HAWASSA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES

DEPARTMENT OF BIOLOGY

The prevalence and associated risk factors of Intestinal Schistosomiasis in school age children at Dura (May Nigus) irrigational dam, Tigray region, Northern Ethiopia

Master's Thesis submitted to the College of natural and computational sciences, Department of Biology for partial fulfillment of Master's degree in biomedical science

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Hawassa, Ethiopia

DECLARATION

I hereby declare that this Master of science thesis entitled " **The prevalence and associated risk factors of Intestinal Schistosomiasis in school age children at Dura (May Nigus) irrigational dam, Tigray region, Northern Ethiopia."** Is my original work and has not been presented for a degree in any other university, and all sources and materials used for this final thesis work have been duly acknowledged.

Explained by: TEKLAY ABRHA

Signature: ____________________

Place: Hawassa University

Date of submission: ____________________

ADVISOR APPROVAL SHEET-I

This is to certify that the thesis entitled " **The prevalence and associated risk factors of Intestinal Schistosomiasis in school age children at Dura (May Nigus) irrigational dam, Tigray region, Northern Ethiopia."** submitted in partial fulfillment of the requirements for the degree of master's with specialization in biomedical science, the Graduate Program of biology, and has been carried out by Teklay Abrha under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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Advisor's Name	Signature	Date

EXAMINERS APPROVAL SHEET –II

We, the undersigned, members of the board of examiners of the final open defense by Teklay Abrha have read and evaluated the thesis entitled " **The prevalence and associated risk factors of Intestinal Schistosomiasis in school age children at Dura(May Nigus) irrigational dam, Tigray region, Northern Ethiopia. ''** and examined the candidate. Therefore, this is to certify that the thesis has been accepted in the partial fulfillment of the requirements for the degree of master science in biomedical science.

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Table of Contents

Contents page

List of tables **page**

List of figures **page**

List of Acronyms

AOR ………………… Adjusted Odd Ratio

BCE……………………Before Christ Era

CE……………………...Common Era

CI………………………Confidence Interval

CNS…………………...Central Nervous System

CSA…………………...Central Statistical Agency

COR…………………...Crud Odd Ratio

EPG……………………Egg Per Gram

GIS ……………………Geographic Information System

MDA…………………Mass Drug Administration

MHCs…………………Major Histocompatibility Complexes

NTD…………………...Neglected transmission disease

SAC……………………School Age Children

SSA…………………...Sub-Saharan Africa

Th2…………………...T helper

WASH………………. Water, Sanitation and Hygiene

Abstract

A water-borne parasitic disease Schistosomiasis, caused by trematode worms of the genus Schistosoma, continues to be a major public health issue in many regions of sub-Saharan Africa, including Northern Ethiopia's Tigray region. This study investigates the prevalence of *S. mansoni* and associated risk factors in the irrigational dams in Dura (May Nigus). A school-age child-based cross-sectional survey was conducted in Debrebrhan secondary and Dura elementary schools in the central Tigray region. Two hundred four schoolchildren aged from seven to twenty-one years were randomly selected to provide stool specimens for Schistosoma infection examination by Kato-Katz techniques. Of the 204 randomly selected students, 190(93.14%) passed the stool collection for stool specimen examination, and 24 (12.6%) were found positive for *Schistosoma mansoni*. The prevalence of *S. mansoni* infection was significantly associated with (Adjusted Odd Ratio (AOD)); for irrigation practice; 13.21, 95% CI (2.35, 74.20); p=0.003, for fetching water 14.52, 95% CI (2.82, 74.7); p=0.001, for washing clothes 6.4, 95% CI, (1.14, 35.4); p=0.035 respectively. Meaning thy are individually associated with *S. mansoni* presence. According to the retrospective data even-though there is decreasing intestinal case examination in St. Merry Hospital Axum for the past ten years the total prevalence(trend) for *Schistosoma mansoni* shows increasing from year to year with slight fluctuation in different age groups and genders. The most prevalent were in males among the age 10 to 25 years old. Based on the prevalence result for *Schistosoma mansoni*, now is the critical time to take controlling measurement and treatment in the community with a full campaign for elimination. A treatment of all school-age children once every two years is recommended with Snail control and non-specific control approaches, including the provision of clean water supply and health education, should also complement to the mass drug administration of praziquantel.

Key-words: Risk-factors; *S. mansoni*; Prevalence; School age children; irrigation

1. INTRODUCTION

1.1 Background of the study

Schistosomiasis, often called bilharzia, is a neglected tropical disease (NTD) caused by intestinal flukes of the genus *Schistosom*a(Di Bella *et al*.,2018, WHO ,2022). The majority of infections are due to three species: *Schistosoma haematobium*, *S. japonicum*, and *S. mansoni*(Grimes *et al*.,2015). The disease can manifest as either urogenital (*S. haematobium*) or intestinal (*S. mansoni*) schistosomiasis(Maddren *et al*., 2021). The disease remains a significant public health concern in the tropical and subtropical areas of the world (WHO,2024). The World Health Organization (WHO) estimates that over 2 million people are infected with schistosomiasis globally(WHO,2024) . The disease is transmitted through freshwater snail infested with the larval form of the parasite, which penetrates the skin upon contact with the contaminated water(WHO,2024).

Inside the body, the parasites mature into adult schistosomes in the blood vessels, producing thousands of eggs and causing various health complications(WHO ,2022). Symptoms range from mild to severe, including abdominal pain, diarrhea, and anemia. Chronic cases can lead to significant morbidity, affecting growth, cognitive development, and overall quality of life(Lee *et al*.,2007, Gray *et al.,* 2011). In 2020, WHO launched a road map for 2021-2030 to end the suffering from NTDs by 2030. The road map specifically targets eliminating schistosomiasis as a public health problem and interrupting its transmission in selected countries by 2030(WHO ,2022).

Ethiopia bears one of the highest burden of schistosomiasis in Africa with 53.3 million people at risk of infection in 2020 (Federal Ministry of Health Ethiopia 2021).The disease is widely distributed (Negussu *et al*., 2017) due to favorable ecological conditions (Maddren *et al*., 2021, Hussen *et al*., 2021) and is endemic in various regions (Deribe *et al*.,2012 ,Dufera et al.2014) , disproportionately affecting school-aged children (SAC)(Hussen *et al*., 2021). The impact of schistosomiasis extends beyond physical health, affecting children's school attendance, cognitive development, and overall quality of life. Consequently, since 2015, the Ethiopian Federal Ministry of Health has implemented a national school-based deworming program to treat SAC. This initiative aims to reduce the prevalence of schistosomiasis to a level where it no longer constitutes a public health problem(Leta *et al*.,2020).

Small dam irrigation has been promoted to enhance agricultural productivity and improve food security in Ethiopia(Ersado *et al*., 2005, Eshete *et al*.,2020, Jambo *et al*., 2021), including the Tigray region, in response to climatic challenges and population growth (Ersado *et al*., 2005). While beneficial for improved crop yields and economic development, these dams can impact the transmission of waterborne diseases like schistosomiasis. Research in many parts of Africa indicates that dam irrigation projects increase schistosomiasis transmission (Grosse 1993,Boelee, and Madsen 1997, Ghebreyesus *et al*., 2002, Lund *et al*., 2021, Jones *et al*., 2021 Senghor *et al*., 2022,) by providing ideal habitat for the snail intermediate hosts (Boelee, and Madsen 1997, Ghebreyesus *et al*., 2002, Dejenie *et al*., 2010, Lund *et al*., 2021, Abbott *et al*., 2022).

Moreover, several studies conducted globally, including in Ethiopia, have identified various factors that increase the risk of infection. These factors encompass demographic elements such as gender(Joof *et al*., 2021) and age(Tazebew *et al*., 2022) ; environmental factors like proximity to water bodies and irrigation activities (Nyati and Z, Chimbari 2017,Tazebew *et al*., 2022, Nkya 2023) ; and behavioral factors such as fishing(Nkya 2023,WHO,2024), swimming(Tazebew *et al*., 2022, Nkya 2023, WHO,2024), washing clothes and fetching water(Hussen *et al*., 2021) , and the level of knowledge and awareness about the disease and its transmission (Sánchez *et al*., 2023).

1.2. Statement of the problem

Irrigation development in Ethiopia has been largely focused on infrastructure construction. That means the important role of irrigation management is largely overlooked (Gebul, 2021). *S. mansoni* and *S. haematobium* infections are a significant public health problem in Ethiopia and have wide distribution in the country. The impact of these diseases is particularly high on school-age children (Hussen *et al*., 2021). The current trend of harvesting water to supplement agricultural productivity is associated with the expansion of *S. mansoni* and other intestinal parasitic infections (Dejenie & Asmelash, 2010). The prevalence of Schistosoma in Tigray was reported at 20.2% (Hussen *et al*., 2021), and the increasing risk of *S. mansoni* in the irrigation sites in central Tigray was reported at 14% in 2001–2002 (Dejenie & Petros, 2009).

The Mai-Nigus irrigation scheme, located in the La'elay Maichew district of the Tigray region, is crucial for enhancing the nearby community's agricultural productivity and food security. Available literature indicates that little information exists on the impact of irrigation dams on the epidemiology of schistosomiasis in Tigray(Ghebreyesus *et al*., 2002, Dejenie *et al*., 2010). However, to the best of our knowledge, no study has been done on the impact of Mai-Nigus irrigation dam on the epidemiology of schistosomiasis in this specific locale. Thus, this study was conducted to assess the prevalence of schistosomiasis and associated risk factors among SAC around the irrigational dam in Dura *kebele* of La'elay Maichew district of Tigray region, northern Ethiopia using the Kato-Katz thick smear technique.

1.3. Objectives

1.3.1. General objective

The general objective of the study was to assess the prevalence of schistosomiasis, and associated risk factors among school age children in Dura (May Nigus) irrigational dam, Tigray region, Northern Ethiopia**.**

1.3.2. Specific Objectives

The specific objectives of the study were:

- To determine the current status of schistosomiasis prevalence in the study area.
- To identify the relationship between *Schistosoma* parasite transmission and associated risk factors in the study area.
- To assess the trends of schistosomiasis infection for the past 10 years (20014– 2023) in the community.

1.5. Significance of the study

This study has a significant role in identifying the prevalence of *Schistosoma* infection and risk factors in order to create an efficient intervention to limit the disease's impact. It will inform the general public about *Schistosoma* infection and raise knowledge of the disease's modes of transmission within the study population. The research results will also provide a foundation for future investigations by other researchers on the prevalence and risk factors of *Schistosoma* parasite infection related to agricultural dams in the study area.

1.6 Scope of the study

The study provides information on the prevalence and risk factors for schistosomiasis in school-aged children around the irrigational dam. The scope of the study includes determining the extent of Schistosoma infection among populations using school-age children near the irrigation dam as a sample

2. LITERATURE REVIEW

2.1. General overview of schistosomiasis (Bilharzia)

Haematuria (blood in the urine) is one of the oldest indications and symptoms of schistosomiasis, dating back to 1900 Before Christ Era (BC). The disease schistosomiasis is a remnant from long ago. Between 1200 and 1000 BC, *S. haematobium* eggs were found in the renal tubules of two Egyptian mummies as cited by (Jordan, et.al. 1993). Additionally, *S. japonicum* ova came from a Chinese cadaver that was dated between 206 and 220 CE. In Egypt in 1851, German pathologist Theodore Bilharz wrote the first description of schistosomiasis.

