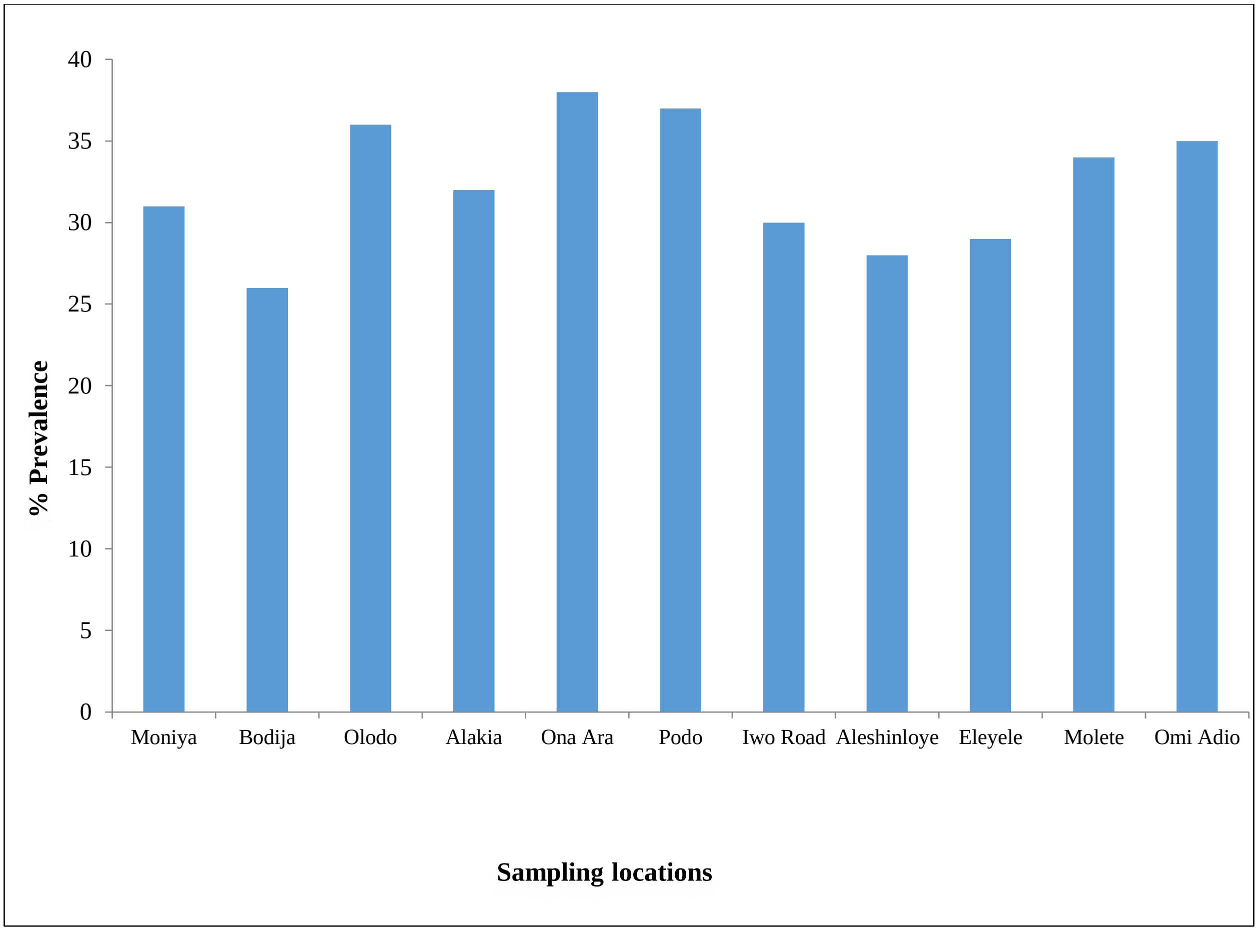

Figure 4.12: Prevalence of STH among participants at the sampled locations (p ≥1.69)

from Bodija (26%). There was no statistical significant variation in the prevalence rate of soil helminths across the sampling locations ($\chi^2 = 52.03$, $p<0.05$). For single infection, 18.2% of the participants were infected with *Ascaris* only, closely followed by those infected with hookworm (10.9%), *Trichuris* (8.9%), and the least were those infected with *Strongyloides* (2.5%). Whereas for multiple infections, infections of both hookworm and *Ascaris* were highest (31.1%), hookworm and *Trichuris* (5.7%), *Ascaris* and *Trichuris* (9.4%), hookworm and *Strongyloides* (5.8%), *Ascaris* and *Strongyloides* (3.8%), *Trichuris* and *Strongyloides* (0.5%), hookworm, *Ascaris*, and *Trichuris* (2.3%), hookworm, *Trichuris* and *Strongyloides* (0.3%), hookworm, *Ascaris*, and *Strongyloides* (1.0%), none of the infected participants had triple infections involving *Ascaris*, *Trichuris*, and *Strongyloides* (Table 4.2).

4.2.2 Intensity of helminths parasites infection

The overall mean intensity was 193.8±49.9 per gram of faeces, whereby the mean intensity of STH parasites ranged from 23.1 ±15.4 to 86.9±17.5 (Table 4.3). *Ascaris* had the highest intensity of STH (1043 epg), followed by hookworm (771 epg), *Trichuris* (315 epg), and the least *Strongyloides* (Figure 4.13). The intensity of STH by location (Figure 4.14) shows that Ona Ara had the highest value of 265 epg, followed by Iwo road (235 epg), Molete (229 epg), Podo (219 epg), Omi Adio (219 epg), Alakia (203 epg), Olodo (186 epg), Aleshinloye (164 epg), Moniya (136 epg), Eleyele (124 epg), and Bodija had the least intensity of 112 epg. The variation in the distribution of parasites was significant ($\chi^2 = 75.21$, $p<0.05$). When the parasite count was compared with the WHO Standard of STH intensity category, all the main STH parasites (*Ascaris*, hookworm, and *Trichuris*) intensity are classified under the light category (Table 4.4). Figure 4.15 shows the species-specific intensity of STH parasites in relation to sampled locations. All the STH parasites were counted in all the sampled locations where *Ascaris* dominated all through the locations. However, *Trichuris* was found to have a higher intensity than *Strongyloides* in all the locations except at Ona Ara, Aleshinloye, and Molete. In addition, hookworm had higher intensity than *Trichuris* in all the locations except at Olodo. There was no statistical significant variation in the intensity of *Ascaris* across the sampled locations ($p \geq 0.05$), although there was a significant difference in the intensity of hookworm, *Trichuris*, and *Strongyloides* across the locations ($p \leq 0.05$).

Table 4.2: Single and multiple infections of STH in sampled populations

	Parasite type(s)	No infected	% Prevalence of infected
Single			
	Ascaris	72	18.2
	Hookworm	43	10.9
	Trichuris	35	8.9
	Strongyloides	10	2.5
Multiple			
	Hookworm + *Ascaris*	**123**	**31.1**
	Hookworm + *Trichuris*	22	5.7
	Hookworm + *Strongyloides*	23	5.8
	Ascaris + *Trichuris*	37	9.4
	Ascaris + *Strongyloides*	15	3.8
	Trichuris + *Strongyloides*	2	0.5
	Hookworm + *Ascaris* + *Trichuris*	9	2.3
	Hookworm + *Ascaris* + *Strongyloides*	1	0.3
	Hookworm + *Trichuris* + *Strongyloides*	4	1.0
N= 1100		395	39.5

Table 4.3: Species specific mean intensity of STH parasites in faecal samples

Parasite	Mean intensity
Ascaris	**86.9± 17.5**
Hookworm	55.5 ± 17.8
Strongyloides	**23.1 ± 15.4**
Trichuris	28.4 ± 13.4
TOTAL	**193.8± 49.9**

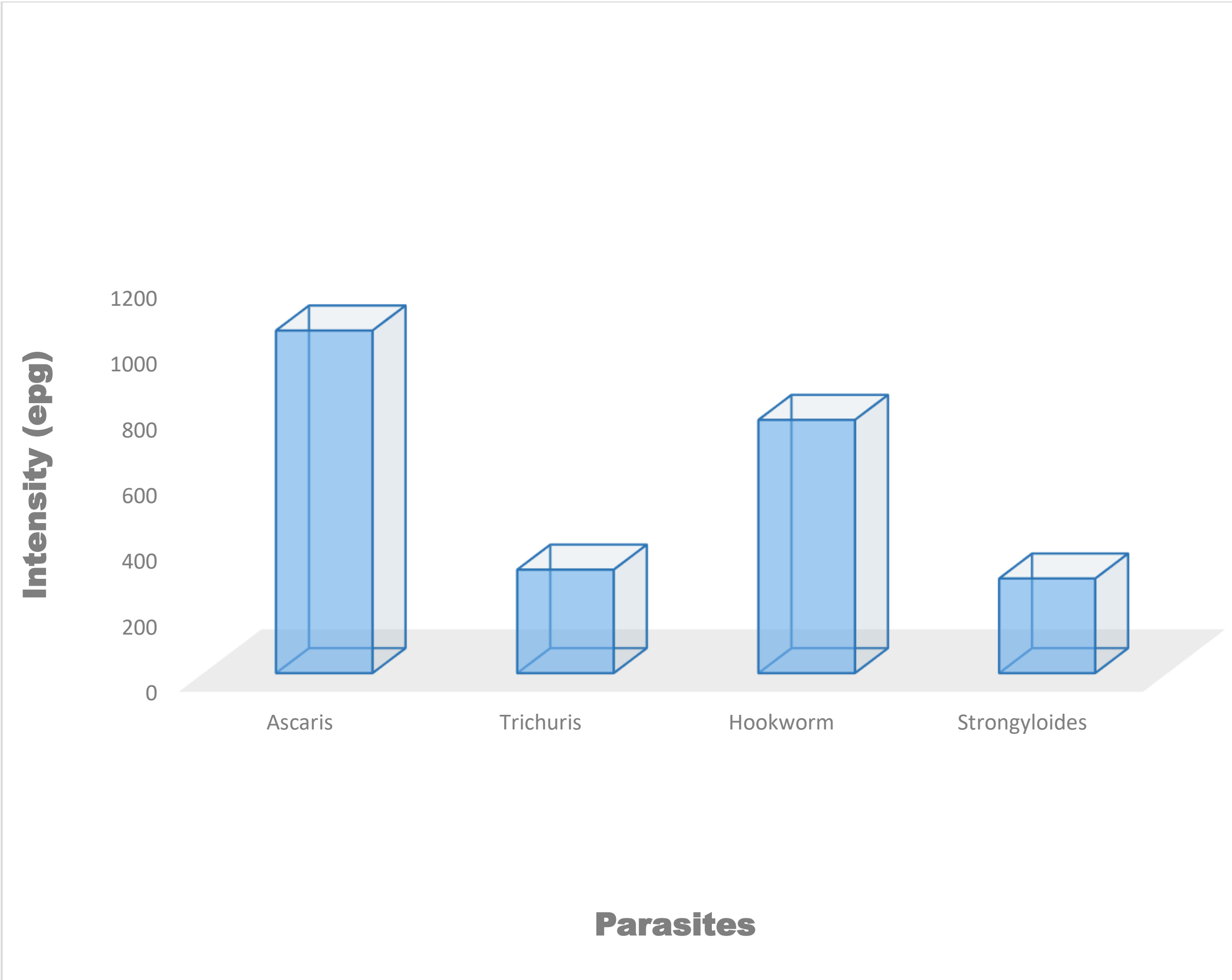

Figure 4.13: Species specific parasite in faecal samples collected

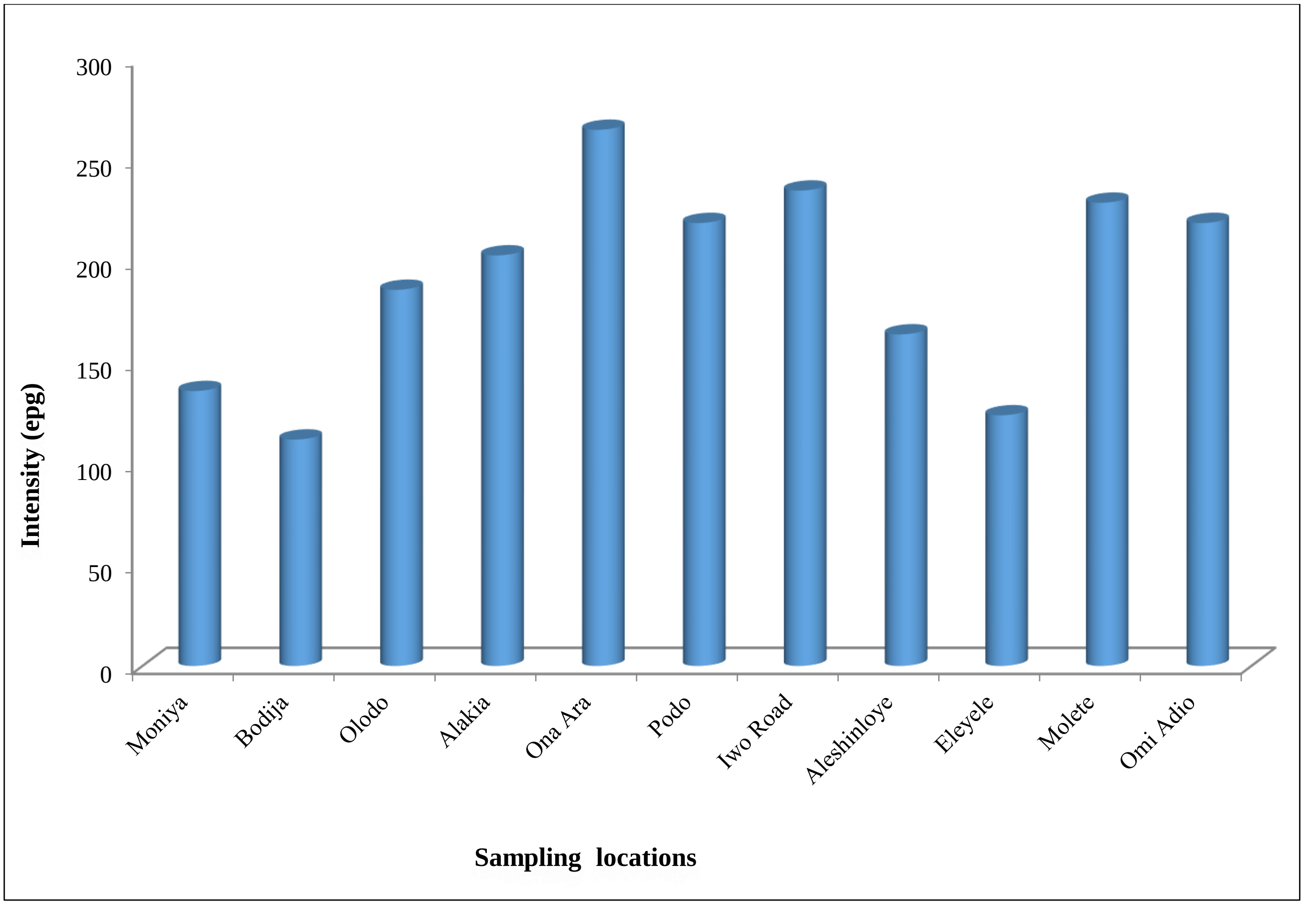

Figure 4.14: Overall Intensity of STH in faecal samples in relation to sampling locations

Table 4.4: Infection rate of STH as compared to WHO standard

Parasite	Intensity (epg)	Intensity infection status
Ascaris	1043	Light
Hookworm	771	Light
Trichuris	315	Light

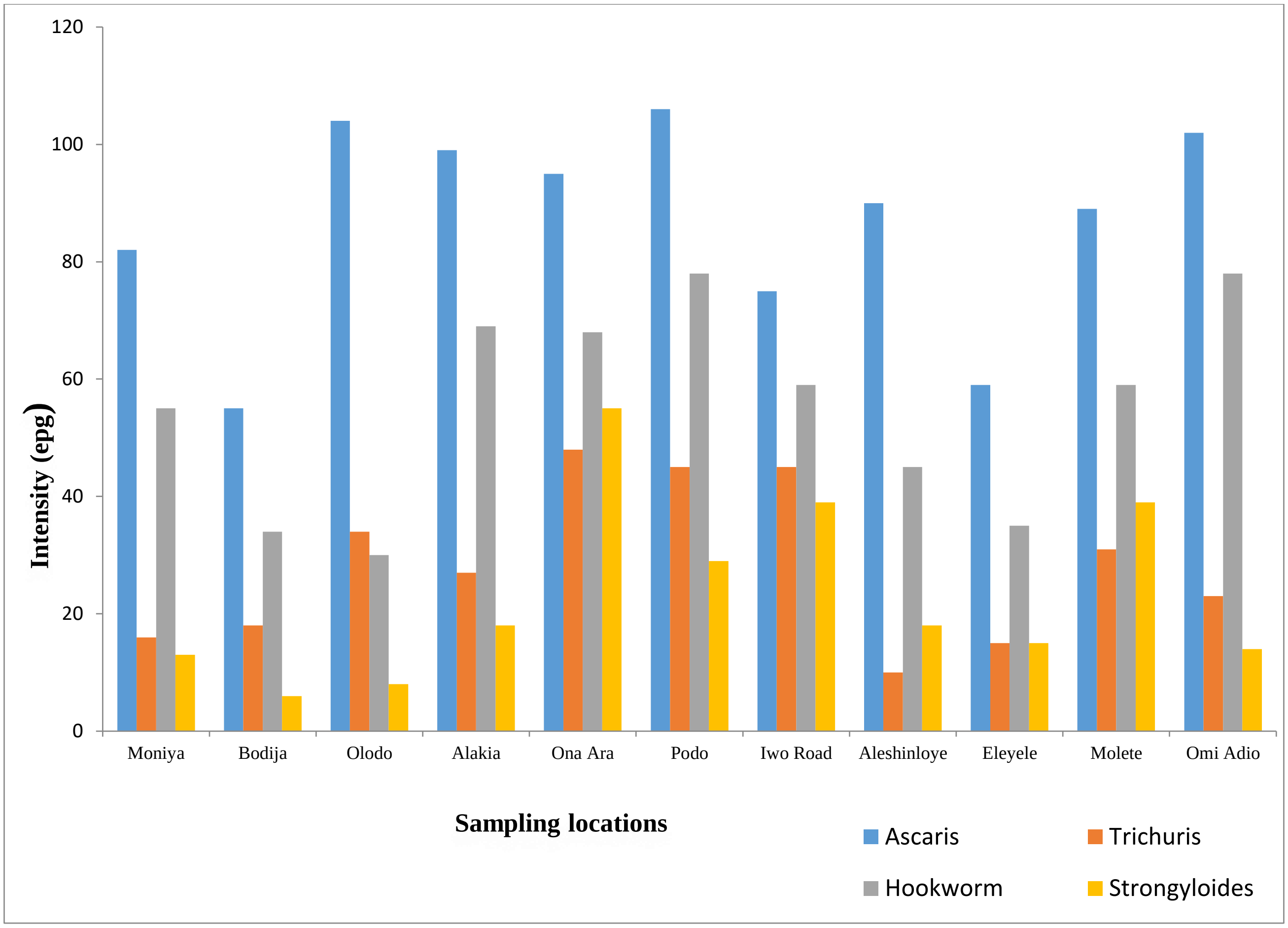

Figure 4.15: Location related species-specific intensity of STH in faecal samples

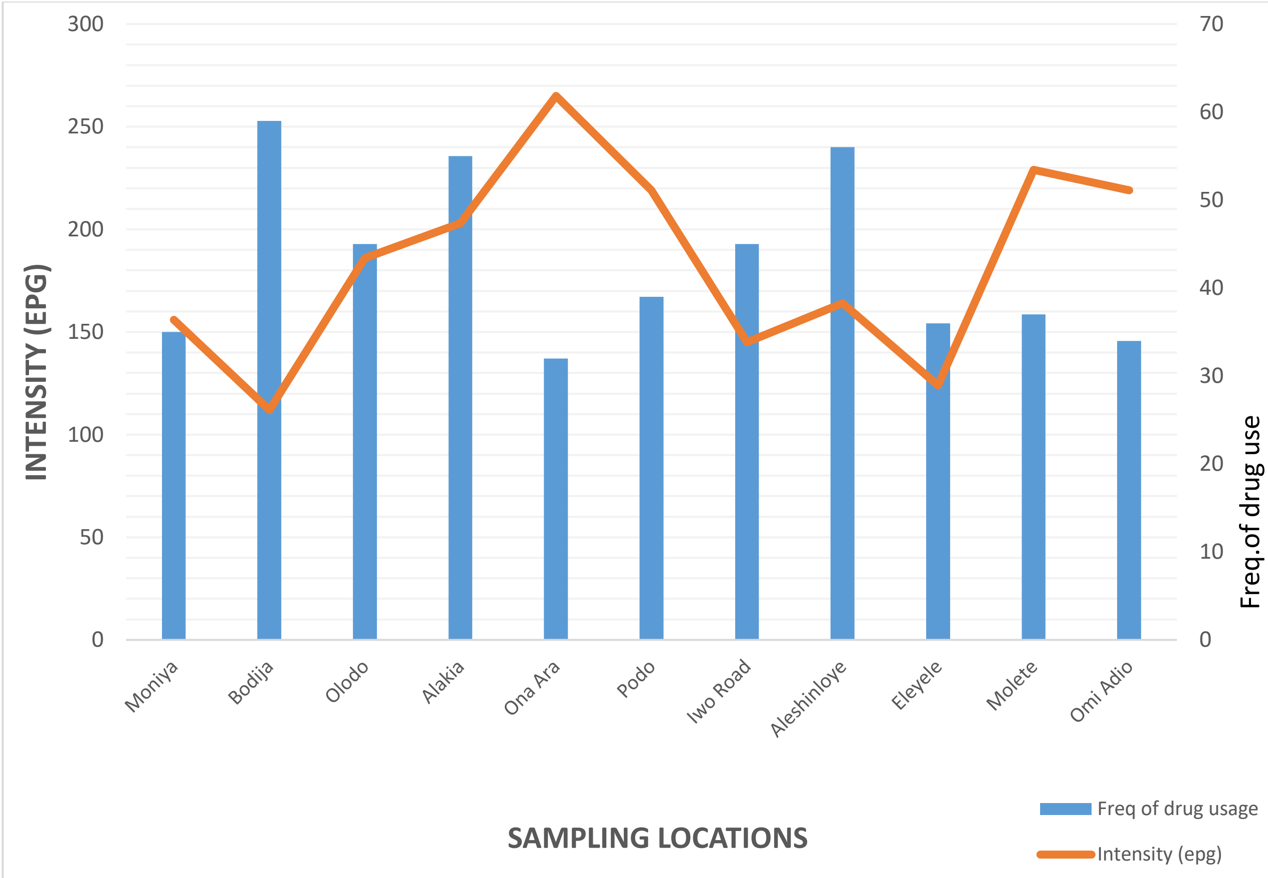

Figure 4.16: Anthelminthic drug usage and parasite intensity across sampling locations

4.3 Intensity of helminths infection in relation to drug use and viability of the parasite

4.3.1 Frequency of drug use and parasite intensity

Figure 4.16 shows the frequency of drug use in relation to parasite intensity across the sampled locations. The highest frequency of drug usage (59) was recorded among participants from Bodija, followed by Aleshinloye (56), Alakia (55), Olodo (45), Iwo road (45), Podo (39), Molete (37), Eleyele (36), Moniya (35), Omi Adio (35), and Ona Ara had the least with 32. There was no significant difference in the intensity and frequency of drug users across the sampling locations ($R=0.44$ $p\geq0.05$). However, the location with the highest frequency of drug usage (59 at Bodija) had the least intensity of infection, while the location with the least frequency of drug usage (32 at Ona Ara) had the highest intensity of infection.

