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Prevalence of Schistosomiasis-Tuberculosis Co-infection and Associated Factors Among Patients With Tuberculosis in the Lake Zone, Tanzania

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ABSTRACT

Background: Infectious diseases such as schistosomiasis and Tuberculosis (TB) are still a public health challenge in Sub Saharan Africa including Tanzania. In such co-endemic settings, schistosomiasis-TB co-infection is a common phenomenon. This population remains inadequately covered by current schistosomiasis control interventions, contributing to ongoing transmission. We investigated the current prevalence of schistosomiasis-TB co-infection and associated factors among patients with TB.

Methods: A baseline survey was conducted among patients with TB to assess the prevalence of schistosomiasis-TB co-infection and its associated factors in Mwanza region. A pre-tested questionnaire was used to collect both sociodemographic and clinical data. A single stool sample was collected from each participant and duplicate Kato Katz smears were prepared for the detection of intestinal schistosomiasis.

Results: A total of 540 patients with TB receiving treatment were enrolled in this study. The median age (IQR) of the studied population was 38 years (32, 45), with majority of the participants aged between 35 and 44 years (37.0%). Males accounted for the majority of participants (400/ 540, 74.1%). Out of the 540 patients screened, 159 (29.4%; 95% CI: 25.7- 33.0) were infected with intestinal schistosomiasis. Most participants had light intensity infections 136/540 (25.2%) while moderate intensity infection was observed in only 23/540 (4.3%). Notably, there was no heavy infection in the studied population. On multivariable regression analysis, being self-employed (aPR=1.98, 95% CI: 1.07-3.67; p=.03) or retired (aPR=2.72, 95% CI: 1.25-5.93; p=.01), presence of comorbidities (aPR=1.56, 95% CI: 1.12-2.05; p=.001), malaria infection (aPR=2.17, 95% CI: 1.56-3.03; p<.0001), abdominal pain (aPR=1.59, 95% CI: 1.20-2.11; p=.001), being anaemic (aPR=1.36, 95% CI: 1.05-1.76; p=.02) and having soft (aPR=1.69, 95% CI: 1.28-2.22; p<.0001) or loose stool (aPR=2.18, 95% CI: 1.37-3.46; p<.0001) were significant factors associated with TB schistosomiasis TB co-infection.

Conclusions: Our study highlights a significant burden of schistosomiasis TB co-infection among patients with TB. Comorbidities, malaria infection, anaemia and stool consistency were significantly associated with this co-infection. There is a need to consider including TB patients in mass drug administration campaigns while also addressing the associated factors through targeted interventions and integrated healthcare approaches to reduce morbidity and transmission among affected populations. Future research should continue to monitor the prevalence and intensity of co-infections and evaluate the effectiveness of praziquantel when co-administered with Rifampicin-based Anti-TB regimen.

BACKGROUND

Schistosomiasis is one of the poverty-related Neglected Tropical Disease (NTD) that continues to cause morbidity and mortality among many people in Sub Saharan Africa (SSA).[1,2] Among the parasitic diseases, schistosomiasis ranks second to malaria in terms of cases, with 779 million people at risk and more than 250 million people infected worldwide [1,2]. In Tanzania, the disease is endemic throughout the country and is more prevalent around the Lake zone, where a prevalence of up to 100% has been previously reported.[3,4] A recent study conducted around Lake Victoria reported a prevalence of intestinal schistosomiasis of about 90% among school-aged children.[5] By 2016, Tanzania had achieved 100% geographical coverage of preventive chemotherapy through praziquantel mass drug administration (MDA). However, despite this MDA coverage, the disease remains prevalent in the country, particularly around the Lake Zone.[4]

On the other hand, Tuberculosis (TB) remains an infectious disease of global health concern, with about 1.7 billion people estimated to have latent TB infection worldwide.[6-8] In 2019, the World Health

Organization (WHO) reported 10 million TB cases and 1.2 million deaths due to TB, with most TB death occurring in low- and middle-income countries.[7] Similarly, in Tanzania, the disease remains a major public health concern and highly populated cities including Dar es Salaam, Arusha, Geita, Dodoma, Manyara, Mbeya and Mwanza contribute more than 50% of the reported cases in the country.[9] In 2019, an estimated TB incidence rate of 237 cases per 100,000 population was reported in Tanzania, with only 54% of the cases notified and a significant number of TB cases remaining undiagnosed or unreported.[7,9]

