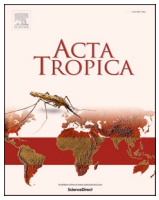
Acta Tropica 268 (2025) 107692

Contents lists available at ScienceDirect

Acta Tropica

journal homepage: www.elsevier.com/locate/actatropica



Three annual cross-sectional community-based Knowledge, Attitudes and Practices (KAP) and prevalence surveys for urogenital schistosomiasis infection in two rural communities within Mangochi and Nsanje Districts, southern Malawi

Peter Makaula [a,b,c,*], Clinton Nkolokosa [a,d], John Archer [b,e], Gladys Namacha [a], Priscilla Chammudzi [a], Donales R. Kapira [a], David Lally [a], Bessie P. Ntaba [a], Ruth Cowlishaw [b], Angus M. O'Ferrall [b], Sam Jones [b], Lucas J. Cunningham [b], Sarah Rollason [b,f], Alexandra Juhász [b,g], Henry Chibowa [h], Victor Kumfunda [h], Bright Mainga [a,h], Gilbert Chapweteka [i], Waleke Khumalo [i], John Chiphwanya [j], James E. LaCourse [b], Sekeleghe A. Kayuni [a,b,k], J. Russell Stothard [b,1], Janelisa Musaya [a,k,1]

[a] Malawi Liverpool Wellcome Programme, Queen Elizabeth Central Hospital, P.O. Box 30096, Chichiri, Blantyre 3, Malawi
[b] Department of Tropical Disease Biology, Liverpool School of Tropical Medicine, Liverpool, L3 5QA, UK
[c] Research for Health Environment and Development, P.O. Box 345, Mangochi, Malawi
[d] Biological and Environmental Sciences Department, University of Stirling, Stirling, FK9 4LA, Scotland, UK
[e] Wolfson Wellcome Biomedical Laboratories, Department of Zoology, Natural History Museum, Cromwell Road, London, UK
[f] School of Biosciences, Cardiff University, Cardiff, CF10 3AX, United Kingdom
[g] Institute of Medical Microbiology, Semmelweis University, H-1089 Budapest, Hungary
[h] Mangochi District Hospital, Ministry of Health, P.O. Box 42, Mangochi, Malawi
[i] Nsanje District Hospital, Ministry of Health, P.O. Box 30, Nsanje, Malawi
[j] National Schistosomiasis and Soil-Transmitted Helminths Control Programme, Community Health Sciences Unit, Ministry of Health, Private Bag 65, Lilongwe, Malawi
[k] Department of Pathology, School of Medicine and Oral Health, Kamuzu University of Health Sciences, Private Bag 360, Chichiri, Blantyre 3, Malawi

ARTICLE INFO

Keywords:
Schistosomiasis
Infection
Prevalence
Interventions
Knowledge
Attitudes
Practices

ABSTRACT

In 2022 the World Health Organization (WHO) issued guidelines with key interventions to control and eliminate schistosomiasis in endemic countries. In Malawi, whilst praziquantel Mass Drug Administration (MDA) campaigns have been ongoing for over a decade, implementation of other interventions have not been formally assessed. To help formulation of an integrated country-specific control strategy, we assessed the Knowledge, Attitudes and Practices (KAP) and infection prevalences in two representative rural communities in Mangochi and Nsanje Districts. Longitudinal cross-sectional community-based questionnaire surveys were undertaken with participants aged from 6 to 45 years in 2022 and later repeated in 2023 and in 2024. Participants (including children aged 2 to 5 years) provided urine samples for parasitological tests. Comparative analysis involved calculation of percentages, tabulations, frequencies, and a logistic regression (logit) model to assess the effect of education level, gender, age, and study area on general and correct knowledge of schistosomiasis. A total of 1964 participants took part in the KAP surveys in 2022, and 1789 and 1908 participants were followed up in 2023 and 2024 respectively, while for the parasitological surveys, 2,319 participants took part in 2022, and 2,006 and 2,014 participants were followed up in 2023 and 2024 surveys respectively. In total, 53.2 % were from Mangochi, 55.5 % were females, 62.1 % were School-Aged Children (SAC) and 37.9 % were adults with their mean ages at 11 and 28 years, respectively. Overall, 65.5 % of respondents demonstrated satisfactory (≥50.0 % – ≤70.0 %) knowledge of schistosomiasis while only 5.1 % correctly mentioned freshwater snails as intermediate hosts. In 2022, prevalence of urogenital schistosomiasis by urine microscopy was 43.6 %, which despite annual MDA increased to 44.1 % in 2023, then after biannual MDA decreased to 27.0 % in 2024. In 2022, 10.5 % of all