The viability of STH ova was highest in Ona Ara (210), followed by Iwo road (201), Molete (199), Podo (196), Omi Adio (196), Olodo (171), Alakia (161), Bodija (132), Aleshinloye (120), Eleyele (113), and Moniya had the least with 107 (Figure 4.17). It was observed that no statistical significant variation between drug use and STH ova viability across the sampled locations ($R=0.36$ $p\geq0.05$). However, the location with the highest frequency of drug usage (59 at Bodija) had the least intensity of infection, while the location with the least frequency of drug usage (32 at Ona Ara) had the highest intensity of infection.

4.4 Climatic factors with respect to prevalence and intensity

4.4.1 Prevalence

Figures 4.18 to Figure 4.20 show the relationships between prevalence and climatic factors.

Rainfall: November had the highest prevalence of STH parasites 60.6% with 39mm of mean monthly rainfall, followed by December (57.0%), October (55.8%), March (53.3%), July (51.3%), September (49.7%), June (48.5%), April (47.3%), February (47.3%), August (46.7%), and the least parasite prevalence (44.8%) was recorded in May (Figure 4.18) with mean monthly rainfall of 176mm. Also, the month of December had the least mean monthly rainfall of 12mm but the prevalence was 57.0%. It was observed from the study that the amount of rainfall did not have an effect on the prevalence of the parasite in the soil environment ($OR= 0.03$, $p>0.05$).

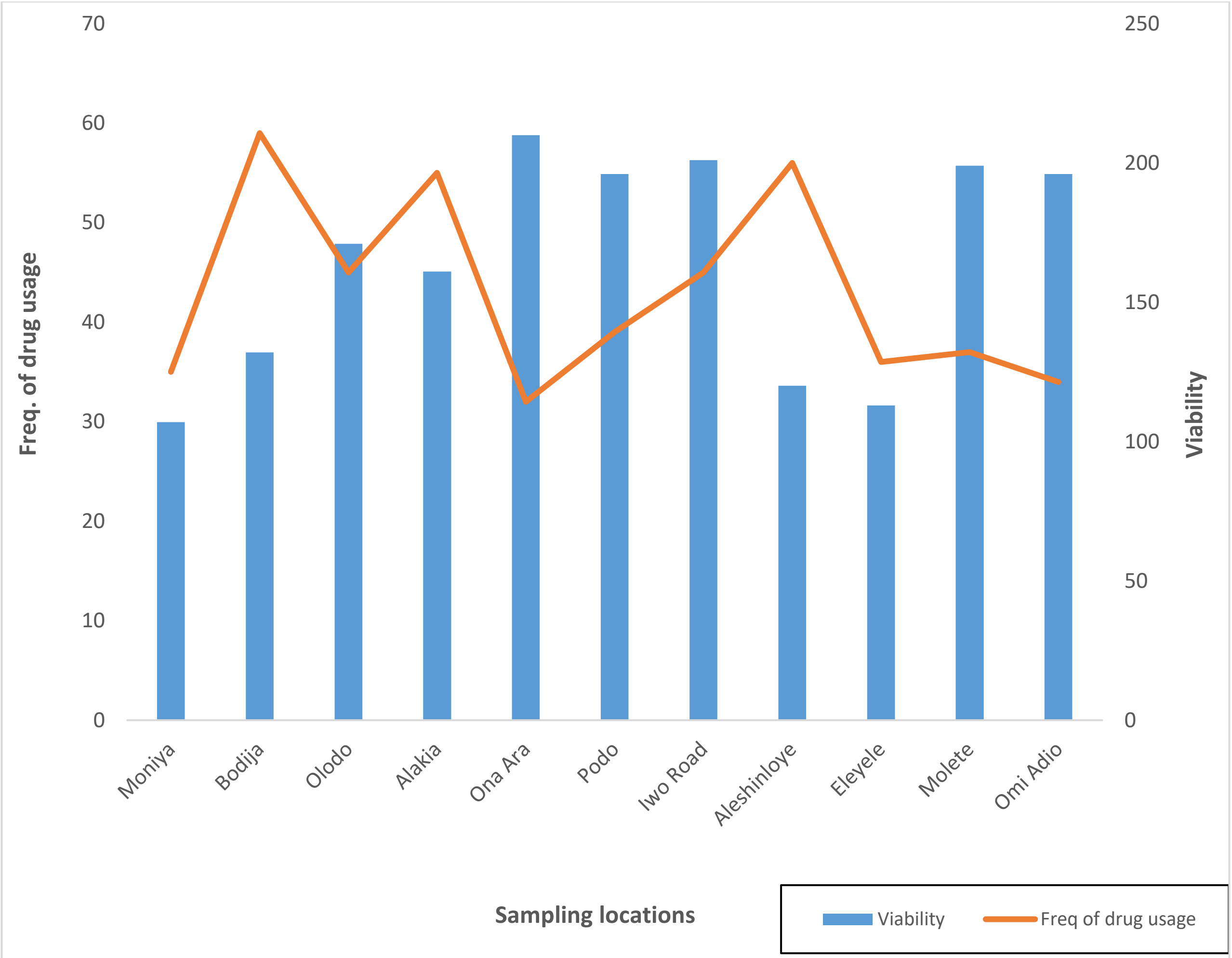

Figure 4.17: Anthelminthic drug usage with respect to viability of parasite

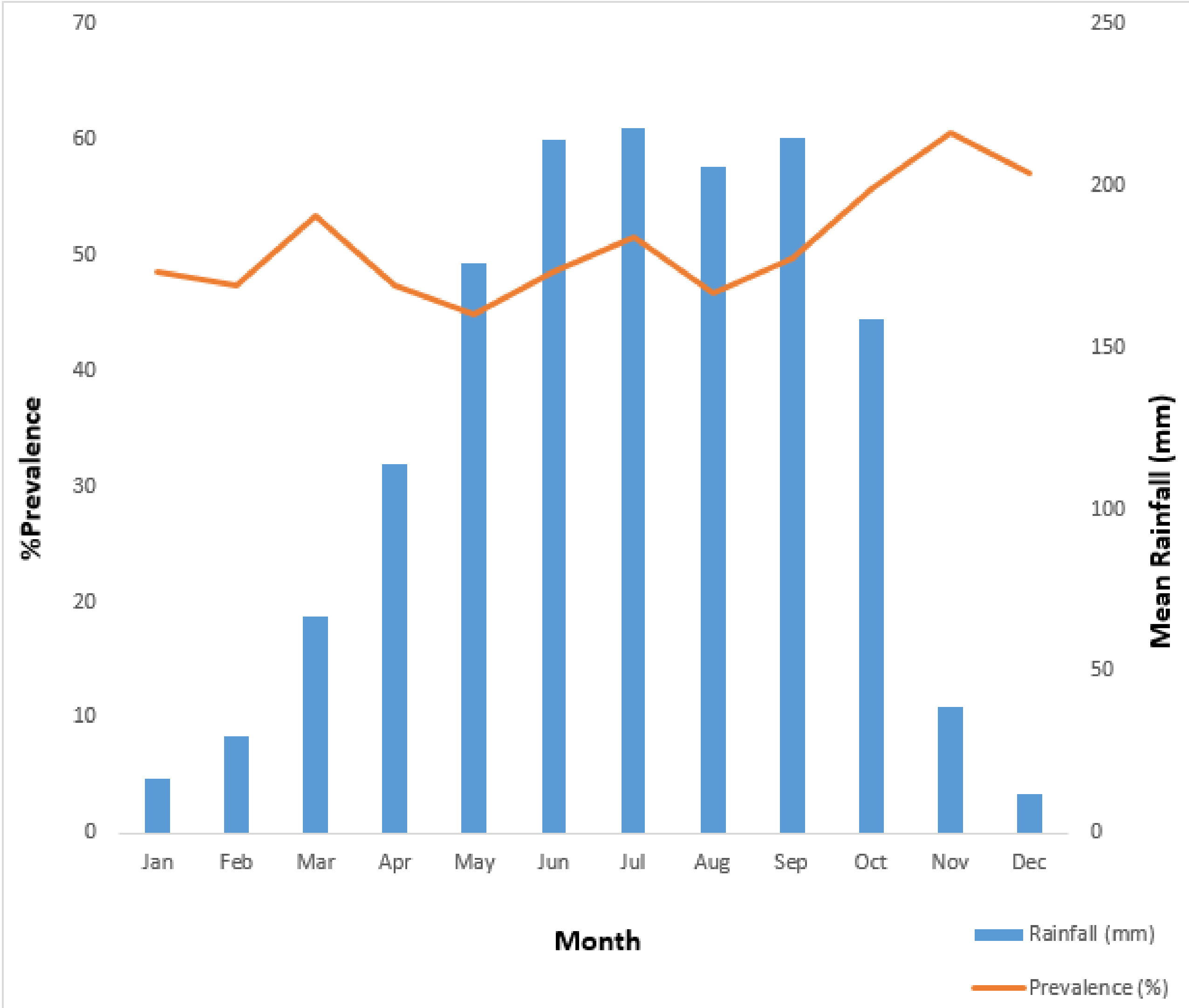

Figure 4.18: Prevalence of STH in faeces in relation to rainfall

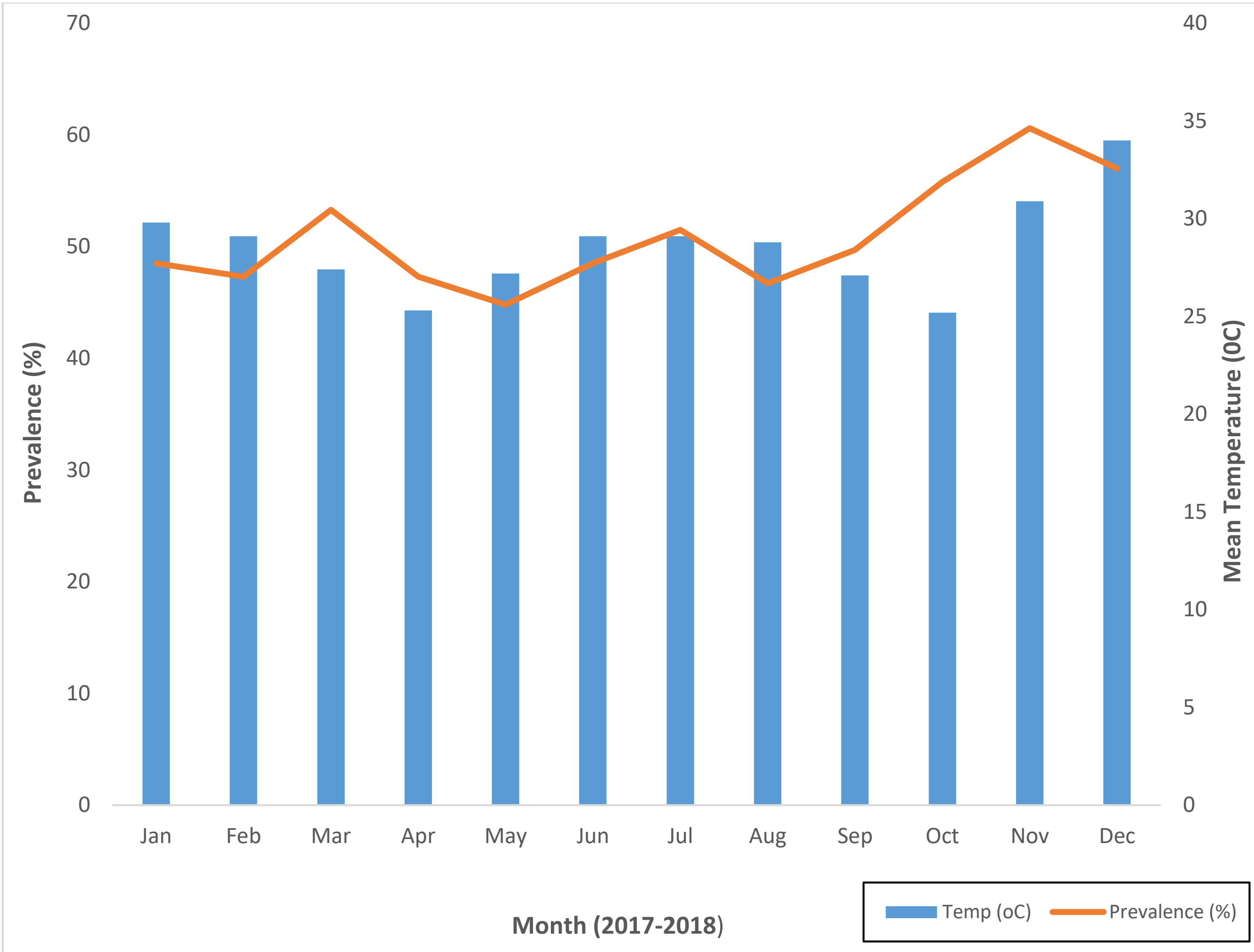

Figure 4.19: Prevalence of STH with respect to temperature

Temperature: For the monthly mean temperature, the highest mean temperature (34.0^0C) was recorded in the month of December with a parasite prevalence of 57.0% (Figure 4.19). Closely followed by that were the mean temperature in November (30.9^0C, 60.6%), Jan. (29.8^0C, 48.5%), Jul. (29.1^0C, 51.3%), Jun. (29.1^0C, 48.5%), Feb. (29.1^0C, 47.3%), Aug. (28.8^0C, 46.7%), Mar, (27.4^0C, 53.3%), May (27.2^0C, 44.5%), Sept. (27.1^0C, 49.7%), Apr. (25.3^0C, 47.3%), and the month with least mean temperature was Oct. (25.2^0C, 55.8%). The variance of the parasite prevalence in relation to mean temperature was not significant monthly (OR= 0.08, p> 0.05).

Relative humidity: The monthly mean Relative humidity, Rh, in response to parasite prevalence, where the Rh ranged from 66.5% to 87% (Figure 4.20). The months of Apr. and Oct. had a mean relative humidity of 87% with different rate of prevalences of 47.3% and 55.8% respectively. This is followed by mean relative humidity in Mar. (86%, 53.3%), Nov. (83%, 60.6%), May (83%, 44.5%), Sept. (81.5%, 49.7%), Aug. (79%, 46.7%), Feb. (78.5%, 47.3%), Dec. (70.5%, 57.0%), Jul. (68%, 51.3%), Jun. (68%, 48.5%), and the least was recorded for Jan. (66.5%, 48.5%). The prevalence of the parasite in relation to monthly mean relative humidity was not statistically significant (OR= -0.09, p>0.05).

4.4.2 Intensity (eggs/larvae/adults per gram)

Figure 4.21 to Figure 4.23 show the intensity of STH with respect to climatic factors and the parasite counts ranged from 322 to 486 eggs/larvae/adults per gram of soil.

Rainfall: The highest parasite count was recorded in the month of March (486) which coincides with the onset of rainfall (Figure 4.21). Followed parasite count in the month of Jan. (430), Apr. (400), Jun. (397), May, and Jul. had the same parasite count (393), Feb. (388), Nov. (388), Oct. (374), Aug. (329), and the least parasite count was recorded in the month of Sept. (322) with a mean rainfall of 215mm.

Temperature: In December, the parasite count was 359 with the highest monthly mean temperature of 34.0^0C (Figure 4.22), followed by Nov. (30.9^0C, 388), three months Feb. (388), Jun. (397), and Jul. (393) had the same mean monthly temperature (29.1^0C), Aug. (28.8^0C, 329), Mar. (27.4^0C, 486), 27.2^0C, 393), Apr. (25.3^0C, 400), Sept. (27.1^0C, 322),

