PREVALENCE OF INTESTINAL PARASITES AMONG PRIMARY SCHOOL PUPULS IN IKPOBA HILL, ,BENIN CITY,EDO STATE.

BY

OSUJI REJOICE

BMS2001201

DEPARTMENT OF MEDICAL LABORATORY SCIENCE,

SCHOOL OF BASIC MEDICAL SCIENCES,

COLLEGE OF MEDICAL SCIENCES,

UNIVERSITY OF BENIN,

BENIN CITY

SUPERVISED BY:

DR.(MRS) . IFUEKO M. MOSES -OTUTU

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BEING A PROJECT SUBMITTED TO THE DEPARTMENT OF MEDICAL LABORATORY SCIENCE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR'S DEGREE IN MEDICAL LABORATORY SCIENCE (BMLS) UNIVERSITY OF BENIN,BENIN CITY, NIGERIA

SUPERVISED BY:

DR.(MRS) . IFUEKO M. MOSES -OTUTU

SEPTEMBER,2025

CERTIFICATION

This is to certify that this **research work** was satisfactorily carried out by **OSUJI REJOICE** with the matriculation number **BMS2001201** under the supervision of **DR.(MRS).IFUEKO M.MOSES -OTUTU** in partial fulfillment of the requirements for the award of the **Bachelor of Medical Laboratory Science (BMLS)** degree of the **Department of Medical Laboratory Science , School of Basic Medical sciences, University of Benin ,**ugbowo, Benin city, Edo state.

This research work has been examined and approved as meeting the required academic standard.

______________________ _______________________________

DR.(MRS). IFUEKO M. MOSES -OTUTU **DATE**

Supervisor

___________________________ ______________________________

DR.(MRS).ZAINAB OMORUYI **DATE**

Head of department

__________________________ _______________________________

PROF.OMORUYI PIUS OMOSIGHO **DATE**

External Examiner

DEDICATION

I dedicate this research work to **God Almighty** for His unwavering grace, strength, guidance and support throughout the course of this research work.

I also dedicate it to my **parents** and **loved ones**,whose love, support and prayers has been a constant source of encouragement.

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ABSTRACT

Intestinal parasitic infections remain a significant public health problem among school-aged children in developing countries, where poor sanitation and inadequate hygiene promote transmission. This study aimed to determine the prevalence and distribution of intestinal parasites among primary school pupils in Ikpoba Hill, Benin City, Edo State. A descriptive cross-sectional survey was conducted among 167 children aged 5–14 years selected from public and private schools. Stool specimens were examined using direct wet mount (saline and Lugol's iodine) and the formol-ether concentration method to identify protozoa and helminths. Socio-demographic data and hygiene practices were obtained through structured questionnaires, and results were analysed using descriptive and inferential statistics.Of the 167 stool samples examined, 50 were positive, giving an overall prevalence of 29.9%. *Entamoeba coli* was the most frequently detected parasite (60%), followed by *Entamoeba histolytica* (24%), while *Ascaris lumbricoides* and *Trichuris trichiura* accounted for 8% each. Infections were more common among children aged 6–10 years and among males, although these differences were not statistically significant (P= 0.726). The use of unimproved toilet facilities was the only factor significantly associated with infection (P=0.030).The moderate prevalence observed suggests that periodic deworming, improved sanitation, and hygiene education have reduced the burden compared with earlier reports from similar communities, but environmental contamination and unsafe water remain important risk factors. Strengthening school-based deworming, ensuring access to safe water, and promoting proper sanitation are recommended to sustain control and further reduce the transmission of intestinal parasites among schoolchildren in this setting.

CHAPTER 1

INTRODUCTION

1.1 Background of study

Intestinal parasitic infections (IPIs) represent a major global health burden, affecting more than one billion individuals globally (Ahmed, 2023). Intestinal protozoa, such as *Entamoeba histolytica*, *Giardia lamblia*, *Cryptosporidium parvum*, and *Cyclospora cayetanensis*, are microscopic organisms that can cause diarrhea, malabsorption, and chronic gastrointestinal symptoms. In contrast, intestinal helminths are multicellular parasitic worms that fall into three main categories: Nematodes (roundworms), Trematodes (flukes), and Cestodes (tapeworms). Notable examples of intestinal helminths include *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, *Necator americanus*, and *Strongyloides stercoralis* (WHO, 2023). These parasites often have complex life cycles involving environmental stages, which makes their control particularly difficult in areas with poor sanitation and hygiene.

Globally, intestinal parasitic infections remain among the most pressing public health challenges, especially in developing countries. These infections are estimated to affect approximately 3.5 billion people annually and contribute to over 200,000 reported deaths (Girma *et al*., 2024). The prevalence is disproportionately higher in low- and middle-income countries, where inadequate sanitation, limited access to clean water, and poor hygiene foster conditions ideal for parasite transmission. According to WHO (1987), infections such as *Amoebiasis*, *A*scariasis, hookworm, and *Trichuriasis* rank among the ten most common infections worldwide. Soil-transmitted helminths alone affect over 1.5 billion people globally, with *Strongyloides stercoralis* infecting an estimated 600 million individuals (WHO, 2023). Among these, *Ascariasis* caused by *Ascaris lumbricoides* remains the most widespread, with global infections estimated between 807 million and 1.2 billion, primarily in sub-Saharan Africa and East Asia (CDC, 2024). Beyond infection, the burden of these diseases includes malnutrition, diarrheal disease, iron deficiency anemia, impaired cognitive development, reduced physical growth, and decreased school performance (WHO, 1987).

In Nigeria, which has the largest population in West Africa, intestinal parasitic infections remain highly endemic. These infections are particularly prevalent among school-aged children and warrant consistent monitoring (Dada-Adegbola *et al*., 2017). Nigeria's tropical climate, combined with poor sanitation, inadequate water supply, and overcrowded urban living, fosters a high rate of transmission. Recent studies across the country have reported varied prevalence rates. One study recorded an overall prevalence of 23.6% among school-aged children, with A. *lumbricoides* being the most common (50.8%), followed by *Gardia*. lamblia (28.8%), *Entamoeba* spp. (16.9%), and *Dipylidium caninum* (3.4%) (Adesola *et al.,* 2023). In Benue State, *Entamoeba histolytica* was most prevalent, especially among rural pupils (51.0%), followed by hookworm (46.2%) and *G. lamblia* (11.5%) (Damen *et al*., 2017). Across West Africa, a systematic review found that approximately 25.8% of children had intestinal protozoa, wit*h Entamoeba. histolytica*/*dispar* and Giardia spp. Being the most common (Erismann *et al.,* 2022). This persistent burden highlights the need for sustained public health interventions in the region.

Primary school children, typically aged 6–14 years, are a critical demographic in both educational and public health planning. While primary education in Nigeria officially targets ages 6–11, many children start late or repeat classes, effectively extending this age range to 14 years (Federal Ministry of Education, 2013). The Universal Basic Education (UBE) program recognizes this age group as foundational for literacy, numeracy, and essential life skills development (Obioma, 2021). Developmentally, children in this stage undergo rapid physical, cognitive, and social changes. Although motor coordination and general physical health improve, their immune systems are still maturing, making them more vulnerable to infections (Bundy et al., 2018). Cognitively, children in this age group begin to understand logical relationships (Piaget, 1977), but still rely heavily on adult supervision for health-related practices. According to WHO (2023), this age group is particularly susceptible to infectious diseases due to their developmental stage and behavior patterns.

Children's play habits and poor hygiene such as walking barefoot, nail-biting, inadequate handwashing, and playing with soil or water expose them to contaminated environments and parasitic organisms. In schools lacking adequate sanitation, the risk of transmission is amplified by overcrowding, shared toilet facilities, and limited access to clean water. Despite the significance of this issue, there is a scarcity of localized data on intestinal parasitic infections in Ikpoba Hill, Benin City, Edo State. This knowledge gap limits targeted interventions. Several socioeconomic factors such as poverty, poor hygiene, inadequate health education, and certain cultural practices contribute to the high burden of these infections. Addressing these issues through improved access to clean water, sanitation, health education, and community-based hygiene promotion can significantly reduce the impact of intestinal parasites in this vulnerable population.

1.2 STATEMENT OF PROBLEM

Despite the recognized burden of intestinal parasitic infections in Nigerian children, Without continuous localized epidemiological data, it is difficult for health authorities and educators to implement effective deworming programs, hygiene education, or sanitation improvements targeted to the affected population. Previous studies in other regions of southern Nigeria, including parts of Edo State, have reported high prevalence rates of intestinal parasites among school-aged children, indicating widespread public health concern (Akinbo *et al*., 2014; Omoruyi and Onimisi, 2020). Hospital-based data from Benin City also identified *Ascaris lumbricoides* as the most common parasite, further emphasizing the burden in this region (Akinbo *et al*., 2011). More broadly, nationwide data confirm that intestinal parasites, particularly helminths, remain highly prevalent among Nigerian schoolchildren, reinforcing the need for localized surveys (Alade *et al*., 2023).

However, the absence of current data on infection rates, parasite species distribution, and associated risk factors in Ikpoba Hill means that the true extent of the problem in this community remains unknown. This lack of information hinders efforts to reduce transmission, prevent anemia and malnutrition, and improve the health and educational outcomes of children in this area. Without proper intervention, these infections may continue to impair growth, development, and school performance among affected pupils.

1.3 Justification of the Study

Intestinal parasitic infections remain a major cause of morbidity among school-aged children in Nigeria, particularly in areas where water supply, sanitation, and hygiene infrastructure are suboptimal. Recent studies in Edo South Senatorial District have reported a prevalence of about 22.9% among primary school pupils, while surveys among children in an internally displaced persons' camp in Benin City recorded rates as high as 89.6% (Okon *et al.*, 2025; Akinbo et al., 2022). Although these investigations confirm that intestinal parasites persist in Edo State, they provide only snapshots of the situation and are not focused on Ikpoba Hill.

Ikpoba Hill is a densely populated urban–peri-urban community where factors such as open defecation, limited access to safe water, and poor school hygiene may sustain parasite transmission. Yet, there is no continuous, localized epidemiological data describing trends, species distribution, or associated risk factors in this specific area. Without such data, interventions—including deworming schedules, hygiene promotion, and improvements in sanitation—risk being poorly targeted or unsustainable.By establishing up-to-date prevalence and risk profiles among primary school children in Ikpoba Hill, this study will bridge the existing information gap and provide an evidence base for ongoing surveillance. Its findings will support tailored health education, regular deworming, and infrastructural improvements, ultimately contributing to the reduction of intestinal parasitic infections and the enhancement of children's well-being and academic performance in the community.

1.4 Aim of the study

The aim of this study was to determine the prevalence of intestinal Parasites among primary school pupils in Ikpoba Hill ,Benin city,Edo state

1.5 SPECIFIC OBJECTIVES

The specific objectives of this study were to;

1.determine the overall prevalence of intestinal parasites among primary school children in Ikpoba hill, Edo state ,Benin City.

2. identify and document the types of intestinal parasites (helminths and protozoa) present in the study population.

3. assess the distribution of parasitic infections based on demographic factors such as age and gender,class level .

4.determine relationship between socio-demographic parameters and prevalence of intestinal parasites among primary school children in Ikpoba hill, Benin city,Edo state.

1.6 RESEARCH QUESTIONS

1.What is the prevalence of intestinal parasitic infections among primary school children in Ikpoba hill Benin City?

2.Which intestinal parasite species are most commonly found in these children?

3.Are there significant differences in infection rates by gender or age group among the pupils?

1.7 RESEARCH HYPOTHESIS

1.7.1 Null Hypothesis (H_0): There is no significant association between intestinal parasite infection and demographic factors (age or gender) among primary school children in Ikpoba hill

1.7.2 Alternate Hypothesis (H_1): There is a significant association between intestinal parasite infection and at least one demographic factor (age or gender) among these children.

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND

Intestinal parasites have been recognized for centuries, with early detection methods like spontaneous sedimentation described in the early 20th century (Dogan, 2024). These foundational techniques were instrumental in identifying eggs of species such as *Schistosoma mansoni* in affected tropical areas, setting the stage for modern parasitological diagnostics.Diagnostic techniques have progressed from simple sedimentation and flotation methods to more sophisticated automated and molecular diagnostics, although challenges remain in low-resource settings (Onwuka *et al.,* 2015; Adekunle *et al*., 2019). Modern low-cost stool examination kits aid routine diagnosis but may lack sensitivity for low-intensity infections in areas with improved sanitation (Onwuka *et al*., 2015). Treatment regimens with antiparasitic drugs have advanced control efforts, although detailed historical treatment progression is less well documented in recent Nigerian studies.Intestinal parasitic infections (IPIs) affect over 3.5 billion people globally, with children disproportionately impacted, especially in tropical areas (World Health Organization [WHO], 2019). WHO estimated that approximately 270 million preschool and more than 600 million school-aged children live in endemic areas requiring intervention (WHO, 2019).

In Nigeria, the prevalence of intestinal parasitic infections among children remains alarmingly high. Agbede *et al.* (2016) found a 63.5% prevalence in rural and 40% in urban preschool children in Benue State, with common parasites including *Entamoeba histolytica*, hookworm, and *Giardia lamblia*. Onyeka and Antip (2025) reported significant parasite burdens impairing child growth and wellbeing in Plateau State. Okonko et al. (2022) documented a 23.95% prevalence among primary school-aged children in Sagbama, Bayelsa State, noting *Ascaris lumbricoides* as the most common parasite. These high rates are linked to poor sanitation, inadequate water supply, and socioeconomic challenges (Agbede *et al*., 2016; Onyeka and Antip, 2025; Okonko *et al.,* 2022). The infections adversely impact nutrition, growth, cognitive development, and educational performance in children, causing long-term health consequences (Agbede *et al*., 2016; Onyeka and Antip, 2025).

Initially, public health responses focused on diagnosis and treatment to reduce morbidity. Control strategies have since broadened to include sanitation improvements, health education, safe water supply, and mass drug administration targeting school-age children (Adekunle *et al.,* 2019; WHO, 2019). Current programs increasingly address socio-environmental determinants such as poverty and inadequate infrastructure to sustain transmission reductions. Despite progress, intestinal parasitic infections remain a neglected health issue in Nigeria, requiring sustained governmental and international commitment (Adekunle *et al., 2*019; WHO, 2019).

2.2 INTESTINAL PARASITES

intestinal parasites inhabit the human gastrointestinal tract and cause infections. They are mainly classified into two groups: Helminths and Protozoa. Helminths are multicellular worms that can be seen with the naked eye as adults, and they include roundworms, tapeworms, and flukes. Protozoa, on the other hand, are microscopic single-celled organisms capable of reproducing within the host's intestines (Ahmed, 2023).Helminths include three primary categories:

NEMATODES, such as *Ascaris lumbricoides*, hookworms like *Ancylostoma duodenale*, and whipworms (*Trichuris trichiura*), mostly colonize the intestines, sometimes migrating to other tissues. They do not multiply inside humans; instead, adult worms lay eggs released through feces, contaminating the environment and perpetuating the infection cycle. Infections with helminths often persist for long periods given their lifespan inside the host (Ahmed, 2023).