During the autopsy, he found both male and female *schistosome* worms and gave them the name Dismoum *haematobium*. This caused him to mistakenly attribute the causes of schistosomiasis and hepato-intestinal diseases to this particular *schistosome* (David and Coon, 2005). This regrettable error and the following uncertainty were cleared up by Robert T. Leiper. He showed how *S. haematobium* and *S. mansoni* have separate life cycles and how their respective etiologies relate to gastrointestinal and urinary disorders (Kayuni *et al*., 2019). The parasite was identified as schistosomiasis by Robert Leiper. Africa, Asia, Australia, Europe, and North America have all experienced schistosomiasis cases. Travellers to Australia and North America are allowed to bring the disease (Nelwan, 2021).

In Ethiopia, *S. mansoni* was initially discovered in 1934 when it started to spread widely across the nation's high plateau (Ayad, N. 1956). Only a few isolated areas were aware of *S. haematobium*, which was discovered much later. The disease's widespread distribution can be explained by a number of factors, such as the growth of irrigation systems in the 1960s that were used to water, wash, and drink by nomadic herds; the construction of the Koka Dam on the Awash River and the related supply and drainage canals that facilitate the spread of the disease; and the migratory patterns of agricultural labourers and pastoral nomads (Ayad, N. 1956).

2.1.1 Etiology of schistosomiasis

Schistosomes are parasitic blood-dwelling fluke worms belonging to the genus *Schistosoma;* family, Schistosomatidae; order, Digenea; class, Trematoda; phylum, Plathyhelminths; and kingdom, Animalia. The genus *Schistosoma* contains six species that are of major pathological importance to man, *Schistosoma haematobium* (*S. haematobium*), *S. mansoni*, *S. japonicum, S. mekongi*, *S. intercalatum,* and *S. guineensis* (Webster *et al*., 2006). When freshwater snails transfer larval forms of the parasite into human skin through contact with infected water, humans can contract schistosomiasis. The larvae become adult *schistosomes* within the body. The female worms deposit their eggs in the blood arteries where the adult worms reside.

To maintain the parasite life cycle, some of the eggs are expelled from the body through urine or feces. Others get lodged in bodily tissues, triggering an immunological response and gradually deteriorating organs. The dynamics of schistosomiasis transmission have evolved over time. It has been discovered that endemic water supplies include human excrement and urine eggs. Different *schistosomes* may be found in cattle and other animals. The water is contaminated by both humans and cattle. This encourages the mingling of various *schistosomes*. Marshlands have experienced this, giving rise to "hybrid" *schistosome* species that re-infect people, typically from the same supply sources(Léger *et al*., 2020).

About 7.7% of individuals with a hepatosplenic illness caused by infections with *S mansoni*, *S japonicum*, and perhaps *S. mekongi* experience this serious consequence. In 2009, estimates of the disease's pulmonary arterial complication prevalence worldwide exceeded 270,000 people(Lapa *et al*., 2009). Congenital infection is established when a placental infection is verified in an infant with the illness. Significant medical and societal issues result from vulval genital schistosomiasis, which is transmitted by *S. haematobium* (A. G *et al*., 2007). *Schistosoma* infections are associated with gallbladder cancer. Rather than the transitional cell type, *S. haematobium* infection can raise the incidence of bladder cancer, which is typically squamous cell(Nmorsi *et al*., 2005).

Egg invasion of local tissue triggers the production of toxins and enzymes, which in turn triggers a Th2-mediated immune response(Coutinho *et al*., 2007).The clinical symptoms of glomerulonephritis can last for years, and the renal abnormalities that result from it are frequently irreversible. The most frequent side effect of gastro-intestinal schistosomiasis is periportal fibrosis, also known as symmers pipestem fibrosis. Gastrointestinal haemorrhage and portal hypertension are caused by the fibrosis. Liver failure is rare, unless cirrhosis or chronic hepatitis B are present(Lapa *et al*., 2009). Due to its small egg size, *S. japonicum* accounts for 60% of all *Schistosoma* brain infections (Walker & Zunt, 2005). Temporal brain masses, which cause paresthesia in the arm and leg with dysphasia, are associated with this species. Neurologic symptoms like cauda equina syndrome, anterior spinal artery syndrome, and quadriparesis can appear months after the initial infection(Walker & Zunt, 2005).

2.1.2 Epidemiology of schistosomiasis

In tropical and subtropical regions, schistosomiasis is common, particularly in impoverished populations lacking access to clean water for drinking and proper sanitation. At least 90% of people with schistosomiasis who need treatment are thought to reside in Africa. In endemic regions, particularly in sub-Saharan Africa, human schistosomiasis continues to be the leading cause of morbidity and mortality, second only to malaria. One of the most common parasite illnesses worldwide is human schistosomiasis as cited by (Kokaliaris *et al*., 2022).

About 200 million individuals become infected with it, and 20 million develop a severe case of the illness. Schistosomiasis is the cause of over 200,000 fatalities annually in sub-Saharan Africa. Additional effects of the illness include development retardation, anaemia, long-term pain, and problems related to nutrition and cognition. This illness has an impact on the person as well as the community, impeding growth and sustaining poverty (Nelwan, 2021).

In many African nations, the frequency of *schistosome* cercaria in freshwater snails has grown recently. The frequency of *schistosomes* among freshwater snails is rising, which emphasizes the necessity of effective snail control measures in the area (Hailegebriel et al., 2020). Schistosomiasis has been identified as a neglected tropical disease in Ethiopia and continues to pose a significant public health risk to school-age children in the nation. Few research have examined the relationship between school-age children's gender and the prevalence of schistosomiasis; the results are not very clear (Woldeyohannes *et al*., 2021).

The highest prevalence of Schistosomiasis (25.9%) was reported in Southern Ethiopia; Tigray (20.2%) and Oromia (18.7%). Compared to other regions, these regions had a greater concentration of water bodies, which may serve as harbours for vectors involved in transmission. The variations across regions may also be explained by the differences in environmental conditions such as temperature and humidity, rainfall patterns and environmental sanitation which influence parasite transmission. Other factors may include availability and abundance of snail intermediate hosts, socioeconomic conditions, levels of community awareness of the disease, variations in study period, and methods of diagnosis, among others (Hussen *et al*., 2021).

The acute and chronic parasitic diseases schistosomiasis and lymphosomiasis are caused by intestinal flukes, often known as trematode worms, of the genus *Schistosoma*. Preventative treatment would be required for at least 251.4 million people in 2021, according to estimates. Preventive treatment will reduce and prevent morbidity, and it should be repeated over several years. There have been reports of schistosomiasis transmission from 78 different countries. Only 51 endemic countries with moderate-to-high transmission require schistosomiasis prevention chemotherapy, which involves intensive treatment for both individuals and communities (Kokaliaris *et al*., 2022).

2.1.2.1 Morbidity and mortality rate of Schistosomiasis

Twenty-million individuals with schistosomiasis today have a severe clinical illness as cited by (Assefa *et al*., 2021). Due to their employment in agriculture, household tasks, and leisure activities that expose them to contaminated water. An estimated 700 million individuals in 76 countries where the disease is endemic are at risk of contracting the illness (Bergquist *et al*., 2017). Katayama fever, also known as acute schistosomiasis, can raise the death rate by as much as 25%. Morbidity impacts health even in cases where an illness has no symptoms. The primary issues include cancer, liver, heart, lung, kidney, and neurological disorders.

Genital infections in women may make pregnancy more difficult. Since there is always a chance of reinfection in endemic locations, repeated sessions of medication are frequently necessary. The long course of schistosomiasis typically causes a delay in diagnosis. Numerous illnesses share certain indications and symptoms in common. Serious systemic problems and multiple organ involvement may ensue from the outcome (Ross *et al*., 2007).

Children are more likely to get sick when they play in dirty water, mud from riverbanks, and poor hygiene (Tazebew *et al*., 2022). In 2010, around 40 million women who were of reproductive age were impacted (Verjee, 2022). An endemic community may have 5–10%

individuals with severe infections, and the remaining individuals may have mild to moderate diseases. Those who live close to rivers or lakes are most at risk of illness. According to Kabaterine *et al*. (2004), hardly any transmission was discovered to have happened in Uganda at elevations higher than 1400 m or in areas with yearly rainfall of less than 900 mm.

2.1.2.2 Vulnerable groups for schistosomiasis

Children are more likely to get sick when they play in dirty water, mud from riverbanks, and poor hygiene. In 2010, around 40 million women who were of reproductive age were impacted (Verjee, 2022). The disease is spreading to new places in Brazil and Africa due to migration to urban areas and refugee migrations. Transmission has expanded as a result of growing populations and their accompanying demands for water and electricity. Communities do not have an even distribution of infections. An endemic community may have 5–10% individuals with severe infections, and the remaining individuals may have mild to moderate diseases. Those who live close to rivers or lakes, migrants, fisherman are most at risk of illness. Addressing the needs of these vulnerable groups requires targeted public health interventions, improved sanitation, access to clean water, and comprehensive health education to reduce exposure and prevent infection. (Rinaldo, *et al*.,2021).

2.2 Biological Characteristics of schistosomiasis

2.2.1 Life cycle of schistosomiasis

Urine or feces from the human host discharge *Schistosoma* eggs into a freshwater habitat. An egg will hatch and release a free-living, ciliated form called a miracidium as soon as it comes into contact with fresh water. This form is contagious for six to twelve hours. The miracidium enters the soft tissue of the snail intermediate host by swimming toward it with ciliary movements. Several freshwater snails act as the intermediate hosts for the *Schistosoma* species, namely *Biomphalaria*, *Bulinus,* and *Oncomelania* for *S. mansoni, S. haematobium, and S. japonicum*, respectively(A G & Ross, 2014).

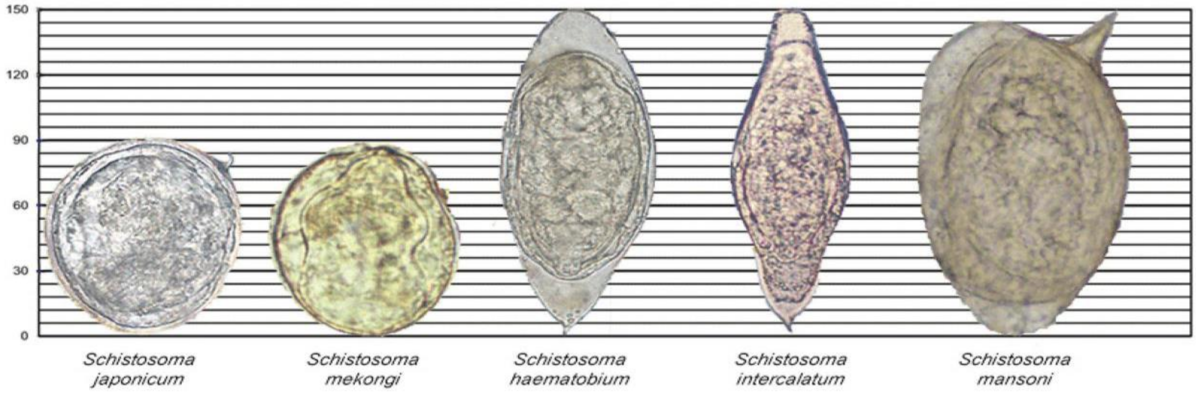

Figure 1 Eggs of *Schistosoma*, species (Verjee, 2022).