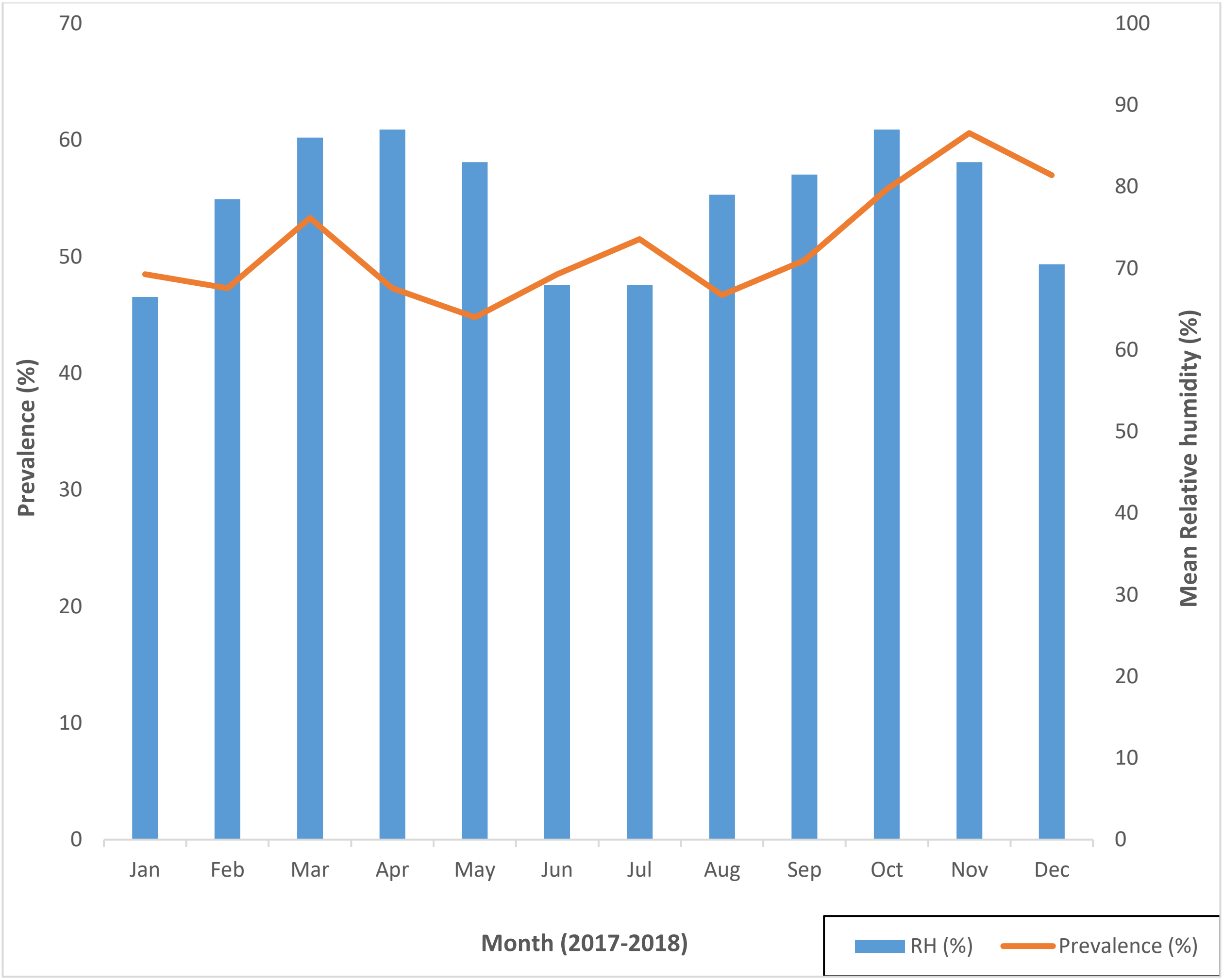

Figure 4.20: Prevalence of STH in faeces with respect to relative humidity

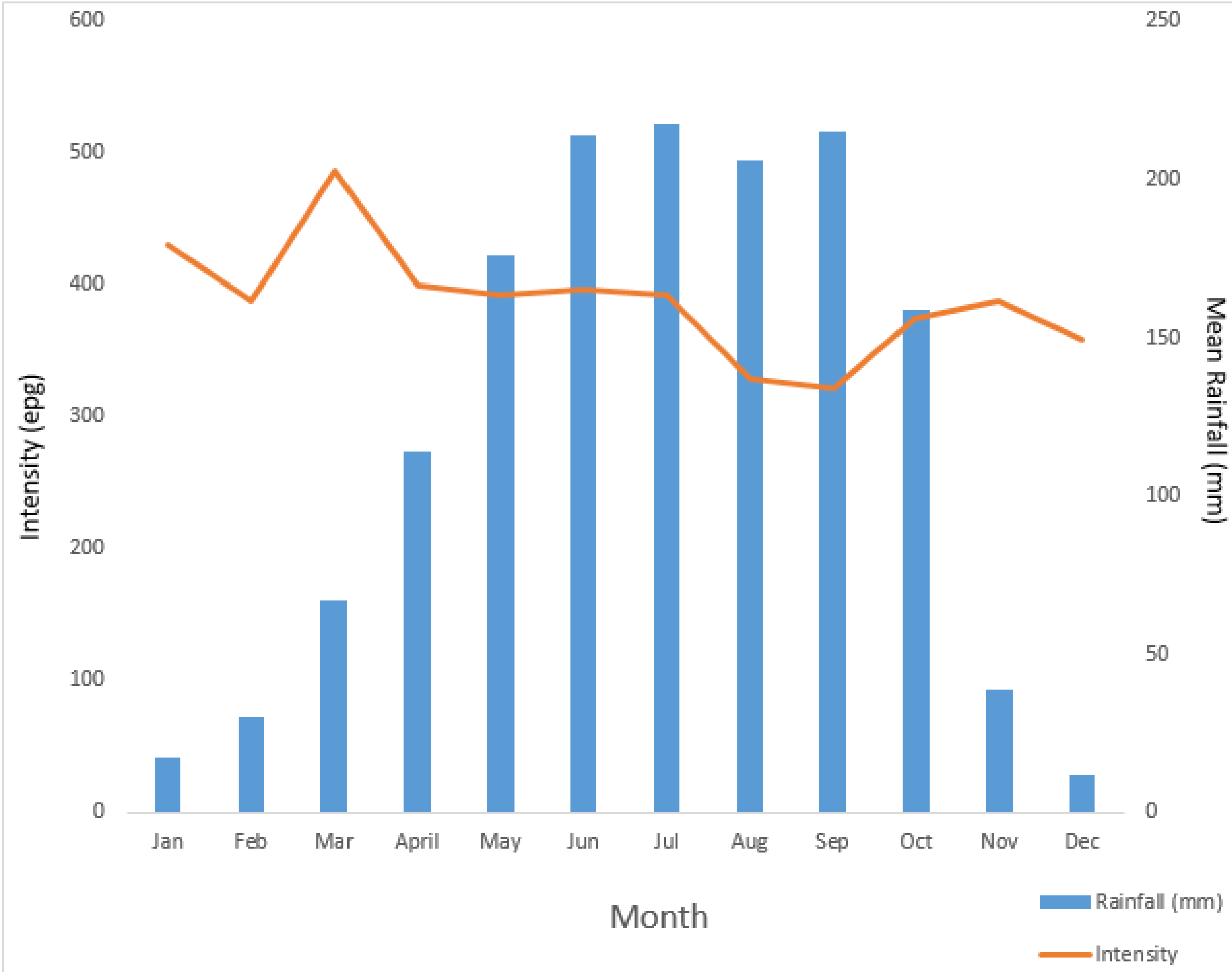

Figure 4.21: Intensity of STH in faeces with respect to rainfall

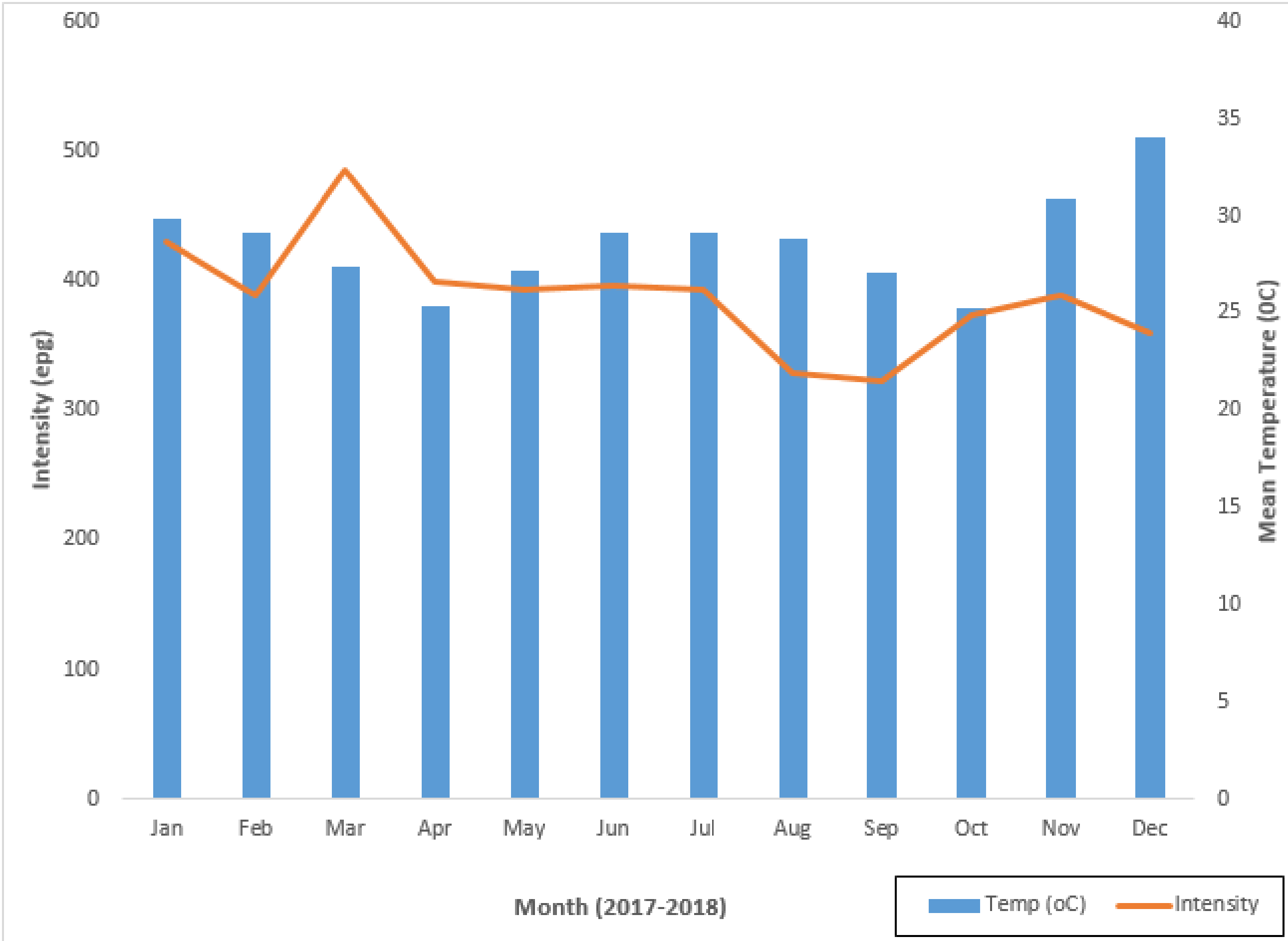

Figure 4.22: Intensity of STH in faeces in relation to temperature

and the last month with the least parasite count in relation to monthly mean temperature was Oct. (25.2^0C, 274).

Relative humidity: In Figure 4.23, the mean monthly relative humidity in relation to parasite counts was shown. The highest parasite count was found in March with a mean Rh of 86%, Followed by Feb. (430, 78.6%), and the month of Apr and Oct had the highest Rh of 87% with parasite counts of 400 and 374 respectively. The regression analysis showed a negative correlation between intensity and climatic factors ($r= -0.89$, $p\geq0.05$).

4.5 Outcome of the questionnaire survey

4.5.1 Demographic characteristics of respondents and prevalence status

In Figure 4.24a, 35.7% and 64.3% of females and males respectively were infected with at least one STH parasite. The age range 11–20 years had the highest parasite prevalence, at 23.4%, followed by the 0–10 age group (21.9%), 21-30 years (20.6%), 31–40 years (18.5%), 41-50 years (12.2%), 51-60 years (3.4%), the least parasite prevalence. No infection was recorded in the age group 61 – 70 years (Figure 4.24b). Approximately 27.8% representing the highest parasite prevalence was recorded among unemployed participants (Figure 4.24c), followed by prevalence among farmers (26.6%), Civil servants (18.0%), Artisans (14.2%), and the least prevalence was recorded among motorcycle riders (12.9%). Participants with primary school education (Figure 4.24d) had the highest STH prevalence (38.0%), followed by SSCE (34.4%), no formal education (10.9%), HND/BSc (8.9%), and the least was found among holders of ND/NCE (7.8%).

4.5.2 Knowledge, attitude, and practice among respondents

Figure 4.25 shows the prevalence of infection with respect to the prevalence of STHs. The category of participants who had no knowledge of infection had the highest prevalence (46.2%), followed by the group that believe sugary substances should be avoided (34.3%), and the least prevalence (19.5%) was the group that believe staying in a clean environ will help them avoid infection. STH infection prevalence fluctuation was of statistical significance ($\chi^2 = 111.09$, $p<0.05$).

Figure 4.26a reveals that 62.6% of the respondents knew about parasitic worms, while 37.4% of the respondents did not know about parasitic infection ($\chi^2 = 13.63$, $p<0.05$). Four

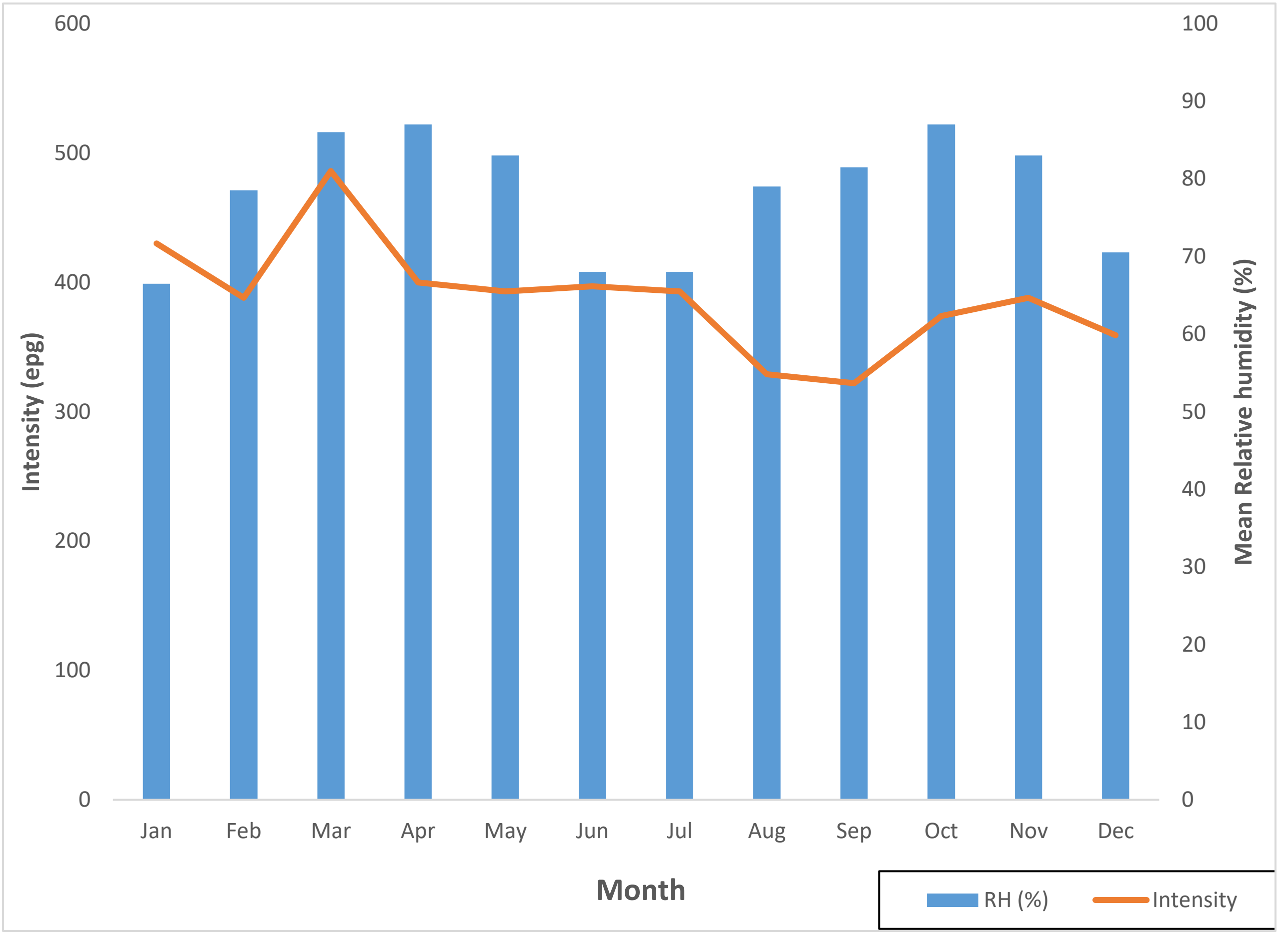

Figure 4.23: Intensity of STH in faeces with respect to relative humidity

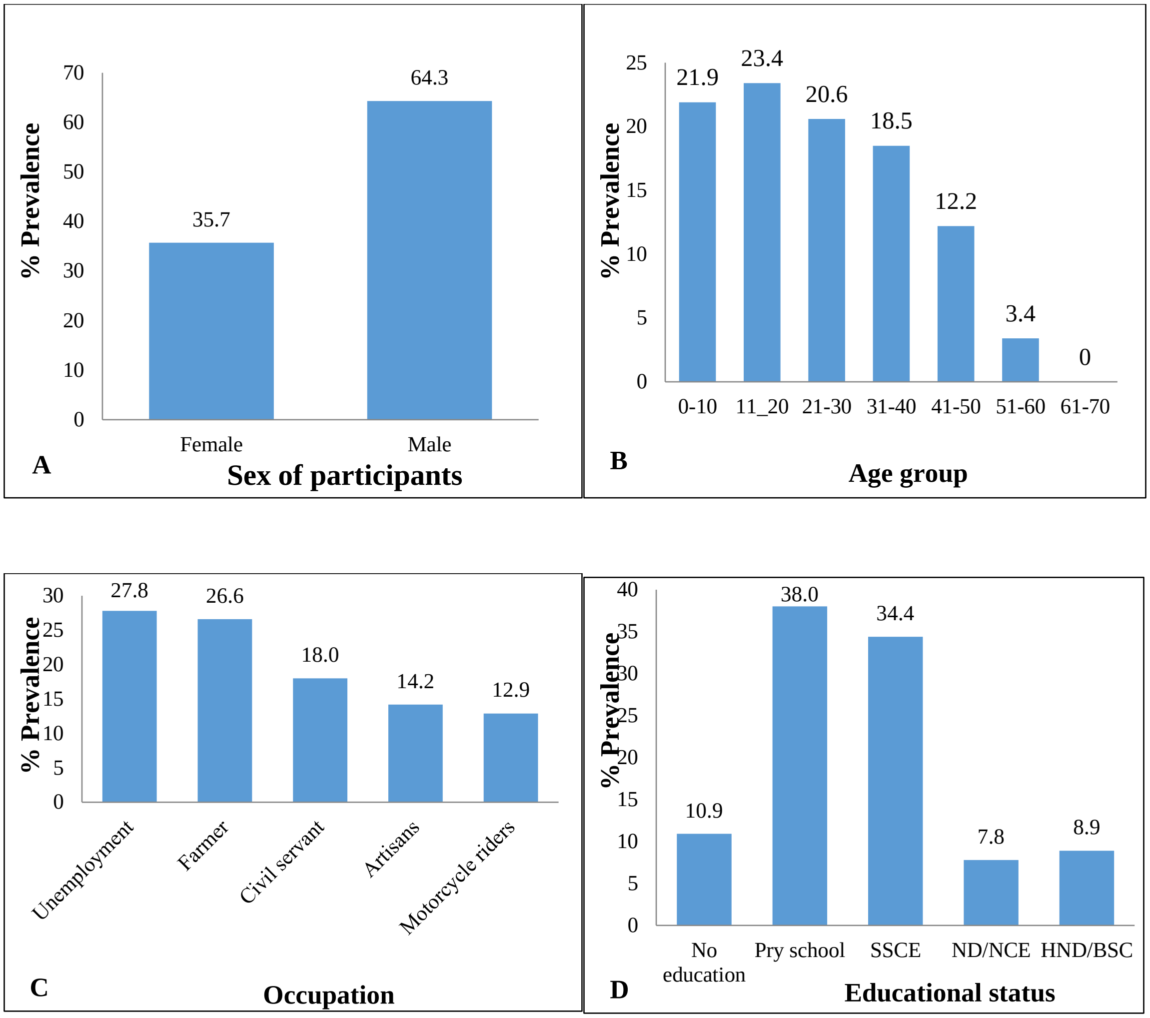

Figure 4.24: Demographics of respondents with respect to infection of STH

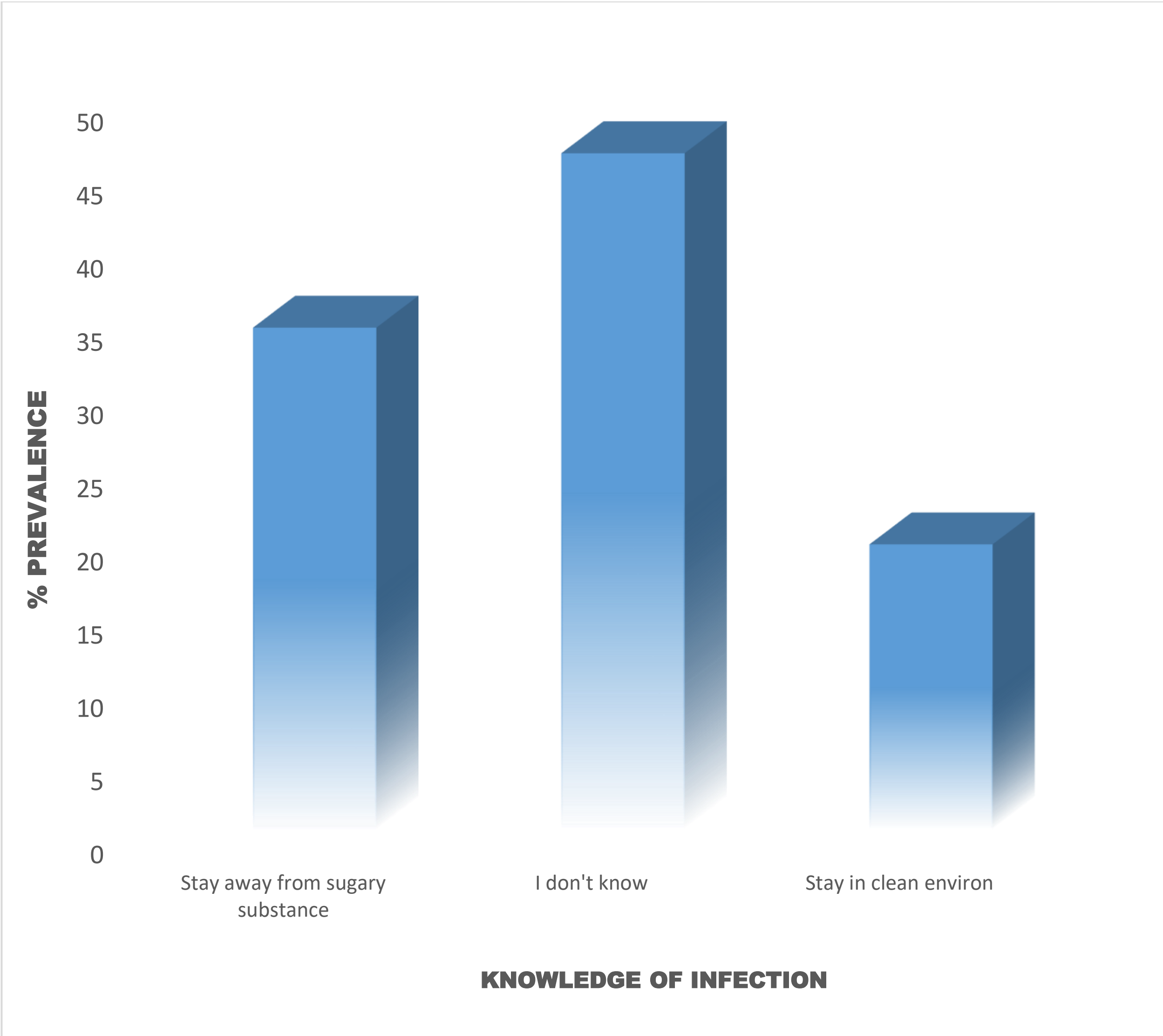

Figure 4.25: Knowledge of infection with respect to prevalence of soil-transmitted helminths

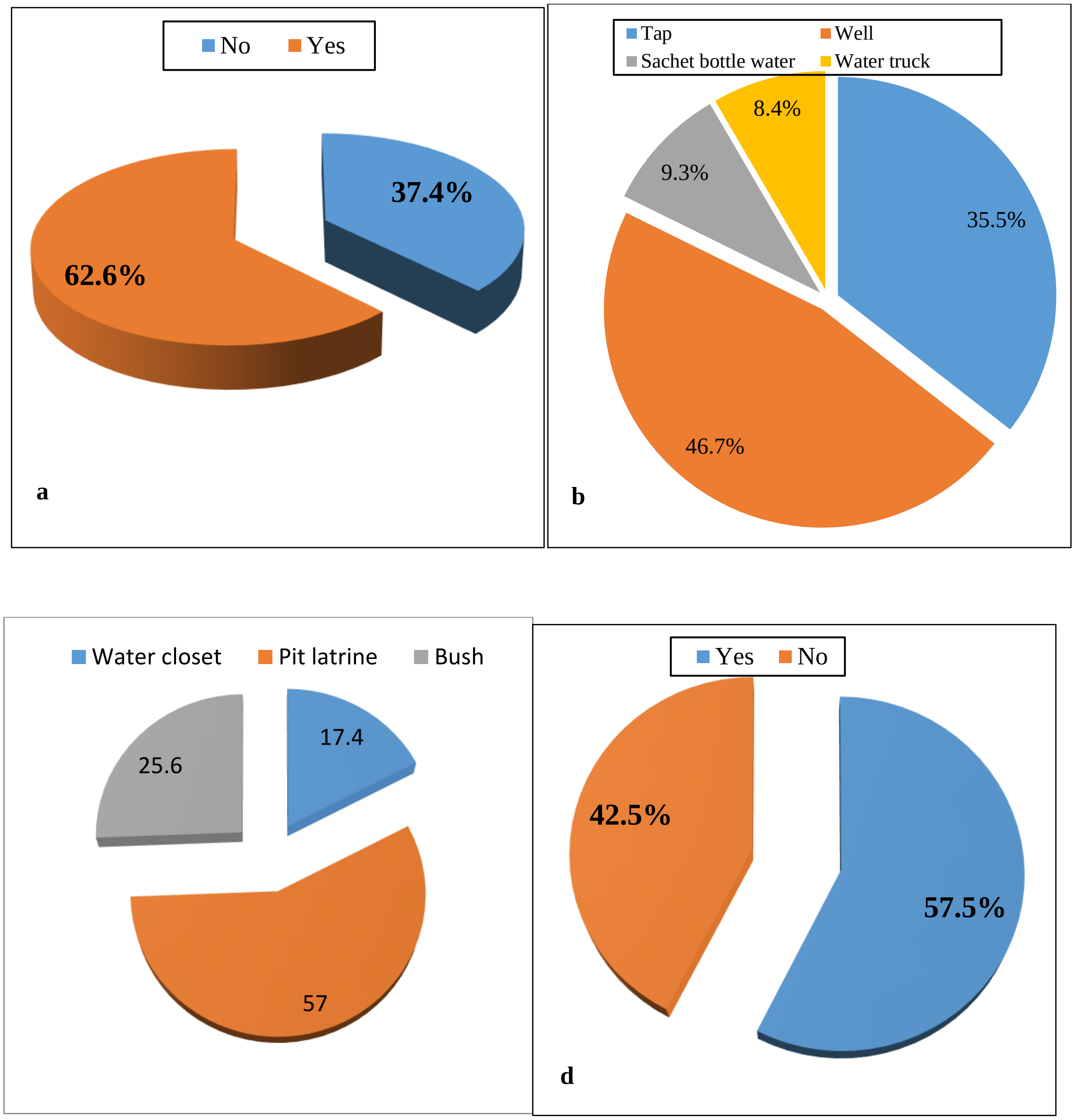

Figure 4.26: Risk factor assessments among respondents. a: Knowledge about STH, b: Source of drinking water, c: Toilet type, d: Ownership of pets/animals

sources of drinking water were reported by the respondents (Figure 4. 26b) and the common origin of drinking water as well (46.7%), which was closely next in line by tap water with 35.5%, 9.3% of the respondents' source of drinking water was sachet/bottled water, and just a small proportion of them got water from water truck (8.4%) (χ^2 = 94.41, $p<0.05$). Approximately 57.0% of the respondents used pit latrines (57%), followed by those who practice open defaecation (25.6%), and 17.4% of the respondents had water closets (Figure 4.26c). Moreover, most of the respondents (57.5%) had pets or animals around the house, while 42.5% of the respondent did not have pets or animals living with them in their various houses (Figure 4.26d).

Figure 4.27a shows a large proportion of the study participants (68.7%) who washed their hands often with water only, followed by 21.5% of the respondents who used soap and water, and the least (9.8%) were those respondents who do not usually wash hands with soap or use water ordinary to their hands after defaecation. About 72.9% of the respondents claimed not to have ever bitten or sucked fingernails (Figure 4.27b), and 25.2% claimed that they bite or suck their fingers always. About 1.9% of the respondents claimed that they sometimes do a bit or suck their fingers. In addition, Figure 4.27c shows that 64.0% of the respondents claimed that they always walked around barefoot, 34.6% claimed that they had never walked barefoot, and 1.4% of the respondents said that they sometimes had the cause of walking barefooted as the nature of their job calls for it or some religious practice. The history of deworming was presented in Figure 4.27d, 58.4% of the respondent cannot ascertain the precise anthelminthic drug that they used for helminthic parasites, 26.8% claimed that they used drugs some years ago, about 14.5% claimed that they never used such drugs before, and the remaining 10.3% claimed that they used drugs for parasitic helminths months ago.