CESTODES, or tapeworms, consist of segmented flatworms that attach to the intestine and shed eggs or segments through feces. These parasites can grow to significant lengths and may contribute to nutritional deficiencies by competing for host nutrients (Ahmed, 2023).

TREMATODES, or flukes, have complex life cycles that involve multiple hosts, with some species infecting humans when they come into contact with contaminated water or aquatic plants (Ahmed, 2023).

Helminth infections detrimentally affect health by consuming host nutrients, causing blockages, triggering inflammation, and inducing anemia particularly in the case of hookworms that feed on blood. These effects can impair physical growth and mental development. Globally, soil-transmitted helminths affect approximately 1.5 billion people, amounting to about a quarter of the world's population (Ahmed, 2023; Aloba *et al.,* 2022).

Protozoan parasites are unicellular and able to multiply within the host's intestine, which can rapidly increase the intensity of infection from even a small initial inoculum. Frequently encountered protozoa include *Giardia lamblia* (responsible for *giardiasis*), *Entamoeba histolytica* (which causes amoebic dysentery), *Cryptosporidium*, and *Cyclospora cayetanensis* (Ahmed, 2023; Aloba *et al.,* 2022). These parasites mainly spread through the fecal-oral route, often through contaminated water or food. Their ability to multiply internally leads to acute or severe gastrointestinal manifestations like diarrhea, abdominal cramps, and malabsorption, sometimes extending to systemic illness (Ahmed, 2023).

Important distinctions between helminth and protozoan infections include

1. Helminths, being large and multicellular, do not multiply inside the human host, spreading instead through eggs or larvae excreted in feces.
2. Protozoa are microscopic and single-celled, multiplying within the host and spreading via cysts or oocysts in feces.
3. Helminth infections tend to be chronic and long-lasting, whereas protozoan infections may manifest acutely or chronically depending on species.

Both parasite groups impose significant public health challenges, especially in areas with inadequate sanitation and poor hygiene (Ahmed, 2023; Aloba *et al.,* 2022).Additionally, research reveals that both helminth and protozoan infections can disrupt the balance of gut microbiota, potentially influencing parasite survival and the host's immune response. This alteration may affect disease progression and the interaction between parasites and their human hosts (Ahmed, 2023; Aloba *et al*., 2022).

2.3 TAXONOMY AND NOMENCLATURE OF INTESTINAL PARASITES

2.3.1 Taxonomic Classification

HELMINTHS

Helminths belongs to kingdom Animalia and it has two phyla which are;

Phylum *Nematoda* (Roundworms)

Class: *Chromadorea*

Order :*Ascaridida*

Family: *Ascarididae*

Genus:*Ascaris*

Specie:*Ascaris lumbricoides* (Giant roundworm)

Family :*Toxocaridae*

Genus:Toxocara

Specie:*Toxocara canis*, *Toxocara cati*

Order: *Strongylida*

Family: *Ancylostomatidae*

Genus: *Ancylostoma*

Specie: *Ancylostoma duodenale* (old hookworm)

Genus: *Necator*

Necator americanus (New World hookworm)

Family :*Strongyloididae*

Genus: *Strongyloides*

Specie:*Strongyloides stercoralis* (Threadworm)

Class *Enoplea*

Order *Trichocephalida*

Family:Trichuridae

Genus:Trichuris

Specie: *Trichuris trichiura* (Whipworm)

Family *Trichinellidae*

Specie: *Trichinella spiralis* (*Trichinella* worm)

Class *secernentea*

Order :*Oxyurida*

Family:*oxyruridae*

Genus:*Enterobiworm*

Specie:*Enterobius vermicularis*(Pinworm)

Phylum *Platyhelminthes* (Flatworms)

Class :*Cestoda* (Tapeworms)

Order: *Cyclophyllidea*

Family :*Taeniidae*

Specie:Taenia solium (Pork tapeworm),*Taenia saginata* (Beef tapeworm),*Echinococcus granulosus* (Hydatid worm)

Family:*Hymenolipididae*

Specie: *Hymenolepis nana* (Dwarf tapeworm),*Hymenolepis diminuta*(Rat tapeworm)

Order *Pseudophyllidea*

Family: *Diphyllobothriidae*

Specie: *Diphyllobothrium latum* (Fish tapeworm)

Class: *Trematoda* (Flukes)

Order *Plagiorchiida*

Family :Schistosomatidae

Specie: *Schistosoma mansoni*, *Schistosoma japonicum*, *Schistosoma haematobium*

Family:Fasciolidae

Specie:*Fasciola hepatica* (Liver fluke),*Fasciola gigantica*

Family :*Opisthorchiidae*

Specie:*Clonorchis sinensis* (Chinese liver fluke), *Opisthorchis viverrini*

Family *Paragonimidae*

Paragonimus westermani(Lung fluke)

INTESTINAL PROTOZOA

Protozoa belongs to kingdom protista and it has four phyla but only two contains Intestinal Parasites of medical important ,they are;

Phylum *Amoebozoa*

Class: *Archamoebae*

Order :*Entamoebida*

Family: *Entamoebidae*

Specie:*Entamoeba histolytica* (Pathogenic amoeba),*Entamoeba dispar* (Non-pathogenic) *Entamoeba coli* (Commensal)

Phylum *Metamonada*

Class: *FoCommensa*

Order :*Diplomonadida*

Family: *Hexamitidae*

Specie:*Giardia lambia* (*Giardia intestinalis*)

Class :*Parabasalia*

Order: *Trichomonadida*

Family:*Trichomonadidae*

Specie: *Trichomonas hominis*

2.4 COMMON INTESTINAL PARASITES AFFECTING CHILDREN IN NIGERIA

The most frequently identified intestinal parasites among primary school children in Nigeria include:

Intestinal Helminths

1.*Ascaris lumbricoides:* Transmission,life cycle and Pathogenesis

Ascaris lumbricoides represents one of the most significant parasitic nematodes affecting human health globally, with the causative agent of *ascariasis* being the most common parasitic worm in humans (Jusino *et al*., 2023). This parasitic infection demonstrates substantial global burden, with approximately one billion people worldwide infected with *Ascaris lumbricoides*, and more than 60,000 people die from the disease annually (Jourdan *et al.,* 2018). *Ascaris lumbricoides* is the largest of the intestinal *nematodes* affecting humans, measuring 15-35 cm in length in adulthood (Hamad *et al.*, 2024). The infection predominantly affects tropical and subtropical regions, with particular prevalence in Sub-Saharan Africa, Latin America, and parts of Asia. Recent epidemiological data suggests that an estimated 5.2 billion persons are at risk of infection in countries with stable transmission (CDC, 2024). The persistence of this infection reflects ongoing challenges related to sanitation, hygiene practices, and socioeconomic factors in endemic areas.

The transmission of *Ascaris lumbricoides* follows a fecal-oral route, making it particularly prevalent in areas with poor sanitation infrastructure. Infection begins with the ingestion of embryonated (infective) eggs in feces-contaminated soil or foodstuffs (Hama*d et al.*, 2024). The parasitic lifecycle demonstrates environmental dependence, as *Ascaris lumbricoides* has a single host life cycle with an obligatory period of development in soil (Jourdan et al., 2018). The transmission process involves several key stages. Initially, fertilized and unfertilized *Ascaris lumbricoides* eggs are passed in the stool of the infected host (CDC, 2024). These eggs require specific environmental conditions for maturation. The infective larva develops within the egg in about 3-6 weeks (Bethony *et al.,* 2006). Following this maturation period, humans acquire the infection directly through consumption of contaminated food or water containing these infective eggs.Environmental factors play a crucial role in transmission success. The eggs demonstrate remarkable resilience in soil environments, where they can remain viable for extended periods under appropriate temperature and humidity conditions. This environmental persistence contributes significantly to the maintenance of transmission cycles in endemic communities. *Ascaris lumbricoides* eggs can survive in soil for months to years depending on environmental conditions, making control challenging in areas with poor sanitation (WHO, 2024).

The life cycle of *Ascaris lumbricoides* represents a complex migratory pattern within the human host, involving both intestinal and extra-intestinal phases. The parasitic infection begins with the ingestion of food, water, or raw vegetables contaminated with the eggs of *Ascaris lumbricoides* (Jourdan *et al.,* 2018). Upon ingestion, eggs hatch, usually in the small intestine (Bethony *et al.,* 2006). The subsequent larval development involves a characteristic migratory pathway through host tissues. These eggs hatch in the small intestine (duodenum) of the host to release the larvae, which then penetrate the intestinal wall to reach the lymphatic system (Jourdan *et al.,* 2018). As illustrated in **Figure 2.1,** the larvae subsequently migrate via the bloodstream to the liver and lungs, where they undergo further maturation before ascending the bronchial tree, being swallowed, and finally returning to the small intestine to develop into adult worms capable of reproduction.The larval migration continues through the circulatory system, reaching the pulmonary circulation where larvae break through alveolar walls into the respiratory tract. From the lungs, larvae ascend the respiratory tree, are coughed up, and subsequently swallowed, returning to the small intestine where they mature into adult worms. Adult worms establish residence in the small intestine, where they reach sexual maturity and begin reproduction. The life span of an adult worm is two years (Jusino *et al*., 2023). Importantly, they do not multiply in the host (Jusino *et al.*, 2023), meaning that infection intensity depends entirely on the number of infective eggs initially consumed and subsequent reinfections. The reproductive capacity of female worms Is substantial, with each female capable of producing thousands of eggs daily. These eggs are released into the intestinal lumen and passed in feces, completing the transmission cycle when they reach suitable environmental conditions for maturation. The complete development from egg ingestion to adult worm reproduction takes approximately 2-3 months (Bethony *et al.,* 2006).

The pathogenesis of *Ascaris lumbricoides* infection involves multiple mechanisms that vary according to the developmental stage of the parasite and the intensity of infection. Ascariasis can be asymptomatic, causing only malnutrition and growth retardation, or it may present with abdominal pain, nausea, vomiting, bloating, and diarrhea (Jusino *et al.,* 2023). During the larval migration phase, pathological changes occur primarily in the lungs and liver. The passage of larvae through pulmonary tissues can trigger inflammatory responses, leading to pneumonitis-like symptoms. This phase may be associated with fever, cough, and eosinophilia as the host immune system responds to the migrating larvae (Jourdan *et al.,* 2018).The Intestinal phase of infection involves adult worms residing in the small intestine, where they cause pathology through several mechanisms. Nutritional deficiencies occur due to the presence of adult worms (Bethony *et al.,* 2006). Adult worms compete with the host for nutrients, particularly affecting protein and vitamin A absorption, which can lead to malnutrition, especially in children. Studies have shown that chronic *Ascaris* infection can significantly impact growth and cognitive development in pediatric populations (WHO, 2024).

Mechanical complications represent another significant aspect of pathogenesis. In individuals who harbor large worm burdens, infection can result in clinical disease, including intestinal, biliary, and pancreatic obstructions (Jourdan *et al.,* 2018). These obstructions occur when adult worms migrate into narrow anatomical spaces or when multiple worms create physical blockages. Adult worms may migrate aberrantly into the biliary tree, causing cholangitis or gallbladder inflammation, while migration into the appendix can result in appendicitis (Bethony *et al.,* 2006).

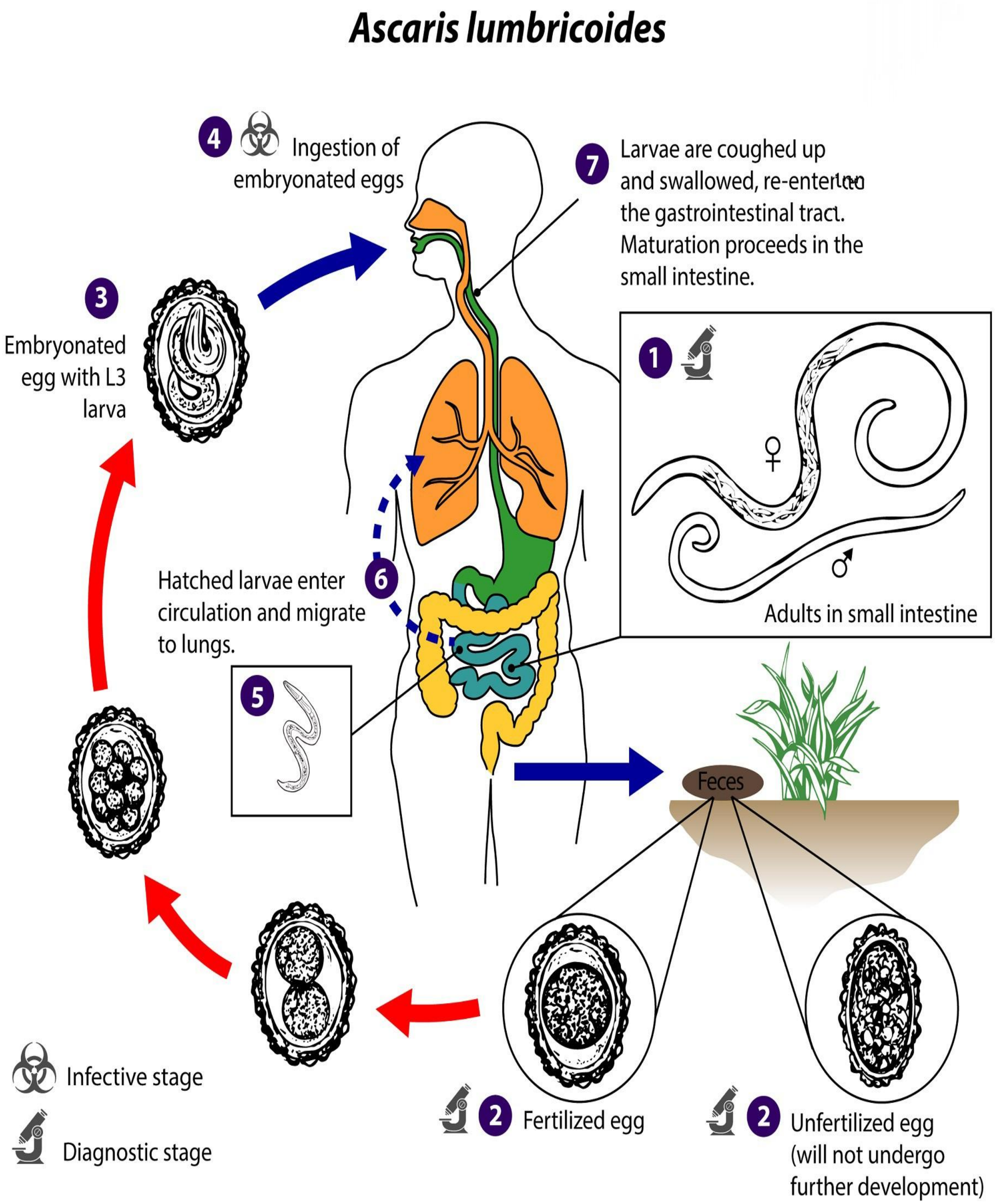

Figure 2.1. Life cycle of *Ascaris lumbricoides* (Source: CDC ,2019)

2.*Trichuris trichiura*: Transmission, lifecycle and Pathogenesis

Trichuris trichiura, also known as the human whipworm, is a soil-transmitted helminth that causes trichuriasis, one of the most common intestinal parasitic infections worldwide (Cooper *et al.,* 2020). The parasite is named after its whip-like appearance, with a thin anterior end and a thicker posterior region (Singh and Mann, 2023). Adult worms, measuring 3–5 cm, reside in the large intestine where they anchor themselves to the mucosa with their slender anterior ends (CDC, 2024; WHO, 2024).*Trichuriasis* is regarded as a neglected tropical disease, particularly affecting children in tropical and subtropical regions where sanitation is poor (Bethony *et al.,* 2006; Kepha *et al*., 2025). Its persistence is strongly linked to inadequate hygiene, contaminated soil, and poverty, which sustain transmission in endemic communities (Jourdan *et al.,* 2018; Aemiro *et al*., 2024).