Due to the high prevalence of schistosomiasis around the Lake Victoria Zone, schistosomiasis TB co-infection remains a common phenomenon. TB patients live in the same environment as those without TB infection, therefore, inadequate and unsustainable vector control programs, lack of access to safe and clean water, poor hygiene and sanitation, and the exclusion of this population from MDA programs for years represent a major pitfall to the control and elimination of schistosomiasis. This is a double neglect as the disease is neglected and the affected population with TB infection is excluded from MDA. Consequently, patients with schistosomiasis TB co-infection remain untreated, serve as reservoirs of infection and sustain ongoing schistosomiasis transmission. There is a paucity of studies assessing the prevalence of and associated factors for schistosomiasis-TB co-infection.[10] The limited evidence available indicates that most common parasite species, including *Schistosoma mansoni*, occur concurrently with Mycobacterium tuberculosis. In Tanzania, despite the scarcity of data in this population, a study conducted around Lake Victoria Zone in 2007 reported a high prevalence (34%) of intestinal schistosomiasis TB co-infection among TB patients.[11] Other parasites such as malaria parasite, *Ascaris lumbricoides*, *Trichuris trichiura* and *Strongyloides stercoralis* were less common among TB patients, each with a prevalence of <5%.[11] These findings indicate that schistosomiasis-TB co infection requires special attention from the National TB & Leprosy Program and the NTD control program.

Schistosomiasis TB co-infection may significantly disrupt the host's immune system, increase antibacterial therapy intolerance and consequently worsen the prognosis of both diseases.[10] *Schistosoma mansoni* infection, the most prevalent *Schistosoma spp* in the Lake Zone has been reported to be an independent risk factor for active TB and may alter the clinical presentation of TB in affected patients.[12] Therefore, there is evidence suggesting that intestinal schistosomiasis plays a role in modulating the pathogenesis of human TB.[12] Previous studies have shown that socio-demographics and clinical factors such as; age sex, HIV status and residence in co-endemic areas influence the occurrence of co-infection.[10] Furthermore, studies have reported that pulmonary tuberculosis (PTB) and parasitic diseases are risk factors for each other.[12] Therefore, there is a need to assess the current prevalence of and factors associated with schistosomiasis-TB co-infection among TB patients. Therefore, this study aimed to investigate the prevalence of and factors associated with schistosomiasis TB co-infection, with the goal of contributing evidence to support the inclusion of TB patients in MDA interventions for schistosomiasis.

METHODS

Study Setting

The study was conducted at the TB clinics of Nyamagana and Sekou Toure hospitals in Mwanza city, Tanzania. According to the 2022 National Population Census, Mwanza region had an estimated population of 3, 699,872 (National Bureau of Statistics, 2022), up from 2,772,509 in 2012.[13] The region is among those in Tanzania that are highly affected by both schistosomiasis and TB.[4,9] For instance, in 2021, a total of 4,409 TB cases were notified from tdifferent TB clinics in Mwanza region.

Study Design and Population

An analytical cross-sectional study was conducted among 540 TB patients receiving care and treatment at selected TB clinics. The study included all patients with TB aged 18 years and above who were receiving first line Anti-TB treatment (Rifampicin-based Anti-TB drugs). Exclusion criteria included severely ill patients who could not communicate, patients not receiving a rifampicin-based regimen e.g. second line anti TB drugs for MDR-TB, XDR-TB, and patients who had used praziquantel within the past 6 months. This duration was selected to minimise the effect of recent praziquantel exposure on egg detection and prevalence estimation.

Data collection Tool and Procedures

Data collection Tools

A pre-tested structured questionnaire was used to collect both sociodemographic and clinical data. Variables collected included; age, sex, body weight and height, education level, occupation, marital status, history of fever and abdominal pain, duration of anti-TB drugs use, HIV status, anaemia status and (Body Mass Index) BMI were collected.