Figure 4.28 shows the proportion of infected participants and their handwashing behaviour. About 50.1% infection rate was found among those that usually do not wash their hands after defaecation, followed by a 29.8% rate of infection amongst those who used just water only to wash their hands after defaecation, and about 20.1% infection rate amongst those who used soap and water. The variation in the infection rate was significant statistically (χ^2 = 124.38). Furthermore, a 60.7% rate of infection was recorded among the

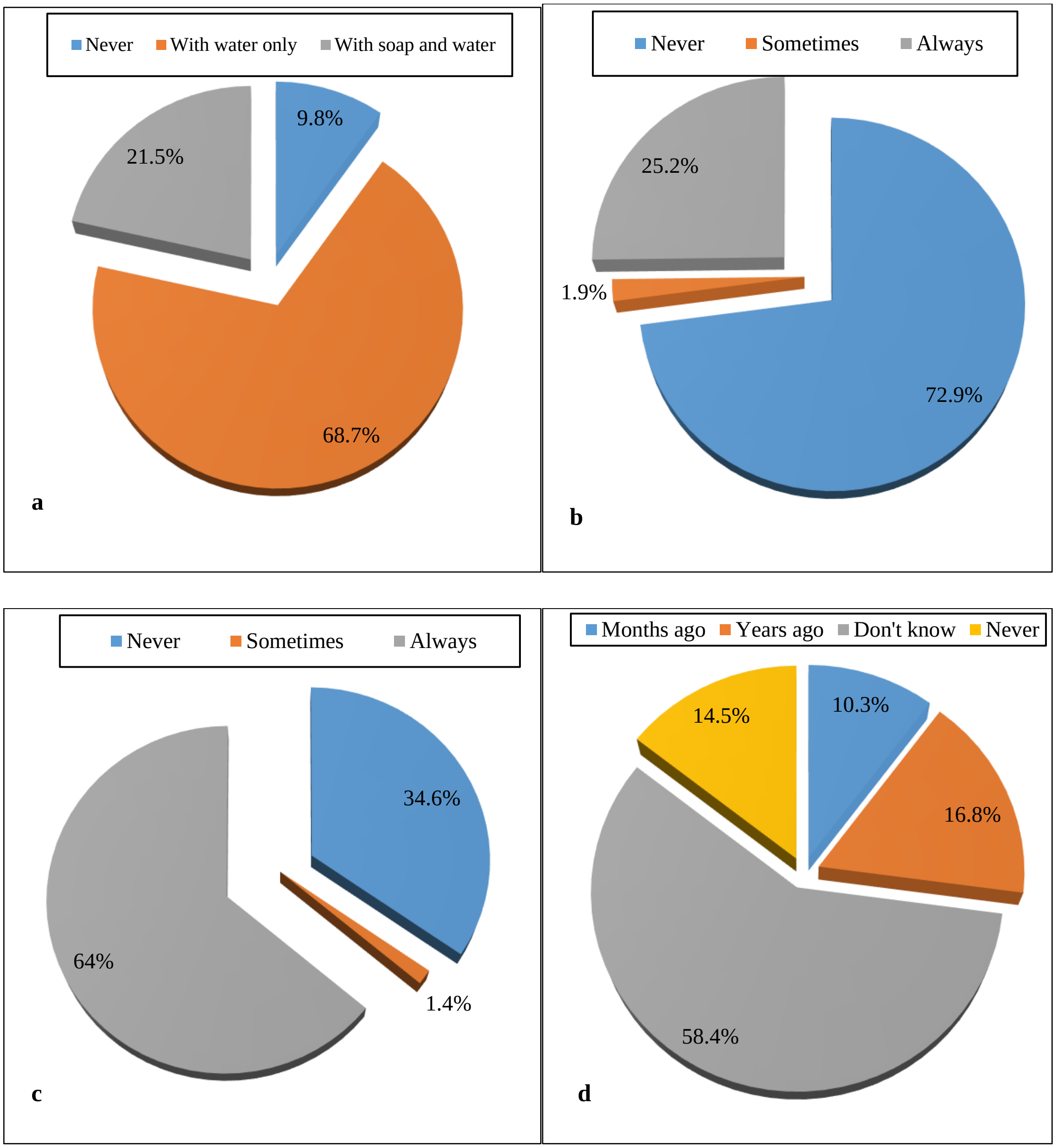

Figure 4.27: Risk factor assessments among respondents. a: Hand washing after defaecation, b: Nail biting/finger sucking, c: Walking barefoot, d: History of deworming

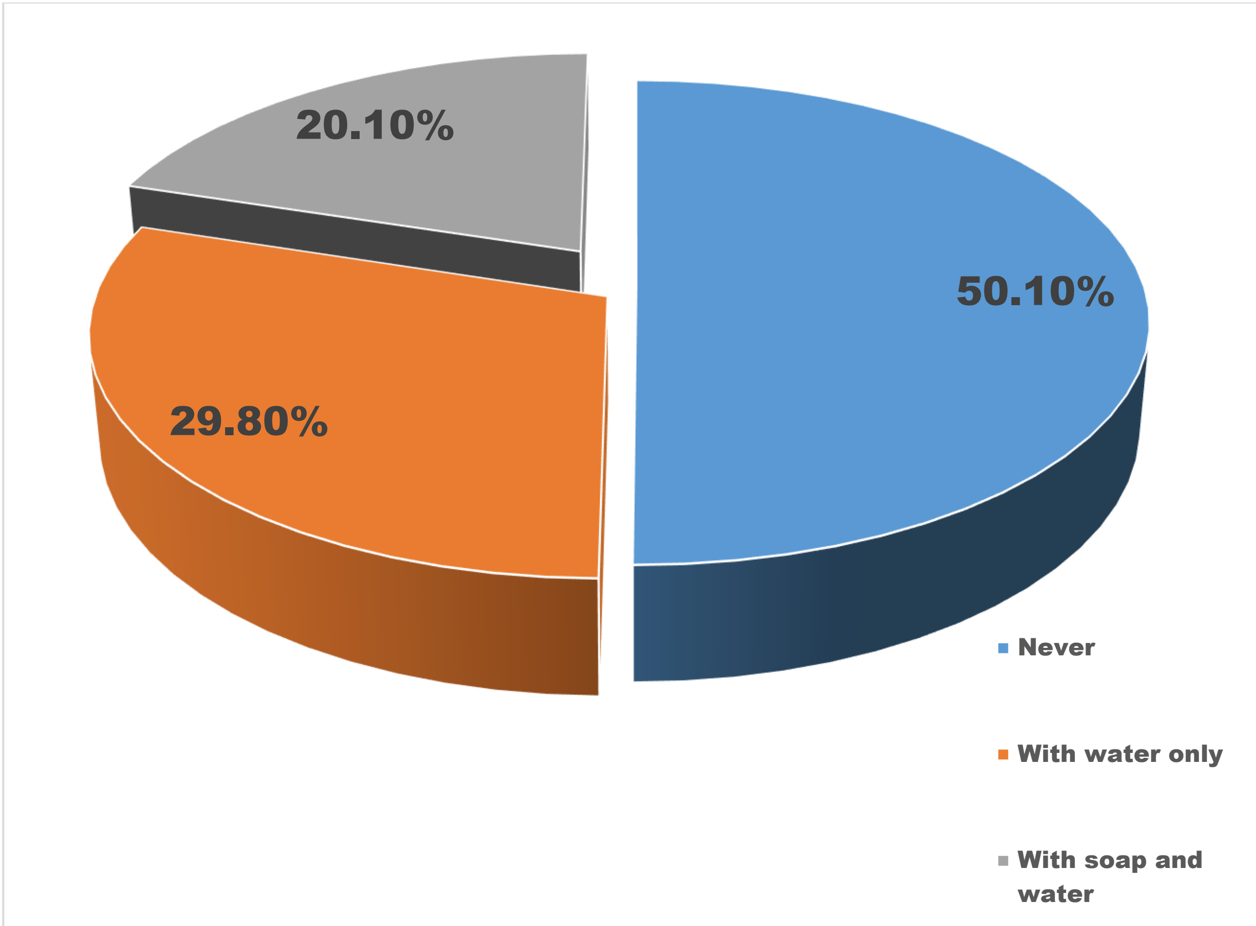

Figure 4.28: Proportion of the infected participants and hand-washing behaviour

respondents who always walked barefooted, 28.4% was recorded for those who sometimes walked barefooted, and the least rate of infection was recorded among those respondents that always put on their footgear (Figure 4.29). There was a significant difference in the infection rate among the respondents with respect to footgear ($\chi^2 = 126.01$, $p<0.05$).

About 29.8% of respondents that had never used the anthelminthic drug were infected with STH infections, closely followed by those who used it between 1 to 4 years ago (28.1%), 22.6% of those that did not know when they used the drug were infected and those that used it recently (1-11 months ago) had the least infection rate of 18.7% (Figure 4.30). The variation in the rate of infection in relation to helminthic drugs was statistically significant ($\chi^2 = 129.29$, $p<0.05$). Finally, in Figure 4.31, 36.0% of the respondents that did not know the specific drug used for treatment were infected with STH, 27.0% of respondents that did not use any drug were infected, some of the respondents that used local concortion (Agbo) had a prevalence rate of 19.0% and the least were those respondents that used anthelminthic drugs (18.0%). There was a significant difference in the rate of STH infections with respect to the history of deworming ($\chi^2 = 111.09$, $p<0.05$).

4.5.3 Socio-economic status

About 94.2% of infected participants lived in mud houses (Figure 4.32) while 5.8% of infected respondents live in concrete houses ($\chi^2 = 177.26$, $p<0.05$). Approximately 80.0% infection rate was recorded among participants who reported that the health centre can easily be assessed from their various homes by car in a few minutes, followed by those that walk few distances, and the least (9.1%) was recorded among those who drive from their homes to the health centre in an hour (Figure 4.33). The variation observed in infection rates was significant ($\chi^2 = 262.27$, $p<0.05$).

Furthermore, Figure 4.34 shows the prevalence of infected respondents with respect to the type of toilet available where it was observed that those practicing open defaecation had the highest rate of STH infections at 59.9%, followed by respondents with pit latrine (30.1%) and the least rate of infection was found among respondents having water closet facilities (10.0%). There was a significant difference in the rate of infection in relation to toilet facility availability ($\chi^2 = 54.09$, $p<0.05$).

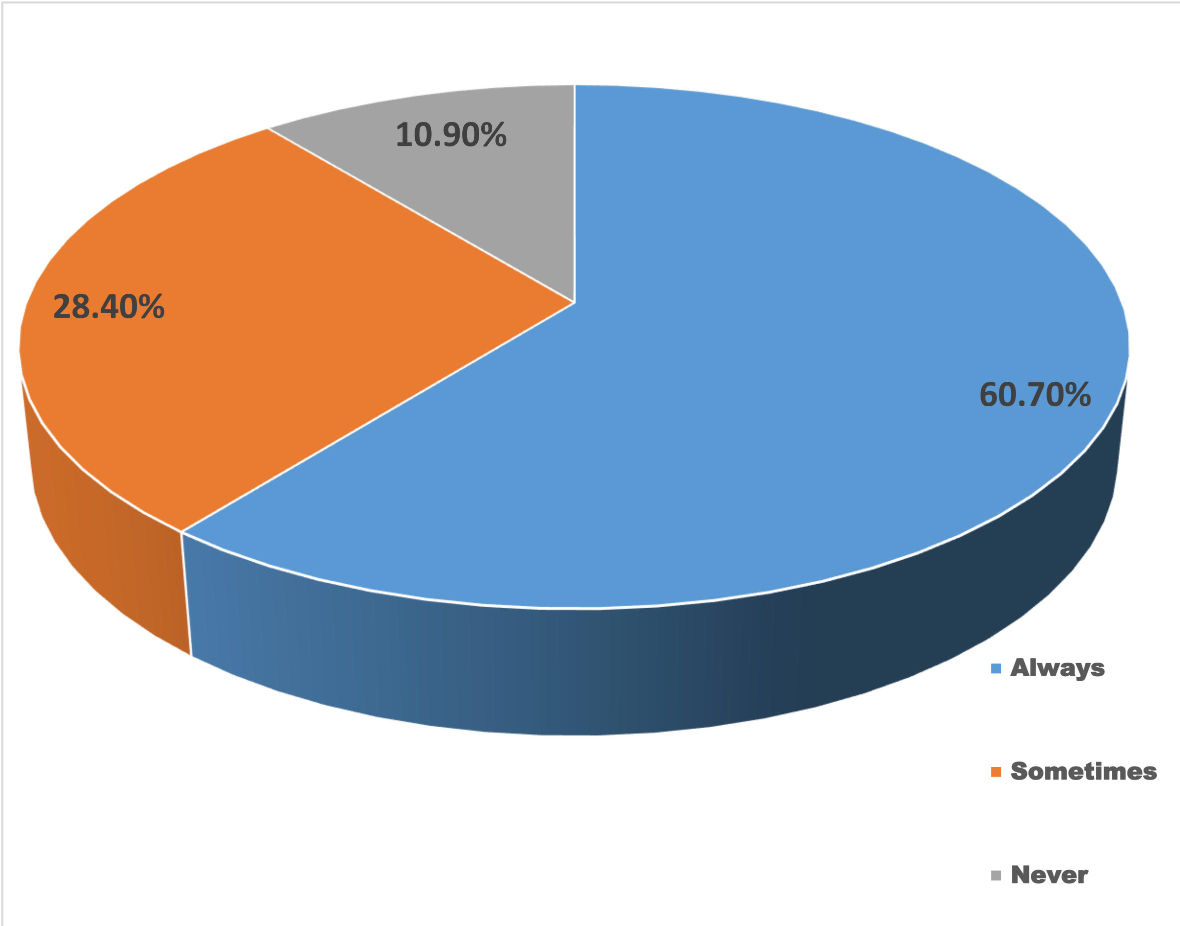

Figure 4.29: Proportion of infected participants and the use of footwear

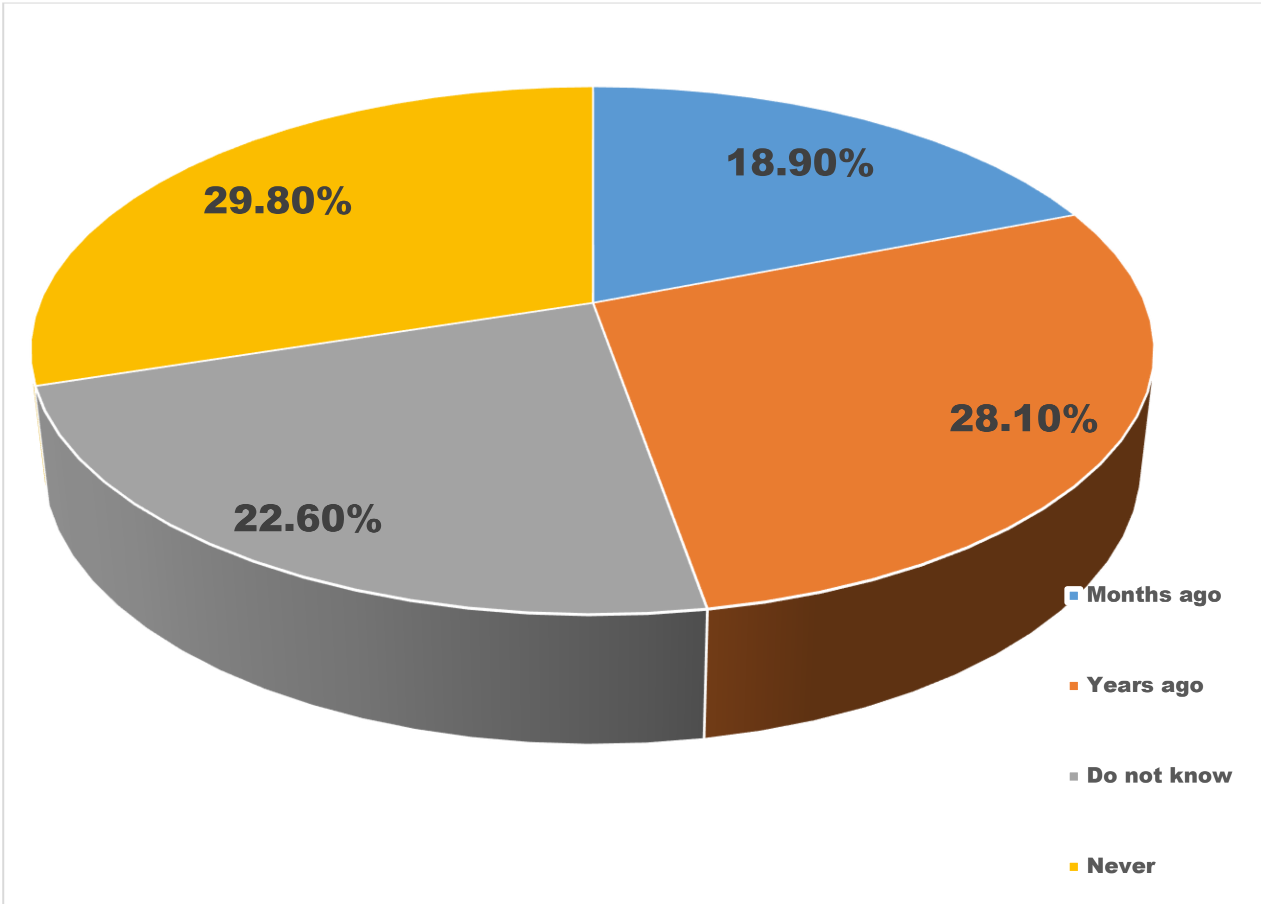

Figure 4.30: Prevalence of infected participants with respect to time last use anthelminthic drug

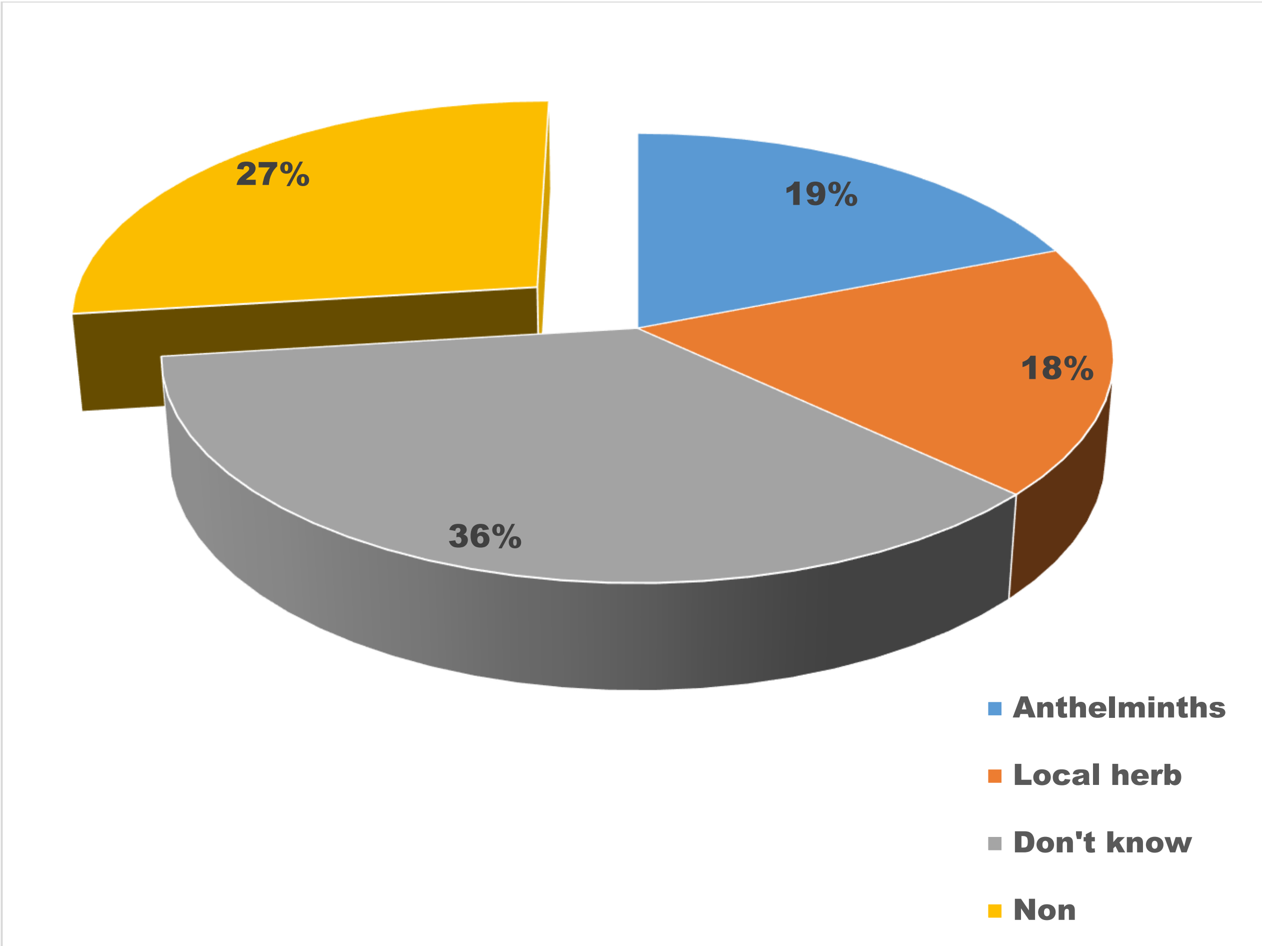

Figure 4.31: Prevalence of participant with respect to treatment seeking behaviour