The infection is transmitted through ingestion of embryonated eggs present in contaminated food, water, or soil (CDC, 2024). Eggs passed in human feces are initially unembryonated and require 15–30 days in a warm, moist environment to become infective (Cooper *et al.,* 2020; Turner *et al.,* 2016). Each female worm is capable of producing 2,000–10,000 eggs daily, contributing to ongoing environmental contamination (Bundy and Cooper, 1989).

The life cycle Is simple and occurs entirely within the human host. After ingestion, the eggs hatch in the duodenum, releasing larvae that migrate to the cecum and colon. There, they penetrate the mucosal epithelium and gradually mature into adults capable of reproduction. As illustrated in **Figure 2.2,** the adults produce eggs that are excreted with feces, thereby continuing the cycle (CDC, 2024; Foth *et al.*, 2014; Levecke *et al.,* 2014).

The pathogenesis of *trichuriasis* is closely associated with the worms' feeding and embedding behavior, which cause mucosal damage, inflammation, and blood loss (Else *et al.,* 2020; Hotez *et al*., 2014). Chronic heavy infections in children can lead to *Trichuris* dysentery syndrome, manifested by diarrhea, abdominal pain, rectal bleeding, anemia, and growth retardation (Cooper et al., 2020). Severe and prolonged cases may progress to rectal prolapse due to persistent irritation and straining during defecation (Bundy and Cooper, 1989; Oliveira *et al., 2*020). More recent findings have also highlighted the parasite's ability to alter the intestinal microbiome and facilitate bacterial translocation across damaged mucosa, resulting in systemic inflammation (Easton *et al.,* 2024; Kepha *et al., 2*025). These effects reinforce the public health burden of whipworm infections, particularly in children from endemic regions.

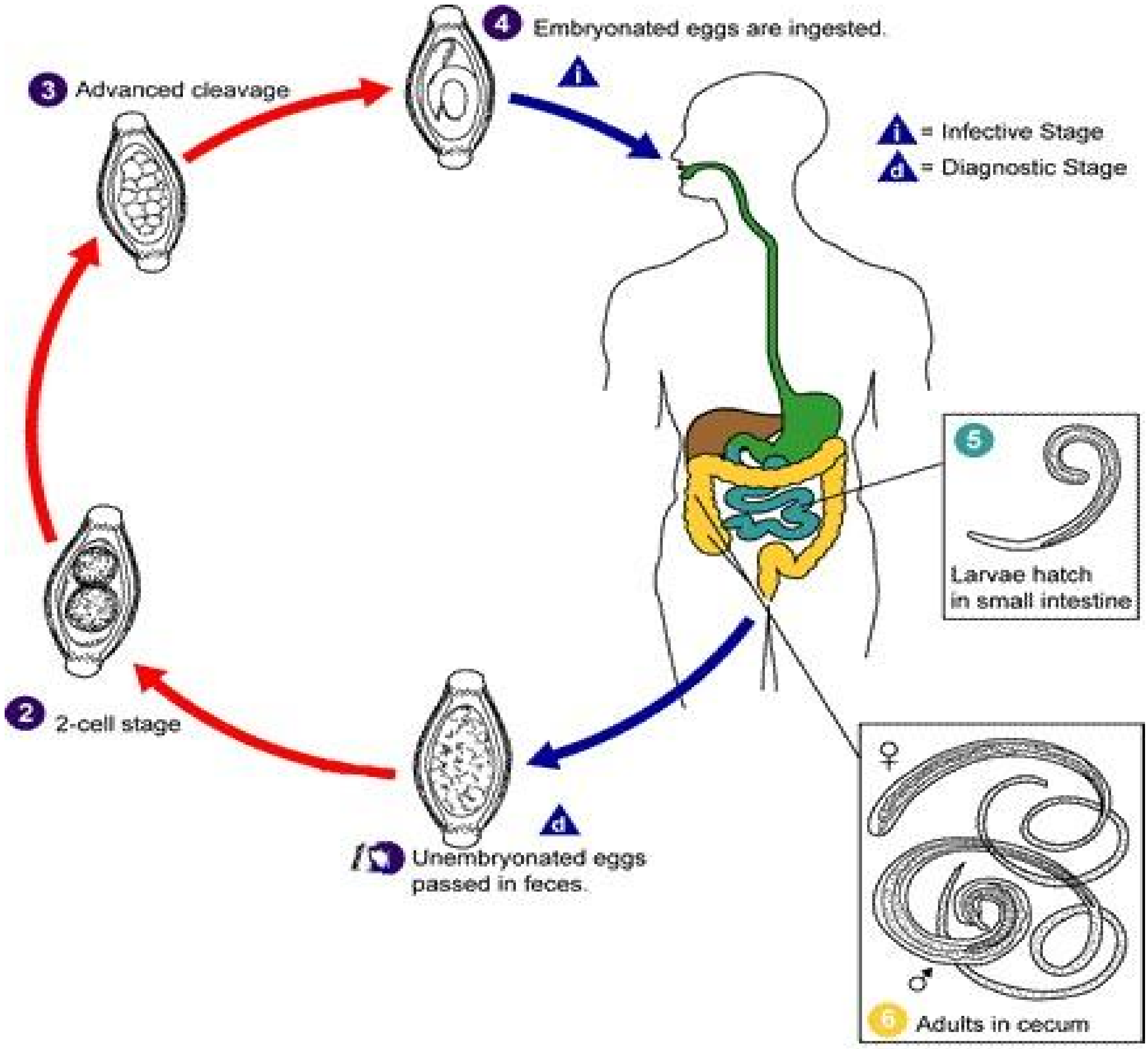

Figure 2.2. Life cycle of *Trichuris trichiura (*Source:CDC, 2024).

3.Hookworms: Mode of transmission, lifecycle and pathogenisis

Hookworm infection represents one of the most significant soil-transmitted helminthiases globally, affecting more than 700 million individuals in tropical and subtropical regions where rural poverty prevails (Loukas *et al.,* 2016). The term "hookworm" encompasses two principal nematode parasites responsible for human infections: *Necator americanus* and *Ancylostoma duodenale,* which together account for more than 90% of all hookworm cases worldwide (Qadir *et al., 2*023). These parasitic roundworms derive their name from their distinctive curved anterior end that resembles a hook, which they use to attach to the intestinal mucosa of their human hosts (CDC, 2024).

The geographical distribution of hookworm species demonstrates distinct patterns. *Ancylostoma duodenale,* commonly referred to as the "Old World hookworm," shows predominant prevalence in the Mediterranean region, northern Africa, northern India, and parts of South America (Bartsch et al., 2021). Conversely, *Necator americanus,* known as the "New World hookworm," demonstrates widespread distribution throughout tropical and subtropical regions globally, including sub-Saharan Africa, Southeast Asia, and parts of the Americas (Loukas *et al.*, 2016). Hookworm infection constitutes a major neglected tropical disease that disproportionately impacts the most vulnerable populations, particularly those living in conditions of extreme poverty with limited access to adequate sanitation infrastructure (Bartsch *et al.*, 2021).

The transmission of hookworm Infection follows a unique percutaneous route that distinguishes it from other soil-transmitted helminths. Unlike parasites such as *Ascaris lumbricoides* and *Trichuris trichiura* that require ingestion of infectious eggs, hookworm transmission occurs through direct skin penetration by infective larvae present in contaminated soil (CDC, 2024). The transmission process begins when infected individuals defecate in areas lacking proper sanitation facilities, depositing hookworm eggs into the surrounding soil environment. These eggs undergo maturation in soil under appropriate temperature and humidity conditions, developing through several larval stages before reaching their infectious potential (Qadir *et al.,* 2023).Environmental conditions play a crucial role in determining the success of hookworm transmission cycles. The optimal developmental conditions for hookworm larvae include warm temperatures ranging between 23-30°C and adequate soil moisture levels that facilitate larval survival and mobility (Bartsch *et al.,* 2021). Under favorable environmental conditions, hookworm eggs hatch in soil and develop through multiple larval stages, ultimately reaching the third-stage larvae (L3) which represents the infectious form capable of penetrating human skin (Loukas *et al.,* 2016).

Human acquisition of hookworm infection typically occurs through contact with contaminated soil, particularly when individuals walk barefoot or have prolonged skin contact with infected environments (CDC, 2024). Transmission requires a minimum of five minutes of skin contact with soil containing viable larvae for successful penetration to occur (WHO, 2024). An allergic reaction known as 'Ground itch' usually occur at the site of penetration and entry is common in patient infected with Necator Americans(Markell *et al.,*2006) .The larvae demonstrate active host-seeking behavior, responding to thermal and chemical stimuli that indicate the presence of potential human hosts (Qadir *et al.,* 2023). Children are particularly vulnerable to infection due to their frequent contact with contaminated soil during play activities, often occurring in areas where open defecation is practiced (Brooker *et al., 2*012).

The life cycle of hookworm represents a complex developmental process involving both environmental and host-dependent phases. Following successful skin penetration, hookworm larvae enter the circulatory system and embark on a characteristic migratory pathway through various host tissues before reaching their final destination in the small intestine (Qadir *et al.,* 2023).The developmental stages of hookworms are illustrated in **figure 2.3** which highlights the sequential progression from infective larvae in the environment to adult worms in host's intestines.The larvae utilize the venous circulation to reach the right side of the heart, subsequently entering pulmonary circulation where they penetrate alveolar walls and gain access to the respiratory tract (Loukas *et al.,* 2016).From the lungs, hookworm larvae ascend the respiratory tree through the bronchi and trachea, eventually reaching the epiglottis where they are swallowed and return to the gastrointestinal system (CDC, 2024). Upon reaching the small intestine, the larvae undergo their final maturation process, developing into adult worms capable of reproduction (Bartsch *et al.*, 2021). The entire developmental process from initial skin penetration to adult worm establishment typically requires 6-8 weeks, during which the parasites undergo several molting episodes as they progress through different larval stages.

Adult hookworms establish permanent residence within the small intestine, particularly in the duodenum and upper jejunum, where they attach to the intestinal mucosa using their characteristic buccal apparatus. The adult worms demonstrate remarkable longevity, with *Necator americanus* adults typically surviving for 3-5 years, while *Ancylostoma duodenale* can persist for up to 6-8 years (Loukas *et al., 2*016). The reproductive capacity of female hookworms is substantial, with *Necator americanus* females producing approximately 9,000-10,000 eggs per day, while *Ancylostoma duodenale* females generate around 25,000-30,000 eggs daily (Bartsch *et al.,* 2021).

The pathogenesis of hookworm Infection involves multiple mechanisms that result from the parasites' feeding behavior and attachment to intestinal mucosa. The primary pathogenic mechanism centers on chronic blood loss caused by the adult worms' hematophagous feeding behavior within the small intestine (Loukas *et al.,* 2016). Adult hookworms maintain their position within the intestinal tract by attaching to the mucosa using specialize mouthparts equipped with cutting structures that enable them to lacerate intestinal capillaries and feed on the resulting blood extravasation (Brooker *et al*., 2012).

The blood consumption patterns differ significantly between hookworm species, with important implications for clinical outcomes. *Ancylostoma duodenale* demonstrates more aggressive blood-feeding behavior compared to *Necator americanus,* consuming approximately 0.15-0.26 ml of blood per worm per day, while *Necator americanus* consumes approximately 0.03-0.05 ml per worm per day (Bartsch *et al.*, 2021). This difference in blood consumption capacity explains why *Ancylostoma duodenale* infections are more frequently associated with severe anemia and iron deficiency, even at lower worm burdens compared to *Necator americanus* infections (Qadir *et al*., 2023).

Recent molecular evidence has revealed that hookworms produce various anticoagulants and platelet aggregation inhibitors that prevent blood clotting at feeding sites, ensuring continuous blood flow for their nutritional requirements while contributing to ongoing blood loss from the host (Brooker *et al*., 2012). The attachment of hookworms to the intestinal wall creates localized inflammatory responses characterized by eosinophilic infiltration, mucosal damage, and villous atrophy at sites of parasite attachment (CDC, 2024).Iron deficiency anemia represents the most significant clinical consequence of chronic hookworm infection, resulting from the cumulative effects of daily blood loss over extended periods. The development of anemia depends on multiple factors including worm burden, duration of infection, host iron reserves, and dietary iron intake (Brooker *et al.*, 2012). Children and women of reproductive age are particularly vulnerable to developing severe anemia due to their increased iron requirements for growth and menstruation, respectively, combined with often inadequate dietary iron intake in resource-limited settings (Loukas *et al*., 2016).