Data Collection Procedures

Measurement of Body Temperature Weight, Height and Body Mass Index

Body weight was measured using a calibrated digital weighing scale and recorded in kilograms (nearest 0.1kg) while participants wore minimal clothing. Height was measured using a potable wooden stadiometer and recorded in centimetres (nearest 0.1 cm). Body mass index (BMI) was calculated as the ratio of weight (kg) divide by square of height in metres (m^2) and expressed as kg/m^2. The body temperature was measured from the patient's armpit using a digital thermometer and recorded in degree Celsius (ºC). A temperature of ≥37.5 ºC was considered indicative of fever.

Laboratory Methods

Screening of *Schistosoma Mansoni* Infection

A single fresh stool sample was collected from each patient for *Schistosoma mansoni* screening. The samples were processed and examined for the presence of *Schistosoma mansoni* eggs using the standard Kato-Katz technique. Prepared smears were examined more than 24 hours after preparations to allow adequate clearing and visualization of the schistosome eggs.[14] The intensity of *Schistosoma mansoni* infection was categorized based on the WHO cut-off value (light infection=1-99 egg per gram

of faeces (epg), moderate infection =100-399 epg and heavy ≥400 epg for *S. mansoni*.[15,16] 10% of both positive and negative smears were re-examined for quality assurance by a second experienced laboratory technician who was independent from the primary examiner.

Screening for Malaria Parasites and Haemoglobin Concentration Estimation

A finger prick blood sample (100 µL) was collected for the detection of malaria parasites using a Malaria Rapid Diagnostic Test (SD Bioline malaria Ag P.f/Pan, SD Standard Diagnostics Inc, Korea). Malaria test results were recorded as either positive or negative. The same blood sample was also used for haemoglobin concentration (g/dL) estimation using the HemoCue method (HemoCue AB Angelholm, Sweden). Severity of anaemia was classified as per WHO guideline.[17]

Study Outcomes

The primary outcome was the prevalence of schistosomiasis-TB co infection and the secondary outcome was associated factors of schistosomiasis-TB co infection.

Data Management and Statistical Data Analysis

Data were entered into Microsoft Excel 2021 (Microsoft Corporation, Redmond, Washington, USA), cleaned and analysed using Statistical Package for Social Sciences (SPSS) Version 20 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used for analysis of both sociodemographic and clinical data. Pearson's Chi-square test or Fisher's exact test, depending on expected cell counts, was used to assess the association between socio-demographic, clinical characteristic of participants and schistosomiasis-TB co infection. A modified Robust Poisson regression model was used to identify predictors of schistosomiasis-TB co infection.

Ethics Approval and Consent to Participate

The ethical permit to undertake the study was granted by the Muhimbili University of Health and Allied Sciences (MUHAS) Institutional Review Board (*Ref No. DA.282/298/01.C/*). Additional permission was obtained from the Districts Medical Officer (DMO), District TB coordinators, and heads of the selected TB clinics before the start of study. Written informed consent from each participant was obtained before inclusion into the study. For confidentiality of the patient's information, only study ID numbers were used in the questionnaires to make the information anonymous.

RESULTS

Sociodemographic and Clinical Characteristics of Study Participants

A total of 540 patients with TB receiving Rifampicin-based Anti-TB medication were enrolled into this study. The median age (IQR) of the studied population was 38 years (32, 45), with majority of the participants aged between 35 and 44 years (37.0%). Males accounted for most of the participants (74.1%). The majority had primary level education (60.0%), were married or cohabiting (62.0%) and were self-employed as either peasants or entrepreneurs (88.7%).

About 18.7% of the participants had comorbidities, of whom 73.3% were living with HIV. The Median BMI (IQR) was 21.8 kg/m^2 (19.7, 25.8), with majority of participants having normal BMI (56.3%). The median haemoglobin concentration (IQR) was 11.7 g/dL (11.3, 12.1) and 32.8% of the participants were anaemic. Only 4.3% of the participants tested positive for malaria. The median duration of Anti-TB treatment (IQR) was 4 months (2, 4) (Table 1). At baseline, abdominal pain (20.7%) was the most presenting symptom among study participants followed by fatigue (11.3%) (Figure 1).