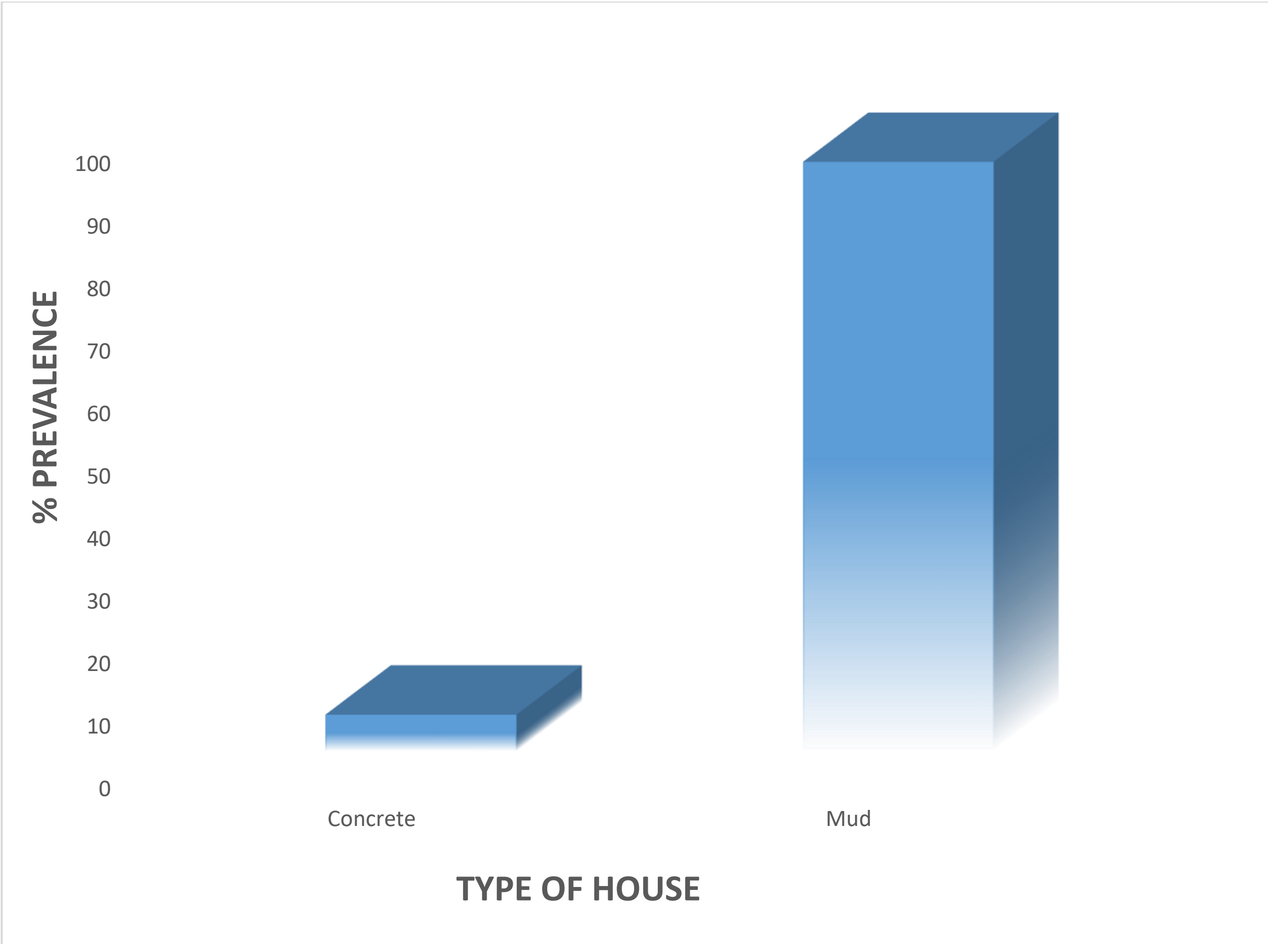

Figure 4.32: Type of house and prevalence of infection

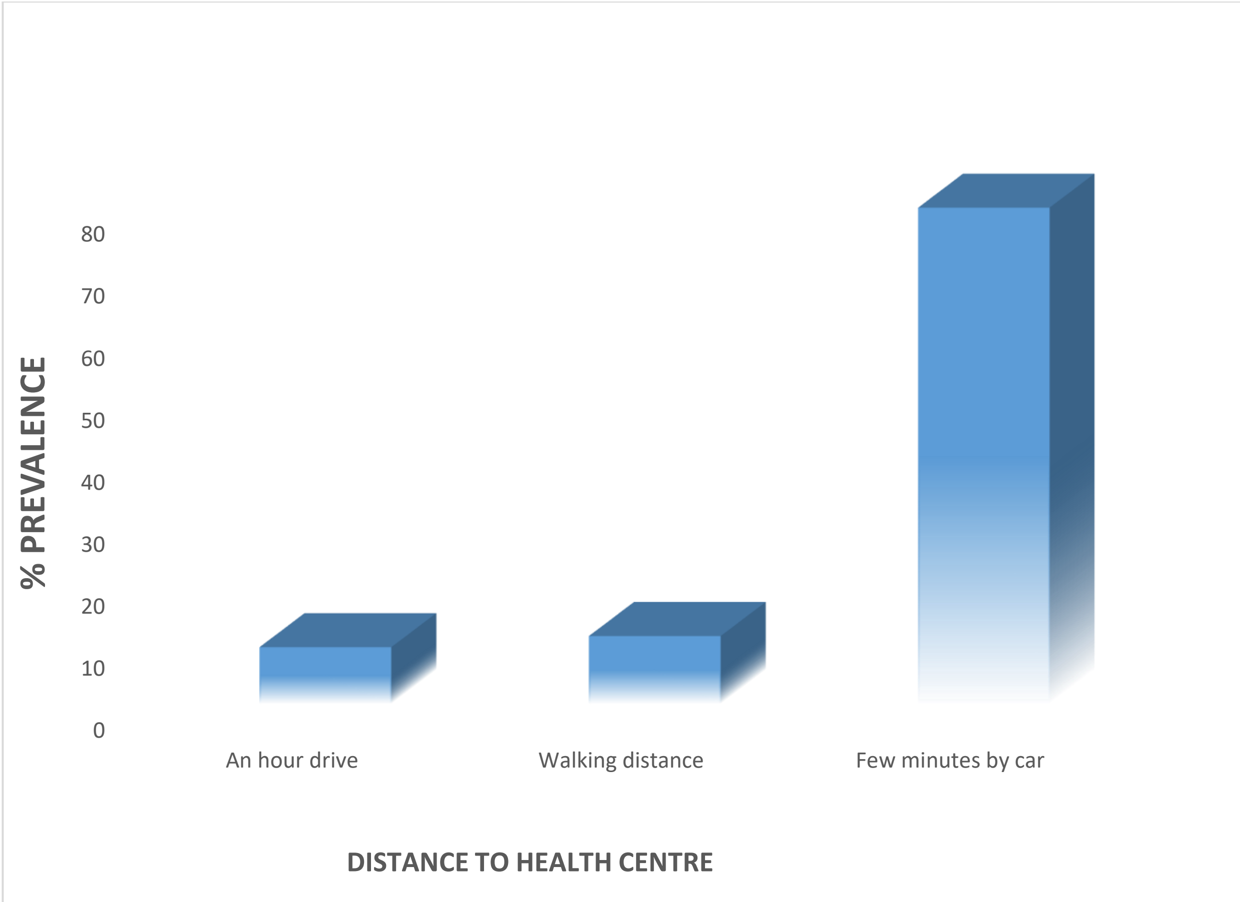

Figure 4.33: Prevalence of infection with respect to the distance to health care centre

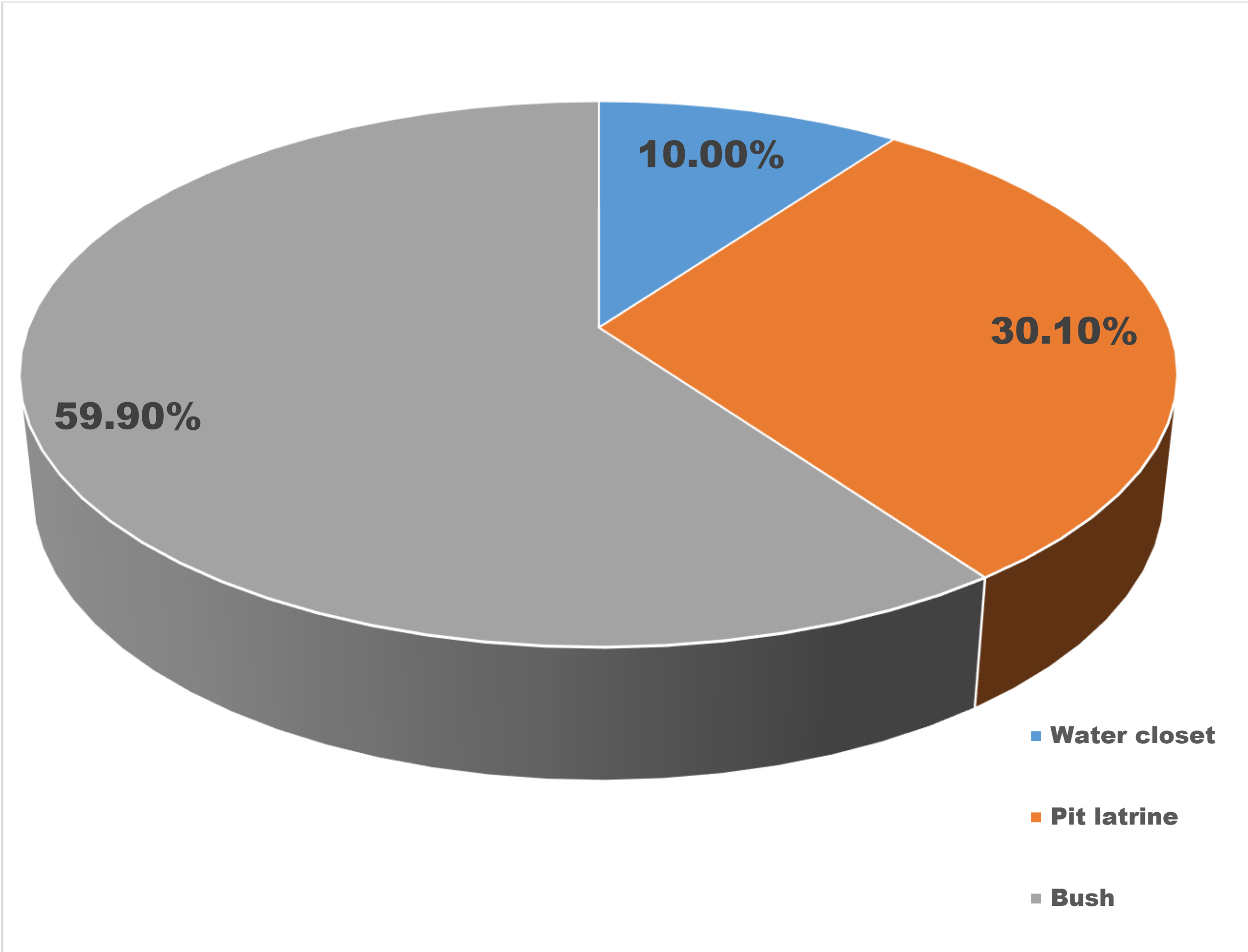

Figure 4.34: Prevalence of infected participants with respect to toilet facility

4.6 Spatial Distributions of STH Prevalence across the LGAs in Ibadan

Figure 4.35 to Figure 4.38 show the spatial distributions of STHs across the 11 LGAs within Ibadan.

4.6.1 Ascariasis distribution across the LGAs in Ibadan

The prevalence range was between very high and high in Lagelu, Egbeda, Ona Ara, Ibadan North East, South West, South East, Oluyole, and Ido LGAs (Figure 4.35). These LGAs can be categorized as hot spots for the prevalence of *Ascaris* among the populations. Using the categorization of settlements into rural, semi-urban, and urban settlements, the majority of the areas with an extreme and very high prevalence of *Ascaris* parasite were semi-urban populations (Lagelu, Egbeda, Ona Ara, some parts in Oluyole and Omi Adio. While it ranged between low or very low in Akinyele, Ibadan North, and Ibadan North West LGAs.

4.6.2 Trichuriasis distribution across the LGAs in Ibadan

Figure 4.36 shows the spatial spread of *Trichuris* across the sampling locations in Ibadan and unlike the prevalence spread observed for *Ascaris*, *Trichuris* was found to dominate and had extreme prevalence mainly in the study participants from Ona Ara, and medium to above medium in IbNE, Egbeda, IbSE, and Oluyole. Some LGAs such as Akinyele, Ido, Ibadan North, Lagelu, Ibadan SW, Ibadan NW, and Omi Adio had between extremely low and below a medium spread of *Trichuris*. Generally, the parasite prevalence is weaning down among human populations in this present study.

4.6.3 Hookworm disease distribution across the LGAs in Ibadan

Hookworm infection was found to range between extremely high and medium among participants from Egbeda, Ibadan NE, Ibadan SE, Ona Ara, Oluyole, and Omi Adio (Figure 4.37). Hookworm had a higher prevalence and wider spread than *Trichuris* among the populations in the study area, contrary to the observed *Ascaris* spread, hookworm had less occurrence and reduced spread. Also, unlike the extremely low prevalence that was observed for *Trichuris* spread in Akinyele and Ido, hookworm prevalence spread for these two locations was found to be above the below medium category.

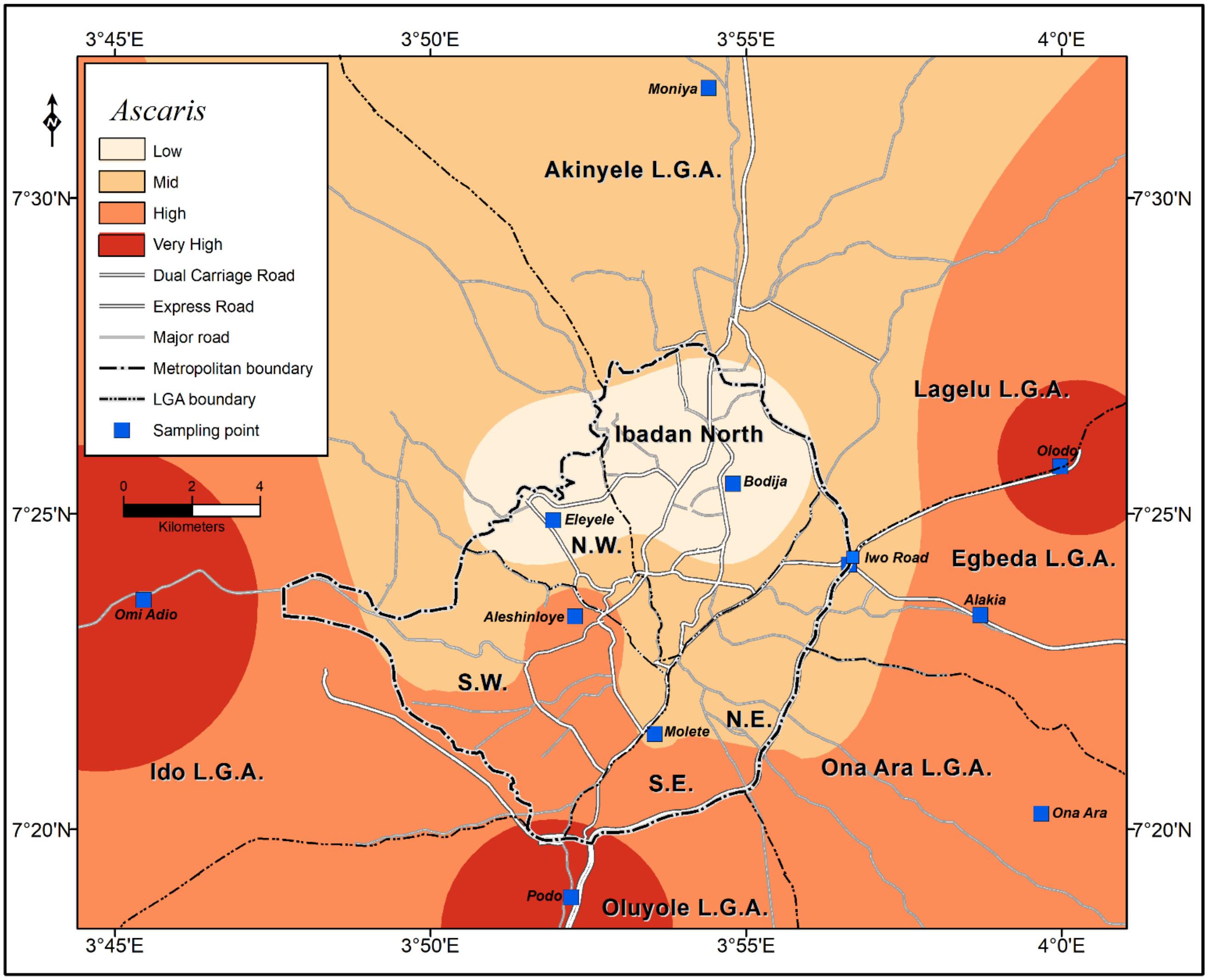

Figure 4.35: Mapping of *Ascariasis* across the LGAs in Ibadan

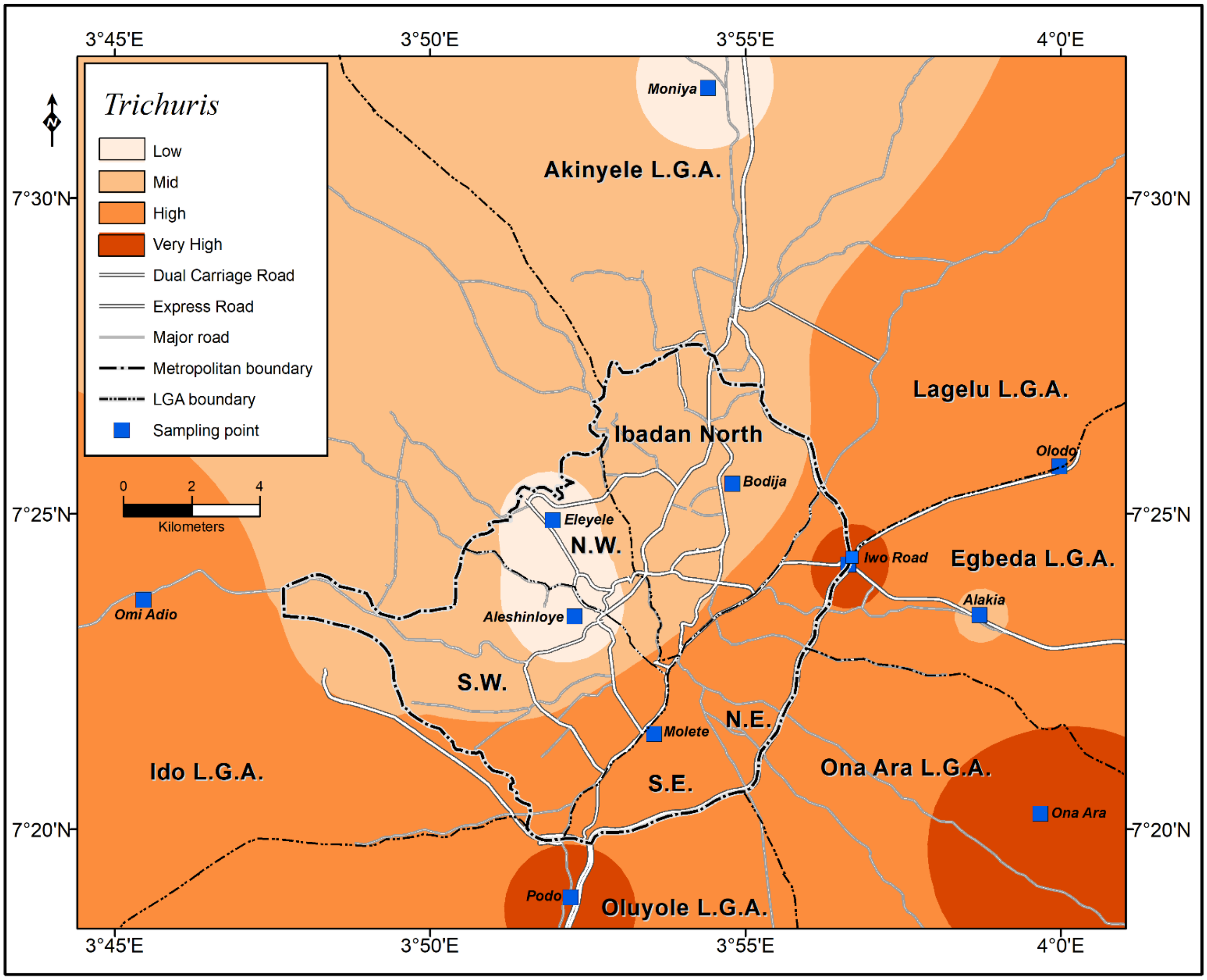

Figure 4.36: Mapping of *Trichuriasis* across the LGAs in Ibadan

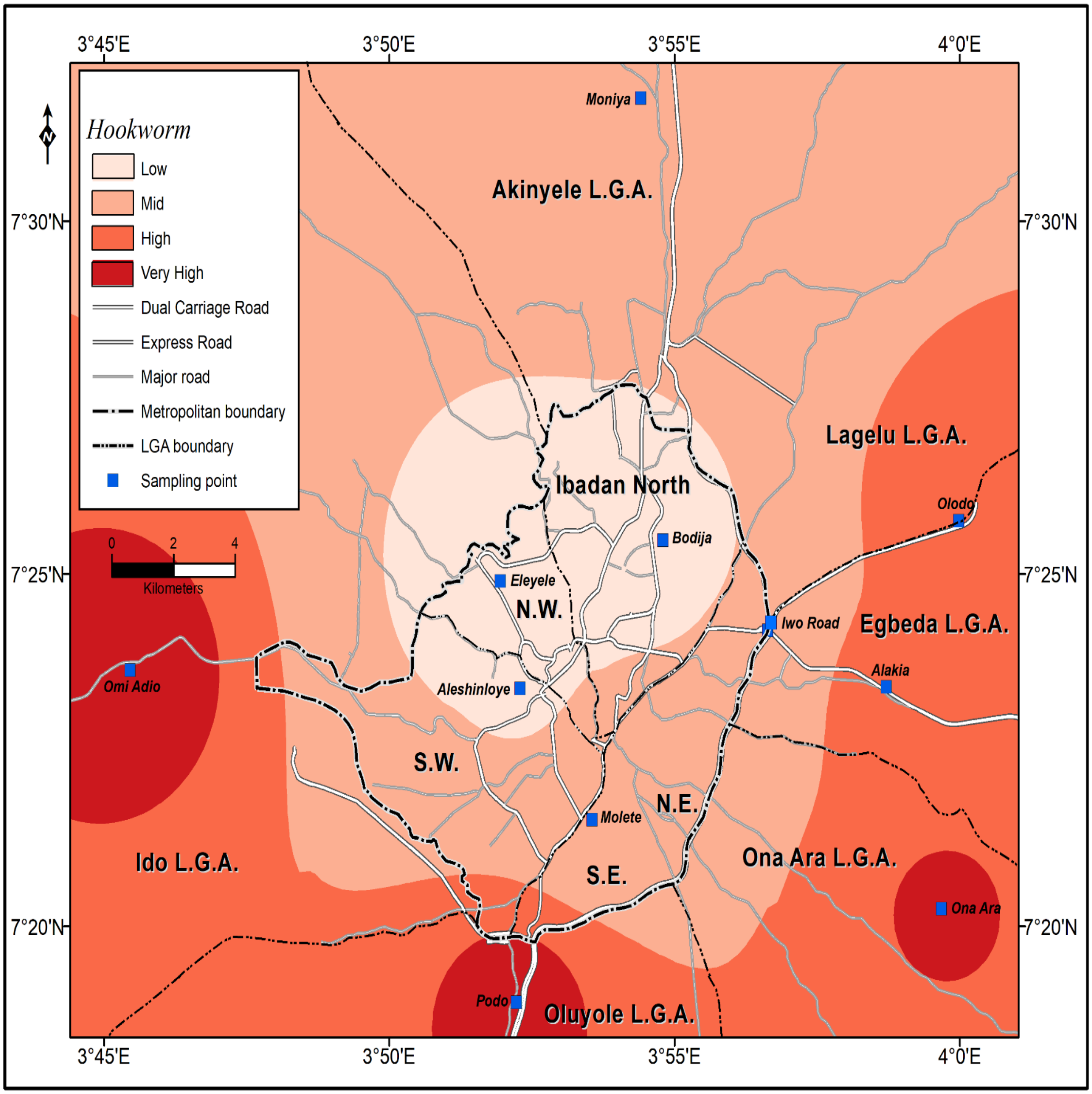

Figure 4.37: Mapping of hookworm disease across the LGAs in Ibadan

4.6.4 Strongyloides distribution across the LGAs in Ibadan

Figure 4.38 shows the mapping of the prevalence of *Strongyloides* across the LGAs in Ibadan. The spread of the parasite among the sample populations showed that many of the study locations had extremely low to below medium prevalence spread. Meanwhile, Ona Ara can be described as a hot spot for *Strongyloides* infection when compared with other locations. IbNE, Egbeda, and Ibadan SE LGAs had medium spread of the parasites. Present observation showed that *Strongyloides* is attaining the level of public health concern.

4.7 Spatial Distributions of Parasites' Viability across the LGAs in Ibadan

Figures 4.39 – 4.42 show the spatial distributions of parasites' viability status across the eleven LGAs within Ibadan.