The distinct life cycle of *Schistosoma* species is reflected in the geographic distribution and etiology of schistosomiasis. In endemic regions, *schistosomes* infect vulnerable freshwater snails; typically, particular *schistosome* species infect particular snail species. After infection, the infected snails release cercariae four to six weeks later. The cercariae are free-swimming, fork-tailed larvae that are about 1 mm in length. They have a 72-hour survival period in fresh water, after which they must either attach themselves to human skin or the skin of another vulnerable host mammal or perish.

Successful cercariae use ventral and oral suckers to adhere to their human hosts. Following their migration through unbroken skin to dermal veins, they eventually reach the pulmonary vasculature over the course of several days. The cercariae undergo a metamorphosis during this migration, losing their tails and exterior glycocalyces in the process of forming double-lipid bilayer teguments that provide them great resistance against host immunological responses. Major Histocompatibility Complexes (MHCs) and blood type antigens are among the host proteins that the organisms now known as *Schistosomula* incorporate into their integuments.

Adult male and female worms couple off within the portal vasculature, with the slender female entering and staying in the gynecophoric canal of the stockier 8mm male worm. Together, they move to the mesenteric (*S mansoni, S japonicum*) or vesicular (*S haematobium*) veins along the endothelium, where they start to make eggs, in opposition to portal blood flow. The slender female worm enters and remains in the gynecophoric canal of the stockier 8mm male worm as the adult male and female worms couple off within the portal vasculature.

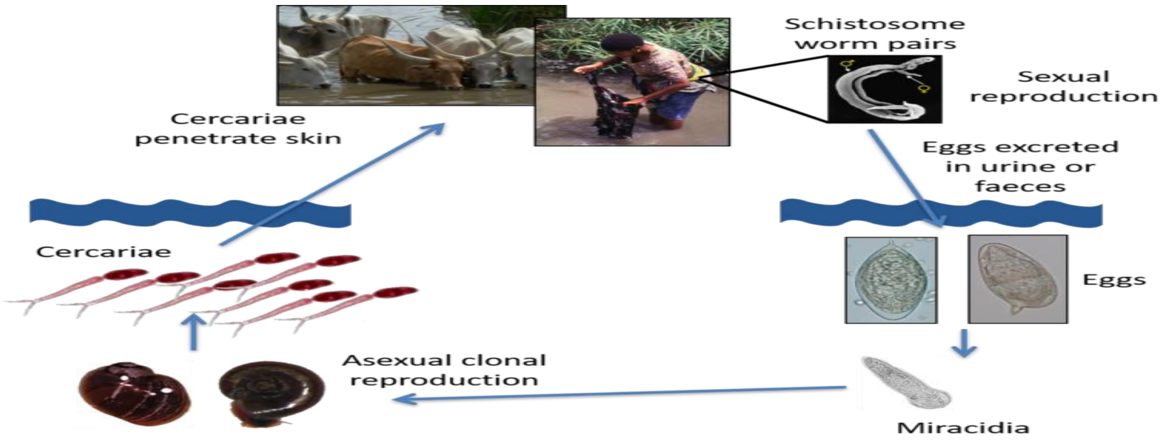

Figure 2. African schistosomiasis lifecycle. by Anouk Gouvras 2022.

2.2.2 Pathophysiology of schistosomiasis

Acute schistosomiasis: In some, but not most, cases of new *Schistosomal* infections, acute schistosomiasis (Katayama syndrome) manifests as a systemic, serum sickness-like illness that takes weeks to manifest. It is most commonly associated with *S japonicum* and *S. mansoni* infections and is most likely to occur in heavily infected individuals after primary infection. It may correspond to the first cycle of egg deposition and is associated with marked peripheral eosinophilia and circulating immune complexes. The illness can be fatal, although symptoms normally go away in a few weeks. After being exposed to cercariae, mild, maculopapular skin lesions may appear several hours later as an acute infection.

With the primary human *Schistosomal* infections, significant dermatitis is uncommon, most likely due to the less immunogenic nature of the invasive and growing cercariae. However, swimmer's itch or severe dermatitis can result from an unsuccessful human infection with *Schistosomal* species that depend on different main hosts. If the same species is seen again, this self-limited process might happen more intensely (Ahmed and fidsa,2023).

Chronic schistosomiasis: The pathophysiology of chronic schistosomiasis, which is significantly more prevalent than the acute form of the illness, is caused by the immunological response triggered by eggs, the formation of granulomas, and the fibrotic alterations that accompany them. *Schistosomal* eggs are highly immunogenic and cause strong circulating and local immune responses, but cercarial and adult worms very slightly generate an immune response. (Eggs may need a strong immunological reaction to help them move through the body.) Host proteins can be absorbed by adult worms. Because they are covered in host antigens, they can survive in the bloodstream for years if the immune system does not destroy them (Ahmed and fidsa,2023).

In the long run, inflammatory colonic polyposis can result from egg retention and granuloma formation (typically caused by *S. mansoni* or *S. japonicum*) in the intestinal wall, which can produce bloody diarrhoea and cramps. Long after travel-related (or endemic) exposure, acute complications of appendicitis, perforation, and bleeding can occur as a result of chronic intestinal schistosomiasis (Badmos *et al.*, 2006). A high death risk from pulmonary hypertension can arise from the ensuing pulmonary granulomatosis and fibrosis. Beyond what is found with hepatitis alone, co-infection with hepatitis B or hepatitis C can hasten hepatic deterioration and increase the risk for hepatocellular cancer. Additionally, *Schistosomal* infection may be linked to gallbladder cancer. In a group, 18.5% of individuals with confirmed hepatosplenic schistosomiasis had pulmonary hypertension(Lapa *et al*., 2009).

Additionally, a higher risk of bladder cancer typically squamous cell as opposed to transitional cell is linked to *S haematobium* infection (Nmorsi *et al*., 2005).Additional clinical symptoms, such as those involving the skin, lungs, brain, and muscles, adrenal glands, genitalia, and eyes, can result from ectopic egg deposition. Transverse myelitis (best characterized for *S haematobium* and *S mansoni*) and/or cerebral illness (most prevalent with *S japonicum* infection) can arise from involvement of the central nervous system (CNS). Toxins and enzymes are released when eggs invade nearby tissue, which also triggers a TH-2-mediated immune response(Coutinho *et al*., 2007).

2.2.3 Symptoms of schistosomiasis

Schistosomiasis symptoms are mostly brought on by the body's response to the worms' eggs. Blood in the stool, diarrhoea, and abdominal pain are all possible symptoms of intestinal schistosomiasis. In more severe cases, liver enlargement is prevalent and is often accompanied by a build-up of fluid in the peritoneal cavity and abdominal blood vessel hypertension. The spleen may also enlarge in such circumstances. Haematuria, or blood in the urine, is the typical symptom of urogenital schistosomiasis patients. In more advanced cases, kidney injury and ureteric and bladder fibrosis may be found. In later stages, bladder cancer is an additional potential risk(Kokaliaris *et al*., 2022).

Urogenital schistosomiasis in women can cause nodules in the vulva, vaginal bleeding, and pain during sexual activity, and genital sores. Urogenital schistosomiasis in men can cause disease in the prostate, seminal vesicles, and other organs. Infertility is one of the other long-term, permanent effects of this illness that may occur. Schistosomiasis has significant negative consequences on the economy and health, and it disables more people than it kills. Although the effects of schistosomiasis are mostly treatable, they can cause anaemia, stunting, and a decreased capacity for learning in children. People with chronic schistosomiasis may experience difficulties at work and, in rare circumstances, may pass away. Because of hidden diseases including bladder cancer, liver and renal failure, and ectopic pregnancies brought on by female genital schistosomiasis, it is challenging to assess the number of deaths caused by schistosomiasis(Kokaliaris *et al*., 2022).

2.2.4 Diagnosis

For the diagnosis of schistosomiasis and the detection of *schistosomes,* several methods are employed. Microscopy is the standard method used in Africa to detect eggs in urine or stool. (Aula *et al*., 2021).The best method for diagnosing schistosomiasis is to look for parasite eggs in the urine and stool. When determining if a patient needs a comprehensive evaluation and treatment, serological and immunological tests can be helpful for those from non-endemic or low transmission areas. Using a Kato-Katz thick smear or rapid Kato procedures, stool samples are analyzed for the presence of parasite eggs in order to quickly diagnose infections (Olveda *et al*., 2013 and A G & Ross, 2014).

2.3 Different snail species and their distribution

Several diseases that affect both people and animals are intermediately hosted by freshwater snails. Planning and implementing efficient disease prevention and control strategies requires a thorough understanding of the distribution of snail intermediate hosts and their infection status. Aquatic environments found in agricultural landscapes were teeming with species of snails that were highly abundant and capable of spreading zoonotic, human, and animal trematodes. Changes in ecosystem structure and water quality, as well as habitat fragmentation, were caused by agricultural practices like crop farming and grazing. As a result, limiting open grazing and animal water interactions together with maintaining good sanitation practices are crucial to lowering the spread of diseases carried by snails (Mereta *et al*., 2023).

Snails' prevalence and density fluctuate greatly between locations, within irrigated regions, and over the course of seasons. These variations are sometimes caused by local conditions, such as poor water management and system upkeep that cause water stagnation and weed growth. These characteristics are typical of African irrigation systems, as are higher densities of people, poor sanitation, and inadequate home water supplies (Boelee & Madsen, 2006). While most *Bulinus*, *Planorbis*, and *Oncomelania* are typically located along the edges of rivers and close to dams, the majority of land snails are found in wet bushy biotopes, the *Lymnaea* in swamps and irrigation canals (Salew, 2018).The dam project can alter the distribution of snails and the prevalence and transmission of schistosomiasis by causing a number of ecological environmental changes, such as changes in water level, bottomland soil wetness, microenvironment temperature, vegetation distribution, and other factors (McCallum *et al*., 2017).

2.3.1 Snail as an intermediate host in the transmission of Schistosomiasis

Schistosomiasis is known to reproduce primarily through two hosts: the intermediate host and the definitive host. The sexual part of the parasite's reproduction cycle occurs in humans, whilst the asexual phase occurs inside the snail. Generations of fertilized *schistosome* eggs within the definitive host are released into freshwater through human feces or urine, where they hatch into free-living, ciliated organisms known as miracidia. This is the first larval phase of the parasite, which can enter and infect aquatic snails, which act as the parasite's intermediate host. After entering the intermediate host, the miracidia proceed with their life cycle to generate many cercariae, the parasite's second larval stage. When human skin comes into contact with contaminated waterways, cercariae can enter the skin and spread infection (Adekiya *et al*., 2020).