* Corresponding author.
E-mail address: petmakau@yahoo.co.uk (P. Makaula).
[1] Joint senior authors on this work.

https://doi.org/10.1016/j.actatropica.2025.107692
Received 7 March 2025; Received in revised form 23 May 2025; Accepted 9 June 2025
Available online 16 June 2025

participants had heavy-intensity infections which increased to 11.4 % in 2023 before decreasing to 7.7 % in 2024. The majority (91.3 %) used a borehole or piped source of drinking water and used a latrine to urinate or defecate (93.8 %) although many (59.6 %) reported to have visited a freshwater body more than once in a day. Since MDA has taken place over several years in these areas and only had insufficient local impact, we strongly encourage addition of complementary methods to bolster its impact. It is therefore essential to engage individuals and communities, improving their understanding of disease and behaviour change to more effectively control and potentially eliminate schistosomiasis.

1. Introduction

Schistosomiasis is a prevalent parasitic Neglected Tropical Disease (NTD) caused by infection with digenetic trematode worms of the genus *Schistosoma* (Buonfrate et al., 2025). Schistosomiasis mostly afflicts rural communities, particularly those residing in agricultural and fishing populations in Low- and Middle-Income Countries (LMICs) (De Leo et al., 2020). Where urogenital schistosomiasis is endemic, chronic infection can also cause severe pathologies related to female and male genital schistosomiasis particularly in adults carrying out daily domestic and/or occupational chores in water infested by infected intermediate freshwater snail hosts (Kokaliaris et al., 2020).

The World Health Organization (WHO) estimated that globally, approximately 1 billion people are at risk of schistosomiasis, with 250 million people affected by the disease across 78 countries (WHO, 2020). In 2022, at least 264.3 million people in 50 countries required preventive chemotherapy by Mass Drug Administration (MDA) of single dose praziquantel for schistosomiasis, of which only 89.1 million people (33.7 %) received the treatment (WHO, 2024). To control and eliminate schistosomiasis as a public health problem, and to move towards interruption of transmission, the WHO in 2022 recommended key interventions, namely, a large-scale treatment of at-risk population groups, adequate access to safe Water, Sanitation and Hygiene (WASH) infrastructure, education and behavior changes to prevent transmission, and freshwater snail intermediate host control and environmental management (WHO, 2022). The aim of this guideline is to empower and support implementers and local communities to extend the use of preventive chemotherapy to support wider target populations in their efforts to control and eliminate this disease. One of the key recommendations for prevention, control and elimination of schistosomiasis is through implementation of education and behaviour change activities to improve knowledge of the signs and symptoms associated with schistosomiasis which helps in early detection as well as in taking subsequent steps to prevent and control the disease. To help in reducing transmission of schistosomiasis through contact with infested water bodies in endemic areas, it is recommended that interventions to promote access to safe WASH should be implemented along with other interventions. For optimal outcomes, the WHO recommends that implementation of these interventions should, where feasible, be fully integrated with and complementary to preventive chemotherapy for schistosomiasis.

In Malawi, two forms of schistosomiasis (urogenital schistosomiasis caused by *Schistosoma haematobium* and intestinal schistosomiasis caused by *Schistosoma mansoni*) are endemic (Makaula et al., 2014). As one WHO recommendation requires regular delivery of treatment to all at-risk population groups in endemic areas, in Malawi, the Ministry of Health through the National Schistosomiasis Control Programme (NSCP) with help from governmental and nongovernmental partners has since 2009 been implementing country-wide MDA campaigns in all districts, annually. High MDA coverage rates above 80 % successes have been registered despite some challenges (Makaula et al., 2022). As a result of a sustained high national MDA coverage of $\geq$ 75 % for School-Aged Children (SAC), prevalences of schistosomiasis in most districts have been reduced from high ($\geq$ 50 %) to moderate ($\geq$ 10 % – $\leq$ 50 %) or low (1 % – $\leq$ 10 %) levels (Makaula et al., 2022). Malawi has attained morbidity control which has prompted the NSCP, in 2022 to change from use of districts to smaller traditional areas (sub-districts) as implementation units for MDA delivery aiming to eliminate schistosomiasis as a public health problem (Makaula et al., 2022). However, apart from the implementation of these MDA campaigns, implementation of the other key WHO recommended interventions has not been formally assessed to help in guiding formulation of effective strategy for control and elimination of schistosomiasis in the country. To address this knowledge gap, our study was carried out annually in three consecutive years to assess changes in infection prevalences, Knowledge, Attitudes and Practices (KAP) related to implementation of the recommended interventions for the control and elimination of schistosomiasis among communities in selected schistosomiasis-endemic areas of Malawi.