4.7.1 Viability of Ascaris eggs across the LGAs in Ibadan

The viability of *Ascaris* eggs fell in the categories of very high, high, and moderate across Lagelu, Egbeda, Oluyole, Ibadan SE, Ibadan SW, and Ido LGAs (Figure 4.39), while in Akinyele, Ibadan N, Ibadan NW, Ibadan NE, and Ona Ara the viability status fell in low and very low categories.

4.7.2 Viability of Trichuris eggs across the LGAs in Ibadan

Figure 4.40 shows the viability of *Trichuris* eggs across the sampling locations in Ibadan and unlike the low and very low viability status observed for *Ascaris*, *Trichuris* eggs viability was found to be very high in Ona Ara LGA and high in Oluyole LGA. The viability of parasites' eggs was between moderate to above medium in IbNE, Egbeda, IbSE, Akinyele, Ido, Ibadan North, Lagelu, Ibadan SW, Ibadan NW, and Omi Adio.

4.7.3 The viability of hookworm eggs across the LGAs in Ibadan

The viability of hookworm eggs was found to be between extremely high and medium among faecal samples collected from participants in Ido, Egbeda, Ibadan SW, Ibadan SE, Ona Ara, Oluyole, and Lagelu LGAs (Figure 4.41). This viability spread has made hookworm have a higher prevalence as well as wider spread than *Trichuris* among the populations in the study area.

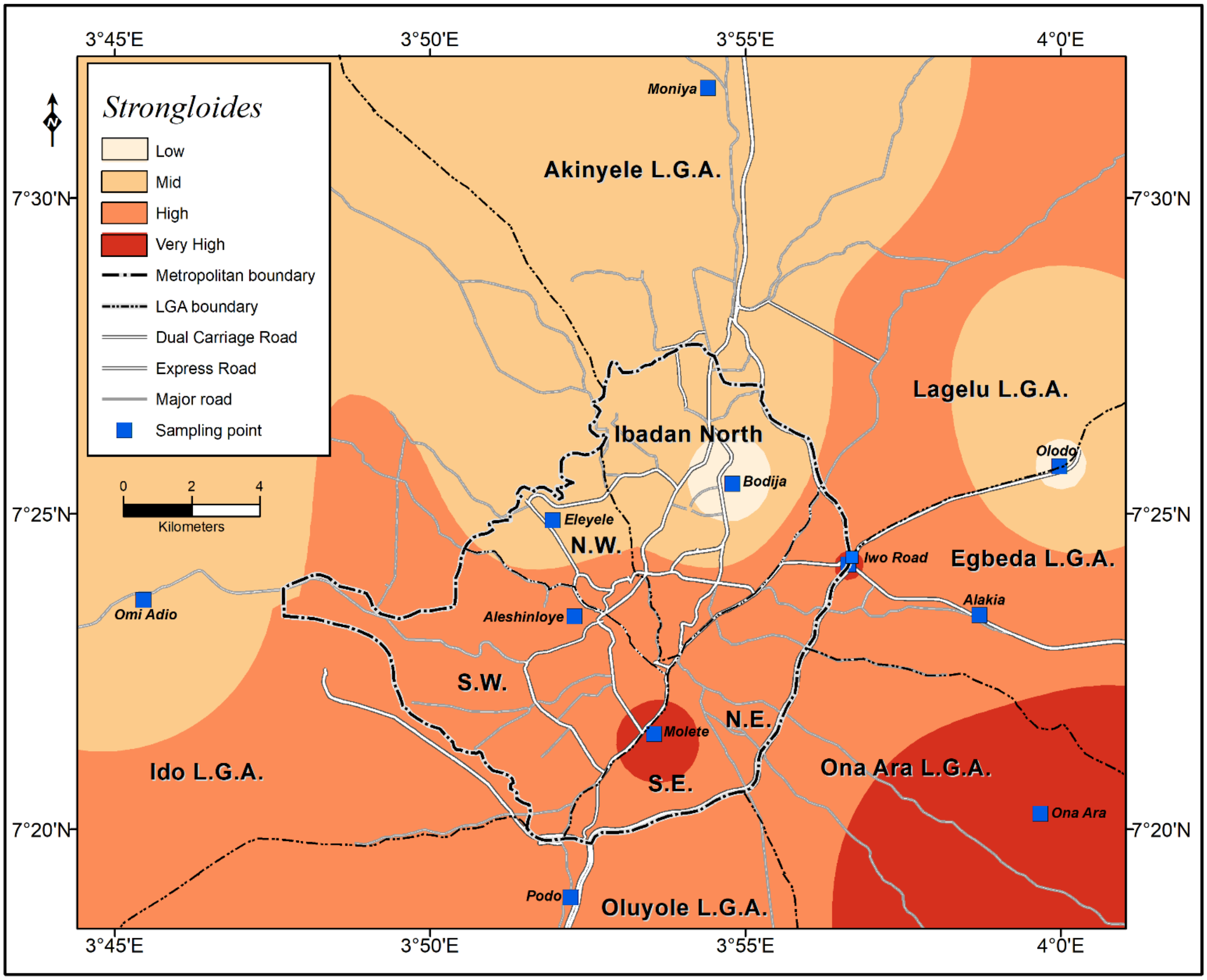

Figure 4.38: Mapping of *Strongyloides* across the LGAs in Ibadan

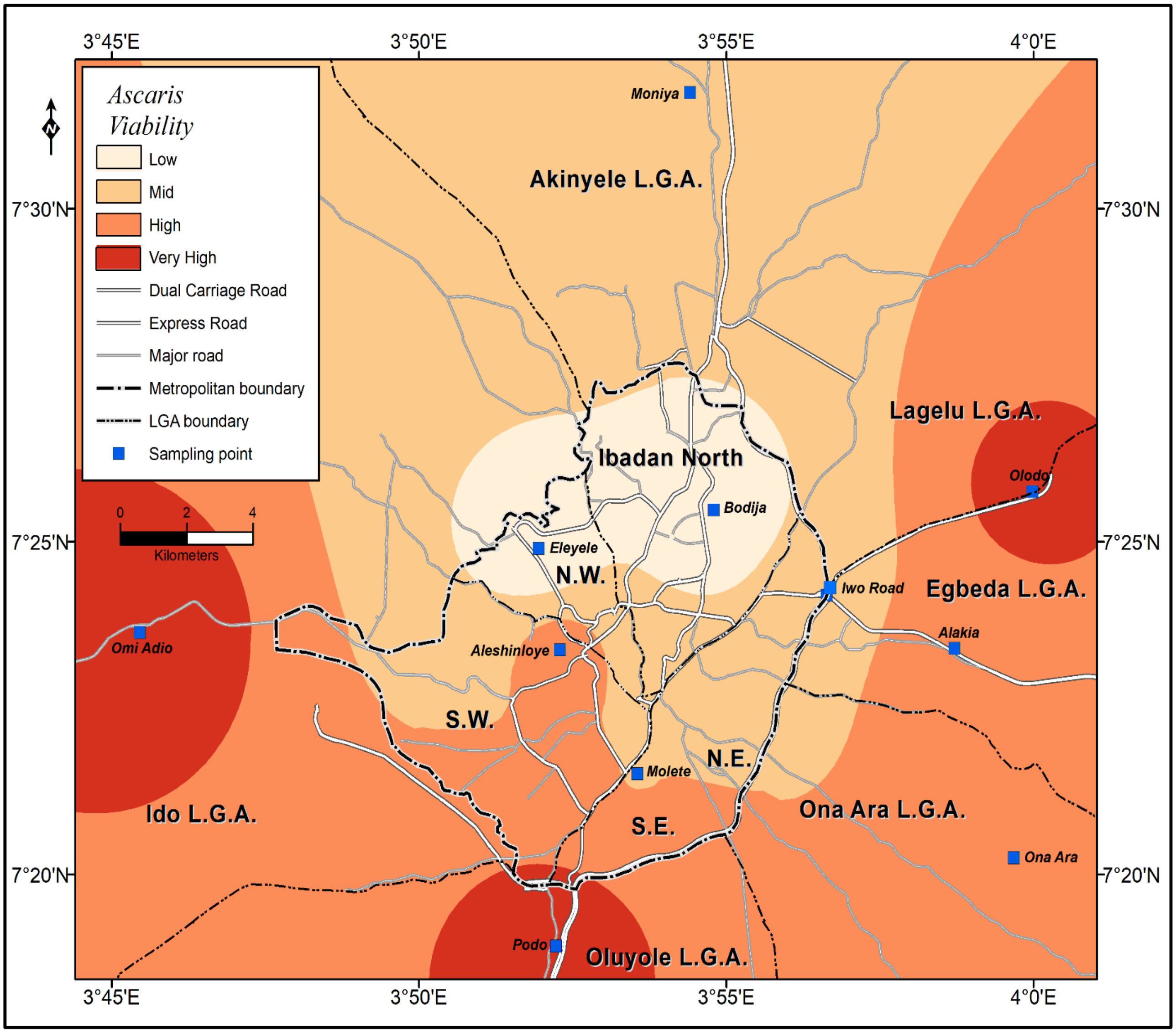

Figure 4.39: Viability of *Ascaris* eggs across the sampling locations

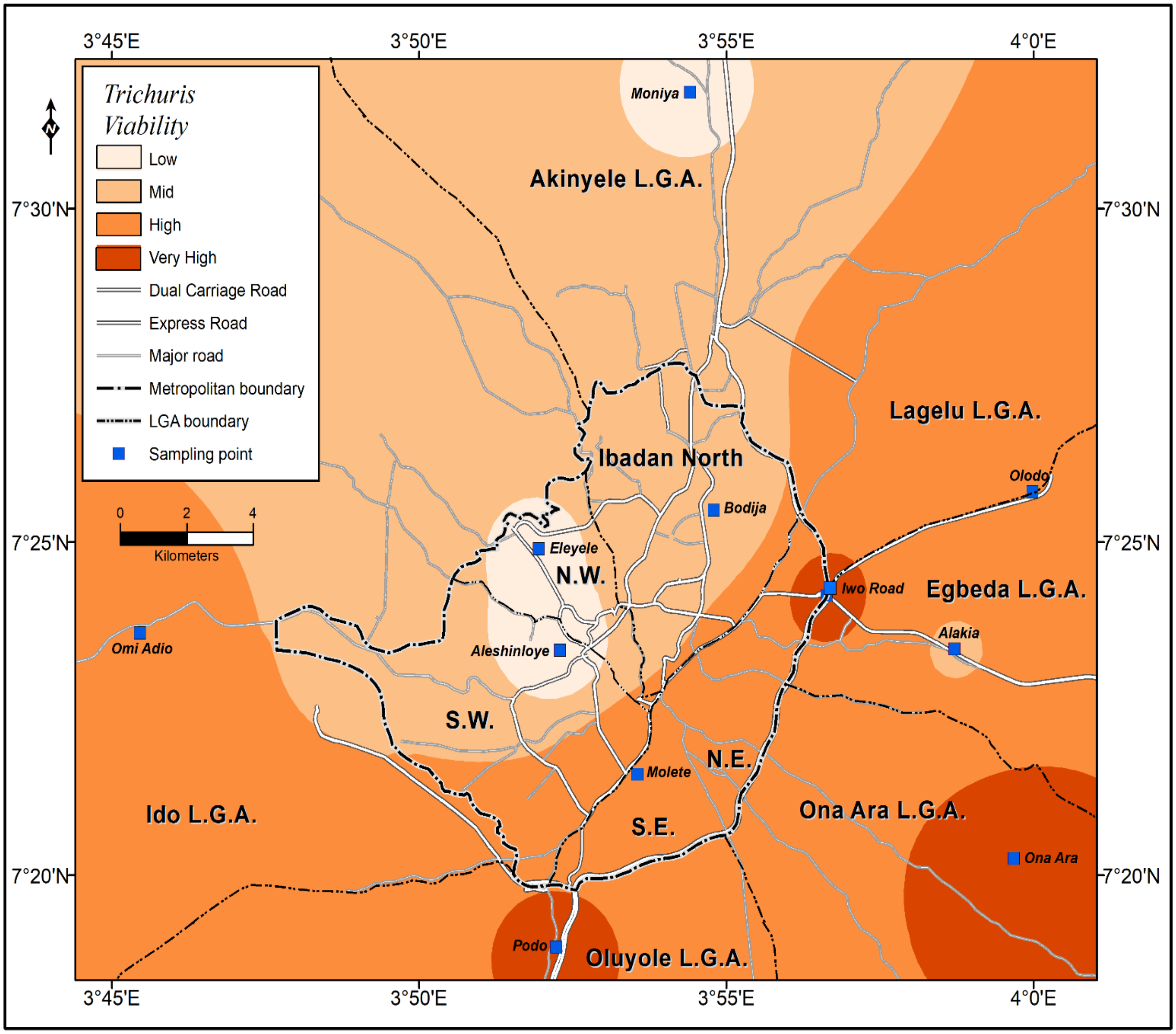

Figure 4.40: Viability of *Trichuris* eggs across sampling locations

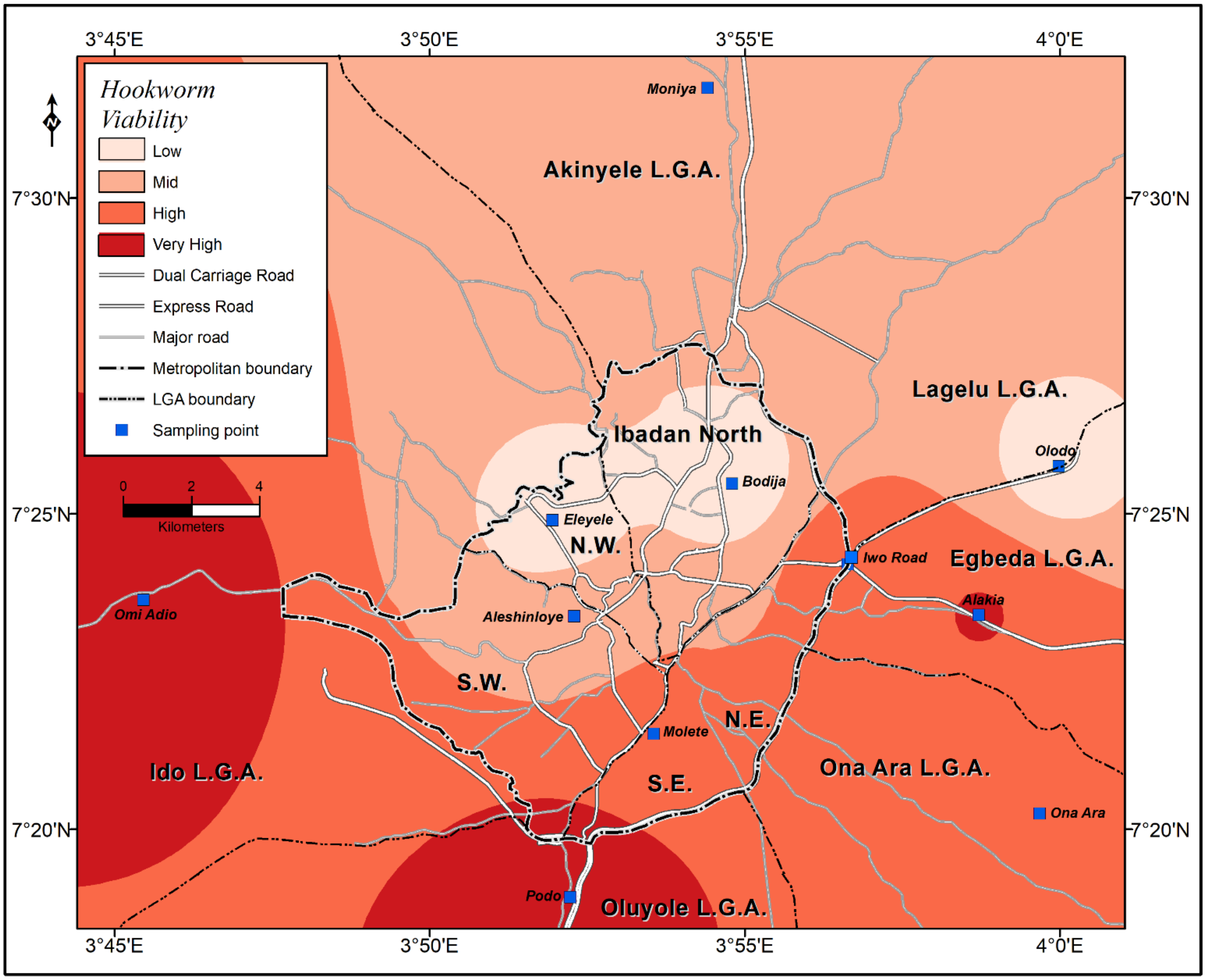

Figure 4.41: Viability of hookworm *eggs* across the sampling locations

4.7.4 The viability of Strongyloides eggs across the LGAs in Ibadan

Figure 4.42 shows the viability of *Strongyloides* eggs across the LGAs in Ibadan. The egg viability spread among the sample populations shows that many of the study locations had extremely low to below medium prevalence spread. Meanwhile, Ona Ara, Ibadan NE, Ibadan WE, and Oluyole LGAs had between very high and moderated viability of Strongyloides eggs when compared with other locations like Akinyele, Ibadan N, Ibadan SW, Ibadan NE, Egbeda, Lagelu, and Ido LGAs.

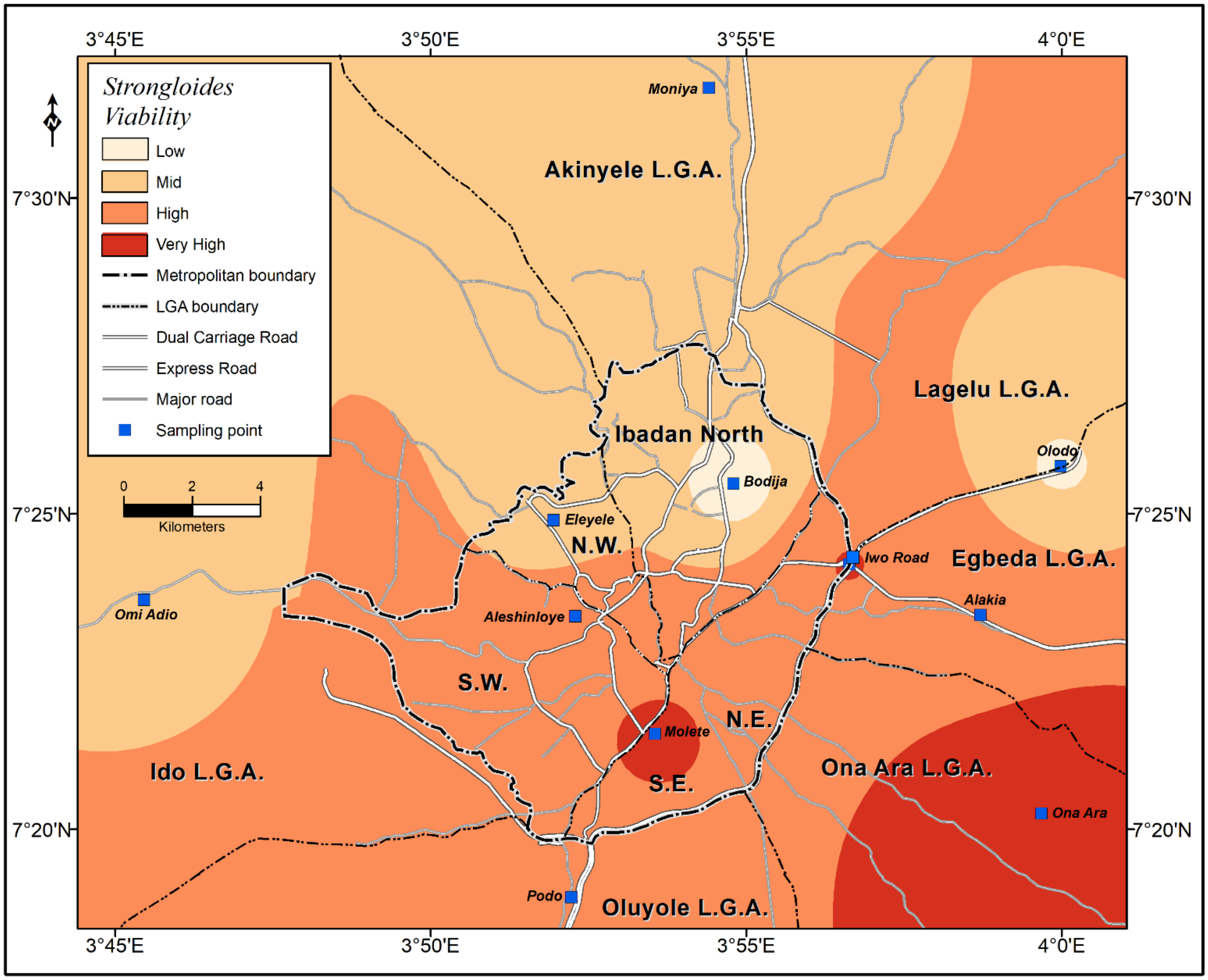

Figure 4.42: Viability of *Strongyloides* eggs across the sampling locations

CHAPTER FIVE

DISCUSSION

5.1 Soil-transmitted helminths encountered

Soil-transmitted helminths are parasites that cause the disease helminthiasis, and the following parasites are the cause of the disease; *Ascaris*, *Trichuris*, hookworm (*Necator americanus* and *Ancylostoma duodenale*), and *Strongyloides*. According to Ekpo *et al*. (2008) and Strunz *et al*. (2013), these parasites still exist and thrive in environments with poor hygiene standards, such as those with poor environmental sanitation, unsafe drinking water sources, insufficient toilet facilities, inadequate faecal disposal means, poverty, as well as low household earnings. In the present study, STH encountered included hookworm, *Strongyloides*, and *Ascaris* in the soil samples and *Ascaris*, *Trichuris*, hookworm, and *Strongyloides* in human faecal samples.

5.2 Relating drug usage to STH intensity and viability of eggs/ova

Currently, there is a global obligation for the elimination and control of NTDs (Onchocerciasis, Schistosomiasis, STH, Lymphatic filariasis (LF), and Tacoma) by the year 2025 to achieve this aim, it is necessary to mobilize resources including funding for NTDs like the Preventive Chemotherapy and Transmission (PCT) for controlling NTDs in every endemic nation which includes Nigeria (Bergquist *et al*., 2015). There has been the implementation of MDA for LF and onchocerciasis control and elimination in Nigeria since the year 2000, nevertheless, the implementation control activities for STH nationwide have been limited to some states. Not all of Nigeria's endemic villages have begun STH MDA control. Ivermectin, a medication used to treat onchocerciasis, has been proven to be very effective against the STH parasite, and albendazole, which is given along with ivermectin to treat LF, is a medication that the WHO recommends for managing STH (Moncayo *et al.*, 2008; WHO, 2016). Therefore, it is expected that the effects of morbidity resulting from the STH burden will be reduced in communities with ongoing onchocerciasis or LF (WHO, 2016). However, the high prevalence (54.9% and 39.5%) recorded on soil and faecal sample respectively coupled with a high rate of transmission stage viability confirmed the persistent nature of transmission in spite of the heavy drug use and availability.