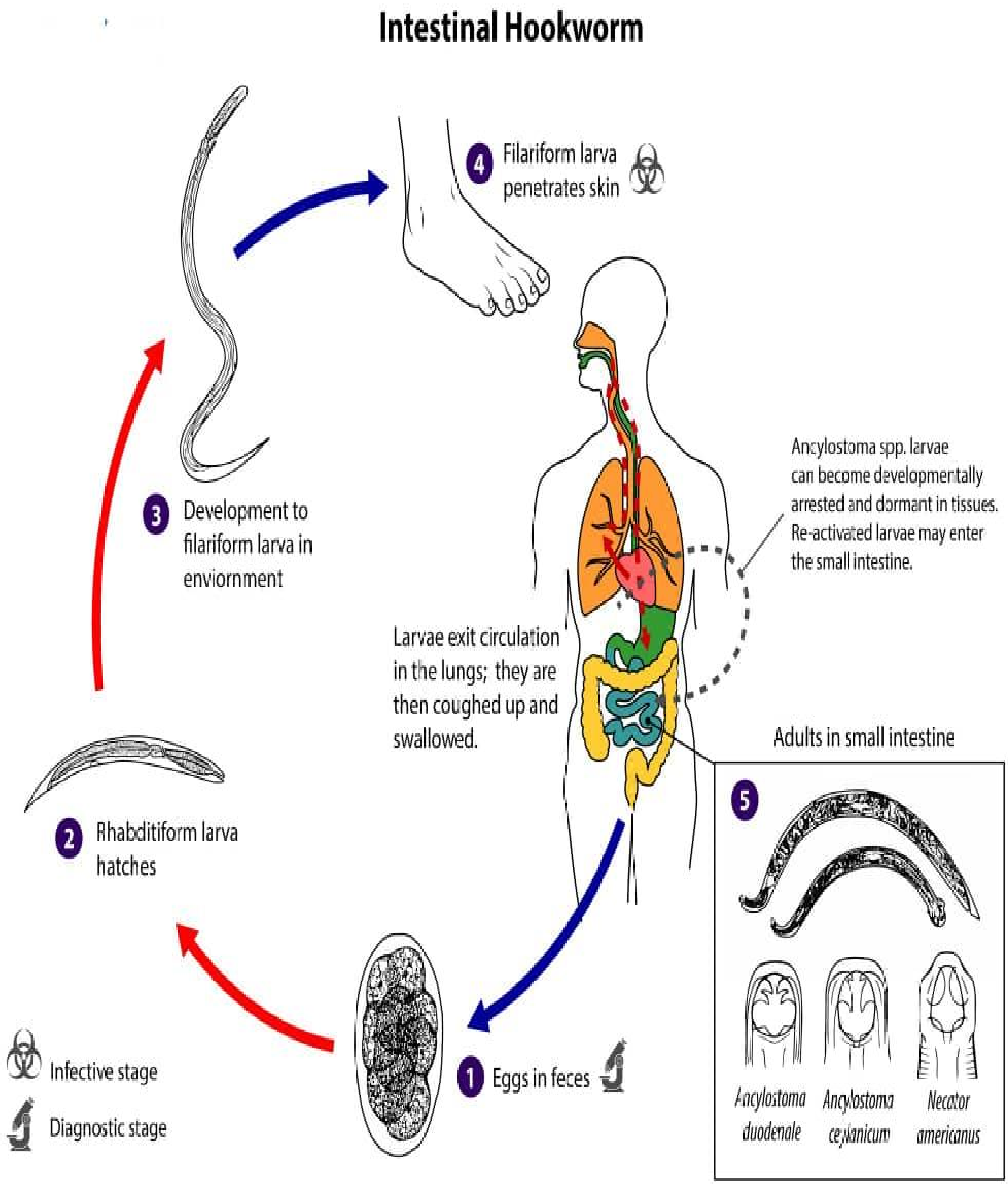

Figure 2.3 Life cycle of hookworms (*Ancylostoma duodenale, Necator americanus)* (Source:CDC, 2019).

4.*Enteriobius vermicularis:* Mode of transmission, lifecycle, Pathogenesis

Enterobius vermicularis,commonly known as the human pinworm or threadworm, is a parasitic nematode belonging to the family *Oxyuridae*. This helminth derives its characteristic name from the distinctive pin-like posterior morphology observed in female specimens (Caldwell *et al.*, 2023). The organism represents the most prevalent intestinal parasitic nematode affecting human populations globally, with infection rates particularly elevated among pediatric demographics (Rawla and Sharma, 2023). Adult female pinworms measure approximately 8-13 mm in length, while males are considerably smaller at 2-5 mm. The females possess a characteristic pointed tail, distinguishing them from other intestinal nematodes (CDC, 2024). Both sexes exhibit a transparent, whitish coloration and cylindrical body structure typical of nematodes.

Enterobius vermicularis transmission occurs through multiple interconnected pathways, all involving the ingestion of embryonated eggs. The primary transmission mechanism involves direct fecal-oral contamination through several routes (CDC, 2024). Direct transmission occurs when individuals inadvertently ingest eggs following contamination of hands during scratching of the perianal region. This autoinfection mechanism represents a significant contributor to persistent and recurrent infections (Kucik *et al.,* 2019). Indirect transmission happens through contact with contaminated fomites, including clothing, bedding, toys, furniture, and household surfaces (Pogorelić *et al.,* 2024). The eggs demonstrate remarkable environmental persistence, remaining viable for up to three weeks under appropriate conditions.Airborne transmission may occur through inhalation of dust particles containing embryonated eggs, particularly in enclosed environments where infected individuals reside (Vargas-Arzola *et al.*, 2024). Sexual transmission has also been documented, particularly among adult populations, representing an additional route of infection spread. The high prevalence of this infection is closely related to poverty conditions, with institutional populations showing increased transmission rates due to close contact facilitation (Abdel-Rahman *et al*., 2024).

The life cycle of *Enterobius vermicularis* is remarkably straightforward, requiring only a single human host without intermediate hosts or vectors. The complete developmental cycle spans approximately 2–8 weeks (CDC, 2024). Following oral ingestion of embryonated eggs, the parasites undergo initial development within the host's digestive system. The eggs become infective within 4–6 hours of oviposition, and upon ingestion, the external egg membrane dissolves in the duodenal environment (Razzaghi *et al*., 2024). First-stage larvae emerge in the duodenum and undergo two molting processes while migrating through the small intestine (Kucik *et al.,* 2019). As illustrated in **Figure 2.4,** the larvae eventually reach the cecum where they mature into adult worms, with gravid females migrating to the perianal region at night to deposit eggs, thereby perpetuating the cycle.The parasites experience four total molts during their development, with the initial two occurring within the egg structure prior to hatching. The larvae continue their migration to the cecum and appendicular regions, where they mature into adult worms (Caldwell *et al.,* 2023). Adult females typically inhabit the cecum and vermiform appendix, remaining attached to the mucosal surface.After mating, gravid females migrate through the colon to the perianal area during nocturnal hours to deposit eggs (CDC, 2024). Each female can produce 10,000-15,000 eggs, which are deposited in the perianal folds. The adult worms die shortly after egg deposition, completing the cycle. This nocturnal migration pattern is responsible for the characteristic symptomatology associated with the infection (Vargas-Arzola *et al.,* 2024).

The pathogenic mechanisms of *Enterobius vermicularis i*nfection primarily result from the mechanical irritation caused by adult worms and the host's inflammatory response to parasitic antigens. The most characteristic symptom, perianal pruritus, develops due to the mechanical irritation caused by female worms migrating to deposit eggs and the allergic response to parasitic secretions (CDC, 2024). This intense itching, particularly pronounced during nighttime hours, leads to scratching behavior that perpetuates the infection cycle through autoinfection.Persistent scratching may result in bacterial superinfection of excoriated perianal tissues (Abdel-Rahman *et al*., 2024). In female patients, migrating worms may cause vulvovaginitis and urinary tract complications when parasites enter the genitourinary tract. Studies have documented significant evidence of vulvovaginitis and bacterial coinfection particularly among young girls, demonstrating the complex pathogenic interactions of this parasite (Vargas-Arzola *et al.,* 2024).

Although most infections remain asymptomatic, some patients develop systemic symptoms including abdominal discomfort, appetite loss, irritability, and sleep disturbances (Rawla and Sharma, 2023). These manifestations likely result from the host's immune response to parasitic antigens and the mechanical disruption caused by adult worms. Mental distress represents another significant aspect of the pathogenesis, particularly in chronic infections where patients experience persistent discomfort and sleep disruption.Infrequently, adult worms may migrate to ectopic locations, causing appendicitis, pelvic inflammatory disease, or peritoneal irritation (Pogorelić *et al*., 2024). These complications occur when worms migrate beyond their typical anatomical locations. Recent systematic reviews have identified *Enterobius vermicularis* as a neglected risk factor for appendicitis, with meta-analyses demonstrating a significant association between pinworm infection and appendiceal inflammation (Razzaghi *et al*., 2024).

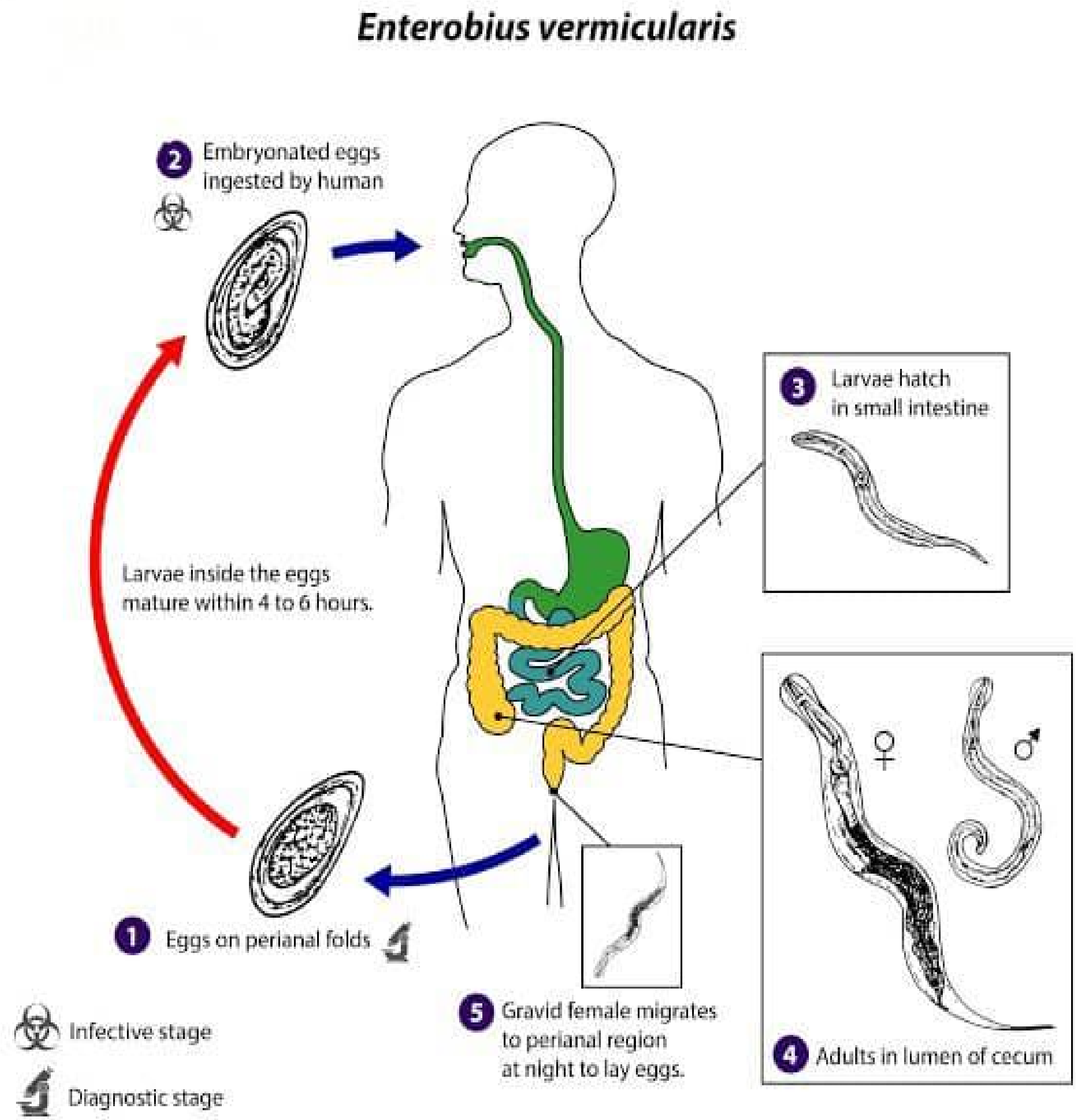

Figure 2.4. Life cycle of *Enterobius* vermicularis (Source: CDC, 2019).

Intestinal Protozoa

1.*Entameoba*(*histolytica* and *coli*): Mode of transmission , lifecycle and pathogenisis

Entamoeba histolytica and *Entamoeba coli* are two morphologically similar protozoan parasites that inhabit the human gastrointestinal tract but differ significantly in their pathogenic potential and clinical significance (Bhattacharya *et al.,* 2023). While *Entamoeba histolytica* serves as the causative agent of amebiasis, affecting approximately 35-50 million individuals worldwide and causing over 55,000 deaths annually, Entamoeba coli exists as a non-pathogenic commensal organism that frequently colonizes the human intestine without causing disease (CDC, 2024). The clinical importance of distinguishing between these species cannot be overstated, as misidentification can lead to unnecessary treatment or failure to provide appropriate therapy for invasive amebiasis.

Both species demonstrate similar transmission patterns, occurring exclusively through the fecal-oral route with mature quadrinucleate cysts serving as the infective forms (Shah *et al.,* 2023). The primary transmission mechanism for both organisms involves ingestion of cysts through contaminated food, water, or contact with contaminated surfaces. Person-to-person transmission represents a significant route for both species, particularly in institutional settings and households with poor hygiene practices. However, *Entamoeba histolytica* shows additional transmission pathways including sexual transmission, especially among men who have sex with men through oral-anal contact (Kantor *et al.,* 2018).Waterborne and foodborne transmission occur through consumption of contaminated drinking water, fresh produce, and other food items that have been exposed to human fecal matter containing viable cysts. Environmental persistence contributes to sustained transmission for both species, as cysts can remain viable for extended periods under appropriate moisture and temperature conditions (Ali *et al.*, 2019). Mechanical vectors such as flies may facilitate transmission by transferring cysts from fecal sources to food, though this represents a less common pathway compared to direct fecal-oral contamination.

The life cycles of both *Entamoeba histolytica* and *Entamoeba coli* follow remarkably similar patterns, involving excystation in the small intestine where quadrinucleate cysts release four trophozoites each (CDC, 2024). Following excystation, trophozoites migrate to the large intestine where they establish colonization and undergo binary fission to maintain population levels. Both species feed on bacteria and organic matter present in the intestinal lumen, and under appropriate conditions, trophozoites undergo encystation to form mature quadrinucleate cysts that are immediately infective upon excretion (Jiménez-González *et al*., 2020). As illustrated in **Figure 2.5**, the life cycle of E. coli demonstrates its strictly non-invasive pattern, remaining confined to the intestinal lumen as a harmless commensal. In contrast, **Figure 2.6** highlights the life cycle of *Entameoba histolytica*, which, unlike E. coli, exhibits the ability of trophozoites to invade the colonic mucosa. This invasive potential represents the critical difference between the two species (Bhattacharya *et al.,* 2023). This fundamental divergence in tissue interaction determines their respective pathogenic potentials and clinical manifestations.

The pathogenesis of these two species represents the most significant point of divergence between them. Entamoeba *histolytica* infection involves complex interactions between parasite virulence factors and host immune responses, resulting in clinical presentations ranging from asymptomatic colonization to severe invasive disease (Ali *et al.,* 2019). Approximately 90% of *Entamoeba histolytica* infections remain asymptomatic, but symptomatic cases develop when trophozoites invade the intestinal mucosa through coordinated action of cytolytic enzymes, cysteine proteinases, and galactose-inhibitable lectin that mediates epithelial adherence.Intestinal invasion by *Entamoeba histolytica* triggers inflammatory cascades, resulting in characteristic colonic ulcerations with bloody diarrhea, abdominal pain, and systemic symptoms (Kantor et al., 2018). Extraintestinal dissemination can occur when trophozoites reach distant organs through portal circulation, with amebic liver abscess representing the most common extraintestinal manifestation, developing in approximately 3-9% of patients with intestinal amebiasis (Shah *et al.,* 2023).