2.3.2 Distribution and habitats of *Biomphalaria*, snail intermediate host of *Schistosoma*

An intermediate host for *S. mansoni*, *Biomphalaria* plays a major role in the transmission of intestinal bilharziasis in the endemic areas. The highest percentages were recovered from dams (27.5%) and rivers (27.2%) (Kock, *et al*.,2004). As *Biomphalaria* snails act as intermediate host, knowledge of their population ecology is an essential prerequisite towards understanding disease transmission (Utzinger, *et al*.,2000). There is limited information on the distribution of *Biomphalaria* snails, an important snail intermediate host of schistosomiasis, in East Africa (Magero, *et al*., 2021). Streams proved to be the habitats most preferred by *Biomphalaria* snails (50% of all of the sites where the snails were found in streams), followed by rivers (20.6%), irrigation canals (8.8%), lake shores (8.8%), springs (5.9%), and dams (5.9%) with snail abundance increasing with increase in temperature and decrease in water depth (Magero, *et al*., 2021). Schistosomiasis due to *Schistosoma mansoni* remains a major public health problem and cause of morbidity and mortality in sub-Saharan Africa despite the implementation of control programs (Odero, *et al*.,2019).

2.4 Factors determining on the intermediate host in the transmission of Schistosomiasis

In sub-Saharan Africa, schistosomiasis is still spreading due to a number of environmental and socioeconomic causes, including: many climatic fluctuations, such as variations in temperature, rainfall or precipitation, air movement, drought, flooding, salinity, and others, can be associated to the development or growth in population dynamics of many health-related disorders in Sub-Saharan Africa (SSA) (Mccreesh *et al*., 2014). Being close to water sources, Ecological changes caused by humans and socioeconomic factors (such as employment in poverty, inadequate sanitation and hygiene, and a lack of potable water for household use (Adenowo *et al*., 2015).

Water resource management connected to agricultural growth has been repeatedly linked to increased prevalence and spread of human schistosomiasis to non-endemic areas (Halstead *et al*., 2018). Depending on the types of snails and *schistosome* species present in the area, the precise impact of a temperature increases on the intermediate host of the parasite, the *Schistosoma* snail, may affect the snail's growth, distribution, survival, and fecundity rate. It may also create unfavorable breeding conditions for both freshwater snails and the *schistosomes* themselves. All of these factors may have an impact on the population dynamics of *Schistosoma* infections (Jungmeister & Haase, 2021).

Numerous studies on the elimination of schistosomiasis in specific regions of Sub-Saharan Africa have demonstrated that temperatures above the ideal range of 26–31 °C can eventually cause a rise in snail mortality rates (Mangal *et al*., 2008). Temperature affects the speed at which the miracidia enter snails, the release of cercariae into the parasite's larval stage, and the parasite's penetration into the skin of its ultimate host (Jungmeister & Haase, 2021).

Additionally, it was demonstrated that years with lower rainfall tended to have a lower prevalence of schistosomiasis, but years with both moderate and high rainfall tended to have a higher prevalence. But there was no discernible link found between the disease and the quantity of rainfall (Codjoe & Larbi, 2016). Increased water turbulence brought on by heavy rainfall may also raise water flow rates, which could disrupt snail habitats and reduce cercariae's capacity to survive (Xue *et al*., 2011). It has been suggested that variations in temperature or weather patterns may lead to an increase in flooding in some regions of Sub-Saharan Africa (SSA), which could have a major negative effect on human health (Diaz, 2007).

During flooding, a large number of people come into contact with contaminated water, which can lead to infection with the *schistosome* parasite (Qi *et al*., 2014). Wu and colleagues' findings, which explained how floods affected the intermediate snail hosts' dispersal patterns in relation to acute and chronic infections brought on by the parasite in the People's Republic of China, provided evidence in favor of this claim. According to observations, the habitats of snails that were present during the years of floods were 2.6-2.7% larger than those during the years of normal water levels (Wu *et al*., 2008).

It is well established that physico-chemical characteristics, such as conductivity and pH in connection to climate, have a significant impact on the population dynamics of schistosomiasis transmission in Sub-Saharan Africa. Water's pH, or acidity, varies substantially from place to place and is heavily influenced by climate change. The ocean releases a significant amount of carbon dioxide into the atmosphere as a result of global warming, which lowers pH by roughly 0.28 to 0.7 U and increases ocean acidity by 7.4 to 7.8 pH units. It is anticipated that increased precipitation will lead the atmosphere or oceans to become more acidic, which might seriously endanger marine life through tropic interactions and biodiversity brought on by calcification (Lannig, *et al*., 2010).

Particular climatic factor may have future effects on the transmission of schistosomiasis in SSA because some snail intermediate hosts, like *Oncomelania*, which is not found in Africa, can actually withstand and survive dry environments for extended periods of time because of their operculum, which can close shell during periods of drought for up to two to four months (McCreesh *et al*., 2015). However, prolonged drought in some countries, like Nigeria, Ethiopia, and Zimbabwe, has led to a notable decline in the prevalence of schistosomiasis due to a decline in the reproductive and survival rate of the snails that are responsible for the parasite's transmission in those areas as well as a decrease in the transmission sites (Mutuku *et al*., 2014).

Another significant element impacted by climate change that has a big impact on the spread of schistosomiasis is salinity. Sea levels may rise as a result of the climatic instability brought on by global warming, which may then increase the salinity of coastal areas' water bodies(Ramasamy & Surendran, 2011). Studies on the effects of salinity on parasites have demonstrated that cercariae are highly resilient to changes in salinity and that these fluctuations can affect the way that they are produced by the intermediate host (Mouritsen, 2002).

2.5 Treatment, Prevention and Control methods of Schistosomiasis

2.5.1 Treatment

Acute schistosomiasis and Katayama fever

Because maturing *schistosomes* are less susceptible to therapy than adult worms, patients should receive both anti-*schistosomal* drugs and corticosteroids, especially if they are critically ill. Steroids reduce inflammation and help suppress changes that result from killing the parasites. A second course of treatment is required, and it is administered several weeks after the first course of therapy. The drug of choice for treating all species of *schistosomes* is praziquantel. Individuals who are not cured have seen a 90% reduction in egg excretion (Fenwick *et al*., 2006). Praziquantel resistance is well-defined and manifests itself in the field.

Following the start of treatment, adverse effects could include fever, urticaria, nausea, vomiting, diarrhea, stomach pain, bloody stool, and dizziness. They normally don't hurt too much and last for a day or so. These are the worms' last reactions(Ismail *et al*., 1999). Certainly, the development of a vaccine for schistosomiasis is not without challenges. However, with modern tools and a renewed interest in elimination of the disease, great progress has been made in recent years and there is increasing hope that a vaccine strategy will be successfully deployed to help eliminate the suffering and death schistosomes have brought for millennia (Molehin, *et al* 2016).

2.5.2 Vector control and prevention of schistosomiasis

Over the past ten years, efforts to manage and eradicate human schistosomiasis have increased. It has proven possible to stop the spread of *schistosome* in some endemic nations and environments. In certain cases, program managers still face difficulties related to *Schistosoma* infections on a variety of fronts, including the intricacy of the transmission cycle, the scarcity of effective treatment choices, the absence of accurate diagnostics that are easy to use in the field, and disagreements on appropriate intervention tactics(Monnier *et al*., 2020).

The best strategy for lowering the prevalence of schistosomiasis has been snail control. The development of molluscicides of indigenous plant origin deserves support. Endod, derived from the berries of the climbing plant *Phytolacca dodecandra*, is the most extensively tested plant molluscicide, but data on its chronic toxicity to non-target organisms are lacking (McCullough *et al*.,1980). The majority of current schistosomiasis control initiatives prioritize MDA using praziquantel above snail treatment, despite evidence that snail control results in long-term disease reduction and elimination.

The most promising approach to eradicate schistosomiasis appears to be combining economical snail management with drug-based control efforts. Key measures in numerous successful attempts to eradicate schistosomiasis have been environmental alteration and snail control. Experts that were contacted and the literature both stressed how crucial vector management is when deciding on disease elimination targets. In addition to being essential for the control and eradication of schistosomiasis, WASH infrastructure and behavior are crucial for the management of water-borne and water-related diseases, including NTDs(Sokolow *et al*., 2016).

Sub-Saharan Africa has seen significant research on the ecology of the intermediate host snails of schistosomiasis, and a variety of control measures are already accessible (Boelee and Madsen 2006). With the development of praziquantel (PZQ) in the late 1970s, the integrated management of schistosomiasis made significant progress. Severe *schistosome*-related morbidities considerably declined after decades of heavy use, but substantial rates of re-infection and transmission persisted. Furthermore, in order to maintain the benefits of PZQ, the medication must be continuously delivered by MDA for an unlimited amount of time without rest in order to avoid morbidities from rebounding.

Additionally, prolonged and persistent medication usage may result in *schistosome* strains that are resistant to PZQ, as noted by(Olveda *et al*., 2013). There is a continuing need for operational research on the most effective way to reduce transmission to the point where interruption of transmission may be achievable. It is also necessary to identify the infection threshold at which a shift from control to elimination is possible. Concurrently, methods for accomplishing and validating elimination must be developed and assessed (Evan & Colley, 2018). The prevention and treatment of schistosomiasis depend heavily on access to clean water supplies and improved sanitation(Adenowo *et al*., 2015).

Additionally, preclinical experiments have examined medications used to treat malaria in conjunction with PZQ. The combination that lowered the number of eggs and the parasite burden proceeded to the clinical stage in endemic areas of Asia and Africa, where there is a high risk of reinfection and transmission. Patients with infections caused by *S. mansoni, S. japonicum,* or *S. haematobium* have received a variety of combinations. The most effective in vitro tests against Schistosoma have been thought to be those using the antimalarial medication mefloquine (MFQ). The tegument, muscular, reproductive, and digestive systems of the parasites were harmed by MFQ.

In order to determine whether these combinations would be more beneficial than PZQ monotherapy, MFQ was tried in conjunction with both PZQ and artemisinin. Clinical trials conducted on children infected with *S. mansoni* and/or *S. haematobium* revealed that the combinations did not perform better than PZQ monotherapy, despite the expectation that PZQ's effect against schistosomula would be enhanced by its interaction with antimalarial medications (Gouveia *et al*.,2018).

3. MATERIALS AND METHODS

3.1 Study area and selection

A school-based parasitological study was undertaken among SAC attending Dura Elementary and debrebrhan Secondary Schools in Dura Kebele of the Tigray region of northern Ethiopia. These two public schools were purposefully chosen for this study because they are close to the May-Nigus irrigational dam and have students aged 7 to 21 years old in fact WHO age category is from 7-19 but specifically in Tigray region have been a war crisis for the past years and schools were terminated, so there is option to get more than 19-year students attending the class.