According to Uga et al. (1997), soil is the most direct predictor of risk for infections caused by soil-transmitted helminths, and the present study's high STH contamination of 54.9% in soil is a sign of the high-risk status of the Ibadan metropolis environment because contaminated soil acts as a continuous pathway for human infection. Similar results were stated in Abuja by Mohammed *et al.* (2011) with an overall prevalence of 68.1% and Ogbolu *et al.* (2011) reported an overall lower prevalence of 55.9% in 5 of the LGAs under investigation in Ibadan, although this current study was conducted in all the eleven LGAs in Ibadan. The significantly varied prevalence (47.4% to 55.1%) and intensity (21.8 ± 6.1 epg/lpg to 309.1 ± 41.4 epg/lpg) found in the sample locations within the study area might however be credited to variations in the personal sanitary behaviours, level of development of the area, and prevailing environmental factors.

The high amount of parasite contamination in the study locations (toilet areas, dumpsites, playgrounds, and roadsides) will provide a constant channel for transmission. In dumpsites, high parasite occurrence was observed, which was found to be similar to the previous findings in Ibadan reported by Hassan *et al.* (2017) and Oyebamiji *et al*. (2018). The resulting high level of STH contamination of soil in dumpsites could be a result of human and animal defaecation at the site. A good toilet facility is lacking in many homes around the sampling locations except for some with pit latrines and a few homes with water closet toilet facilities. While some individuals frequently defaecate in polythene bags and toss them into the dumpsite as a habit known as "shot—putting," others frequently do it in open bushes near the dumpsites. According to Ojurongbe *et al*. (2014) and Oyebamiji *et al.* (2018), children defaecating while on playgrounds may be the cause of soil contamination in the play area. Because they frequently pick up objects off the ground, go barefoot (particularly when playing), and simultaneously bite or suck their nails, youngsters are more likely to develop a chronic infection. As stated by WHO (2016), children are found to be the utmost susceptible age groups to soil-helminthic infection.

The fact that most people who use pit latrines defaecate at the back and sides of the toilet contribute to the high prevalence of parasites in toilet locations. According to a report by some authors (Ziegelbauer *et al.,* 2012), adequate sanitation facilities do protect against STH infections where they found that many households having functional toilet provisions had a lower STH prevalence when compared to those who had inadequate toilet facilities. The households' vicinities had a low level of STH soil contamination when compared with other sites, this might be due to the actuality that house yards are regularly swept by inhabitants. However, the little contamination might somehow be ascribed to the fact that some people farm around their houses and some do keep either domestic or farm animals. Those with domestic animals allowed those animals to roam freely, and as such littered faeces around the house vicinity which could lead to zoonotic infections. Animals also roamed around the shops, and this could be the reason for parasite contamination in these areas. A significant proportion of study participants confirmed that they had pets which include cats and dogs at home, while other participants reported keeping animals such as turkeys, chickens, and goats at home.

Most female traders also allowed their little children and toddlers to defaecate around the house and shops, after which they cleaned them up with water in the same location. These factors will increase the level of contamination of soil, which can lead to an increase in the rate of transmission. Walking barefoot in these contaminated areas will increase the prevalence of hookworm infection. Also, parasite eggs can be deposited on foodstuffs by coprophagous insects. Heavy rainfall can wash off the eggs/larvae into wells and rivers used for domestic activities.

This study examined the prevalence and intensity of STH and correlated it with parasitic infection among the human population living in the eleven different LGAs in the Ibadan metropolis. The incidence of intestinal helminthiases and asymptomatic malaria co-infection among children residing in a few chosen rural communities in Ibadan was reported by Oyebamiji *et al.* (2018). Their findings were consistent with the overall frequency of 35.9% found in this study. Whereas Just like the previous report on the prevalence rate of STH in faecal samples collected from participants in the Southwestern regions, other parts of Nigeria, and many tropical regions with helminth infections, *Ascaris* was found to dominate in all the LGAs in the study area. However, there was a twist to the prevalence of other STHs as it was seen from this current study that hookworm had a higher prevalence among participants than the usual *Trichuris*. This may be due to the fact that there was the highest occurrence of hookworm in the study environmental matrix, and also favourable climatic conditions aid the production of viable infective larva stage of the parasite. This higher hookworm prevalence than *Trichuris* was also reported by Ugboimoiko *et al.* (2007), in which out of 489 faecal samples collected from school children in Oba Ile, 76.9% had *Ascaris*, 54.6% had hookworm while 29.2% had *Trichuris*. Also from the study reported by Ojurongbe *et al.* (2014), out of all the faecal samples examined in Ile-Ife, none of the samples had *Trichuris*.

Furthermore, when the prevalence of STH parasites across the sampling locations, STH prevalence was shown to be greater in rural and semi-urban areas when compared with the urban settings like IBN, IBNW, IBSW, IBSE, and IBNE LGAs. Also, Ona Ara, one of the semi-urban areas may be considered the highest ‘hotspot’ for STH transmission. Many of the participants had the highest multiple infections for both *Ascaris* and hookworm in the study area, this might be attributed to the fact that these STH parasites have the ability to manipulate their way in the environment by either arresting their development or tolerance level in the soil which later pave way for infective stages of the parasites for human infection.

5.3 Impact of climatic variations on intensity and prevalence of STH infections

For each of the stages of STH lifecycles outside the human host, there are climatic thresholds for both the development and growth of the STH parasites (Weaver *et al*., 2010). And these other conditions can change the infectivity of the parasite to positive or negative. Because the growth of parasitic stages in the soil is influenced by various parameters such as temperature, relative humidity, pH, soil texture, and annual rainfall, the high number of positive samples found in this study could be linked to ideal environmental and climate circumstances (Amadi and Uttah, 2010). These environmental factors may have an impact on development by speeding up embryonation and infectivity. The high prevalence of parasitic forms of the STHs was a result of their unique ability to withstand some environmental hazards. Looking at Central Africa, hookworms appeared to have a higher survival threshold exceeding 40–47^{0}C, in contrast to either *T. trichiura* or *A. lumbricoides* which could not survive wherever the mean land surface temperatures exceed 37^{0}C –40^{0}C

(Weaver *et al*., 2010). In Cameroon, rainfall surpassing 1500 mm per year resulted in *T. trichiura* and *A. lumbricoides* occurrences of more than 50% (Weaver *et al*., 2010). This information proposes that all species are in a way susceptible to an increasing temperature, while hookworms on the other hand are seemingly more susceptible to growing desiccation (Brooker *et al.*, 2006). Hookworm L3 can, however, find acceptable soil microhabitats in deeper levels of the soil to compensate for poor conditions experienced at the ground level. Eventhough the study area's average monthly rainfall of 55mm, average temperature of 23.8°C ±0.7, and moderate mean relative humidity of 60.6 ±26.7% further aid in the development of parasite infective stages. Because hookworm eggs are resistant to the environment and can live in the soil for three weeks while remaining infective (Amadi and Uttah, 2010), there was a significant abundance of hookworm in the examined regions, which can be explained as previously indicated.

The maximum number of parasites per gram of soil was noted in March (486 epg) when the relative humidity was about 86.0%, but the occurrence was high throughout the sampling period. According to Hotez *et al*. (2003), *Ascaris* eggs increase their survival rate as the soil depth increases. Deeper soil provides STH eggs with protection from direct sunlight and provides higher humidity. Despite the start of the dry season in November, the soil was found to nonetheless sustained the emergence of parasites with a prevalence of 60.6% and a soil strength of 388 epg. Higher soil contamination rates during the wet season correspond to other research findings (Ogbolu *et al*., 2011). During the investigation, several embryonated helminth eggs with larvae were discovered, implying that the study area's environmental conditions generated viable eggs for transmission. This is evidence that active transmission is taking place. The transfer of an infection that makes patients more susceptible to intestinal parasite infections may be facilitated by the rainy season. Untreated faeces are flushed into nearby streams and open sewers, both of which are common in these areas. This can lead to bacterial contamination of drinking water, increasing the risk of infection among residents in the communities at large.

5.4 Influence of intrinsic factors (human behaviour, socio-economic factors)

A large proportion of the inhabitants know about parasitic worms, but they do not know how to avoid the infection. A small proportion of the respondents (teachers and civil servants with HND or BSc. Degrees) indicated that suitable drinking water as well as a healthy environment can help in preventing STH infection. This implies that educational status may influence the transmission of STH. Also, a greater proportion of the study participants do not have knowledge of how STH infection can be prevented. It can be said that the inhabitants of these communities had shallow knowledge about the transmission of STH infection, and this ignorance puts them in a position of getting infected easily. Onuoha (2009) and Adekeye *et al.* (2016) described comparable results in their respective studies.

The questionnaire survey also revealed that most of the inhabitants do not drink good water, as a significant proportion of the study participants drank well water. Studies have reported that the source of drinking water is a major vehicle for parasite transmission. In a study carried out by Onuoha, (2009) in Enugu to evaluate the patterns of occurrence, transmission, as well as intensity of STH diseases, it was reported that people who drank bottled or ‘sachet’ water were less infected, followed by people that drank pipe-borne water. To avoid contamination, drinking water must be carefully maintained and treated. Because most of the respondents drank water from open wells that were not adequately constructed, predisposes residents to STH infections. According to Onuoha (2009), some individuals who took well water, particularly during the rainy season experienced a higher frequency of soil-helminthic infections than people who drank water from ‘sachets’. This could be because rains washed parasites into these wells during rainfall. Additionally, the area directly beneath the wall is frequently occupied by a fetcher that is used to take water from wells. From the ground, it is returned again into a well having not been properly washed. This could contaminate the whole well and can also serve as a source of parasitic infection. Faecal contamination of drinking water, according to Mbae *et al.* (2013), could enhance the population's risk of parasite infection.

According to Campbell *et al.* (2017), the degree of *Ascaris* infection increases with increasing valley runoff and drainage following rainfall. Downhill-washed *Ascaris* eggs can be carried away in rivers, streams, or open or badly built wells, according to Brooker and Micheal (2000) and Oyebamiji *et al*. (2018). Therefore, it is of great distress that a greater number of the participants disclosed frequently drinking well water. Anthelminthic single-handedly might not be adequate for STH elimination or control in this study's locations, because the accessibility of potable drinking water can only lead to reinfection after treatment.

Furthermore, numerous findings on the infections of STH have found that toilet habits have an effect on the rate of STH infection (Gyawali *et al.,* 2013; Hassan *et al.,* 2017). A huge proportion of the study participants made use of pit latrines, a few had water closets, while some admitted to defaecating in the bush close to their houses. On the other hand, in view of the extraordinary amount of soil contamination, this lower proportion of individuals who defaecate bushes may be incorrect for the reason that many persons are often ashamed to divulge that they defaecate outside. Adults were the majority of those who defecated in the bush. A good number of people do not often wash their hands whenever they return home after defaecating in the wild. Also, do not clean themselves after excrement by going to the bushes with tissue paper or water.

Some adults usually make use of nearby waste papers or leaves for cleansing after defaecations. These are not proper anal cleansing materials, and they are not hygienic. Despite this, the majority of respondents said they always cleaned their hands after using the restroom with tissue or water, and only a small number said they never did. Persons who had or used a toilet were half as prone to be infested with soil helminthiasis as those who did not have or did not use a toilet, according to Ziegelbauer *et al*. (2012). As a result, providing access to sanitary facilities and facilitating their use is an effective means of controlling soil-transmitted disease (Zelgelbauer *et al*., 2012). In many rural and suburban environments (e.g., Ona Ara), STH management strategies need to focus on the knowledge of people about STH transmission, attitude and practicing proper hygiene. The combination of proper hygiene and preventive chemotherapy and health education on STH disease will greatly help control soil helminth infections in this community.

Furthermore, hand-washing after defaecation and immediately before eating has been found to be linked with significantly lower probabilities of infection with any STH (Stunz *et al*., 2014) since the ova of STH are transmitted orally. One of the main ways to become infected is by hand-to-mouth transmission of STH eggs; people who were found not regularly washing their hands frequently with water alongside soap have a higher propensity to consume helminth eggs. A big proportion of the population just washed their hands with water before eating, while a smaller proportion washed their hands with soap and water. Less people said they forget to cleanse their hands afterward before eating because they are hungry. Xu *et al.* (2001), Ogbolu *et al.* (2009), Bieri *et al.* (2013), and Gyorkos *et al.* (2013) have found evidence that improved handwashing with soap can lead to lower STH infection compared to the use of water-only. Looking at reports of Birrie *et al*., (1998), soap is said to be toxic to STHs and may protect against infection.

Asides from hand washing, another risk factor is the habit of biting or sucking nails. A vast amount of respondents indicated they had never bitten or sucked their fingernails, while a tiny fraction said they always sucked their nails, with children and young teenagers accounting for the majority of the respondents. This could account for one of the reasons why they are the worst hit in STH infection. The result also revealed that most of the inhabitants walked barefooted around the house, and the children interviewed stated that they do not put on footwear while playing football or other outdoor games. Hookworm is transmitted by direct skin exposure to soil containing third-stage infective filariform larvae. Thus, those who expose their feet to soil stand a greater risk of hookworm infection. In view of the high level of STH soil contamination in playgrounds and the fact that the children play on this soil and some adults play football without footwear, the infection rate of hookworm might be high among these populations. The kind of flooring used in the home is an additional risk factor for soil helminth infections. According to reports by Oyebamiji *et al.* (2018) and Oyebamiji and Hassan (2021), concrete floor types have been shown to decrease the frequency of STH infections when paired with anthelmintics.

The occurrence of STH infection was shown to be higher among residents of homes with unfinished floor types (Worrell *et al*., 2016). There is minimal confirmation to substantiate this association between *A. lumbricoides* and *T. tricuira*, despite the fact that unfinished floors have been thought to be linked to hookworm infection over time (Pullan *et al.*, 2010; Soares Magalhaes *et al.*, 2011). According to Worrell *et al*. (2016), uncompleted floor types might be more challenging during cleaning, which can lead to an accumulation of different pathogens, and such floors can easily aerosolize these pathogens, which might lead to the contamination of the household setting. In this study, a larger proportion of the population

said they lived in concrete houses, while a small proportion said they lived in mud houses which could expose them to STH infection, especially hookworm larvae.
Finally, the history of deworming as well as the health centers' closeness to the individuals living in a community has been found to have an impact on the infection rate of soil helminths as reported by Oyebamiji *et al.* (2018). The majority of the participants in this study may not have established when they last dewormed, a greater proportion affirmed that they had never dewormed before, however, a small fraction acknowledged that they dewormed some months earlier.

Those who dewormed months and years ago were however not able to establish the kind of anthelminthic drugs they used. They stated different drugs ranging from anti-malarial drugs, paracetamol, and to the local herb known in the community as ‘Agbo Jedi’. It could perhaps be probable that the drugs endorsed by World health Organisation for treating STH infections (albendazole 400mg, mebendazole 500mg. pyrantel 10mg/kg, and levamisole 2.5mg/kg) are not known by the inhabitants of this community. The herbal mixture (Agbo Jedi) is a combination of herbs and concoctions utilized by the majority of Nigerians, particularly the Yoruba people. The majority of people said they used this herb to deworm themselves. But there was no proof that ‘Agbo Jedi’ was effective in deworming.

Eighty percent of Africans, according to WHO, utilize traditional medicinal herbs for primary health care generally as they think that it does work more quickly than popular conventional pharmaceuticals and are far less expensive (WHO, 2017). Mass deworming and target deworming can be used for the control of STH transmission. Mass deworming is intended for areas with a fairly high prevalence of the infections (WHO, 2017), while targeted deworming is often focused on at-risk populations, especially school-aged children (5-14 years), young children (12-23 months), preschool children (1-4 years), women of children bearing age (including pregnant women in second and third trimesters and breastfeeding women), and adults in certain high-risk occupations like mining (WHO, 2017).

According to a meta-analysis of 2,000 studies, albendazole was successful in reducing the occurrence of all 3 (three) soil helminths, albeit it was more effective for ascariasis than for trichuriasis or hookworm infection (Benneth and Guyatt, 2000). However, recent findings from modeling studies suggest that deworming campaigns should be expanded community-wide for effective control of STH transmission (Clarke *et al.,* 2017). It is widely believed that water, sanitation, and hygiene development with anthelminthic medicine could break STH transmission cycles in settings where anthelminthic alone are insufficient (Campbell *et al.,* 2017).

5. 5 Species specific prevalence and intensity of infection in sampling areas

The soil-transmitted parasite that was observed in this investigation had a clustered geographic distribution pattern. Although at varying prevalence rates, the risk of parasitic infection for hookworm, *Strongyloides, Trichuris,* and *Ascaris* was prevalent everywhere around the sampled locations, suggesting that human populations residing in these areas are more prone to contract any or all of these parasites. When compared to the other eleven LGAs, the distribution maps for all the parasites demonstrate that Ona Ara consistently had a higher prevalence of STHs, which qualifies the LGA as a "hotspot" location for STH transmission. Areas like this are a result of being a rural community, many people living in this place are predominantly farmers, and this may be due to the high prevalence recorded for the location. Furthermore, special attention is needed for this location in respect of health education on parasite transmission and proper hygiene as most of the individuals in the area were seen walking barefooted, provision of adequate water, and course twice a year administration of anthelminthic drugs.

In the urban locations comprising Ibadan North, Ibadan Northeast, Ibadan Northwest, Ibadan Southwest, and Ibadan Southeast, apart from Ibadan Southwest and Ibadan Southeast that had a distribution of STH parasites between moderate and high, other Local Governments alternate between the low and moderate parasite distribution. Unlike the other LGAs (Akinyele, Oluyole, Lagelu, Ido, Egbeda, and Ona Ara) that had a predominantly moderate, extremely high, and very high prevalence of STH parasites. As was evident throughout the sample times, the majority of these rural areas lack basic sanitary amenities, while many residents regularly perform defaecation in the open. The outcome of the spatial distribution of parasites in this study poses a threat as contact between infectious and susceptible individuals cannot be ruled out. The somehow predictive spatial disseminate of the infection in the areas will assist in planning targeted control and intervention programmes.

CHAPTER SIX

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

6.1 Summary

Soil-transmitted helminth infection is a common public health problem in developing and low-income nations like Nigeria. According to the WHO guidelines, a population with a prevalence of 50% or more should be given drugs twice a year while a population with less than 50 is given drugs once a year. Many studies on STH infections are carried out mostly among school-age children because of easy accessibility and their vulnerability and also most rely on stool investigation. However, infected adults, climatic factors, environmental pollution with refuse, human waste, and occasional leakage of sewage pipes may contribute to the prevalence of STH infections in many areas. Therefore, this study was carried out to determine the influence of personal hygiene, climatic variations, and drug use on the current prevalence and intensity of STHs in soil and faecal samples in the Ibadan metropolis.

About 100g of soil samples (1980) were collected randomly at a depth of 2-3cm from five sampling sites (toilets, dumpsites, playgrounds, roadsides, and house vicinities) in eleven Local Government Areas (LGAs); Ibadan South East (ISE), South West (ISW), North East (INE), North West (INW), Ibadan North (IN), Akinyele (A), Ido (I), Lagelu (L), Egbeda (E), Oluyole (O) and Ona Ara (OA), between January 2017 and December 2018. Additionally, 1100 faecal samples were obtained from volunteers who visited Primary Health Centres in the LGAs. Prevalence (%) of parasites in soil and faecal samples and egg load per gram (epg) of faeces were determined using standard parasitological techniques. Temperature, Rainfall, and Relative humidity data were obtained through the Nigerian Meteorological Agency. Study questionnaires were also administered to agreeing on participants in order to acquire the necessary information on types of toilet facilities in use, hand washing habits, and frequency of drug usage among the study population. Statistical data analysis was carried out using descriptive, regression, PCA, and ANOVA at $\alpha_{0.05}$.

A total of 1087 (54.9%) of soil samples examined were contaminated with at least one STH parasite. Parasite species comprised hookworms' larvae (35.9%), *Strongyloides* larvae (26.8%), *Strongyloides* adult (19.9%), and *Ascaris* eggs (13.4%). Prevalence by LGAs ranged from 47.4 at IN to 55.1 at L. Dumpsite had the highest (35%) while house vicinity had the least (2%) parasite prevalence. A total of 395 (39.5%) examined faecal samples contained at least one parasite. Parasite-specific prevalence was 41.6, 24.5, 23.5, and 10.1 for *Ascaris*, hookworm, *Trichuris,* as well as *Strongyloides* in that order. Intensities were 265, 235, 229, 219, 219, 203, 186, 164, 136, 124, and 112 for OA, INE, ISE, I, O, E, L, ISW, A, INW, and IN LGAs respectively. The prevalence of parasites correlated positively with temperature and relative humidity (r=0.75), while intensity and all climatic variables were negatively correlated (r^2= -0.98). Ibadan North sampled populations were found to have the highest drug usage with the least intensity of infection when compared to other LGAs, and the correlation variation (r^2=0.94, $p \leq 0.05$) between intensities and drug usage across the sampling locations was significant. About 57.0% of respondents use pit-latrine, 20.6% have water-closet facilities, and 22.4% still practice open defaecation ($\chi2$=54.09, $p<0.05$). Approximately 68.7% of respondents rinsed their hands after using the toilet, 21.9% used soap and water and 9.2% do not use either water or soap after defecating ($\chi2$=124.28, $p<0.05$).

A substantial risk of reinfection exists in the research area even after treatment due to the high contamination of the soil samples that were found in the study, as well as the large number of respondents who had an insufficient understanding of how to prevent STH transmission. As a result, the metropolitan has to be properly educated about parasite transmission.

6.2 Conclusion

STH has infected more than a billion individuals worldwide. Tropical and subtropical climates are where the parasites are most prevalent, and in underdeveloped nations due to poor sanitation, insufficient access to clean water, and poor or nonexistent personal hygiene. Similarly, the study area especially in the rural and semi-urban settings, such as Ona Ara, Lagelu, Ido, Akinyele, and Egbeda had poor access to clean water, sanitation, and hygiene. This explains why soil contamination with helminth parasites is so high. It is also clear that the study area's high amount of rainfall, with the combination of lack of parasite transmission awareness, and personal hygiene, including the long survival of helminth eggs and larvae in the soil, creates a fertile environment for STH transmission. Unfortunately, environmental variables such as rainfall, temperature, and relative humidity cannot be modified, but risks can be managed by creating awareness and improving personal hygiene and sanitation practices. In the Ibadan metropolis, anthelminthic administration will not achieve the desired goal of control of soil-transmitted helminths unless it is backed up with the provision of basic amenities like pipe-borne water, good toilets, and public awareness of STH infection which is absent or inadequate. If these procedures are not added to the mass treatment of the populace, reinfection will be inevitable.

Unexpectedly, *Trichuris*, one of the major STHs was not found in the soil samples and the prevalence in faecal samples has reduced during this present study probably due to socio-economy, climate change, or drug use. This suggests further investigation into the possibility of existing conditions for the development as well as survival of *Trichuris* species in the soil, just as Ogbolu *et al.* (2011) also working with soil samples reported low prevalence rates of *Trichuris*. Ojurongbe *et al.* (2014) also reported a lower rate of *Trichuris* from faecal samples collected from school children in Osun State. Furthermore, attention needs to be given to Strongyloides like other main STH parasites because it has been shown from this study that the parasites are beginning to be established or emerge both in the soil and faecal examination.

6.3 Recommendations

Recommendations are therefore made as follows:

- Every age group living in the Ibadan metropolis should be dewormed at least once a year in line with WHO proposals to deworm the entire population once a year when STH infections are greater less than or equal to 50%
- Adequate public toilet facilities with an adequate supply of water should be provided in many of the hotspot locations in form of the WASH programme
- Ministry of Health should endeavour to routinely monitor the status of STHs in the metropolis to know when drug intervention should be carried out.