In contrast, *Entamoeba coli* pathogenesis is fundamentally different as this organism functions as a non-pathogenic commensal that typically causes no tissue damage or inflammatory responses (CDC, 2024). Most individuals harboring *Entamoeba coli* remain completely asymptomatic throughout their infection. However, recent research has suggested potential associations with mild gastrointestinal symptoms in certain individuals under specific circumstances, such as immune compromise or concurrent intestinal infections (Jiménez-González *et al.*, 2020).The primary clinical significance of *Entamoeba coli* lies not In direct pathogenicity but in its potential for misidentification with *Entamoeba histolytica*, which can lead to inappropriate clinical management (Bhattacharya et al., 2023). Accurate species differentiation is crucial to prevent unnecessary antiparasitic treatment for *Entamoeba coli* infections and to ensure appropriate therapy for *Entamoeba histolytica* infections that require specific antiamebic medications.

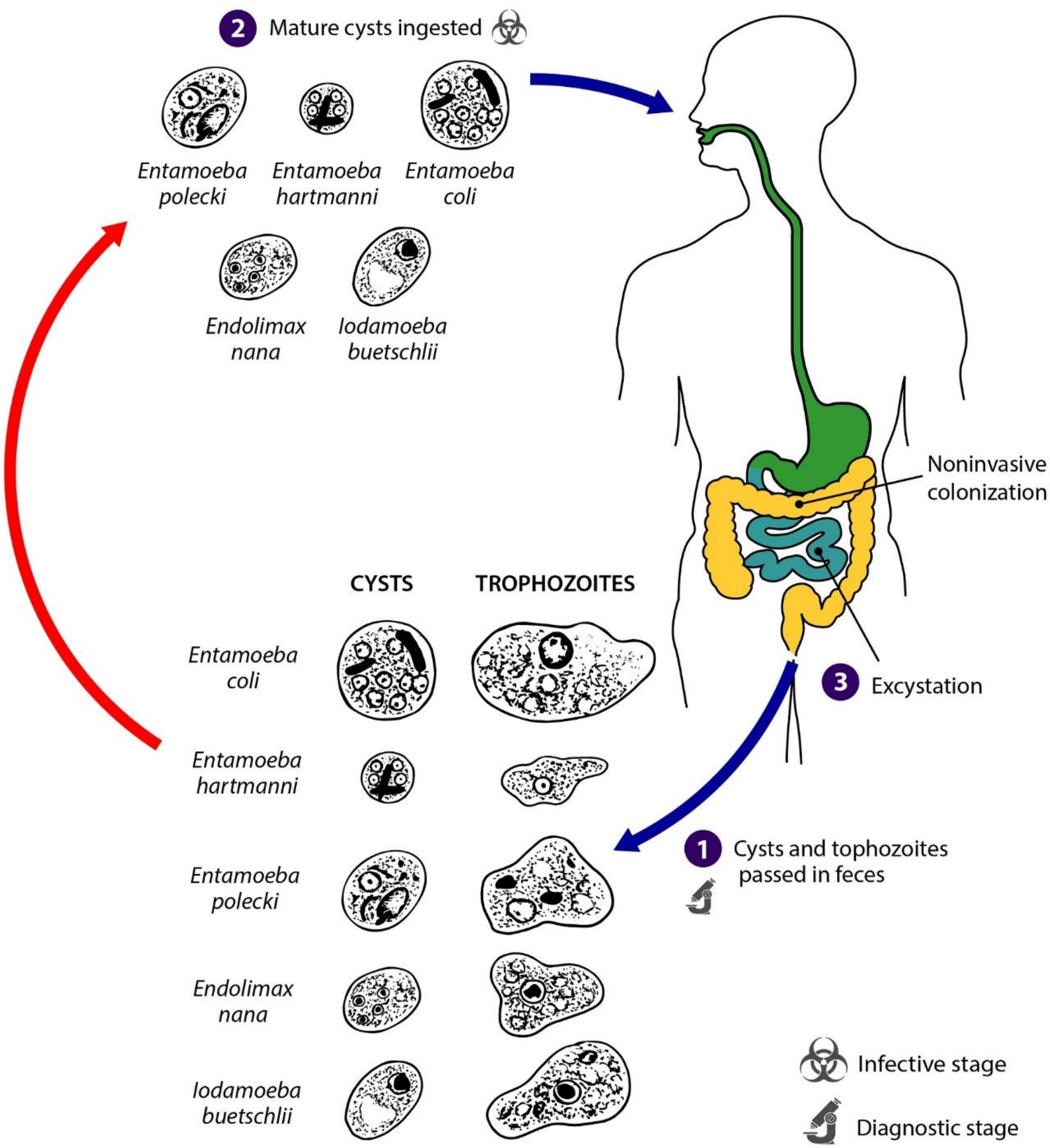

Figure 2.5. Life cycle of *Entamoeba coli* (Source: CDC, 2019.)

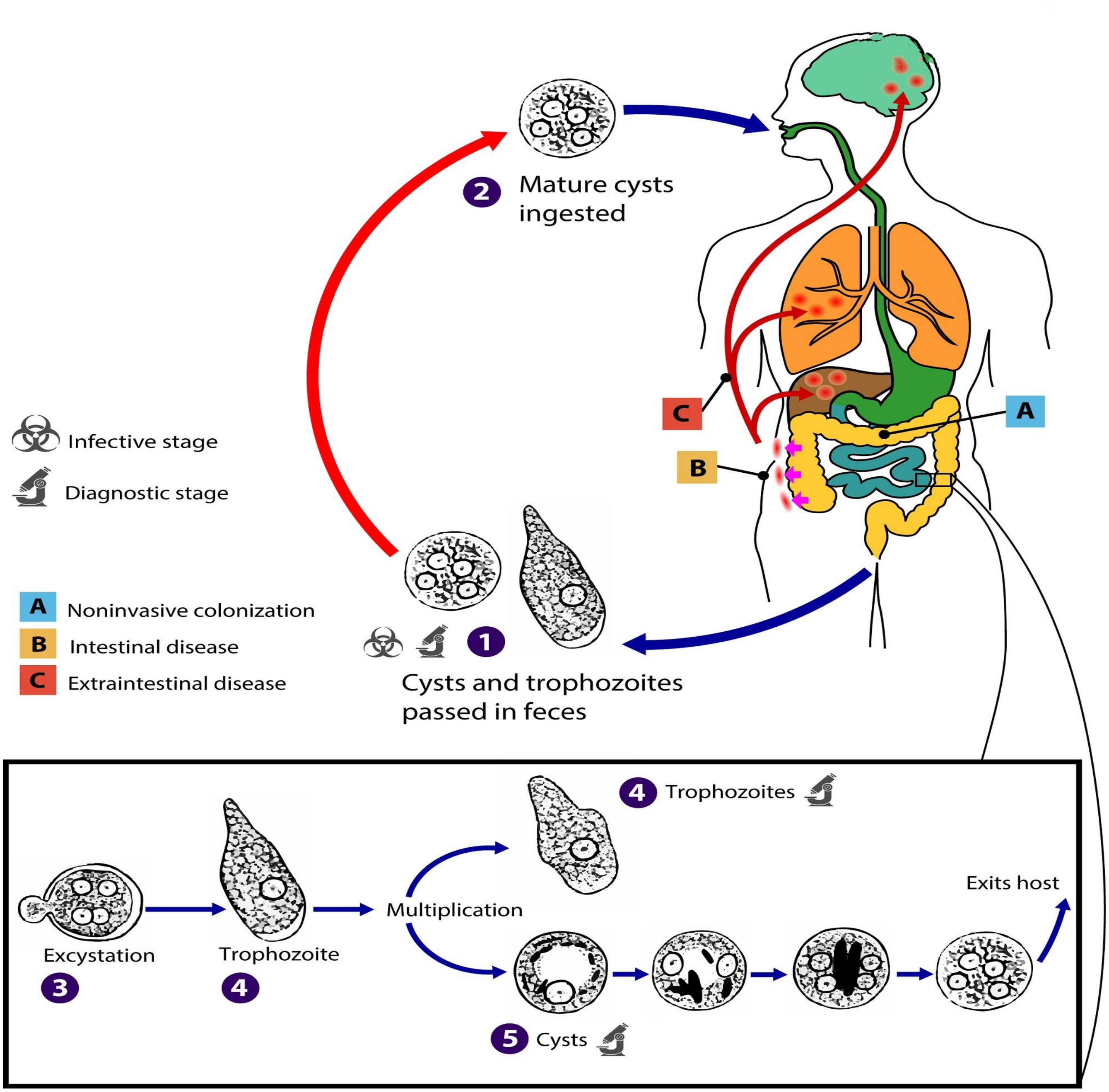

Figure 2.6. Life cycle of *Entamoeba histolytica* (Source: CDC, 2019).

2.Giardia lamba:Mode of transmission, lifecycle and pathogenisis

Giardia lamblia, also known as *Giardia duodenalis* or *Giardia intestinalis,* is one of the most common intestinal protozoan parasites affecting humans worldwide. This flagellate parasite is a leading cause of waterborne diarrheal disease and represents the most frequently identified intestinal parasite in the United States (Painter *et al.,* 2015). The organism's clinical significance extends beyond acute gastrointestinal symptoms, with potential implications for nutritional status and long-term health outcomes.

Transmission of *Giardia lamblia* occurs predominantly through the fecal-oral route via multiple pathways. The infectious cysts demonstrate remarkable environmental resilience and can survive several months in cold water (Adam, 2021). Contaminated water sources represent the primary transmission vehicle, particularly in regions with inadequate sanitation infrastructure. Food-borne transmission occurs when produce becomes contaminated with cyst-containing fecal matter, while direct person-to-person transmission frequently occurs in institutional settings such as daycare centers (Einarsson *et al.*, 2016). Animal-to-human transmission can also occur through contact with infected domestic or wild animals. The infective dose is remarkably low, with as few as 10-25 cysts capable of establishing infection in susceptible individuals

The lifecycle encompasses two distinct morphological forms: the environmentally resistant cyst and the metabolically active trophozoite. Infection begins with ingestion of cysts in contaminated water or food. Following ingestion, cysts traverse the gastric environment and reach the small intestine, where alkaline pH triggers excystation (Bartelt and Sartor, 2015). Each cyst releases two trophozoites, which exhibit characteristic pear-shaped morphology with four pairs of flagella and a distinctive adhesive disc. Trophozoites colonize the upper small intestine, particularly the duodenum and jejunum, where they attach to intestinal epithelium via their ventral adhesive disc.

Reproduction occurs through binary fission, enabling rapid population expansion. Environmental triggers initiate encystation, during which trophozoites develop protective cyst walls before being excreted in feces, completing the transmission cycle (Nash *et al.*, 2018). The developmental sequence is illustrated in Figure 2.7, which shows the transition from cyst ingestion to trophozoite multiplication and subsequent encystation, emphasizing the critical stages responsible for host colonization and environmental transmission.

This parasite causes disease through mechanical and biochemical disruption of normal intestinal function without tissue invasion. The primary pathogenic mechamnism involves physical disruption of the intestinal epithelial barrier through trophozoite attachment, causing mechanical damage to microvilli and resulting in decreased surface area for nutrient absorption (Halliez and Buret, 2013). This interference contributes to malabsorption of fats, carbohydrates, and fat-soluble vitamins, leading to characteristic steatorrhea. Biochemical pathogenesis involves parasite-released enzymes and metabolic products that compromise intestinal barrier function and trigger inflammatory responses. Clinical manifestations typically develop one to three weeks following exposure, with subacute onset of loose, greasy stools, flatulence, and weight loss (Muhsen and Levine, 2012). Fever is uncommon, distinguishing giardiasis from other infectious diarrheal diseases. Malabsorption syndrome can have significant nutritional consequences, particularly in children, potentially resulting in failure to thrive and vitamin deficiencies.

Giardia lamblia represents a significant global health challenge due to its efficient transmission mechanisms and diverse pathogenic effects. Understanding these fundamental aspects is essential for developing effective prevention strategies and optimizing therapeutic interventions.

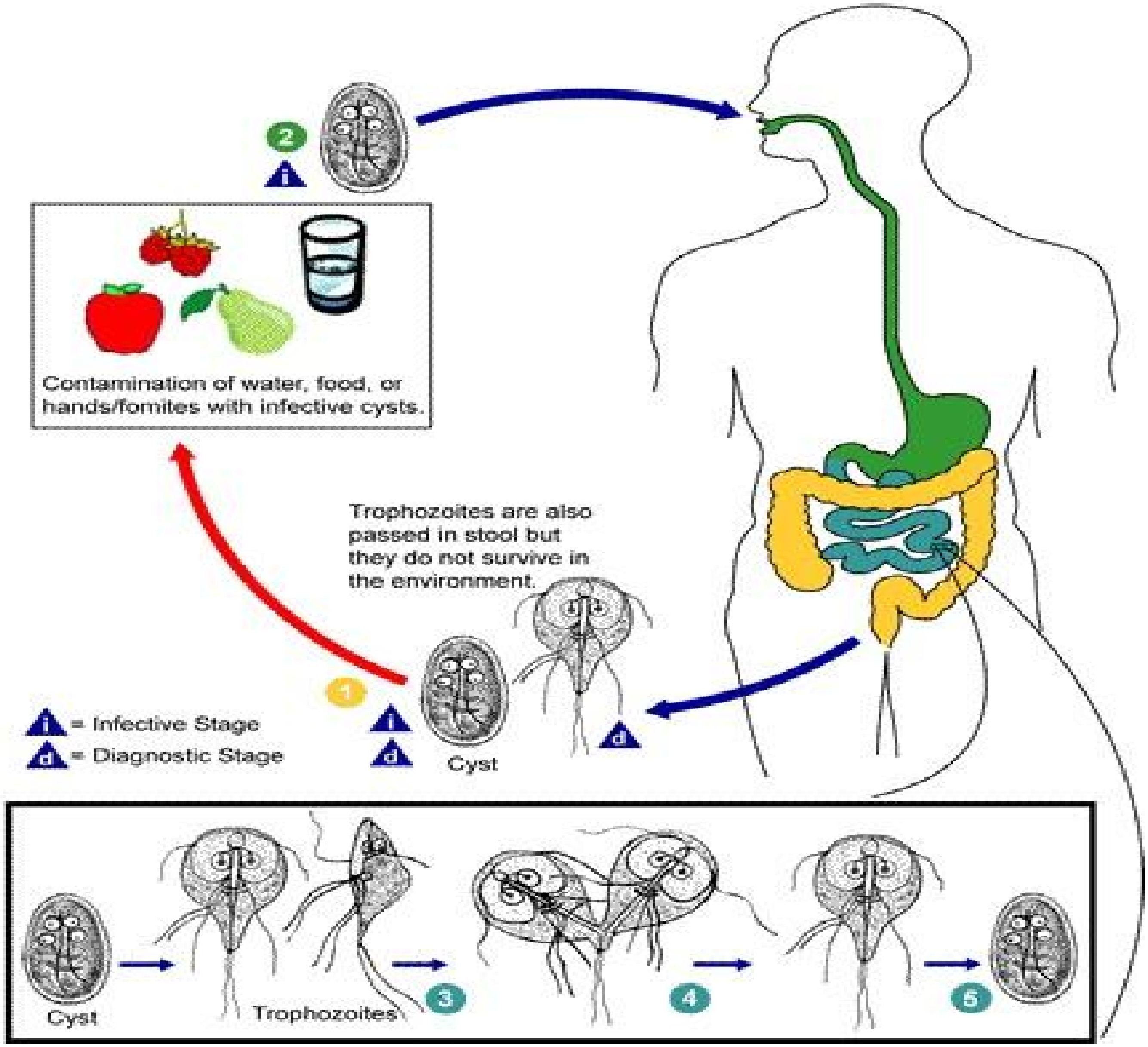

Figure 2.7. Life cycle of Giardia lamblia (Source :CDC, 2024).