2. Materials and methods

2.1. Study design and study area

These were longitudinal cross-sectional, community-based surveys, and were carried out in 2022 (as baseline), then in 2023 and 2024, respectively, as annual follow-ups within the Hybridisation in UroGenital Schistosomiasis (HUGS) investigation [https://www.lstmed.ac.uk/hugs]. The HUGS investigation was carried out in two southern Malawi districts of Mangochi and Nsanje (Fig. 1), purposively selected because they are endemic to urogenital schistosomiasis and located close to Lake Malawi and the Shire River where previous studies documented occurrence of atypical *Schistosoma* spp. eggs in urine samples suggestive of a possible interspecies hybridisation with schistosomes present in local livestock (Webster et al., 2019). In these districts, a total of 11 villages from within catchment areas of Samama and Mthawira schools in Mangochi and Nsanje districts were selected to participate in the HUGS investigation with the main objective of tracking hybrids within the sampled cohort.

2.2. Study population and sampling

All people aged from 2 and above years resident in the selected study areas comprised the study population for the main HUGS investigation. The sample size for the entire HUGS cohort was estimated at 2400, but only 1964 participants aged 6 years and above participated in the KAP survey after exclusion of minors aged below 6 years. Sampling procedures involved several steps starting with a Global Positioning System mapping and census of every household in the 11 selected villages in both districts (Fig. 1). Thereafter, a computer assisted random selection of households based on village sizes was performed. All eligible participants in the selected households who were present on the visit days were invited to take part in the study.

2.3. Data collection

In every village, community sensitization meetings to present and discuss the study with the whole community were conducted by responsible community-based health workers and community leaders after initial orientation by the study team.

The study employed a survey questionnaire, which was programmed in electronic tablets (Samsung Electronics Co., Ltd.) using Kobo Toolbox (version 2022.2.3) (Kobo Toolbox, 2022) as a method for data

collection. The questionnaire comprised 75 questions about respondents' demographic and socio-economic characteristics, and to determine their knowledge, attitudes, and practices regarding the WHO recommended interventions for prevention, control and elimination of schistosomiasis was administered to every eligible household member available on the visit day (see Supplementary file 1). Each year, data were collected at household level in all selected villages by teams of 14 graduate research assistants who were locally recruited based on their prior knowledge and skills in the research field. The research assistants were initially trained and later engaged in data collection. In addition, the research assistants were provided with guiding notes to help them determine correct responses during engagements with survey respondents. During the survey, respondents aged 6 years and above were asked about their knowledge, attitudes and practices or experiences with ongoing treatment efforts by the NSCP in their communities. To assess community practices related to water and animal contacts, the surveys asked respondents about the closeness they lived and got in contact with freshwater bodies such as the lake or rivers and with livestock/domestic animals. At the end of the questionnaire interview, participants (including minors aged 2–5 years) were issued plastic containers to provide 20 ml urine samples for further laboratory parasitological examinations to determine their infection status with urogenital schistosomiasis by urine microscopy.

2.4. Data management and analysis

The annually collected survey data was exported as Microsoft Excel database and later processed and analyzed using Statistical Package for Social Sciences (SPSS) software version 28 (IBM Corp., Armonk, NY, USA). Analysis involved calculation of percentages, tabulations, and frequencies to estimate knowledge, attitudes, and practices levels. Data which had closed questions were measured using aggregated percentages while attitudes and practices were measured using percentages derived from a five-point Likert scale from which respondents indicated their extent of agreement or disagreement with statements to rate their responses to evaluative questions. To help with interpretation of the data analyzed, all scores of 70 % and above were rated as 'high or strong', ≥ 50 %–≤ 70 % as 'moderate or satisfactory', ≥ 30 %–≤ 50 % as 'low or unsatisfactory', and ≤ 30 % as "very low or very poor" (Macias and Glasauer, 2014).