TABLE 1: Sociodemographic and Clinical Characteristics of Study Participants

Variable/ Category	Frequency (n)	Percentages (%)
Age (years)		
18 – 24	47	8.7
25 – 34	140	25.9
35 – 44	200	37.0
≥ 45	153	28.3
Sex		
Male	400	74.1
Female	140	25.9
Site		
Nyamagana	205	38.0
Sekou Toure	335	62.0
Education level		
No formal education	5	0.9
Primary education	324	60.0
Secondary education	179	33.2
College/University	32	5.9
Occupation		
Civil servant	29	5.4
Peasant/Business	479	88.7
Retired	18	3.3
Student	14	2.6
Marital status		
Single	156	28.9
Married/Cohabiting	335	62.0
Divorced/Widow	49	9.1
Presence of Comorbidity		
Yes	101	18.7
No	439	81.3
Type of comorbidity		
HIV	74	73.3
Diabetes mellitus	6	5.9
Hypertension	18	17.8
Hypertension + Diabetes mellitus	1	1.0
Asthma	1	1.0
Skin disease	1	1.0
Use of other medications		
Yes	99	18.3
No	441	81.7
Type of medications		
Antiretroviral drugs	74	74.7
Antidiabetics	6	6.1
Antihypertensives	18	18.2
Antihypertensives+ Antidiabetics	1	1.0
Body weight in kg Median (IQR)	58 (52.0, 66.5)	

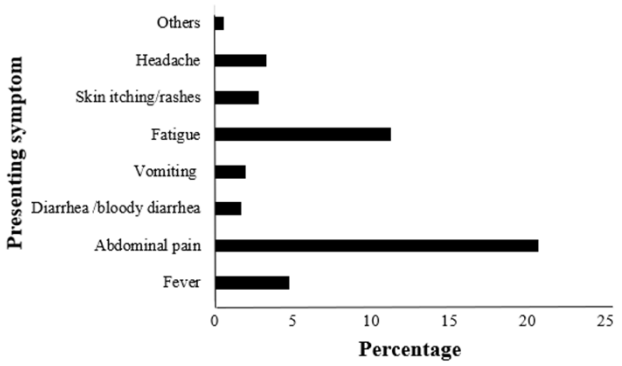
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TABLE 1: Continued

Variable/ Category	Frequency (n)	Percentages (%)
Body mass index (BMI) kg/m2		
Underweight	66	12.2
Normal BMI	304	56.3
Overweight	130	24.1
Obese	40	7.4
Haemoglobin concentration g/dL Median (IQR)	11.7 (11.3, 12.1)	
Anaemia status		
Anaemic	177	32.8
Not anaemic	363	67.2
MRDT test / Malaria results		
Positive	23	4.3
Negative	517	95.7
Duration of anti-TB drugs use (month) Median (IQR)	4 (2, 4)	

Use of other medications referred to medications other than anti-TB treatment

FIGURE 1: Presenting Symptoms Among Participants During Screening



Prevalence of Schistosomiasis-TB Co-infection and Intensity of Infection

Out of the 540 patients screened, 159 were infected with intestinal schistosomiasis, giving a prevalence of 29.4% (95% CI: 25.7-33.0). Most of participants had formed stools (80.5%), followed by soft (18.2%) and loose stool consistencies (1.3%). Regarding infection intensity, most participants had light infection 136/540 (25.2%) and moderate infection was observed in 4.3% (23/540). Notably, there was no heavy infection.

Association Between Sociodemographic, Clinical Characteristics and TB Schistosomiasis Co-infection

On bivariate analysis, age, occupation, marital status, presence of comorbidities, malaria positivity, presence of abdominal pain, anaemia status and stool consistency were significantly associated with schistosomiasis-TB co-infection ($p<.05$). Participants aged 35 years and above ($p=.005$), those who were retired ($p=.009$), divorced or widowed ($p=.01$), had comorbidities ($p<.0001$), were malaria parasite ($p<.0001$), reported abdominal pain ($p<.0001$), were anaemic ($p<.0001$) or had loose stool consistency had a significantly higher prevalence of schistosomiasis co-infection than their counterparts (Table 2).