2.5 Immune response to intestinal Parasites

The human gastrointestinal tract represents a complex immunological environment where the host immune system must balance tolerance to beneficial microorganisms while mounting effective responses against pathogenic parasites. Intestinal parasites, including helminths and protozoa, have evolved sophisticated mechanisms to survive within this environment, often modulating host immune responses to establish chronic infections (Cortés et al., 2017). The prototypical immune response to intestinal parasites is characterized by a robust Type 2 or Th2-mediated response involving key cytokines including interleukin-4 (IL-4), IL-5, and IL-13, which orchestrate coordinated defense against parasitic infections (Maizels and McSorley, 2016). IL-4 and IL-13 are essential for parasite expulsion from the intestinal tract, with research revealing an inverse correlation between parasitemia levels and IL-4 expression against nematodes like *Trichinella spiralis* (Finkelman *et al*., 2004).Innate immune cells serve as the first line of defense, with Type 2 innate lymphoid cells (ILC2s) playing crucial roles in early parasite recognition. ILC2-derived IL-5 induces eosinophil accumulation, while IL-13 promotes goblet cell hyperplasia and smooth muscle contraction to promote worm expulsion (Roan *et al.*, 2018). Macrophages undergo alternative activation (M2 phenotype) driven by IL-4 and IL-13, essential for tissue repair and parasite containment (Gause et al., 2018).

The Type 2 response employs multiple effector mechanisms including increased smooth-muscle contractility, intestinal permeability, and goblet-cell mucous secretion (Grencis, 2015). These changes create a hostile environment for parasites through increased gut motility and mucus production. Eosinophils recruited through IL-5-mediated mechanisms can directly damage parasites through toxic granular proteins and extracellular traps.Intestinal parasites have evolved sophisticated evasion strategies, demonstrating their capacity to manipulate immune system function (Zaiss *et al.,* 2015). Many parasites secrete immunomodulatory molecules that suppress inflammatory responses and promote regulatory T cell activation, allowing persistence while providing protection against excessive inflammatory responses.

Recent research highlights complex interactions between intestinal parasites, gut microbiota, and the immune system. Parasites can modulate the gut microbiome, inducing alterations in microbial diversity and metabolic activity that influence immune responses (Singh *et al.*, 2024). This creates a bidirectional relationship where parasites impact microbial composition while microbes influence parasitic survival and expulsion (Cotton *et al*., 2024).

2.6 Epidemiology of Intestinal Parasites.

Intestinal parasitic infections affect over one billion people worldwide, with prevalence rates of 30-60% in developing countries within tropical and subtropical regions (Ahmed *et al*., 2023; Teshome *et al.,* 2021). The epidemiological patterns are influenced by complex interactions between environmental factors, socioeconomic conditions, and host characteristics. Soil-transmitted helminth (STH) infections affect approximately 1.5 billion people worldwide, with 819 million infected with *Ascaris lumbricoides*, 464 million with *Trichuris trichiura*, and 438 million with hookworm species (Wang *et al.*, 2024; Pullan et al., 2014). STHs account for a disease burden of 3.38 million disability-adjusted life years (DALYs), representing the largest infection burden among neglected tropical diseases. *Ascaris lumbricoides i*s the most common STH globally with 24.07% prevalence, followed by *Trichuris trichiura* at 16.04% (Karagiannis-Voules *et al.,* 2015). Hookworm*, Ascaris lumbricoides and Trichuris trichiura i*nfections contribute 1.76 million, 1.08 million and 0.54 million DALYs respectively, with infections concentrated in Africa and the Americas.

Among protozoan parasites, prevalence rates reach 46.3% among food handlers in some regions, with *Blastocystis hominis em*erging as the most prevalent species globally (Hajare et al., 2021; Rajaei et al., 2022). Over 600 million people are infected by *Strongyloides stercoralis* globally, overlapping geographically with other STHs due to shared poor sanitation requirements (WHO, 2023). Pediatric populations bear disproportionate burden, with 37% prevalence among school-going children aged 5-19 years in low- and middle-income countries (Wang et al., 2024; Mekuria *et al., 2*024). In Ethiopian preschool children, pooled national prevalence reaches 32.52%, with single infections at 31.08% and mixed infections at 1.44% (Sitotaw *et al.*, 2019).Environmental and socioeconomic factors significantly influence transmission patterns. STH infections disproportionately affect the poorest communities through fecal contamination of soil in areas with poor sanitation (Bethony *et al.,* 2006). Approximately 300 million people with heavy infections suffer severe morbidity, resulting in over 150,000 deaths annually (Crompton *et al.,* 2006).

Recent trends show evolving distribution patterns from 1990-2021, with DALY estimates of 5.18 million globally in 2010 and hookworm DALYs increasing from 1.5 million in 1990 to 1.8 million in 2001 (Wang *et al.,* 2024; Jourdan *et al.,* 2017). Control programs have treated over 99 million women through mass drug administration, though reinfection challenges persist (WHO, 2023).Mixed infections commonly occur, complicating diagnosis and treatment while potentially exacerbating health impacts (Brooker *et al.,* 2006). Food handlers represent epidemiologically important groups due to transmission potential (Omemu and Bankole, 2022). Climate change continues influencing parasite survival and distribution through altered precipitation and temperature patterns (Caminade *et al.,* 2019).

2.7 . Risk factors for intestinal parasitic infection

Sanitation and Hygiene: Poor sanitation and inadequate hygiene practices represent the most significant risk factors for intestinal parasitic infections. The distribution of these infections is mainly associated with poor personal hygiene, environmental sanitation, and limited access to clean water (Alemu *et al.,* 2019). Lack of toilet facilities, poor defecation practices, and inadequate waste disposal systems create environmental contamination with parasite eggs and cysts (Karan *et al.,* 2012). Poor handwashing habits, particularly after defecation and before eating, significantly increase infection likelihood (Sitotaw *et al.,* 2019).

Socioeconomic and Environmental Conditions:Lower socioeconomic status consistently correlates with higher infection prevalence due to inadequate housing, limited healthcare access, and poor nutrition (Yimam *et al*., 2016). Families with no members having secondary education show higher childhood infection rates compared to educated households (Alemu *et al.*, 2019). Rural areas demonstrate higher infection rates than urban settings due to limited infrastructure development (Chandrasekar *et al.,* 2018). Unemployment and irregular employment patterns correlate with increased infection rates, reflecting limited financial resources for maintaining adequate hygiene (Karan *et al*., 2012).

Behavioral Risks in Children: Children exhibit specific behavioral patterns that increase susceptibility to intestinal parasitic infections. Younger children show higher infection rates due to developing immune systems and behavioral characteristics that increase exposure (Alemu *et al*., 2019). Poor handwashing practices and natural tendency to explore environments through touch and oral contact increase exposure to contaminated surfaces (Sitotaw *et al.,* 2019). Children who frequently go barefoot show significantly higher infection rates, especially for hookworm infections (Karan *et al.*, 2012). Consumption of unwashed fruits and vegetables, drinking untreated water, and eating with unwashed hands create transmission opportunities (Teklu *et al.,* 2024). Inadequate school sanitation facilities and overcrowded classrooms further contribute to transmission among school children.

2.8. Primary school children (As a vulnerable population)

Primary school children generally fall within the age bracket of 5 to 14 years, depending on national education policies and enrollment structures (UNESCO, 2021). In Nigeria, this corresponds to children in Basic 1 through Basic 6, who represent the foundation stage of formal education (FME,2019). This age group is a critical developmental period characterized by rapid physical growth, ongoing cognitive maturation, and increased independence in daily activities. At the same time, children are becoming more socially active, spending substantial portions of the day in classrooms and playgrounds, where close peer interaction increases exposure to communicable diseases (WHO, 2020).From a developmental standpoint, children in this stage are still learning essential life skills, including personal hygiene, self-care, and responsibility. Their immune systems, while more developed than in early childhood, remain in the process of adaptation, which makes them susceptible to infections when exposed to contaminated environments (Kumar *et al.,* 2021). Behavioral tendencies such as curiosity-driven play, frequent hand-to-mouth contact, geophagia, and reluctance to consistently use footwear amplify their exposure to soil-transmitted and waterborne parasites (Alemu *et al*., 2019). These habits, though developmentally typical, interact with poor environmental sanitation in many low- and middle-income countries to heighten infection risk.

In addition to their developmental characteristics, primary school children hold a unique social position. They are highly visible in communities and spend much of their time in structured environments such as schools. This makes them a strategic group for public health interventions, particularly school-based deworming and hygiene education programs, which can reach large numbers of children simultaneously (WHO, 2020; Kavitha *et al*., 2024). Moreover, because this group is at an age when learning and growth lay the foundation for future health and productivity, protecting them from preventable infections is considered a key investment in human capital development (Ezeamama *et al.,* 2017).Socioeconomic context also defines who primary school children are in many low-resource settings. In rural and peri-urban communities, children may combine school attendance with household chores, farming, or fetching water, activities that further increase their risk of exposure to contaminated soil and water sources (Gbonhinbor *et al.,* 2022). In some cases, irregular school attendance caused by illness, poverty, or domestic responsibilities compounds vulnerability by limiting consistent access to health education and school-based interventions (Gemechu *et al.*, 2024).

In Ikpoba Hill, Benin City, Edo State, these vulnerabilities are particularly relevant. The area represents a mix of urban and peri-urban communities, with pockets where poor sanitation, overcrowding, and reliance on unsafe water sources persist. Many households lack access to improved toilet facilities and safe drinking water, while refuse disposal and drainage systems remain inadequate in certain neighborhoods. These environmental challenges, combined with the behavioral patterns typical of primary school children, make this population highly susceptible to intestinal parasitic infections. The school setting in Ikpoba Hill therefore becomes a critical point of both exposure and intervention, underscoring the importance of prevalence studies to guide targeted deworming, hygiene promotion, and sanitation improvements in the community.Taken together, primary school children are not only defined by their age and schooling stage but also by their developmental characteristics, social roles, and exposure contexts. These dimensions converge to make them one of the most accessible yet highly vulnerable groups to intestinal parasitic infections. This combination of vulnerability and accessibility underscores why they are the central focus of global deworming campaigns, water and sanitation interventions, and school health programs in endemic regions (WHO, 2020; Kavitha *et al.*, 2024).

2.9 Impact of Intestinal Parasites on primary school children

Intestinal parasites remain a significant public health concern among primary school children, particularly in low- and middle-income countries where sanitation and hygiene are often inadequate. The impact of these infections extends beyond immediate health problems, as they interfere with the physical, nutritional, and cognitive development of children during a critical stage of growth and learning (Gemechu *et al.,* 2024). Since primary school age represents a foundational period in a child's educational journey, the consequences of intestinal parasites are not limited to medical concerns but also affect long-term educational attainment and overall well-being.

2.9.1 Clinical Manifestations

The clinical signs of intestinal parasitic infections in primary school children vary widely depending on the species involved, the intensity of infection, and the child's nutritional and immune status. Common symptoms include diarrhea, abdominal pain, bloating, nausea, and recurrent gastrointestinal discomfort (Gemechu *et al*., 2024). Infections caused by *Ascaris lumbricoides* often present with abdominal distension and intestinal obstruction in heavy infestations, while *Trichuris trichiura* may cause chronic colitis and rectal prolapse in severe cases (Kumar *et al., 20*21). Hookworm infections are particularly associated with chronic blood loss, leading to fatigue and weakness (WHO, 2020). These manifestations not only affect daily functioning but also compromise children's capacity to actively participate in school and play.

2.9.2 Nutritional and Physical Effects

Intestinal parasites exert a profound effect on children's nutritional status and physical development. Many parasites compete with the host for vital nutrients, while others directly damage intestinal mucosa, impairing absorption. Hookworms, for instance, attach to the intestinal wall and feed on blood, contributing significantly to iron-deficiency anemia (Kavitha *et al.*, 2024). Chronic parasitic infections are strongly linked to undernutrition, stunted growth, and wasting, especially in children residing in endemic areas where diets are already deficient in key micronutrients (Alemu *et al.,* 2019). Anemia resulting from prolonged parasitic infections reduces physical endurance and weakens immune responses, thereby increasing susceptibility to secondary infections (Gemechu *et al.,* 2024). Collectively, these outcomes interfere with healthy growth and delay physical milestones during the critical years of primary education.

2.9.3 Cognitive and Academic Impact

Beyond physical health, intestinal parasites significantly undermine children's learning and academic performance. Persistent infections contribute to learning difficulties, poor concentration, and reduced cognitive abilities, largely due to malnutrition, anemia, and chronic fatigue (Ezeamama *et al.,* 2017). Several studies have demonstrated that infected children often score lower on memory, reasoning, and problem-solving tests compared to their uninfected peers (Kumar *et al.,* 2021). Additionally, recurrent illness leads to absenteeism, further widening educational gaps (Gbonhinbor *et al.,* 2022). Fatigue caused by anemia and gastrointestinal discomfort limits classroom participation, and prolonged absence from school reduces long-term academic achievement (WHO, 2020). These educational setbacks are particularly concerning because primary school is a foundational stage that shapes lifelong learning and productivity.

2.10 Laboratory Diagnosis of Intestinal Parasites

- **Iodine and saline method**

Accurate laboratory diagnosis of intestinal parasites remains a cornerstone for effective management, treatment, and control of parasitic infections among primary school children. Laboratory investigations not only confirm the presence of infection but also provide insights into parasite load, which is critical for assessing the severity of disease and guiding public health interventions.The primary method for diagnosing Intestinal parasites involves the microscopic examination of stool samples. Direct wet mount preparations are widely used in resource-limited settings due to their simplicity and rapidity. In this method, a small portion of fresh stool is emulsified in saline or iodine solution and examined under the microscope for the presence of motile trophozoites, cysts, ova, or larvae (Cheesbrough, 2019). While cost-effective, this technique has limited sensitivity, particularly in cases of light infections.

- **Concentration Technique**

Concentration techniques such as the formalin-ether concentration method and flotation techniques have been developed to improve diagnostic sensitivity. These methods increase the likelihood of detecting parasites by separating and concentrating eggs, larvae, or cysts from fecal debris (Levecke *et al.,* 2020). The Kato-Katz technique, recommended by the World Health Organization, is particularly useful for quantifying helminth egg counts, making it a valuable tool in epidemiological surveys and prevalence studies among school children (WHO, 2020).In addition to stool microscopy, immunological methods have emerged as highly effective in diagnosing protozoan infections such as *Giardia lamblia* and *Entamoeba histolytica.* Antigen detection assays, including enzyme-linked immunosorbent assays (ELISA), have been shown to be more sensitive and specific than conventional microscopy (de Lucio *et al.,* 2016). Rapid diagnostic tests are increasingly applied in field studies, offering a practical solution for large-scale screenings in endemic communities.