Dura Kebele, located in the La'elay Maichew district of Tigray region, Northern Ethiopia, is home to this long-standing man-made irrigational micro-dam. The presence of Mai-Nigus irrigation scheme, a long-standing manmade micro-dam for agricultural crop production characterizes the areas. The Mai-Nigus irrigational dam is located in Dura Tabiya (Kebele: the lowest administrative unit), La' Elai Maichew district, central Tigray region. Geographically, the site is located at an elevation of 2,131 meters above sea level, between latitude 14^0 7' 5" north and longitude 38^0 42' 53" east, approximately 7 kilometers west of Axum town (the zonal capital of Tigray's central zone).

The Mai-Nigus dam area has a unimodal rainfall pattern, with the primary rainy season lasting from June to August. The remaining months are dry. The average annual rainfall in the area is 662.7 mm. Founded in 1998 by the Commission for Sustainable Agriculture and Environmental Rehabilitation in Tigray, the dam has the capacity to irrigate around 310 hectares.

The people of this area visit Axum at different health facilities for their medication, especially St. Merry Hospital Axum and Aksum University Comprehensive Hospital. Renowned public hospital St. Marry Hospital Axum is located 5 kilometres out from the city core. This hospital is preferred by both town residents and rural residents from the surrounding areas due to its fair prices, good services, and availability of human and material resources. This leads to a very high patient load at this facility.

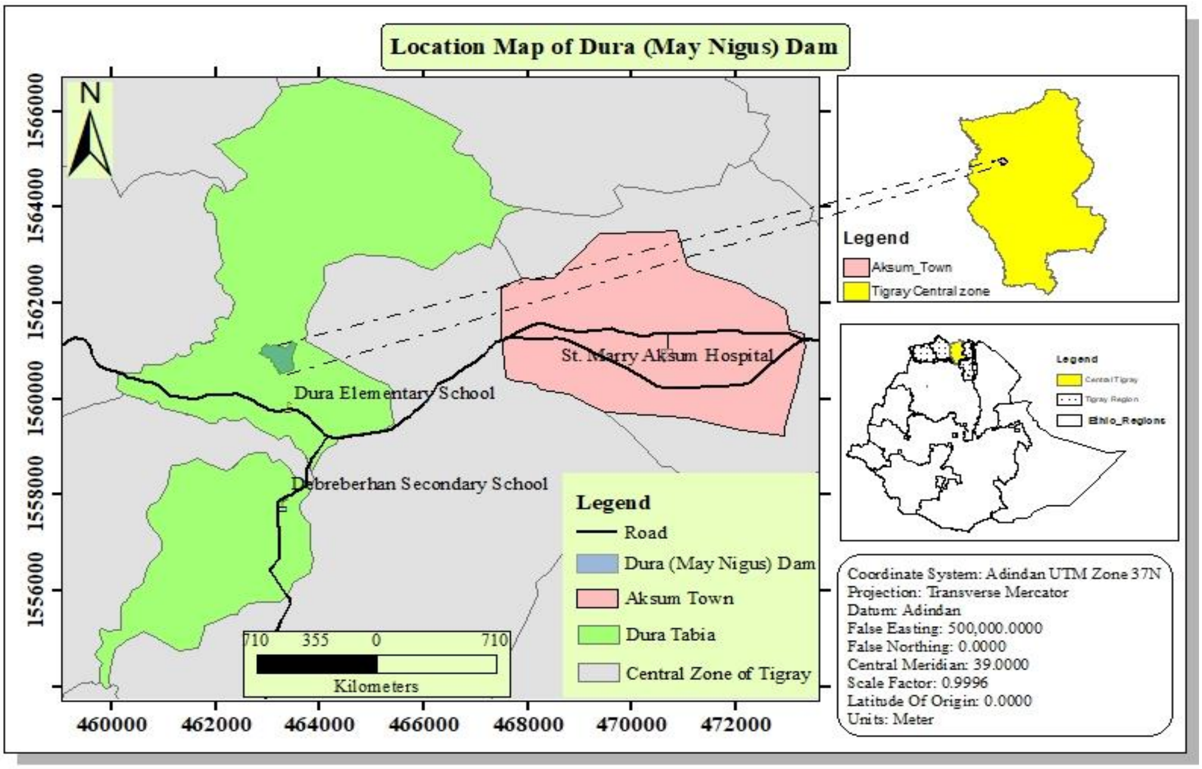

Figure 3. Map of the study area 2024 GC. (Source: Own Survey, Google Earth 2024; and CSA 2009 and developed by Arc GIS software version 10).

3.2. Study Design and Period

A school-based cross-sectional study was employed to assess the prevalence, burden, and risk factors of schistosomiasis among SAC residing near Mai-Nigus irrigation dam from February 2024–April 2024. A well-prepared checklist was prepared to collect retrospective data in St. Merry Hospital Axum from 20014–2023.

3.3 Study population

The study population comprised SAC aged 7-21 years residing in Dura *kebele*, including both primary and high school students. This cohort was selected due to their likelihood and easiness of complying with stool collection requirements. Additionally, the prevalence of infection among SAC serves as a valuable proxy for assessing the overall community prevalence.

3.4 Inclusion and exclusion criteria

Inclusion criteria: The study included participants who met the age criteria between 7 and 21 years and resided in communities surrounding the Mai-Nigus irrigation scheme. These participants were enrolled in the selected schools and were not undergoing treatment for schistosomiasis at the time of the study. Children who voluntarily provided verbal assent and whose parents or legal guardians consented to their participation were included in the study.

For the retrospective data all the intestinal cases from September 2014- august 2023 were included with identified age and sex.

3.5 Sample size determination and Sampling Strategy

The sample size was calculated using the single population proportion formula (Cochran, 1977) as follows:

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

Where "n" is the required total sample size, "z" *is* the level of confidence, "p" is the estimated prevalence of *S. mansoni* infection, and "d" is the margin of error. Taking an estimated prevalence (p) of 14% (Dejenie & Petros, 2009), Z (1-α/2) of 1.96 at a 95% confidence interval (CI), and precision value (d) of 5%, the total sample size was calculated to be 185. Assuming a 10% non-response, the sample size was adjusted to 204. Dura Primary School (Grades 1-8) have a total size of 562 students, while Debrebrhan Secondary School (Grades 9-12) have 191 students, with each grade consisting of a single class. The number of children enrolled in the study from each school was proportional to the total number of students. Then, accordingly, 52 and 152 SAC were enrolled from Debrebrhan Secondary and Dura Primary Schools, respectively. First, at school level, students were stratified according to their grade level (class) from grad one up to grad 12. Then, the sample size of each school was reallocated to each class proportional to their sizes according to our sample size required. The sampling interval k was determined (calculated) by using the formula: k =$\frac{N}{\mathrm{nc}}$, where N is the total number of students in each class listed as grade 1,2, 3…. N, and n_c is the sample size allocated to each class. The first student was selected using systematic sampling from the list 1 to k using the class roster as a sampling frame (Tamir *et al*.,2022).

3.6 Data collection and processing

A semi-structured questionnaire was administered to collect data on socio-demographic and behavioral practices related to schistosomiasis transmission among children. The collected data includes children's profiles, including sex, age, grade level, and water contact-associated activities like swimming habit in the dam, washing clothes in the dam, fetching water from the dam, engaging in irrigation practices using the dam's water, and awareness about the disease. After instructing on collecting stool specimens without contamination with the soil, urine, or any dirty material, each selected SAC was provided with a clean, dry, and leak-proof stool cap to collect 3g stool specimens.

Then, the samples were transported to and processed at Aksum University Comprehensive Hospital using a one-slide Kato-Katz technique (WHO 1991). Eggs were counted, recorded, and later converted to egg per gram (epg) by multiplying with a factor of 24(WHO 1991&2011). The intensity of *S. mansoni* infection was calculated to determine the worm burden based on the intensity categories set by WHO as light (1-99 epg), moderate (100-399 epg), and heavy (epg > 400) infection (WHO 2002). After A well-prepared checklist was prepared to collect retrospective data then Parameters such as date of examination, total clinically treated and confirmed cases in years, types of schistosomiasis species, and socio-demographic data such as age and sex were collected and interred to SPSS software for analysis.

3.7 Data Analysis

Data were entered into Epidata and analyzed using SPSS version 25. Descriptive statistics, including frequency and percentage, were computed to summarize the socio-demographic characteristics of the SAC and the retrospective data with prevalence of schistosome infection. The arithmetic mean intensity of infection was calculated to evaluate the intensity of infection. The arithmetic mean intensity of infection was calculated as:

$$\text{Arithmetic Mean Intensity of infection} = \frac{\sum_{1}^{n} mi}{n},$$

Where m_i is the egg counts in epg per study participant i, and n is the total number of individuals sampled.

Univariate and multivariate binary logistic regression model were used to determine the associations of socio-demographic characteristics and other factors with a 95% confidence level. A p-value of less than 0.05 was considered statistically significant.

3.8 Ethical considerations

Ethical approval for the study was obtained from the Research Ethical Review Committee (RERC) of Hawassa University (reference number: CNCS-REC019/24). Relevant authorities were given a detailed explanation of the study's objectives, and permission to conduct the study was granted by the La' Elai Maichew district health and educational authorities and the directors of the selected schools. Written informed consent was obtained from the parents or legal guardians of the participating children before stool specimen collection. Participating children were given a detailed explanation of the study's objectives, provided their oral consent before the specimen collection. They were given the full right to withdraw from the study at any time and were informed of their right to withdraw at any time. Other relevant authorities were given a detailed explanation of the study's objectives, and all the collected information was kept confidential. Children diagnosed with *S. mansoni* infection were also referred to their nearby health facilities for treatment.

4. RESULT

4.1 Socio-demographic and behavioral characteristics of the study participants

Among the 204 SAC enrolled in this study, 190 (93.1%) provided sufficient stool samples. The majority (65.3%) were aged 7-14, with a slight female predominance (53.2%). The highest group (40.5%) had an education level below grade 4. Moreover, 17.9%, 19.5%, 22.6%, and 24.2% of the children had the habit of swimming in the irrigation dam, fetch water directly from the dam, use the dam water for washing clothes, and engage in irrigation activities using dam water, respectively. Regarding awareness, a slight majority of the study participants (52.6%) were unaware of the disease (Table 1).

Table1: Socio-demographic and behavioral characteristics of the study participants among SAC attending primary and secondary schools around Mai-Nigus irrigation dam, northern Ethiopia ([n=190], 2024).