Factors Associated with Schistosomiasis-TB Co-infection

A Modified Robust Poisson regression model was used to identify factors independently associated with schistosomiasis-TB co-infection. All variables with p-value of < .20 in the univariable analysis were included in the multivariate logistic regression model. In the multivariable analysis, being self-employed (aPR=1.98, 95% CI: 1.07-3.67; $p=.03$) or retired (aPR=2.72, 95% CI 1.25-5.93; $p=.01$), presence of comorbidities (aPR=1.56, 95% CI: 1.12-2.05; $p=.001$), malaria infection (aPR=2.17, 95% CI: 1.56-3.03; $p<.0001$), presence of abdominal pain (aPR=1.59, 95% CI: 1.20-2.11; $p=.001$), being anaemic (aPR=1.36, 95% CI: 1.05-1.76; $p=.02$) and having soft (aPR=1.69, 95% CI: 1.28-2.22; $p<.0001$) or loose stool (aPR=2.18, 95% CI: 1.37-3.46 $p<.0001$) were significant factors associated with TB schistosomiasis co-infection (Table 3).

TABLE 2: Association Between Sociodemographic, Clinical Characteristics and Schistosomiasis TB Co-Infection

Variable	Category	TB schistosomiasis co infection status Yes n (%)	No n (%)	P - value
Age (years)	18 – 24	7 (14.9)	40 (85.1)	.005
	25 – 34	31 (22.1)	109 (77.9)	
	35 – 44	71 (35.5)	129 (65.5)	
	≥ 45	56 (32.7)	103 (67.3)	
Sex	Male	116 (29.0)	284 (71.0)	.75
	Female	43 (30.7)	97 (69.3)	

Continue

TABLE 2: Continued

Variable	Category	TB schistosomiasis co infection status Yes n (%)	No n (%)	P - value
Site	Nyamagana	55 (26.8)	150 (73.2)	.33
	Sekou Toure	104 (31.0)	231 (69.0)	
Education level	No formal education	1 (20.0)	4 (80.0)	.602
	Primary	98 (30.2)	226 (69.8)	
	Secondary education	54 (30.2)	125 (69.8)	
	College/University	6 (18.8)	26 (81.3)	
Occupation	Civil servant	5 (17.2)	24 (82.8)	.009
	Peasant/Business	143 (29.9)	336 (70.1)	
	Retired	10 (55.6)	8 (44.4)	
	Student	1 (7.1)	13 (92.9)	
Marital status	Single	34 (21.8)	122 (78.2)	.01
	Married/Cohabiting	104 (31.0)	231 (69.0)	
	Divorced/Widow	21 (42.9)	28 (57.1)	
Presence of comorbidity	Yes	55 (54.5)	46 (45.5)	<.0001
	No	104 (23.7)	335 (76.3)	
BMI categories	Underweight	24 (36.4)	42 (63.6)	.612
	Normal BMI	88 (28.9)	216 (71.1)	
	Overweight	36 (27.7)	94 (72.3)	
	Obese	11 (27.5)	29 (72.5)	
Malaria test	Positive	18 (78.3)	5 (21.7)	<.0001
	Negative	141 (27.3)	376 (72.7)	
Abdominal pain	Yes	60 (53.6)	52 (46.4)	<.0001
	No	99 (23.1)	329 (76.9)	
Anaemia status	Anaemic	78 (44.1)	99 (55.9)	<.0001
	Not anaemic	81 (22.3)	282 (77.7)	
Stool consistency	Formed	99 (22.8)	335 (77.2)	<.0001
	Soft	53 (54.1)	45 (45.9)	
	Loose	6 (85.7)	1 (14.3)	

Pearson's chi-square test was used unless the expected cell count was less than 5, in which case Fisher's exact test was applied.

TABLE 3: Univariable and Multivariable Regression Analysis for Factors Associated with TB Co-infection

Variable/ Category	% co-infection	Univariable analysis cPR	95%CI	p-value	Multivariable analysis aPR	95%CI	p-value
Age							
18 – 24	14.9	Ref			Ref		
25 – 34	22.1	1.49	0.70 – 3.15	.30	1.12	0.49 – 2.60	.79
35 – 44	35.5	2.38	1.17 – 4.84	.12	1.71	0.73 – 3.99	.22
≥ 45	32.7	2.19	1.07 – 4.51	.03	1.38	0.58 – 3.32	.47
Sex							
Male	29.0	0.94	0.71 – 1.27	.70			
Female	30.7	Ref					
Site							
Nyamagana	26.8	0.86	0.66 – 1.14	.30			
Sekou Toure	31.0	Ref					
Education level							
No formal education	20.0	Ref					
Primary education	30.2	1.51	0.26 – 8.79	.65			
Secondary education	30.2	1.51	0.26 – 8.83	.65			