- **Molecular Diagnostic Technique**

Molecular diagnostic techniques, particularly polymerase chain reaction (PCR), have revolutionized parasitology diagnostics by allowing for precise species identification and differentiation between pathogenic and non-pathogenic strains. For instance, PCR enables the distinction of *Entamoeba histolytica* from the morphologically similar but non-pathogenic *Entamoeba* dispar (Fletcher *et a*l., 2018). Despite their high sensitivity and specificity, molecular methods are often limited to research and advanced laboratories due to their cost and technical requirements.Stool culture methods are occasionally employed for the detection of *Strongyloides stercoralis* larvae, while serological tests may be used to detect antibodies in cases of tissue-invasive parasites, though these are less applicable for intestinal protozoa and helminths (Bisoffi et al., 2017).

In recent years, there has been a growing interest in integrating point-of-care diagnostic tools in school-based surveys. These portable, easy-to-use technologies offer rapid results and hold promise for improving diagnostic coverage in low-resource settings (Barda *et al*., 2020).In conclusion, laboratory diagnosis of intestinal parasites relies on a combination of traditional microscopy, concentration techniques, immunological assays, and molecular methods. Each approach has its advantages and limitations, but when appropriately applied, they provide a comprehensive framework for detecting infections among primary school children. Accurate diagnosis not only ensures effective treatment but also strengthens epidemiological surveillance, which is essential for the design of targeted intervention strategies in endemic areas such as Ikpoba Hill, Benin City.

2.11 Control and Prevention of Intestinal Parasites

The control and prevention of intestinal parasites in primary school children require a combination of medical, behavioral, and environmental strategies. Since these infections are largely transmitted through the fecal–oral route, poor sanitation, contaminated water, and inadequate hygiene practices are central risk factors. Effective interventions therefore focus on interrupting transmission while also treating existing infections.Mass deworming programs remain the most widely used public health approach, particularly in endemic areas. The World Health Organization recommends periodic administration of anthelmintic drugs such as albendazole or mebendazole to school-aged children as a cost-effective means of reducing parasite burden and preventing reinfection (WHO, 2020). Complementary measures such as ensuring access to clean water, safe disposal of feces, and promoting handwashing with soap are equally essential to break the cycle of transmission (Strunz *et al.,* 2019).

Health education also plays a crucial role in prevention. Teaching children proper hygiene practices such as washing hands before meals and after using the toilet, and wearing footwear to avoid contact with contaminated soil significantly lowers infection rates (Gyorkos *et al.*, 2019). Furthermore, community-wide sanitation improvements, including provision of latrines and clean water infrastructure, provide long-term benefits by reducing environmental contamination with parasite eggs and cysts (Campbell *et al., 2*018).

Sustainable control of intestinal parasites among primary school children requires an integrated approach that combines periodic deworming, improved hygiene, and better sanitation infrastructure, reinforced with health education. Such combined measures not only reduce the prevalence of infections but also help safeguard children's growth, development, and academic potent

CHAPTER 3

MATERIALS AND METHOD

3.1 Study Area

The study was carried out in Ikpoba Hill, located within Ikpoba-Okha Local Government Area of Edo State, Nigeria. Ikpoba Hill lies about 7 kilometers from the center of Benin City, along the Benin–Agbor Road. The area is one of the major suburban settlements of Benin City, with a mix of residential and commercial activities. Edo State is geographically situated around latitude 6.34°N and longitude 5.62°E, within the humid tropical region of southern Nigeria. The area has numerous public and private primary schools, making it suitable for a study on intestinal parasites among school children.

3.2 Study population

The study population comprised male and female primary school pupils aged 5 to 14 years residing in Ikpoba Hill, Benin City, Edo State. A total of 167 stool samples were collected from children within this age group.

Inclusion Criteria

- Primary school pupils aged 5 to 14 years residing in Ikpoba Hill, Benin City.
- Pupils whose parents or guardians provided signed informed consent.
- Pupils who were present on the day of sample and data collection.

Exclusion Criteria

- Pupils who were on anti-parasitic medication or had received deworming treatment within the three weeks prior to data collection.

- Pupils whose parents or guardians did not provide consent.
- Pupils who were unwilling to participate or unable to provide stool samples.
- Pupils with chronic gastrointestinal illnesses unrelated to parasitic infections.

3.3 Sample size determination

The minimum sample size for this study was determined using the world health organization standard sample formula for the calculation of samples size (Daniel *et al.*,1999)

$N=Z^2P(1-P)/d^2$

Where:

n-Sample size

Z- Z-score for 95% confidence level (1.96)

P- Estimated prevalence

d- Margin of error (0.05)

From the prevalence of intestinal Parasite in primary school children as 12% =0.12

(Hajissa *et al.*,2022)

$Z^2=3.8416$

$1-p=1-0.12$

$=0.88$

$D^2=0.0025$

$N=(3.8416 \times 0.12 \times 0.88)/0.002$

N=162.27

However,to allow for a level of attrition,the sample size used was 167.

3. 4 Ethical consideration : Ethical clearance for this study was obtained from the Ethics committee of the Edo state ministry of health,Benin city, Nigeria with approval number HA/737/25/D/07230734 (see appendix I) Parents or guardians of the participating pupils received written information about the study and provided signed informed consent, while the children gave verbal assent before sample collection. Participation was entirely voluntary, and pupils were free to withdraw at any stage without penalty. To ensure confidentiality, each child was assigned a unique code number, and no personal identifiers appeared on the data sheets. All results were kept secure and used strictly for research purposes, and all procedures adhered to internationally recognized ethical standards for research involving minors.

3.5 Sample collection :A total of 167 stool samples were collected from 167 consenting pupils. Each pupil was given a clean, labeled container with instructions on how to collect a fresh mid-morning stool sample. The collected samples, weighing about 5–10 grams each, were properly coded to maintain anonymity and transported the same day to the Medical Microbiology Laboratory of the University of Benin Teaching Hospital (UBTH) for examination.

QUESTIONNAIRE

- A well designed questionnaire was given to the subjects to provide information on socio-demographic variables

3.6 Sample Analysis

Stool specimens were examined using standard parasitological methods. Initially, a direct wet mount in both normal saline and Lugol's iodine was prepared to detect motile protozoa, trophozoites, cysts, and helminth eggs (Garcia, 2016). To enhance detection sensitivity, the formol-ether concentration technique was performed. In this procedure, 1 g of stool was emulsified in 5 mL of formol saline, and the homogenate was sieved into a centrifuge tube. An additional 2 mL of formol saline was added to reach a total volume of 7 mL, followed by 3 mL of diethyl ether. The tube was capped, shaken vigorously to mix, and centrifuged at 3,000 rpm for 1 minute, resulting in sedimentation of parasitic elements. The sediment was resuspended, and a drop was placed on a clean glass slide for microscopic examination, with ×10 objective used for focusing and ×40 for detailed viewing (WHO, 2020). Parasites were identified to genus or species level based on morphology such as egg, cyst, or trophozoite characteristics (Cheesbrough, 2019).

3.7 Statistical Analysis

Data analysis was conducted using SPSS version 27. Descriptive statistics such as mean, standard deviation, frequency, and percentage were employed to summarize the demographic and clinical characteristics of the participants. Results were presented in tables and figures for clarity. The Chi-square test was applied to assess associations between intestinal parasitic infection and selected demographic as well as clinical variables. A significance level of $p < 0.05$ was considered statistically significant, while values greater than 0.05 were regarded as not significant.

CHAPTER FOUR

RESULTS

Table 4.1 presents the demographic characteristics of the study participants. The mean age of the respondents was 9.66 ± 2.90 years. The distribution by age range shows that the majority were within 11–14 years (46.7%), followed by those aged 6–10 years (42.5%), while the least proportion were between ≤5 years (10.8%). In terms of gender, slightly more males (53.3%) participated compared to females (46.7%). Regarding class level, Primary 1 and Primary 2 had the highest proportion of participants (19.8% each), whereas Primary 3 had the least representation (13.2%). See Fig 4.1-4.3.

Table 4.1: Demographic Characteristics of the Study Participants

Variables	Frequency	Percent
Age Range		
≤5 Years	18	10.8
6–10 Years	71	42.5
11–15 Years	78	46.7
Total	167	100.0
Mean Age ± SD	9.66 ± 2.90	
Gender		
Female	78	46.7
Male	89	53.3
Total	167	100.0
Class Level		
Primary 1	33	19.8
Primary 2	33	19.8
Primary 3	22	13.2
Primary 4	27	16.2
Primary 5	25	15.0
Primary 6	27	16.2
Total	167	100.0

Table 4.2: Prevalence of Intestinal Parasites Among Primary School Pupils in Ikpoba Hill,Benin City, Edo State

Table 4.1 illustrates the overall prevalence of intestinal parasites among the study participants. Out of 167 stool samples examined, 117 (70.1%) were negative, while 50 (29.9%) tested positive for intestinal parasites. Among the infected cases, *E. coli* accounted for the highest proportion (60.0%), followed by *E. histolytica* (24.0%), whereas *Ascaris lumbricoides* and *Trichuris trichiura* each represented 8.0% of the infections.

Table 4.2: Prevalence of Intestinal Parasites Among Primary School Pupils in Ikpoba Hill,Benin City, Edo State

Iodine preparation	Frequency	Percentage (%)
Positive	50	29.9
Negative	117	70.1
Total	167.	100

Table 4.3: Distribution of Intestinal Parasite Among Primary School Pupils in Ikpoba Hill,Benin City, Edo State Based on Age

Table 4.2 presents the distribution of intestinal parasite among primary school children in Ikpoba Hill in Benin city, Edo State in relation to age. The results show no statistically significant association between age and the prevalence of intestinal parasitic infection ($p > 0.05$). However, children aged 6–10 years recorded the highest number of positive cases (46.0%), followed by those aged 11–15 years (42.0%), while the lowest prevalence was observed in the ≤5 years group (12.0%).

Table 4.3: Prevalence of Intestinal Parasite Among Primary School Pupils in Ikpoba Hill,Benin City, Edo State Based on Age

Age range	Sample size	No. of positive	% positive	p-value	Odds ratio	95% CI
≤5 years	18 (12.8)	6	12.0	0.726	0.816	0.496 – 1.344
6–10 years	71 (50.7)	23	46.0			
11–15 years	78 (55.7)	21	42.0			
Total	167 (100)	50				

Table 4.4: Distribution of Intestinal Parasite Among Primary School Pupils in Ikpoba Hill, Benin City, Edo State Based on Gender

Table 4.3 presents the distribution of intestinal parasite among primary school children in Ikpoba Hill,Benin city, Edo State in relation to gender. The results show no statistically significant association between gender and the prevalence of intestinal parasitic infection ($p > 0.05$). However, males accounted for a higher proportion of infections (62.0%) compared to females (38.0%).

Table 4.4: Distribution of Intestinal Parasite Among Primary School Pupils in Ikpoba Hill,Benin City, Edo State Based on Gender

Gender	Sample size	No. of positive	% positive	p-value	Odds ratio	95% CI
Female	78 (44.3)	19	38.0	0.140	1.660	0.844 – 3.264
Male	89 (50.7)	31	62.0			
Total	**167 (100)**	**50**				

Table 4.5: Distribution of Intestinal Parasite Among Primary School Pupils in Benin City, Edo State Based on Class Level

Table 4.4 presents the distribution of intestinal parasite among primary school children in Ikpoba Hill, Benin city, Edo State in relation to class level. The results show no statistically significant association between class level and the prevalence of intestinal parasitic infection ($p > 0.05$). However, Primary 4 pupils had the highest infection rate (24.0%), whereas Primary 3 pupils recorded the lowest (10.0%).

Table 4.5: Distribution of Intestinal Parasite Among Primary School Pupils in Ikpoba Hill,Benin City, Edo State Based on Class Level

Class level	Sample size	No. of positive	% positive	p-value	Odds Ratio	95% CI
Primary 1	33 (19.4)	10	20.0	0.479	1.073	0.886 – 1.298
Primary 2	33 (19.4)	7	14.0			
Primary 3	22 (12.9)	5	10.0			
Primary 4	27 (15.9)	12	24.0			
Primary 5	25 (14.7)	8	16.0			
Primary 6	27 (15.9)	8	16.0			
Total	**167 (100)**	**50**				

Table 4.6: Distribution of Intestinal Parasite Among Primary School Pupils in Ikpoba Hill,Benin City, Edo State Based on Lifestyle and Clinical Characteristics

Table 4.5 prevalence of intestinal parasite among primary school children in Ikpoba Hill,Benin city, Edo State in relation to lifestyle and clinical characteristics. A statistically significant association was observed between type of toilet facility used and prevalence of parasitic infection ($p = 0.030$). Children who used pit latrines recorded the highest infection rate (48.0%), followed by those practicing open defecation (32.0%), while the lowest prevalence was among those using water system toilets (20.0%).

For other clinical factors, no statistically significant associations were observed ($p > 0.05$). However, variations in infection rates were noted. Children who always washed their hands had higher infection rates (44.0%) compared to those who washed sometimes (32.0%) or never (24.0%). Similarly, those who never treated or boiled their water showed the highest prevalence (48.0%) compared to those who sometimes treated water (28.0%) or always treated water (24.0%). With respect to drinking water source, infections were most common among those relying on streams/rivers (28.0%) and tap/borehole water (28.0%), while the lowest was observed among those using sachet/bottled water (20.0%).

Children who reported bathing twice daily recorded higher infection prevalence (44.0%) compared to once daily bathers (20.0%). Likewise, those who wore footwear sometimes (36.0%) and never (34.0%) had higher infection rates than those who always wore footwear (30.0%). Regarding waste disposal, irregular disposal was associated with higher prevalence (32.0%), while daily disposal was lowest (22.0%). Deworming patterns also varied, with those not sure of ever being dewormed showing the highest infection rate (34.0%) compared to those who reported regular deworming (38.0% yes vs. 28.0% no). Children who dewormed once a year had the highest prevalence (32.0%), compared to those who dewormed more than twice (26.0%).

In terms of symptoms, diarrhea (24.0%), itching anus (22.0%), vomiting (14.0%), and weight loss (14.0%) were commonly reported among infected children, while only 6.0% of infected children were asymptomatic. Children not sure if they were treated for worms in the last six months had slightly lower prevalence (28.0%) compared to those not treated (32.0%) or treated (40.0%). Finally, consumption of street food was associated with higher infection prevalence among those who always ate street food (30.0%) and those who rarely ate street food (32.0%) compared to those who never ate it (18.0%).