Variable (s)	**Category**	**n examined (%)**
Age	7 to 14	124(65.3)
	15 to 21	66(34.7)
Sex	Male	89(46.8)
	Female	101(53.2)
Grade level	Grades 1 to 4	77(40.5)
	Grades 5 to 8	70(36.8)
	Grades 9 and 10	20(10.5)
	Grades 11 and 12	23(12.1)
School name	Dura Primary School	147(77.4)
	Debrebrhan Secondary School	43(22.6)
Heard about schistosomiasis	Yes	90(47.4)
	No	100(52.6)

Swimming habit	Yes	34(17.9)
	No	156(82.1)
Irrigation practice	Yes	46(24.2)
	No	144(75.8)
Fetching water	Yes	37(19.5)
	No	153(80.5)
Washing clothes	Yes	43(22.6)
	No	147(77.4)

4.2 The prevalence and intensity of *S. mansoni* infection

The study found a 12.6% (24 out of 190) prevalence of *S. mansoni* infection in SAC near the Mai-Nigus irrigational dam, with 20(16.1%) infection in individuals aged 7-14 years. Both genders had an equal prevalence of 50% (n=12 each). Based on the educational levels, the highest prevalence was observed in students below grade 4, at 50%. Behavioural characteristics showed varying prevalence rates, with 44.1% of infected children habitually swam in the dam, 45.7% were involved in irrigation activities, 46.5% wash clothes using dam water, and 45.9% fetch water from the dam (Table 2).

Table 2: Prevalence of *S. mansoni* infection across the different socio-demographic and behavioral characteristics of the study participants ([n=190], 2024)

Variables	**Category**	**Examined n (%)**	**Positive n (%)**
Age (years)	7 to 14	124(65.3)	20(16.1)
	15 to 21	66(34.7)	4(6.1)
Gender	Male	89(46.8)	12(13.5)
	Female	101(53.2)	12(11.9)

Grade level	Grades 1 to 4	77(40.5)	12(15.6)
	Grades 5 to 8	70(36.8)	9(12.9)
	Grades 9 and 10	20(10.5)	1(5)
	Grades 11 and 12	23(12.2)	2(8.6)
Heard about schistosomiasis	Yes	90(47.4)	10(11.1)
	No	100(52.6)	14(14)
Swimming habit in the dam	Yes	34(17.9)	15(44.1)
	No	156(82.1)	9(5.8)
Irrigation practice	Yes	46(24.2)	21(45.7)
	No	144(75.8)	3(2.1)
Fetching water from the dam	Yes	37(19.5)	17(45.9)
	No	153(80.5)	7(4.6)
Washing clothes in the dam	Yes	43(22.6)	20(46.5)
	No	147(77.4)	4(2.7)

The mean egg count of the *S. mansoni* among the infected participants was 39±3.5, with parasitic load varying from 24 to 72. All of the infections were due to the light intensity of the infection.

4.3 Potential predictors of *S. mansoni* infection

Table 3 shows the results of a logistic regression model investigation of potential risk variables for intestinal schistosomiasis. The univariate logistic regression analysis showed that SAC who habitually swim in the dam exhibited 13 times higher infection rate compared to their peers who do not swim (Crude odds ratio [COR= 12.9, 95% CI: (4.9, 33.5) P=<0.001]). Those SAC engaged in irrigation practices faced a 39.5fold higher infection rate than those who do not participate in such activities [COR= 39.5, 95% CI: (10.9, 102.3) P=<0.001]). SAC who fetched water from the dam experienced nearly 18 times higher infection rate than those who did not engage in washing clothes in the dam [COR= 17.7, 95% CI: (6.5, 48.03) P=<0.001]). Lastly, those study participants who commonly wash clothes in the dam were 31 times [COR= 31.1, 95% CI: (9.7, 99.2) P=<0.001]) more likely to be infected with *S. mansoni* compared to those who do not.

In the multivariate logistic regression analysis model, the following observations were made: those SAC who fetch water from the dam [AOR= 14.5, 95% CI: (2.8, 74.7)], wash clothes in the dam [AOR= 6.4, 95% CI: (1.1, 35.4)] were nearly 15 and seven times more likely to be infected with *S. mansoni* compared to their respective counter parts, respectively. Moreover, SAC engaged in irrigation practices faced a 13-fold higher infection rate than those who do not participate in such activities (Table 3).

Table 3: Predicted risk factors of *S. mansoni* infection among the SAC attending primary and secondary schools around Mai-Nigus irrigation dam, northern Ethiopia ([n=190], 2024).

Variable(s)	**Category**	***S. mansoni* infection status**		**COR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**
		Positive n (%)	Negative n (%)				
Age (years)	7 to 14	20(16.1)	104(83.9)	2.98(0.9, 9.1)	0.056	8.7(0.5, 167)	0.150
	15 to 21	4(6.1)	62(93.9)	Ref		Ref	
Gender	Male	12(13.5)	77(86.5)	Ref		Ref	

	Female	12(11.9)	89(88.1)	0.86(0.4, 2.04)	0.740	0.5(0.09, 2.3)	0.345
Grade level	Grades 1 to 4	12(15.6)	65(84.4)	Ref		Ref	
	Grades 5 to 8	9(12.9)	61(79.2)	0.79(0.3, 2.03)	0.637	4.8(0.5, 43.7)	0.164
	Grade 9 and 10	1(5)	19(95)	0.28(0.03, 2.3)	0.242	2.7(0.04, 169.9)	0.636
	Grade11 and 12	2(8.6)	21(91.3)	0.52(0.1, 2.5)	0.410	2.5(0.06, 99.8)	0.625
Heard about schistosomiasis	Yes	10(11.1)	80(89.9)	0.77(0.3, 1.8)	0.550	0.2(0.03,1.2)	0.077
	No	14(14)	86(86)	Ref		Ref	
Swimming habit in the dam	Yes	15(44.1)	19(55.9)	12.9(4.9, 33.5)	<0.001	5.7(0.9, 35.1)	0.059
	No	9(5.8)	147(94.2)	Ref		Ref	
Irrigation practice	Yes	21(45.7)	25(54.3)	39.5 (10.9, 142.3)	<0.001	13.2(2.4,74.2)	0.003
	No	3(2.1)	141(97.9)	Ref		Ref	
	Yes	17(45.9)	20(54.1)	17.7 (6.5, 48.03)	<0.001	14.5(2.8, 74.7)	0.001

Fetching water from the dam	No	7(4.6)	146(95.4)	Ref		Ref	
Washing clothes in the dam	Yes	20(46.5)	23(53.5)	31.1 (9.7, 99.2)	<0.001	6.4(1.1, 35.4)	0.035
	No	4(2.7)	143(97.3)	Ref		Ref	

4.4 Trend of the *S. mansoni* prevalence in St. Merry hospital Axum from 2014-2023.

4.4.1 Total patient's (intestinal cases) examined in St. Merry hospital Axum

During the last ten years (2014-2023 GC), the St. Merry Hospital Axum examined over 104,224 stool samples for intestinal cases, according to retrospective data. The total number of clients (patients) and total positive cases in various examination years for the previous ten years at St. Merry Hospital Axum show a significant variation (fluctuation) in the retrospective data. The greatest record for the total number of clients (patients) examined in the hospital was 26,400 in the year 2016 GC, while the lowest record was 5,700 in the year 2019 GC. The overall prevalence of *Schistosoma mansoni* were 560(0.53%) for the past ten years in the hospital from the 104,224 stool samples tested. Overall, there was a sharp decline in the number of clients between 2017 and 2023 (Figure 4).

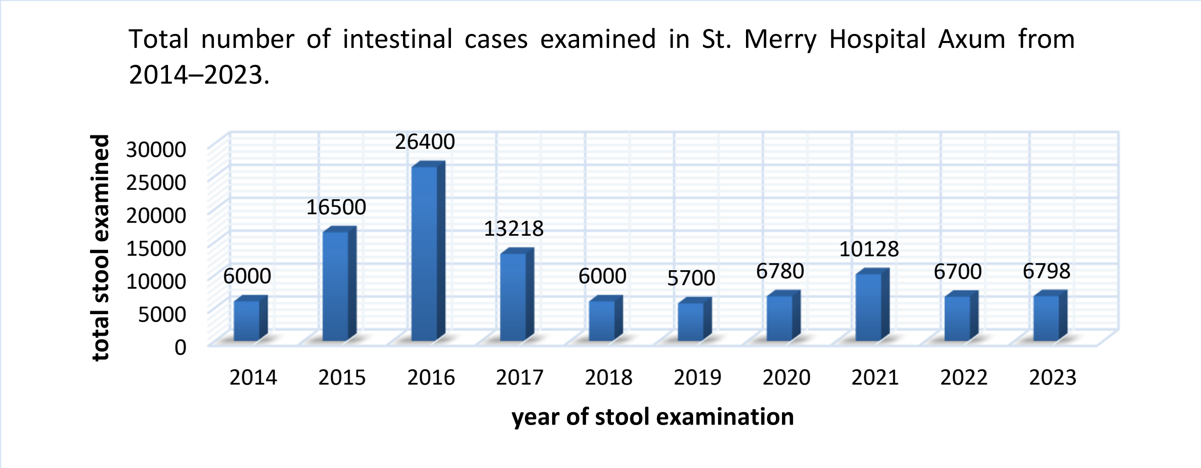

Figure 4: Total intestinal cases examined in St. Merry Hospital, Axum Tigray, for the past ten years. (2014-2023GC)

4.4.2 Prevalence of *S. mansoni* in males and females in St. Merry hospital Axum

The retrospective data from the medical registration book shows that, of the 560 positive stool samples tested, 205 (37%) were female cases and 355 (63%) were male cases. Additionally, male cases had a higher *S. mansoni* positivity rate (63%) than female cases (37%), over the previous ten years (2014-2023).

The greatest recorded prevalence of *S. mansoni* in males was 56 (10%) in the year 2016 GC, and the lowest was 8 (1.4%) in the year 2019 GC (figure 6). The highest result in females was 28 (5%) in the year 2015 GC, and the lowest was 7 (1.25%) in the year 2014 GC, as Figure 5 illustrates. The line-graph (Figure 5) shows that throughout the previous ten years, there has been a fluctuation in the prevalence of *S. mansoni* in both males and females.

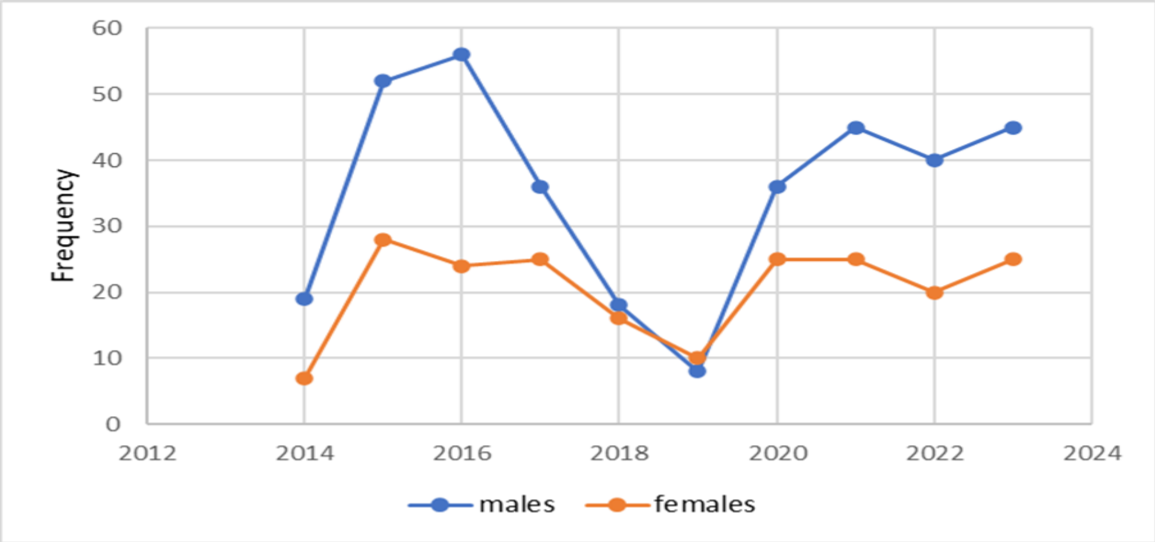

Figure 5: The prevalence of *S. manson* in St. Merry Hospital Axum from 2014 to 2023 in terms of gender.