Continue

TABLE 3: Continued

Variable/ Category	% co-infection	Univariable analysis cPR	95%CI	p-value	Multivariable analysis aPR	95%CI	p-value
College/University	18.8	0.94	0.14 – 6.24	.95			
Marital status							
Single	21.8	Ref			Ref		
Married/Cohabiting	31.0	1.42	1.12 – 1.99	.04	1.19	0.83 – 1.73	.33
Divorced/Widow	42.9	1.96	1.26 – 3.05	.003	1.00	0.62 – 1.62	.99
Occupation							
Civil servant	17.2	Ref			Ref		
Peasant/Business	29.9	1.73	0.77 – 3.89	.18	1.98	1.07 – 3.67	.03
Retired	55.6	3.22	1.31 – 7.91	.01	2.72	1.25 – 5.93	.01
Student	7.1	0.41	0.05 – 3.22	.40	0.87	0.12 – 6.22	.89
Comorbidity							
Yes	54.5	2.29	1.79 – 2.94	<.0001	1.56	1.12 – 2.05	.001
No	23.7	Ref			Ref		
BMI categories							
Underweight	36.4	Ref					
Normal BMI	28.9	0.80	0.55 – 1.15	.22			
Overweight	27.7	0.76	0.49 – 1.16	.21			
Obese	27.5	0.75	0.42 – 1.37	.36			
Malaria status							
Positive	78.3	2.87	2.22 – 3.71	<.0001	2.17	1.56 – 3.03	<0.0001
Negative	27.3	Ref			Ref		
Presence of abdominal pain							
Yes	53.6	2.32	1.82 -2.96	<.0001	1.59	1.20 – 2.11	.001
No	23.1	Ref			Ref		
Anaemia status							
Anaemic	44.1	1.98	1.53 – 2.55	<.0001	1.36	1.05 – 1.76	.02
Not anaemic	22.3	Ref			Ref		
Stool consistency							
Formed	22.8	Ref			Ref		
Soft	54.1	2.37	1.84 – 3.05	<.0001	1.69	1.28 – 2.22	<.001
Loose	85.7	3.76	2.65 – 5.32	<.0001	2.18	1.37 – 3.46	.001

DISCUSSION

This study investigated the prevalence of schistosomiasis-TB co-infection and its associated factors in Northwestern Tanzania. Our major findings were that: (i) approximately one-third of patients with TB were infected with intestinal schistosomiasis, with the majority having light to moderate infection intensity and (ii) occupation, presence of comorbidities, malaria positivity, anaemia and stool consistency were the significant factors associated with TB-schistosomiasis co-infection.

The prevalence of schistosomiasis TB co-infection in our study was 29.4%. This relatively high prevalence indicates that schistosomiasis remains a significant public health concern among patients with TB. Our findings are almost similar to another study conducted in the same locality in 2007 that reported *Schistosoma mansoni* infection to be common in patients with TB, with prevalence of 34%.[11] On the other hand, a study conducted in Dar es Salaam in 2017 reported a low prevalence of co-infection (5.7%).[12] This difference is not surprising because the Coast region is predominantly endemic for *Schistosoma haematobium* rather than *Schistosoma mansoni*.[3,18] Similarly, Sikalengo et al. (2018) reported a prevalence of *Schistosoma mansoni* co-infection of 16.4% among patients with active TB in the rural area of Ifakara ward in Morogoro region.[19] A recent systematic review reported a prevalence of schistosomiasis TB co-infection ranging from 4% to 34%.[6,10] Collectively, these findings suggest that TB and schistosomiasis co-infection remains an important public health challenge in co-endemic settings, particularly in low and middle income countries. Importantly, schistosomiasis TB co-infected patients are not part of the MDA campaigns for the control and elimination of schistosomiasis in most endemic countries, including Tanzania. Furthermore, as in many endemic countries, schistosomiasis control in Tanzania is remains largely centred on preventive chemotherapy through MDA, with limited integration into routine health care services.[18,20] Consquently, this neglected population remains untreated, potentially sustaining schistosomiasis transmission. Such fragmented treatment coverage presents a major challenge to global schistosomiasis control and elimination efforts.[21] In addition, *Schistosoma mansoni* infection has been reported to be an independent risk factor for active TB and a modulator of TB immunopathogenesis.[6,12]