Table 4.6: Distribution of Intestinal Parasite Among Primary School Children in Ikpoba Hill,Benin City, Edo State Based on Lifestyle and Clinical Characteristics

Variables	Positive	Negative	χ^2	df	p-value
Toilet Facility					
Open defecation	16 (32.0%)	39 (33.3%)	6.99	2	0.030
Pit latrine	24 (48.0%)	34 (29.1%)			
Water system	10 (20.0%)	44 (37.6%)			
Uses Toilet at School					
No	23 (46.0%)	56 (47.9%)	0.05	1	0.825
Yes	27 (54.0%)	61 (52.1%)			
Handwashing Habit					
Never	12 (24.0%)	42 (35.9%)	3.06	2	0.217
Sometimes	16 (32.0%)	38 (32.5%)			
Always	22 (44.0%)	37 (31.6%)			
Handwashing Material					
Water & ash	19 (38.0%)	40 (34.2%)	0.30	2	0.863
Water & soap	14 (28.0%)	37 (31.6%)			
Water only	17 (34.0%)	40 (34.2%)			
Washes Fruits/Vegetables					
No	13 (26.0%)	38 (32.5%)	0.70	2	0.705
Sometimes	19 (38.0%)	40 (34.2%)			
Yes	18 (36.0%)	39 (33.3%)			
Bathing Frequency					
Once daily	10 (20.0%)	36 (30.8%)	2.39	2	0.302
Twice daily	22 (44.0%)	40 (34.2%)			
Occasionally	18 (36.0%)	41 (35.0%)			
Wears Footwear					
Never	17 (34.0%)	44 (37.6%)	0.22	2	0.895
Sometimes	18 (36.0%)	41 (35.0%)			

Always	15 (30.0%)	32 (27.4%)			
Drinking Water Source					
Sachet/Bottled	10 (20.0%)	21 (17.9%)	1.81	3	0.613
Stream/River	14 (28.0%)	30 (25.6%)			
Tap/Borehole	14 (28.0%)	26 (22.2%)			
Well	12 (24.0%)	40 (34.2%)			
Treats/Boils Water					
Never	24 (48.0%)	43 (36.8%)	3.11	2	0.211
Sometimes	14 (28.0%)	30 (25.6%)			
Always	12 (24.0%)	44 (37.6%)			
Waste Disposal					
Daily	11 (22.0%)	27 (23.1%)	1.82	3	0.610
Weekly	14 (28.0%)	30 (25.6%)			
Occasionally	9 (18.0%)	31 (26.5%)			
Irregularly	16 (32.0%)	29 (24.8%)			
Ever Dewormed					
No	14 (28.0%)	39 (33.3%)	0.86	2	0.651
Not sure	17 (34.0%)	32 (27.4%)			
Yes	19 (38.0%)	46 (39.3%)			
Deworming Frequency					
More than twice	13 (26.0%)	28 (23.9%)	0.81	3	0.848
Twice a year	11 (22.0%)	27 (23.1%)			
Once a year	16 (32.0%)	32 (27.4%)			
Irregularly	10 (20.0%)	30 (25.6%)			
Recent Symptoms					
Abdominal pain	4 (8.0%)	13 (11.1%)	8.64	6	0.195
Diarrhea	12 (24.0%)	12 (10.3%)			
Itching anus	11 (22.0%)	22 (18.8%)			
Loss of appetite	6 (12.0%)	17 (14.5%)			
Vomiting	7 (14.0%)	13 (11.1%)			

Weight loss	7 (14.0%)	21 (17.9%)			
None	3 (6.0%)	19 (16.2%)			
Treated for Worms (6 months)					
No	16 (32.0%)	29 (24.8%)	2.33	2	0.311
Not sure	14 (28.0%)	47 (40.2%)			
Yes	20 (40.0%)	41 (35.0%)			
Eats Street Food					
Always	15 (30.0%)	23 (19.7%)	3.28	3	0.350
Sometimes	10 (20.0%)	32 (27.4%)			
Rarely	16 (32.0%)	33 (28.2%)			
Never	9 (18.0%)	29 (24.8%)			

CHAPTER FIVE

DISCUSSION, CONCLUSION , RECOMMENDATIONS AND LIMITATIONS

5.1 DISCUSSION

The findings of this study provide valuable insights into the prevalence and distribution of intestinal parasites among primary school children in Ikpoba Hill, Benin City. The participants had a mean age of 9.66 ± 2.90 years, with most participants being within the 11–15 year range, followed by those aged 6–10 years, while the youngest (≤5) formed the smallest proportion. There was a slight predominance of males over females, and enrolment across class levels was relatively even. This demographic pattern is consistent with observations from Osun and Kwara States, where male pupils were slightly more represented in similar surveys (Odetoyin *et al.,* 2023; Salawu and Ughele, 2020). The structure of the population likely reflects the typical composition of Nigerian primary schools.

The overall prevalence of Intestinal parasites in this study was 29.9%, which aligns with reports from Osun (24.4%) and Kwara (23.6%) States (Salawu and Ughele, 2020; Odetoyin *et al.,* 2023). However, it is markedly lower than the 86.2% reported among children in Lagos slums (Akinbo *et al.*, 2019). This difference may stem from better sanitation infrastructure and school-based deworming activities in the Ikpoba Hill area, which likely reduced transmission compared to more densely populated and poorly serviced environments.Age-related differences showed that children aged 6–10 years bore the highest burden of infection, followed by those aged 11–15 years, while the youngest group had the lowest prevalence. Similar age trends have been described in Bayelsa and Benue States, where younger pupils were more vulnerable to intestinal parasites (Chukwuma *et al*., 2021; Udeh *et al., 2*023). This pattern may reflect greater exposure to contaminated environments and less consistent personal hygiene among middle childhood groups, whereas older children may have developed improved hygiene practices and partial immunity through repeated exposure.Although the difference between sexes was not statistically significant, males recorded a higher percentage of infections than females. This outcome is comparable to findings in Kwara and Osun States (Odetoyin *et al.,* 2023; Salawu and Ughele, 2020). Boys' frequent outdoor play, barefoot walking, and contact with contaminated soil or water could explain their slightly higher prevalence.

Sanitation practices emerged as an important determinant of infection. Children who relied on pit latrines or practised open defecation had higher infection rates than those with access to flush toilets, echoing findings from Osun and Kwara, where inadequate sanitation was strongly associated with parasite transmission (Salawu and Ughele, 2020; Odetoyin *et al.,* 2023). Although some lifestyle variables did not show statistically significant associations, trends were apparent. Pupils who reported always washing their hands surprisingly showed higher infection rates than those who admitted doing so only sometimes, possibly due to over-reporting of good habits or poor handwashing technique. Drinking untreated water was also linked to higher infection prevalence, reinforcing the importance of safe water supply in controlling parasitic infections (World Health Organization, 2022).

Other factors such as bathing frequency, footwear use, and waste disposal habits showed weaker associations but suggested that hygiene behaviours alone may not be protective if other environmental risks persist. Children with irregular or infrequent deworming schedules were more likely to be infected than those who had taken anthelmintic drugs more than twice yearly, underscoring the value of consistent deworming as advocated by global guidelines (World Health Organization, 2022). Reported symptoms among infected participants including diarrhoea, perianal itching, vomiting, and weight loss mirror those documented in similar Nigerian studies (Chukwuma *et al.,* 2021), supporting the clinical relevance of the parasites identified.

5.2 Conclusion

Overall prevalence of intestinal parasitic infections among primary school children in Ikpoba Hill, Benin City was 29.9%, indicating a moderate burden, with *Entamoeba coli* and *Entamoeba histolytica* as the most common organisms, while helminths such as *Ascaris lumbricoides* and *Trichuris trichiura* were less frequent. Prevalence was highest among pupils aged 6–10 years and among males. The type of toilet facility was the only lifestyle factor associated with infection, underscoring the importance of sanitation. These findings align with evidence from other Nigerian and African contexts, highlighting that intestinal parasitic infections remain a significant public health challenge for school-aged children. Improvements in sanitation, water safety, and routine deworming have reduced prevalence compared with earlier reports from more deprived communities, yet gaps in hygiene education and environmental management continue to support transmission. Variations between this and other studies may reflect differences in study locations, sample sizes, diagnostic techniques, or seasonal timing, all of which are known to affect prevalence (World Health Organization, 2022). Strengthening school health initiatives, providing continuous hygiene education, and improving sanitation facilities are recommended to consolidate the gains achieved and further reduce the burden of intestinal parasites among children in this setting.

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5.3 Recommendations

1. Strengthen school-based deworming programmes and ensure pupils receive treatment at least twice yearly, in line with WHO guidelines.
2. Improve environmental sanitation by providing adequate, functional toilet facilities in schools and communities.
3. Promote sustained hygiene education for pupils, parents, and teachers, emphasising correct handwashing techniques and safe food handling.
4. Ensure consistent access to treated or safe drinking water in schools and households.
5. Encourage regular monitoring and surveillance of intestinal parasites to assess the effectiveness of control measures and identify high-risk groups.
6. Future research should employ multiple stool samples and more sensitive diagnostic techniques to provide more accurate prevalence data.

5.4 Limitations

1. a single stool specimen was collected from each participant, which might have underestimated the prevalence of parasites with intermittent shedding.
2. Microscopy was the sole diagnostic method; more sensitive techniques (e.g., concentration or molecular methods) could have detected additional infections.
3. The cross-sectional design limits the ability to infer causality between risk factors and infection.
4. Self-reported hygiene and deworming practices may have been affected by recall or social desirability bias.
5. The study was conducted in selected schools in one area, so findings may not be generalizable to all children in Benin City or Edo State

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APPENDIX I

ETHICAL APPROVAL

EDO STATE MINISTRY OF HEALTH
HEALTH RESEARCH ETHICS COMMITTEE

EDO HREC

PROTOCOL NUMBER	HA/737/25/D/06050734 (PLEASE QUOTE IN ALL ENQUIRIES)
APPROVAL NUMBER	HA/737/25/D/07230734
TITLE OF RESEARCH PROPOSAL	PREVALENCE OF INTESTINAL PARASITE AMONG PRIMARY SCHOOL CHILDREN IN IKPOBA HILL, BENIN CITY
PRINCIPAL INVESTIGATOR (S)	OSUJI REJOICE
DATE CONSIDERED	23RD JULY, 2025.
DECISION OF THE COMMITTEE	APPROVED

THIS APPROVAL DATES 23/07/2025 TO 23/07/2026. IF THERE IS A DELAY IN STARTING THE RESEARCH, PLEASE INFORM THE HREC EDO SMoH SO THAT THE DATES OF APPROVAL CAN BE ADJUSTED ACCORDINGLY

REMARK: Please kindly note that the HREC Edo SMoH seal authenticates this approval

DR (MRS.) OMONYEMEN B. BELLO
(MBBS, MPH, FPHCM) *(CHAIRMAN)*

SIGNATURE & DATE 01/08/2025

SUPERVISOR(S) DR (MRS) I.M. MOSES-OTUTU

ATTESTATION BY INVESTIGATOR(S)

No participant accrual or activity related to this research may be conducted outside of the approval dates. All informed consent forms used in this study must carry the Edo SMoH HREC-assigned number and duration of your research. No changes are permitted in the research without prior approval of the Edo SMoH HREC except in circumstances outlined in the Code. The Edo SMoH HREC reserves the right to conduct compliance visits to your research site without previous notification.

EDO STATE MINISTRY OF HEALTH
SECRETARIAT
DATE 23/07/2025
SIGN
DATE
RESEARCH & ETHICS COMMITTEE

Signature & Date 2/8/25

edohrec@edostate.gov.ng

Room 16, Block D, 2nd floor, State secetariat building.

APPENDIX II

INFORMED CONSENT FORM

Title of Study:

Prevalence of Intestinal Parasites among Primary School Children in Ikpoba hill, Benin City

Researcher: OSUJI REJOICE

Department of Medical Laboratory Science, University of Benin

Introduction:

You are invited to allow your child to participate in a research study. This study is designed to investigate the prevalence of intestinal parasites among primary school children in Ikpoba hill, Benin City. Please read the following information carefully before making your decision.

Procedures:

Your child will be asked to provide a stool sample for laboratory examination.

A brief questionnaire will be completed by you, the parent or guardian.

All procedures are simple, non-invasive, and safe.

Risks and Benefits:

There are no foreseeable risks to your child. If intestinal parasites are detected, appropriate medical advice or treatment will be provided. The results will help improve awareness and control of parasitic infections in children.

Confidentiality:

All information and samples collected will be kept strictly confidential. Your child's name will not appear in any publication or report of the research.

Voluntary Participation:

Participation is voluntary. You may withdraw your child from the study at any time without any negative consequence.

Consent Statement

I have read and understood the information provided above. I voluntarily agree to allow my child to participate in this study.

Name of Parent/Guardian: ___________________________________

Signature: ___________________________ Date: ________________

Name of Child: ____

Age/Class of Child: ____

Researcher's Signature: ___________________________ Date: _________

APPENDIX III

QUESTIONNAIRE FOR PARENTS/GUARDIANS

RESEARCH STUDY: Prevalence of Intestinal Parasites in Primary School Children in Ikpoba hill, Benin City

Could you please spare your precious time to fill this questionaire?

Please answer the following questions honestly. All information will be kept confidential and used for research purposes only.

Your cooperation and support is deeply appreciated

Tick(✔) where appropriate.

SECTION A: DEMOGRAPHIC INFORMATION

Age of child: __________

Gender of child: □ Male □ Female

Class level: __________________________

SECTION B: HYGIENE AND SANITATION PRACTICES

What type of toilet facility is used in your home?

□ Water system (flush) □ Pit latrine □ Open defecation □ Other: _______________

Does your child use the toilet at school?

□ Yes □ No

Does your child regularly wash hands after using the toilet?

□ Always □ Sometimes □ Never

What does your child use to wash hands?

□ Water only □ Water and soap □ Water and ash

Does your child wash fruits/vegetables before eating them?

□ Yes □ No □ Sometimes

How often does your child bathe in a day?

□ Once □ Twice □ Occasionally

Does your child usually wear slippers or shoes when playing outside?

□ Always □ Sometimes □ Never

SECTION C: WATER SOURCE AND ENVIRONMENT

What is your primary source of drinking water?

□ Tap/Borehole □ Well □ Stream/River □ Sachet/Bottled□ Other: ________________

Do you treat or boil your drinking water before use?

□ Always □ Sometimes □ Never

How often is your household waste disposed of?

□ Daily □ Weekly □ Occasionally □ Irregularly

SECTION D: MEDICAL AND NUTRITIONAL HISTORY

Has your child ever been dewormed?

□ Yes □ No □ Not sure

If yes, how often?

□ Once a year □ Twice a year □ More than twice □ Irregularly

Has your child recently experienced any of the following symptoms? (You may tick more than one)

□ Abdominal pain □ Diarrhea □ Loss of appetite □ Weight loss□ Itching around the anus?

□ Vomiting□ None of the above

Has your child been treated for worms in the past 6 months?

□ Yes □ No □ Not

Does your child eat food purchased from street vendors or school canteens?

□ Always □ Sometimes □ Rarely □ Never

SECTION E: CONSENT

Are you willing to allow your child to participate in this study and provide a stool sample for analysis?

□ Yes □ No