4.4.3 *Schistosoma mansoni* prevalence in different age groups

From the youngest age (10–12 months) to the oldest 84 years old, *S. mansoni* is prevalent for the past ten years (Figure 6). In the age range from 10–25 years old, the highest positive case was recorded in 2015 which is 60 (61.6%), followed by 20 (24.8) years old in the 26–45 age group. As we can see in the figure below (Figure 6), the relative distributions of the prevalence in the age groups under 10 and 46–75 years old are, 4 (6.1%) and 6 (6.4%) respectively. Between 2015 and 2023, the overall prevalence in the 10 to 25-year-old age range was decreased except in 2020 and 2021 shows some raising phenomena. The remaining age categories adhere to a somewhat regular norm every year (Fig 6).

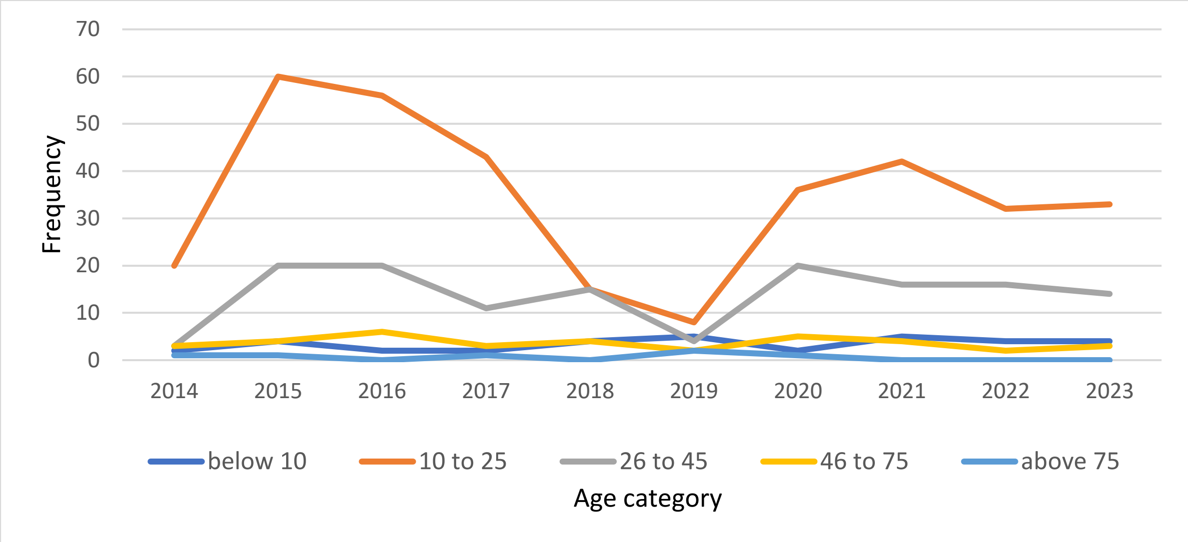

Figure 6. Age-group-specific prevalence of *S. mansoni* infection in St. Merry Hospital Axum from 2014 to 2023 with different age groups.

4.4.4 Distribution of positive (*S. manoni*) by age and sex

Males made up 224 (40%) of the highest positive cases under the age group of 10 to 25, followed by females at 121 (21.6%) (fig 7). The age group over 75 years old had the fewest positive cases, with 4 (0.71%) in males and 2 (0.35%) in females (Figure 7).

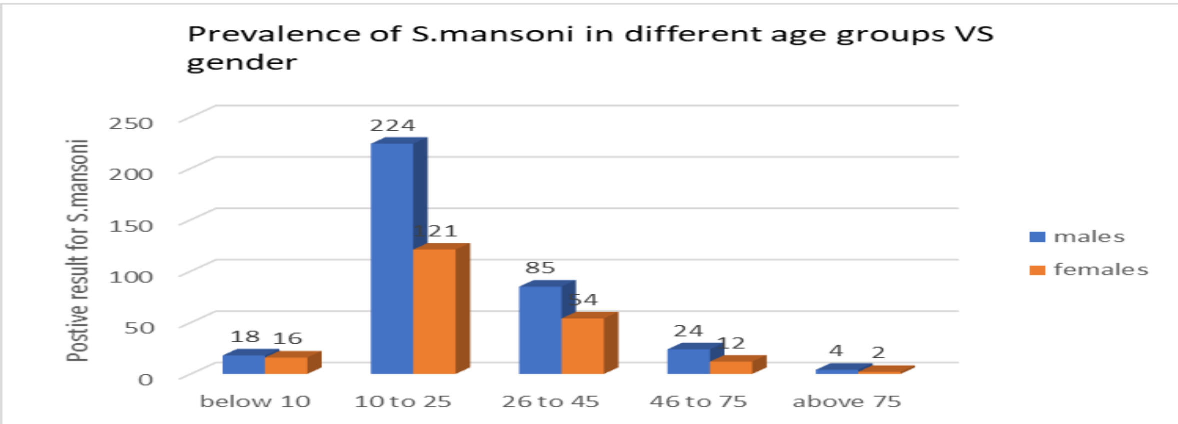

Figure 7. Distribution of positive cases by age and gender, Axum St. Marry Hospital, Tigray, from 2014–2023 GC.

4.4.5 Trends of *S. mansoni* prevalence for the past ten years (2014-2023 GC).

As we can see in figure 8, the most positive findings for *S. mansoni* were obtained in the year 2023 GC (1%) and the smallest were in 2019 GC (0.3%). According to the total stool sample analysed, the overall route for the prevalence (trend) of S. mansoni from 2014 to 2023 GC indicates that it is rising year over year, with a minor dip in 2016 and 2019.

Figure 8: Trend in *S. mansoni* distribution by total number of stools examined in the year vs total positive cases in percentage (%) in St. Marry Hospital Axum, Tigray, from 2014–2023.

5. DISCUSSION

Knowledge of the prevalence, burden, and drivers of schistosomiasis is critical for disease control (Andargie and Abera,2018). The study confirmed that, the prevalence of *S. mansoni* infection in school age children in both of the schools around Dura irrigational dam was relatively similar to the findings of previous studies from different parts of Ethiopia and other continents. Especially in central Tigray, the prevalence of *S. mansoni* in areas of irrigation practice was recorded at 14% (Dejenie & Petros, 2009), 12.6% in northwest Ethiopia's Guangua district (Tazebew *et al*., 2022), and 16.67% in Sanja health center, north-west Ethiopia (Andargie & Abera, 2018).

However, the prevalence in the present study is lower than the studies reported from Gorgora Town, Northwest Ethiopia, 20.6% (Essa *et al*., 2013), South Ethiopia, 25.9% (Hussen *et al*., 2021), and 41.3% in Busega district, Northern Tanzania (Ogweno *et al*., 2023), 49% in Maksegnit and Enfranz Towns, north-western Ethiopia (Gashaw *et al*., 2015*)*, and 34.9% in Lake Tana, north-western Ethiopia (Hailegebriel *et al*., 2021). The observed variation in prevalence might be due to the difference in water contact behaviour of the school age children, socioeconomic status, environmental sanitation, ecological distribution of snails, local endemicity.

The highest prevalence of *S. mansoni* infection recorded in the study area was in children with ages ranging from 7 to 14 years old, followed by those with ages ranging from 15 to 21 4(16.6%). This agrees with reports from many investigators in different localities of Ethiopia. In the Amhara region, Jiga town (Ketemaw and Destaw 2020), in southern and central Tigray (Tadesse and Beyene, 2009). This might be due to the higher rate of water contact in those children with ages ranging from 7 to 14 years and the lower infection in the age groups 15 to 21 years, which might be due to low outdoor water contact activities and the development of age-acquired immunity to re-infection, respectively.

In the present study, a sex-related difference in the prevalence of *S. mansoni* infection among school-age children was not observed. The prevalence was distributed equally among both males and females (50%). This result agrees with research done in Zarima town, northwest Ethiopia (Alemu *et al*., 2011), in Amhara regional state Ethiopia (Bekana *et al*., 2021), in northwest Ethiopia's Guangua district (Tazebew *et al*., 2022), in Busega district, northern Tanzania (Ogweno *et al*., 2023), and in south-west Nigeria (Ojo *et al*., 2021). These studies suggest that while gender-specific activities can influence the intensity of *S. mansoni* infections, the overall prevalence can sometimes show a relatively equal distribution between males and females, especially in regions where both genders are equally exposed to infested water sources.

Based on these results, there's no clear evidence that age, gender, or education level and awareness level are strongly associated with the presence of *S. mansoni* in the sample of school age children in dura (May-Niguse) irrigational dam according to univariate logistic regression. This agrees with research in Maksegnit and Enfranz Towns, northwestern Ethiopia (Gashaw *et al.*, 2015), in Mbita Sub-County, Western Kenya (Cheruiyot *et al*., 2024), in western Côte d'Ivoire (Assaré *et al*., 2020), and in Benin (Ahamidé *et al*., 2023).

The result of the research(investigation) on associated risk factors shows similarities with different studies, like those in Kenya (M'Bra *et al.*, 2018) and Côte DeVore (Angora *et al.*, 2019) in northwest Ethiopia (Tazebew *et al*., 2022). This result also shows similarities with the investigation done in endemic lowland areas in Western Ethiopia (Assefa *et al.,* 2021*)*, the endemic localities of Ethiopia (Legesse *et al.,* 2009*)*, and research done in Mbita District, Western Kenya (Nag *et al.*, 2014).

The results from univariate analysis suggest that there are strong statistical relationships(associations) with different Crud odd ratio (COR) between swimming, irrigation practice, fetching dam-water directly, and washing clothes in the dam water, all with *S. mansoni*. But after the multivariate (after accounting for other factors in the model) the variables: irrigation practice, fetching from dam-water directly, and washing clothes in the dam water respectively remains a risk factor all with *S. mansoni*. Meaning thy are individually associated with *S. mansoni* presence.