For statistical analysis, a logistic regression (logit) model, a binary classification technique, was carried out to assess the effect of education level, gender, age, and study area on the likelihood of having general knowledge of schistosomiasis (Yes/No), and correct knowledge of schistosomiasis (Correct/Incorrect). The model estimated odds ratios (ORs) and 95 % confidence intervals (CIs) to determine the probability that a study participant either had or lacked knowledge, and sound knowledge of schistosomiasis based on their education level, gender, age, and district of residence. The analysis was conducted using R Statistical Software (version 4.3.3) (R Core Team, 2024). The respondents were first asked a general dichotomous question followed by probing open-ended questions, for example, (i) Do you know what schistosomiasis is? (Yes/No), If yes, explain what schistosomiasis is? (Correct/Incorrect); (ii) Do you know what causes schistosomiasis? (Yes/No), If yes, please explain what is it that causes schistosomiasis? (Correct/Incorrect) (see Supplementary file 1). The purpose of this was to assess correct knowledge and common misconceptions about schistosomiasis that either contribute to its control or perpetuate its transmission, and to retrospectively evaluate progress towards its elimination. Comprehensive and accurate knowledge of schistosomiasis is critical for fostering behaviors such as treatment-seeking, improved hygiene, and sanitation practices, which are essential for reducing the risk of schistosomiasis (re) infection.

Parasitological examination of urine samples that were collected from the participants involved on-site visual examination to screen for macrohematuria recorded as "yes" for positive or "no" for negative, using urine chemical reagent strips to test for microhematuria recorded as "-" for negative, trace, and "+, ++ or +++" for positives, and finally

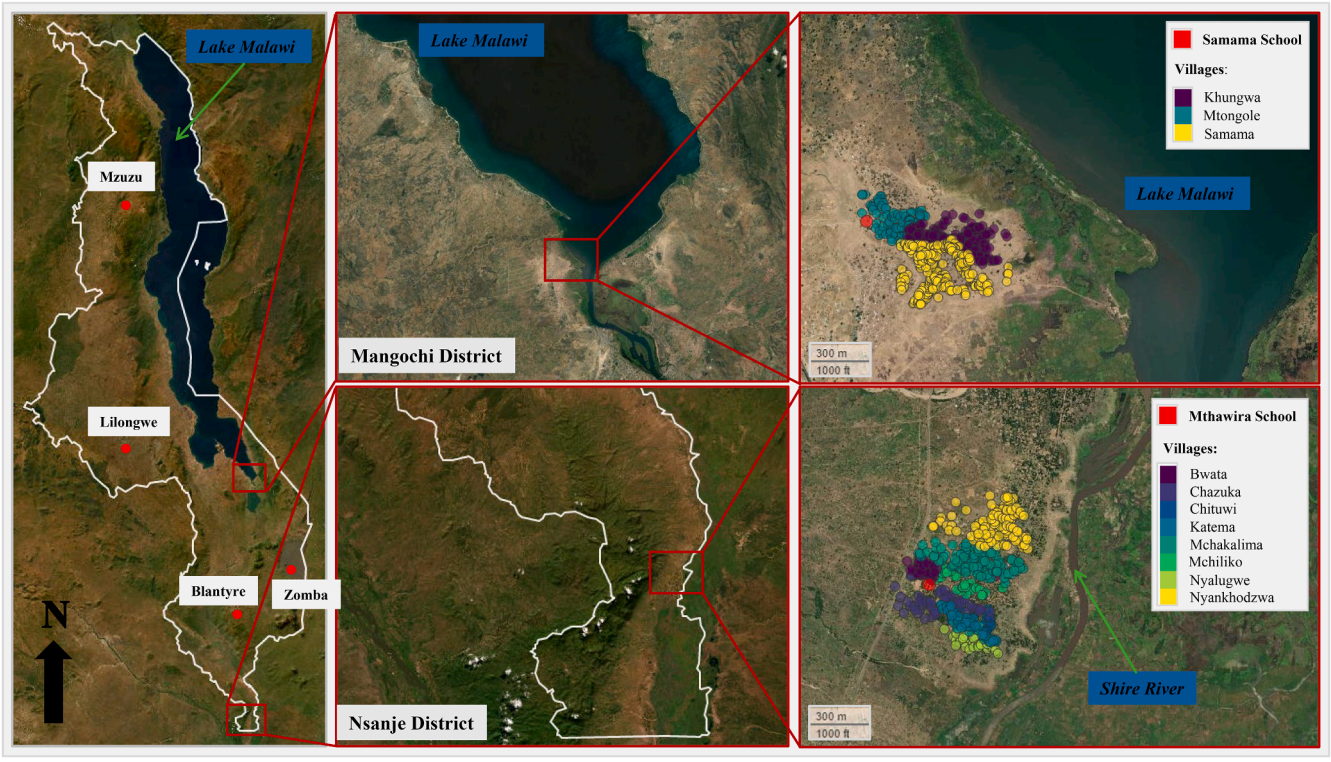


Fig. 1. Map of Malawi showing locations of major cities of Mzuzu, Lilongwe, Blantyre and Zomba; Mangochi and Nsanje study districts and the sampled households (coloured circles) according to their respective selected 11 study villages around Samama and Mthawira schools (red dots) where study participants were recruited. (Source: HUGS Study).