Therefore, there is a need to consider this special group in MDA campaigns as suggested by others.[12] Alternatively, in line with WHO recommendation to integrate schistosomiasis control programs into primary health care system,[22] TB control programs could incorporate routine screening and treatment for schistosomiasis. This could be achieved through training healthcare workers in TB clinics to diagnose and manage schistosomiasis. However, a recent study assessing the capacity of primary healthcare facilities to diagnose and treat schistosomiasis reported inadequate diagnostic capacity, limited treatment availability, weak reporting systems and insufficient healthcare worker knowledge.[20] Strengthening these areas, together with health education on schistosomiasis prevention among patients attending TB Clinics, could contribute to reducing the burden of co-infection.

In this study, the majority of infections were of light intensity with moderate infections comprising 14.5% of the cases. Notably, there were no cases of heavy infection observed. The predominance of light-intensity infections is in agreement with other studies conducted in endemic regions,[6,12] indicating that while schistosomiasis is common among patients with TB, the infection burden per individual tends to be low to moderate. However, it should be noted that these studies were conducted in urban areas where exposure to infested water bodies is relatively limited and hence, they may not fully reflect the infection intensity in highly endemic rural communities. Continued surveillance is needed to monitor both the prevalence and intensity of schistosomiasis among patients with TB. In addition, further studies should evaluate the effectiveness of praziquantel when co-administered with Rifampicin-based Anti-TB regimen. Co-administration of praziquantel and rifampicin presents a potential therapeutic challenge because of drug-drug interactions.[23] Studies in normal health volunteers (NHV) have shown that concomitant administration of Rifampicin markedly reduces praziquantel plasma concentrations to almost undetectable levels.[23] Reduced praziquantel exposure in infected patients could compromise treatment efficacy. In fact, a recent study demonstrated that this interaction may reduce praziquantel effectiveness among TB patients receiving rifampicin-based regimens.[24]

Our study found that occupation, presence of comorbidities, malaria infection, anaemia and stool consistency were significant predictors of schistosomiasis TB co-infection. Previous studies have reported similar findings, particularly regarding HIV infection, which was the most common comorbidity in this study.[11] Malaria-positive patients were also more likely to have schistosomiasis co-infection. This finding may be explained by the immunomodulatory effects of schistosomiasis, whereby suppression of the host Th-1 immune response, and enhancement of the Th-2 response may impair protective immunity against other infections, including malaria.[6] Anaemia was also independently associated with schistosomiasis TB co-infection, which could be due to the blood loss caused by schistosomiasis, and the general debilitating effects of chronic infections. Anaemia may also be a consequence of or exacerbate the severity of TB, suggesting a complex interplay between these conditions.[25] Moreover, changes in stool consistency was also associated with schistosomiasis infection among patients with TB, which most likely reflect gastrointestinal involvement by the parasite. These associated factors can be used as index of suspicion at the TB clinics and emphasises the need for regular parasitological examinations in TB patients presenting with such features.

A limitation of this study is that it assessed only *Schistosoma mansoni* infection and did not investigate *Schistosoma haematobium* because of resource constraints. However, the findings provide an important basis for future studies to investigate the prevalence and epidemiological interaction between tuberculosis and *S. haematobium* infections in endemic settings.

CONCLUSIONS

Our study highlights a significant burden of TB-schistosomiasis co-infection in the study population. The presence of comorbidities, malaria infection, anaemia and changes in stool consistency were the key predictors of this co-infection.

There is a need to include TB patients in MDA campaigns while also addressing the associated factors through targeted interventions and integrated healthcare approaches to reduce morbidity and transmission of these diseases among affected populations. Future research should continue to monitor the prevalence and intensity of co-infections and evaluate the effectiveness of praziquantel when co-administered with Rifampicin-based Anti-TB regimen.

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