This investigation was in line with research done in northwest Ethiopia Guangua district (Tazebew *et al*., 2022), cultivated near irrigation areas had a significantly higher risk of *S. mansoni* infection. in Sanja health centre north-west Ethiopia (Andargie and Abera, 2018), in Amhara regional state Ethiopia (Bekana et al., 2021), and in Busega district, Northern Tanzania (Ogweno et al., 2023), in Ethiopia: A Systematic Review (Hailegebriel, *et al*.,2022).

The intensity of *S. mansoni* infection according to age groups or sex categories ranges from 24-72 and is grouped into light egg intensities based on WHO standards and has some similarities to the research done in southwest Ethiopia Jimma town (Tefera *et al*., 2020), which shows almost all have light egg intensity. This may be due to the fact that single-slide smear preparation in the stool examination and formal-ether concentration techniques were not used. The reason for single slide preparation was that the stool collected from the student was too small to prepare a double slide, so I decided to prepare a single slide smear for the stool examination simply for prevalence identification and simple egg counting.

According to the retrospective data, there is a high variation (fluctuation) in the total number of clients and total positive cases in different examination years for the past ten years at St. Merry Hospital Axum. For example, in 2016, the total number of clients was 26,400, which is the highest record, and 5700 in 2019 GC, the smallest record in the number of clients (stool examined) in the hospital. From those, the highest positive result for *S. mansoni* was recorded in 2023 (1%). In 2016 and 2019, the total positive results for *S. mansoni* were 0.3%, which is the smallest result recorded for the past ten years in the hospital. The overall prevalence of *Schistosoma mansoni* were 560(0.53%) for the past ten years in the hospital. This is similar with the investigation in Grarigy Health Center, Northwest Ethiopia (Abere *et al*., 2023).

The total female positive cases for the previous ten years were 205, the total male positive cases were 355, and a total of 560 positive cases for *S. mansoni* were recorded in the hospital. There has been a higher prevalence of males than females for the past ten years (2014–2023). This agrees with the research done in the Lake Tana Basin (Ethiopia) (Abera *et al*.,2023), in finchaa western Ethiopia (Dufera *et al*.,2014), in the South African public health sector (De Boni *et al*.,2021). The prevalence ranges from the smallest age (10–12 months) to 84 years old and the highest prevalence were between the age 10-25 this agrees with research done in Gondar poly health centre northwest Ethiopia (Ayelgn, *et al*.,2019). This may be individuals in this age group are more likely to engage in activities that involve contact with contaminated water, such as swimming, bathing, and washing clothes. These activities increase the risk of exposure to *Schistosoma mansoni* larvae. In rural areas, young people often participate in agricultural work, which may involve contact with irrigation systems and other water sources that harbour *S. mansoni* larvae.

Overall, a complex interaction between environmental, socioeconomic, and public health factors affects the variation (fluctuation) in Schistosoma prevalence from year to year.

In general, as we compared the entire examination year, the prevalence showed an increase from year to year, except in 2016 and 2019 (which shows a decreasing). This agrees with research done in northeast Brazil (Bezerra A, *et al*.,2024) and a research focus on Africa (Aula *et al*., 2021). But at its prevalence in the retrospective data, it is reverse to the research done in

Ethiopia (Hussen *et al*.,2021) at national-wide which shows decreasing of the *Schistosoma mansoni* trend. This my due to the difference in the distribution of drug or the awareness of the community in the prevention and treatment mechanisms'. Despite ongoing efforts, including MDA programs and health education campaigns, schistosomiasis remains a challenge due to environmental changes, water resource developments, and socioeconomic conditions.

6.LIMITATION OF THE STUDY

The study's findings should be interpreted with the following considerations in mind. This research utilized a single-slide Kato-Katz smear preparation method. The primary reason for this choice was the limited quantity of stool samples collected from the study participants, which was insufficient to prepare a double-slide smear for stool examination. It is important to note that single-slide preparation may affect the sensitivity and accuracy of the parasitological diagnosis, potentially leading to an underestimation of the true prevalence of infection in the study area.

7.CONCLUSION

The study reveals a concerning prevalence of intestinal schistosomiasis among school-age children living near the Mai-Nigus irrigation dam, with 12.6% of the participants infected. The light intensity of infection suggests that while the immediate risk may appear low, the presence of the disease indicates ongoing epidemiological dynamics that require attention. In conclusion, although demographic factors can affect the prevalence of *S. mansoni* infection, behavioural and environmental factors frequently have a greater influence on the dynamics of *S. mansoni* transmission than educational status, awareness, age, or sex. This emphasizes how crucial it is to implement all-encompassing control techniques that handle water contact behaviours, enhance sanitation, and regulate environmental factors in order to successfully lower transmission. For control measures to be successful, they must consequently address these broader circumstances.

Our findings highlight several significant risk factors contributing to schistosomiasis transmission among SAC in the study area, notably water-related activities, including fetching water from the dam, washing clothes in the dam, and engaging in irrigation activities. These activities increase exposure to contaminated water and underscore the critical need for improved public health interventions and community education. Targeted strategies such as promoting safe water practices, practical hygiene education, and regular screening can play an essential role in mitigating the risk of schistosomiasis. Continued epidemiological monitoring and community engagement are crucial to reducing the prevalence of this disease and safeguarding the health of future generations in the area.

According to the retrospective data for the past ten years there is a decreasing intestinal case examination in St. Merry Hospital Axum and this may be due to the expansion of private health centre and the Aksum university comprehensive hospital also opened in 2015Gc in the town, this enables peoples to use additional options for their medication. The other reason also may be due to the out-break of Covid-19 and the conflict that have been for the past almost three years in Tigray region. But even-though there is decreasing intestinal case examination in St. Merry Hospital Axum the total prevalence(trend) for *Schistosoma mansoni* shows increasing from year to year with slight fluctuation in different age groups and genders. The most prevalent were in males among the age 10 to 25 years old. Based on the prevalence result for *Schistosoma mansoni*, now is the critical time to take controlling measurement and treatment in the community with a full campaign.

8. RECOMMENDATIONS

Understanding these dynamics is crucial in order to execute focused interventions and management tactics aimed at diminishing the incidence of schistosomiasis. It is recommended to focus on raising the awareness of school-age children about the prevention and control measures of *S. mansoni* in the locality. In addition, responsible bodies on irrigational practices should work on the regular cleaning of water canals, which favour the reproduction of snails. At the end of my recommendation, a community-based cross-sectional study must be done in the study area with different predictors that were not included in my investigation. Future studies should aim to collect larger stool samples to enable the use of double slide smears, thereby enhancing the reliability of the results. Comprehensive strategies combining drug administration, improved sanitation, and public health education are essential to control and eventually eliminate the disease

Since in the area there is high agricultural activity, the following should be done in advocacy for the community:

- Make community awareness programs to educate individuals about the transmission of schistosomiasis and the role of agricultural dams for reproduction of different vector borne diseases.
- Instruct children to avoid swimming, playing, or bathing in water bodies near agricultural dams especially if the water is exposed for Schistosomiasis.
- Encourage children to wear shoes, especially in and around water, to minimize the risk of skin penetration by schistosome larvae.
- Encourage the active participation of parents, teachers, and community leaders in promoting a safe environment for children and implementation of regular testing and treatment programs for those at risk.

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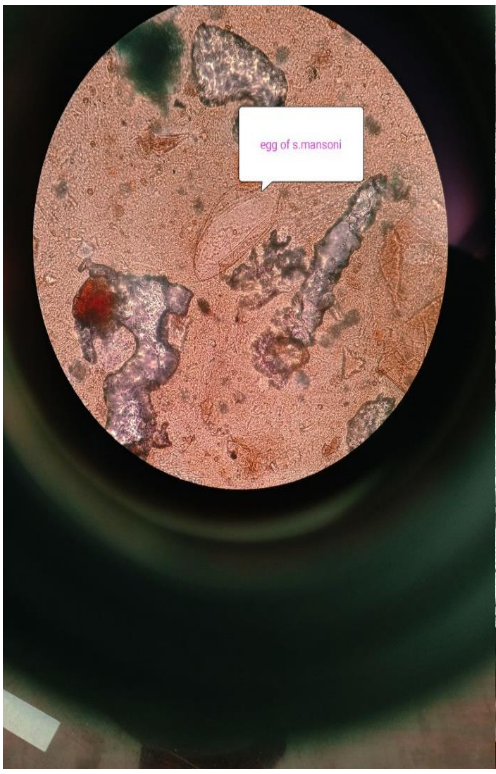
Appendices one

Some procedural images(photo) in Aksum university comprehensive hospital and elementary schools



Microscopic images of *S. mansoni egg*


CLASSIC FASHION
giving the stool cap
for stool collection

CLASSIC FASHION

Dura elementary school students' photo

Appendices two: Some supportive official letters

አክሱም ዩኒቨርስቲ
ኮምፕርሂንሲቭ ስፔሻላይዝድ ሆስፒታል
የ ህክምና ላቦራቶሪ አገልገሎት ክፍል

Aksum University
Comprehensive Specialized Hospital
Medical Laboratory Office
ቁጥር/Ref.N°AK/UN/CSH/ 24/16
ቀን /Date16 / 07 /2016E.C

<u>ለሚመለከተው ሁሉ</u>

ጉዳዩ፡- <u>ዉጤት ስለመላክ ይመለከታል</u>

በርዕሱ ለመግለፅ እንደተሞከረው በሀዋሳ ዩኒቨርስቲ ባዮሎጂ ትምርት ክፍል የማስተርስ ባዮመዲካል ሳይንስ ዘርፍ ተማሪ የሆነው ተክላይ አብርሃ በቀን 29/05/2016 በተፃፈ የትብብር ደብዳቤ መሰረት በሆስፒታላችን ውስጥ እየሰራ መቆየቱን እየገለፅን ዝርዝር ውጤቱን ከዚህ ሸኚ ደብዳቤ ጋር በ 4 ገፅ የላክን መሆናችንን እየገለፅን መልካም ሁሉ ይገጥማቸው ዘንድ እንመኛለን።

ከሰላምታ ጋር!!

ክብሮምረጋሳ
የህክምና ላቦራቶሪ ክፍል አስተባባሪ

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Questionaries

Full name -- signature----------------------

PART I: QUESTIONNAIRES RELATED TO PERSONAL INFORMATION OF THE RESPONDENT

1. Age: From 7-14 ☐ From 15-21 ☐

2. Gender: Male ☐ Female ☐

3. Education level:

Below grade 4 ☐ Grade 4-8 ☐

Grade 9-10 ☐ Above grade 10 ☐

Part II: QUESTIONNAIRE RELATED TO ASSOCIATED FACTORS FOR SCHISTOSOMIASIS

1. Did you have always a contact with water in the dam? A, YES ☐ B, NO ☐

2 If your answer is yes for question number one how?

A, by swimming in the dam ☐ B, participating in irrigation ☐ C, directly by fetching water from the dam ☐

D, washing closes ☐

NB. If there is another activity put it in the written form____

____

____

PART III: QUESTIONNAIRE RELATED TO AWARNESS OF SOCIETY TO DAM AND SCHISTOSOMIASIS TRANSMISSION

1. Have you heard about schistosomiasis or bilharzia before now

A, Yes ☐ B, No ☐