by drawing 10 ml using the filtration method to visualize and count the eggs to determine infection status, whereupon cases were defined as only those with a positive egg count, and those with <50 eggs per 10 ml of urine were categorised as light-intensity infections and those above 50 eggs per 10 ml of urine as heavy-intensity infections.

2.5. Ethical considerations

The study protocol, including the informed consent forms were reviewed and approved by both the Kamuzu University of Health Sciences (KUHeS) Research Ethics Committee (KUREC) (Approval # P.08/21/3381) and the Liverpool School of Tropical Medicine (LSTM) Research Ethics Committee prior to the commencement of the study. Informed consent (see Supplementary file 2) was individually obtained from every study participant at the very beginning before proceeding with their involvement after being explained about the study objectives and aims (see Supplementary file 3) using local languages of Chichewa, Chiyao and Chisena used in the study areas. For participants who were literate, a written consent was obtained while for those not literate a written informed consent was obtained through their legally acceptable representatives. Similarly for the study participants who were children (under 18 years of age), written consent to participate was collected from their parents or guardians on their behalf. All the research instruments, including participants' information leaflets that were used and distributed at community level were also translated into local languages. Participants were issued copies of signed consent or assent and information leaflets for their records and references.

Table 1
Demographic and socio-economic characteristics of study participants over three years according to study areas.