- Children should be encouraged to wear shoes or sandals at all times (except for some religious rights).
- Playing with soil or picking food from the soil should be discouraged via proper regular health talks from the health sector.

6.4 Contributions to the knowledge

From the current study, the following listed are some of the contributions made:

- The study has provided evidence that there is still transmission of STH infection in the entire Ibadan metropolis despite the deworming campaign going on for school-aged children
- Hotspots of STH infection in the study area require twice-a-year drug treatments.
- The practice of open defecation is still high despite the effort of the government to eliminate the act in the year 2020.
- The development of risk maps on the prevalence of STH in the study will help decision makers in the state to take a proactive step in controlling the transmission of the disease.
- Unlike the normal trend of STH prevalence, hookworm and *Strongyloides* are becoming relevant both in the soil environment and in human subjects. The observed trend in the pattern of STH prevalence has shown that hookworm and *Strongyloides* are emerging at par with *Ascaris* with public health concerns.
- Lastly, there is a need to increase access to drug therapy to all other age groups with the current school-age children under the mass deworming program

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APPENDIX I

TELEGRAMS................ TELEPHONE................

OYO STATE: THE PACESETTER

MINISTRY OF HEALTH

DEPARTMENT OF PLANNING, RESEARCH & STATISTICS DIVISION

PRIVATE MAIL BAG NO. 5027, OYO STATE OF NIGERIA

Your Ref. No. ....

All communications should be addressed to the Honorable Commissioner quoting

Our Ref. No. AD 13/479/601

16th November, 2017

The Principal Investigator,
Department of Zoology,
Faculty of Science,
University of Ibadan,
Ibadan.

Attention David Anuoluwapo

ETHICAL APPROVAL FOR THE IMPLEMENTATION OF YOUR RESEARCH PROPOSAL IN OYO STATE

This is to acknowledge that your Research Proposal titled: "Molecular Epidemiology of Soil Transmitted Helminths in Ibadan, South-Western Nigeria" has been reviewed by the Oyo State Ethical Review Committee.

2. The committee has noted your compliance. In the light of this, I am pleased to convey to you the full approval by the committee for the implementation of the Research Proposal in Oyo State, Nigeria.

3. Please note that the National Code for Health Research Ethics requires you to comply with all institutional guidelines, rules and regulations, in line with this, the Committee will monitor closely and follow up the implementation of the research study. However, the Ministry of Health would like to have a copy of the results and conclusions of findings as this will help in policy making in the health sector.

4. Wishing you all the best.

Dr. Abbas Gbolahan
Director, Planning, Research & Statistics
Secretary, Oyo State, Research Ethical Review Committee

APPENDIX II

INSTITUTE FOR ADVANCED MEDICAL RESEARCH AND TRAINING (IAMRAT)
College of Medicine, University of Ibadan

Director: Prof. IkeOluwapo O. Ajayi,
MBBS (Ib), M. Cl.Sc., Ph.D, MD, FMCGP, FWACP
Tel: 08023268431
E-mail: ikeajayi2003@yahoo.com

UI/UCH EC Registration Number: **NHREC/05/01/2008a**

NOTICE OF FULL APPROVAL AFTER FULL COMMITTEE REVIEW

Re: Epidemiological Status and Molecular Identification of Soil-Transmitted Helminths in Ibadan, South-Western Nigeria

UI/UCH Ethics Committee assigned number: UI/EC/21/0711
Name of Principal Investigator: **David A. Oyebamiji**
Address of Principal Investigator: Department of Zoology
University of Ibadan, Ibadan

Date of receipt of valid application: 23/11/2021

Date of meeting when final determination on ethical approval was made: **N/A**

This is to inform you that the research described in the submitted protocol, the consent forms, and other participant information materials have been reviewed and *given full approval by the UI/UCH Ethics Committee.*

This approval dates from **04/03/2022 to 03/03/2023.** If there is delay in starting the research, please inform the UI/UCH Ethics Committee so that the dates of approval can be adjusted accordingly. Note that no participant accrual or activity related to this research may be conducted outside of these dates. *All informed consent forms used in this study must carry the* UI/UCH EC *assigned number and duration of* UI/UCH EC *approval of the study.* It is expected that you submit your annual report as well as an annual request for the project renewal to the UI/UCH EC at least four weeks before the expiration of this approval in order to avoid disruption of your research.

The National Code for Health Research Ethics requires you to comply with all institutional guidelines, rules and regulations and with the tenets of the Code including ensuring that all adverse events are reported promptly to the UI/UCH EC. *No changes are permitted in the research without prior approval by the* UI/UCH EC *except in circumstances outlined in the Code. The* UI/UCH EC *reserves the right to conduct compliance visit to your research site without previous notification.*

UI/UCH EC
04 MAR 2022
APPROVED
COLLEGE OF MEDICINE

Professor IkeOluwapo O. Ajayi
Director, IAMRAT
Chairperson, UI/UCH Research Ethics Committee
E-mail: uiuchec@gmail.com

APPENDIX III

INFORMED CONSENT FORM

TITLE: EPIDEMIOLOGY STATUS OF SOIL-TRANSMITTED HELMINTH INFECTIONS IN IBADAN, SOUTH-WESTERN NIGERIA

Names and Affiliation of Reseracher: Oyebamiji David Anuoluwapo, Department of Zoology, University of Ibadan, under the supervision of Professor Adesola A. Hassan, Department of Zoology, University of Ibadan.

Sponsor of research: Self

Purpose of research: This study is designed to determine the status of STH from soil and stool samples and its human and environmental factors in all the 11 LGAs of Ibadan. (This is towards the award of Ph.D. in Zoology, Parasitology option).

Procedure of research: Soil samples will be collected from various LGAs and questionnaires will be self-administered to the willing literate participant and non-illiterate will be interviewed in their local language in the areas. Stool samples will be collected. Both the soil and stool samples will be examined for parasite eggs and/or larvae. The result obtained from participant will be kept confidential.

Expected duration of research and of participants' involvement: The study will begin as soon as approval is granted by the ethical committee. Everyone who takes part will have their stools sampled just once. Soil samples will be taken once in two months for 24 months. Laboratory analysis and interpretation of result will be done as samples are been collected.

Risks: There is no risk involved in this study.

Benefit: This study will educate the participants on the transmission patterns of the disease and their control measures. Also it will help in getting the demographic and health condition of people in Ibadan in terms of STH and proper intervention by the government whereby infected areas will get Mass Drug Administration.

Confidentiality: The questionnaire to be administered to participants will be coded numbers, which will be employed in the processing of samples, screening and analysis of result. Personal information provided will remain confidential and will not be used in any publication or report in this study. Records will be confidential.

Voluntariness: Participation in this study is entirely voluntary, and therefore patients reserve the right to withdraw from the study at any time without prior notice or giving a reason for such decision. Such participant will not be denied any benefit that may arise as a result of the study.

Due inducement: There is no monetary or material compensation.

What happens to research participants and communities when the research is over: After the study is completed study participants can get their result from the principal investigator. The state ministry of health will be informed about the result of the study and proper step will be taken about the result.

Statement of person obtaining given consent:

The research's description has been read by me, and I either had it translated into a language I can comprehend. Also, I have discussed it to my satisfaction with the doctor. I am aware that I can choose not to participate. I am familiar enough with the research study's objectives, methodologies, risks, and rewards to decide whether or not I want to participate. I am aware that I can voluntarily opt out of this study at any time. I received a duplicate of this consent form and a supplementary information sheet, which I will keep for my records.

……………………………………….	……………………………
Signature/thumbprint of participant	Interview date
……………………………………….	…………………………….
Signature/thumbprint of witness (if require)	Date

APPENDIX IV

UNIVERSITY OF IBADAN, OYO STATE, NIGERIA

QUESTIONNAIRE DESIGNED FOR A SURVEY OF SOIL-TRANSMITTED HELMINTH INFECTION IN IBADAN, NIGERIA

The aim of this study is to investigate the prevalence, intensity and distribution pattern of soil transmitted helminths in Ibadan, Oyo State. I therefore appeal to you to fill this questionnaire with all honesty and sincerity. Any information given here shall be treated with utmost confidentiality.

No………………………..

LGA……….………………………………………..

Please answer as appropriate

DEMOGRAPHIC DATA

Sex: ☐ Male ☐ Female
Age: ☐ 0-10 ☐ 11-20 ☐ 21-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 1-70 ☐ -80
Religion: ……………………………………………………
Marital status: ☐ Married ☐ Single
Educational Qualification: ☐ Primary Sch. ☐ SCE ☐ D/NCE ☐ D/BSc Others; specify…………………………
Occupation………………………………………

PERCEPTION/KNOWLEDGE OF PARASITES

1.	Do you know what parasitic worms are? ☐ Yes ☐ No
2.	If yes, what types do you know? …………………………………………………………

	…………………………………………………………
3.	Do you know the effects worms can have on human health? ☐ Yes ☐ No ☐ Do not know
4.	How can one avoid getting infected? …………………………………………….……… ………………………………………………………..………………………
5.	How often do you receive treatment for worms' infection? ☐ Monthly ☐ Yearly ☐ Do not know

RISK FACTOR GROUP 1: HOUSEHOLD

6.	Community………………………………………. B- House address (street/sector/lot) ……………………… ☐ Do not know …………………………. C- Means of transportation to work? ☐ Okada ☐ Taxi ☐ Bus ☐ Other Specify……………………………. D- For how long does it take you to arrive at work (in minutes)? ……………………
7.	What type of house do you live in? ☐ Concrete house ☐ Mud house
8.	In your home, do you cook using kerosene, gas, firewood, or carbon? Gas ☐ Carbon ☐ Kerosene ☐ Firewood ☐ Other ☐ Do not know ☐
9.	A- Does your residence have a source of drinkable drinking water? ☐ Yes ☐ No Do not know ☐

	B- If no, where do you get water for your domestic activities? ☐ Neighbor's tap Tank River ☐ Public pool ☐ Well ☐ Water truck ☐ Other ☐ Don't know ☐
10.	What type of water do you drink? ☐ Treated tap water (boiled, filtered Directly from tap (untreated) ☐ ☐ Others Specify……………………………..
11.	What type of toilet facilities do you have? ☐ Water closet ☐ Pit latrine ☐ Others, specify……………………………………….
12.	How many people are there in your household? Adult:……………………………… Children……………………………
13.	A-Do you have any animals? ☐ Yes ☐ No ☐ Do not know B- If yes, what kind of animal(s)? ☐ Dog ☐ Cat ☐ Other…………………… ☐ Not applicable ☐ Do not know C- If yes, do you allow them to stray? ☐ Yes ☐ No D-If yes, do you feed these animals? ☐ Yes ☐ No E-Do you provide Vet care for your animals? ☐ Yes ☐ No ☐ Not applicable

RISK FACTOR GROUP II: HYGIENE

14.	Do you use tissue paper or water to clean up after defecating - always, sometimes, or never? ☐ Always ☐ Sometimes ☐ Never ☐ Don't know
15.	How many times in a day, roughly, do you wash usually your hands? ……………………………………times/day Do you use a soap whenever you wash your hands – sometimes, always, or never? Always ☐ Sometimes ☐ Never ☐ Don't know ☐
16	How do you wash your hand? ☐ With soap and water ☐ With water only

17	Do you eat with your fingers? ☐ Always ☐ Sometimes ☐ Never ☐ Don't know
18.	A-Do you wash your hands before eating – always, sometimes or never? ☐ Always ☐ Sometimes ☐ Never ☐ Don't know C- Do you use a soap at all when washing your hands before eating – sometimes, always, or never? Always ☐ Sometimes ☐ Never ☐ Don't know ☐
19.	Do you have bath daily? Yes ☐ No ☐ B-If No, how many times do you bathe yourself? ....times/week
20.	Do you bite nails or suck fingers? – always, sometimes or never? Always ☐ Sometimes ☐ Never ☐ Don't know ☐

RISK FACTOR III: ACTIVITIES

21	A Are you in employment or self employed? ☐ Yes ☐ No ☐ Do not know B If yes, what do you do for living? Work …………………………………………… Not applicable ☐

RISK FACTOR GROUP IV: WEARING SHOES

22.	Do you go outside barefooted? – always, sometimes, or never? ☐ Always ☐ Sometimes ☐ Never ☐ Don't know
23.	When at home, do you wear slippers? ☐ Always ☐ Sometimes ☐ Never ☐ Don't know
24.	In what actions do you not put on shoes? Activity…………………………………. Always wears shoes ☐ Activity……………………………………..

RISK FACTOR GROUP V: THE USE OF HEALTH SERVICES

25.	How far is the health centre facility to your resident? ☐ About one-hour drive ☐ Walking distance ☐ few minutes by car ☐ Do not know
26.	In the previous year, how frequently did you get sick? …………………times
27.	How many times did you visit the hospital/clinic/traditional healer in the previous year for an arranged check-up, vaccinations or chemotherapy? ………………………………….times in last year

RISK FACTOR GROUP VI: RECORD OF DEWORMING

28.	A-Have you ever been given treatment (either modern or traditional medicine) for intestinal worms? ☐ Yes ☐ No ☐ Do not know B-If yes, what were you given? …………………………………… ☐ Not applicable C-If yes, when did you deworm last? ☐ Months ago ☐ Over one year ☐ Do not know ☐ Not applicable

APPENDIX V

UNIVERSITY OF IBADAN, OYO STATE, NIGERIA

ÌWÉ ÌBÉÈRÈ YÍÍ DÁ LÈ LÓRÍ ÌWÒYE ARÀN TÍ A LÈ KÓÓ NÍNÚ ERÙPÈ NÍ ÌLU ÌBÀDÀN, ÌPÍNLẸÈ ỌYỌ, GUSU IWỌ OÒRÙN ORÍLẸ ÈDÈ NAIJIRIA

Èróngbà ètò ẹkọ yii nílàti se ìwádìí lórí ipò, imọlara ati bi aràn inú erùpè se n tàn yíká ní ìlú ìbàdàn, Ipilẹ Ọyọ. Fún ìdíèyì, mo rọ yin ki ẹ bami dahun awọn ibeere wọnyi pẹlu gbogbo òtítọ ati inú funfun. Gbogbo ìdáhùn àti àwon oun tí ẹ dáhùn tó jẹtí ìdàkan ni yin ti ẹba fun wa niyoo jẹ oun àsírí tí a kónìpín pèlú enìkéni.

No………………………. Ìjọba Ìbílè…………………………..

Ẹ jọọ ẹ báwa fi ìdáhùnsi bí ó titọ.

ÌBÉÈRÈ NÍPA ARA ẸNI

Èdà èniyàn: ☐ Ọkùnrin ☐ Obìnrin
Ọjọ ori: ☐ 0-10 ☐ 11-20 ☐ 21-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 61-70 ☐ 71-80
Ẹsìn: ………………………………..
Ìbéèrè lóri ìbágbépọ lọkọláya: ☐ Mo ti se ìgbéyàwò ☐ Nkotí se ìgbéyàwò
Ipèle Ẹkọ tímokà: ☐ Iwe alákọbẹrẹ ☐ Ilé ìwé girama ☐ ND/NCE ☐ HND/BSc Àwon èkọ tó kù, ẹ kọọ sílẹ………………………
Isẹ sise:……………………………………………

IWOYE/ IMỌ NIPA KOKORO AJẸNIRU

1.	N jẹ o mọn nipa awon kokoro aran inu ara? ☐ Bẹẹni ☐ Bẹẹkọ
2.	Ti o bajẹ bẹẹni, iru ewo lo mọn? …………………………………………………………… ………………………………………………………………..
3.	N jẹ o mọn ipati aran nko ninu ilera eniyan? ☐ Bẹẹnii ☐ Bẹẹkọ ☐ Emi komọ
4.	Bawo ni eniyan se le see lati ma ko o? ………………………………………………… ……………………………………………………………

5.	Igba woni o ma ngba itọju tabi loo ogun lori aran? ☐ Osoosu ☐ Ọdọọdun ☐ Emi komọọ

ONFA EWU IPELE KINI: TI INU ILE

6.	Agbegbe…………………………………… B- Adirẹẹsi Ile (adugbo/ abala/ayika)……………………… ☐ Emi komọ C- Ounelo fun irinajo lọ si ibiisẹ? ☐ Okada ☐ Taxi ☐ Ọkọ elero pupu ☐ Awon iyoku, ẹ kọọ silẹ…………………………………… D- Akoko woni ẹ ma n de ibiisẹ (niisẹju)? ------------------------------
7.	Iru ile wo ni ẹ n gbe? ☐ Ile oni simẹnti ☐ Ile alamọ
8.	N jẹ ẹ ma n lo eefin gasi, kẹrosini, eefin tabi ina igi lati da ina niile bi? ☐ Eefin gaasi ☐ Eefin ☐ kerosini ☐ Ina igi ☐ Omiran ☐ Emi komọ
9.	A- N jẹ ẹni omi ẹrọ ti o mọ gaara niile yin (omi ẹrọ)? ☐ Bẹẹni ☐ Bẹẹkọ ☐ Emi komọ B- Ti o bajẹ bẹẹkọ, niboni ẹ ti nri omi lo fun awon isẹ ile yin? ☐ Ero omi aladugbo yin ☐ Omi tio n san ☐ Omi adagun gbogbogbo ☐ Omi kanga ☐ Omi inu ọkọ ☐ Awọn iyoku ☐ Emi komọ
10	Iru omi wo ni ẹ n mu? ☐ Omi ẹrọ ti wọn se itọjurẹ (Nipa sise itoju ree) ☐ Taara lati ẹnu ẹrọ (eyiti koni itọju) ☐ Awọn iyoku, e kọ wọn silẹ........................
11.	Iru ile igbọnse wo ni ẹ nlo? ☐ Ile igbọnse igbalode ☐ Shalanga ☐ Awọn iyoku, ẹ kọọ won silẹ ………………..
12.	Àwon ènìyàn mélo ni ó ngbé inú ilé yín? Àgbàlagbà:………………………., Àwọn ọmọdé:………………………

13.	A- N jẹ ẹni ẹranko kankan niile bi? ☐ Bẹẹni ☐ Bẹẹkọ ☐ Emi komọ B- Ti o bajẹ bẹẹni, iru ẹranko woni? ☐ A☐ Olon☐ Awọn iyoku………. ☐ Eyiti kojọ arawọn ☐ Emi komọ C- Ti o bajẹ bẹẹni, n jẹwọn ma nrin kirii bi? ☐ Bẹẹni ☐ Bẹẹkọ D- Ti o bajẹ bẹẹni, njẹ ẹ ma nfun awọn ẹranko naa ni ounjẹ bi? ☐ ẹni ☐ kọ E- N jẹ ẹ ma n se eto iwosan igbalode fun awọn ẹranko yin? ☐ Bẹẹni ☐ Bẹẹkọ ☐ Eyiti ko baa lọ

O NFA EWU IPELE KEJI: IMỌTOTO

14.	N jẹ ẹ ma nlo tisu peepa tabi omi lati fi san ara lẹyinti ẹ ba se igbonse/iga tan- Nigba gbogbo, lẹkan ọọkan, tabi rara? ☐ Nigba gbogbo ☐ Lẹkọ ọkan ☐ Rara ☐ Emi komọ
15.	A- Igba melo ni ojumọ kan ni ẹ ma n fọọwọ? ------------------------------------igba melo/ọjọ B- N jẹ ẹ ma n lo ọsẹ fi fọọwọ yin- niigba gbogbo, ni ẹkọọ kan, tabi rara? ☐ Ni igba gbogbo ☐ Lẹkọọ kan ☐ Rara ☐ Emi komọ
16.	Bawo ni ẹ se ma n fọọwọ yin? ☐ Pẹlu omi ati ọsẹ ☐ Pẹlu omi nikan
17.	N jẹ ẹ ma n fi ọwọ jẹun bii? ☐ Ni igba gbogbo ☐ Lẹkọọ kan ☐ Rara ☐ Emi komọ
18.	A- N jẹ ẹ ma n fọọwọ yin ki ẹ to jẹun bii- niigba gbogbo, ni ẹkọọ kan, tabi rara? ☐ Ni igba gbogbo ☐ Lẹkọọ kan ☐ Rara ☐ Emi komọ B- N jẹ ẹ ma n fọọwọ pẹlu ọsẹ ki ẹ to ma jẹun bii- niigba gbogbo, ni ẹkọọ kan, tabi rara? ☐ Ni igba gbogbo ☐ Lẹkọọ kan ☐ Rara ☐ Emi komọ
19.	A- N jẹ ẹ ma nwẹ lojoojumọ bii? ☐ Bẹẹni ☐ Bẹẹkọ B- Ti o bajẹ bẹẹkọ, igba melo ni ẹ ma n wẹe ara yin?

	………………………… Igba/ Ọsẹ
20.	N jẹ ẹ ma n jẹe ekanna tabi mu ekanna bii? Niigba gbogbo, ni ẹkọọ kan, tabi rara? ☐ Ni igba gbogbo ☐ Lẹkọọ kan ☐ Rara ☐ Emi komọ

O NFA EWU IPELE KETA: ISẸ SISE

21	A- N jẹ ẹ nsisẹ fun eniyan tabi ẹ nsisẹ ti ara yin? ☐ Bẹẹni ☐ Bẹẹkọ B-Ti o bajẹ bẹẹni, iru isẹ wo ni ẹ n se? Isẹ ……………………………... ☐ Eyi ti ko baa lọ

O NFA EWU IPELE KERIN: BATA WIWỌ

22.	N jẹ ẹ ma n fi ẹse lasan rin bii? Niigba gbogbo, ni ẹkọọ kan, tabi rara? ☐ Ni igba gbogbo ☐ Lẹkọọ kan ☐ Rara ☐ Emi komọ
23.	Ti o bawa nile, igba wo gan ni ẹ ma n wọo bata? ☐ Ni igba gbogbo ☐ Lẹkọọ kan ☐ Rara ☐ Emi komọ
24	Iru awon isẹ sise wo ni ẹ ma n se ti ẹ kii fi wọbata? Isẹ sise .... ☐ Ni gbogbo igba ni mo ma n wọ bata Isẹsise...

O NFA EWU IPELE KARUN: LILO AWỌN ETO ILERA

25	Bawo ni ile iwosan alabọde ti ijọba se jinna si ile yin si? ☐ Irinajo wakati kan ☐ Irin ibusọ ☐ Irin ibusọ isẹju diẹ ☐ Isẹju diẹ pẹlu ọkọ ayọkẹlẹ ☐ Emi komọ
26.	Igba melo ni e se aisan ni Ọdun ti o kọja? .... Igba melo
27.	Igba melo ni ẹ lọsi ile iwosan/ile iwosan alabọde ti ijọba/onisegun ibilẹ ni ọdun ti o kọja fun ayẹwo lore koore, fun abẹrẹ ajẹsara, fun ayẹwo gbogbo ara patapata? .... igba melo ninu ọdun kan

O NFA EWU IPELE KEFA: ITAN LORI OGUN NIPA ARAN

28	A-N jẹ ẹ ti gba itọju ri lori aran (ti ibilẹ tabi ti igbalode ti oogun) fun awọn aran inu oofun? ☐ Bẹẹni ☐ Bẹẹkọ ☐ Emi komọ B- Ti o ba jẹ bẹni, kini oun ti wọn fun yin fun itọju? --------------------------------- ☐ Eyi ti ko baa lọ C- Ti o ba jẹ bẹni, igbawo ni ẹ lo oogun fun aran? ☐ Opọlọpọ osu sẹyin ☐ Lẹyin ọdun kan sẹyin ☐ Emi komọ ☐ Eyi ti ko baa lọ