Characteristic	Number (%) of respondents who participated in annual surveys								
Study area name	Mangochi			Nsanje			All districts		
1) Survey type and year	Baseline 2022	Follow up 1 2023	Follow up 2 2024	Baseline 2022	Follow up 1 2023	Follow up 2 2024	Baseline 2022	Follow up 1 2023	Follow up 2 2024
2) Total catchment population	2,485 (44.6)	-	-	3,083 (55.4)	-	-	5,568 (100)	-	-
3) Sample size N	1,045 (53.2)	1,016 (56.8)	1,063 (55.7)	919 (46.8)	773 (43.2)	845 (54.3)	1,964 (100)	1,789 (100)	1,908 (100)
4) Gender									
Female	599 (57.3)	585 (57.6)	606 (57)	491 (53.4)	427 (55.2)	444 (52.5)	1,090 (55.5)	1,012 (56.6)	1,050 (55)
Male	446 (42.7)	431 (42.4)	457 (43)	428 (46.6)	346 (44.8)	401 (47.5)	874 (44.5)	777 (43.4)	858 (45)
5) Age groups in years									
Primary School-Aged Children (6-13)	486 (46.5)	486 (47.8)	497 (46.8)	440 (47.9)	383 (49.5)	391 (46.3)	926 (47.2)	869 (48.6)	888 (46.5)
Secondary School-Aged Children (14-17)	158 (15.1)	157 (15.5)	169 (15.9)	135 (14.7)	103 (13.3)	137 (16.2)	293 (14.9)	260 (14.5)	306 (16.0)
Young Adults (18-24)	183 (17.5)	177 (17.4)	184 (17.3)	139 (15.1)	121 (15.7)	136 (16.1)	322 (16.4)	298 (16.7)	320 (16.8)
Adults (25 and above)	218 (20.9)	196 (19.3)	213 (20.0)	205 (22.3)	166 (21.5)	181 (21.4)	423 (21.5)	362 (20.2)	394 (20.7)
Mean age for all participants	17.1	16.8	17.1	17.3	17.2	17.6	17.8	17	17.3
Range	6-45	6-46	6-46	6-45	6-46	6-46	6-45	6-46	6-46
6) Marital status*									
Single	880 (84.2)	756 (74.4)	780 (73.4)	651 (70.8)	552 (71.4)	597 (70.6)	1,531 (77.9)	1,308 (73.1)	1,377 (72.2)
Married	143 (35.7)	229 (58.0)	235 (59.2)	249 (72.4)	203 (70.7)	224 (70.7)	392 (52.6)	432 (65.4)	459 (64.3)
Separated	3 (0.7)	6 (1.5)	21 (5.3)	10 (2.9)	5 (1.7)	3 (0.9)	13 (1.7)	11 (1.7)	24 (3.4)
Divorced	14 (3.5)	20 (5.1)	21 (5.3)	2 (0.6)	10 (3.5)	18 (5.7)	16 (2.1)	30 (4.5)	39 (5.5)
Widowed	5 (1.2)	5 (1.3)	6 (1.5)	7 (2.0)	3 (1.0)	3 (0.9)	12 (1.6)	8 (1.2)	9 (1.3)
7) Tribe									
Chewa	787 (75.3)	791 (77.9)	920 (86.5)	-	-	3 (0.4)	787 (40.1)	791 (44.2)	923 (48.4)
Yao	133 (12.7)	123 (12.1)	87 (8.2)	-	-	-	133 (6.8)	123 (6.9)	87 (4.5)
Sena	-	-	1 (0.1)	901 (98)	771 (99.7)	838 (99.1)	901 (45.9)	771 (43.1)	839 (44)
Lomwe	13 (1.2)	4 (0.4)	7 (0.7)	9 (1)	-	3 (0.4)	22 (1.1)	4 (0.2)	10 (0.5)
Mang'anja	11 (1.1)	54 (5.3)	38 (3.6)	7 (0.8)	-	-	18 (0.9)	54 (3)	38 (2)
Ngoni	4 (0.4)	3 (0.3)	4 (0.4)	-	-	-	4 (0.2)	3 (0.2)	4 (0.2)
Other	97 (9.3)	41 (4)	6 (0.6)	2 (0.2)	2 (0.3)	1 (0.1)	99 (5)	43 (2.4)	7 (0.4)
8) Religion									
Christian	926 (88.6)	911 (89.7)	955 (89.8)	897 (97.6)	770 (99.6)	835 (98.8)	1,823 (92.8)	1,681 (93.9)	1,790 (93.8)
Islam	111 (10.6)	104 (10.2)	108 (1.2)	6 (0.7)	1 (0.1)	4 (0.5)	117 (6)	105 (5.9)	112 (5.9)
Other	8 (0.8)	1 (0.1)	-	16 (1.7)	2 (0.3)	6 (0.7)	24 (1.2)	3 (0.2)	6 (0.3)
9) Education level									
None	221 (21.1)	204 (20.1)	192 (18.1)	211 (22.9)	170 (22)	126 (14.9)	432 (22)	374 (20.9)	318 (16.7)
Primary	752 (72)	740 (72.8)	822 (77.3)	649 (70.6)	539 (69.7)	661 (78.2)	1,401 (71.3)	1,279 (71.5)	1,483 (77.7)
Secondary	71 (6.8)	60 (5.9)	49 (4.6)	53 (5.8)	42 (5.4)	53 (6.3)	124 (6.3)	102 (5.7)	102 (5.3)
Tertiary	1 (0.1)	12 (1.2)	-	6 (0.7)	22 (2.9)	5 (0.6)	7 (0.4)	34 (1.9)	5 (0.3)
10) Occupation									
Business	110 (10.5)	100 (9.8)	206 (19.4)	18 (2)	19 (2.5)	33 (3.9)	128 (6.5)	119 (6.6)	239 (12.5)
Farming	92 (8.8)	84 (8.3)	52 (4.9)	271 (29.5)	218 (28.2)	237 (28)	363 (18.5)	302 (16.9)	289 (15.2)
Fishing	29 (2.8)	20 (2)	46 (4.3)	4 (0.4)	1 (0.1)	4 (0.5)	33 (1.7)	21 (1.2)	50 (2.6)
Employed	5 (0.5)	4 (0.4)	8 (0.8)	10 (1.1)	6 (0.8)	6 (0.7)	15 (0.8)	10 (0.6)	14 (0.7)
Unemployed	182 (17.4)	272 (26.8)	35 (3.3)	32 (3.5)	22 (2.8)	27 (3.2)	214 (10.9)	294 (16.4)	62 (3.3)
Schooling	448 (42.9)	374 (36.8)	515 (48.4)	466 (50.7)	405 (52.4)	432 (51.1)	914 (46.5)	779 (43.5)	947 (49.6)
Other	179 (17.1)	162 (15.9)	201 (18.9)	118 (12.8)	102 (13.2)	106 (12.6)	297 (15.1)	264 (14.8)	307 (16.1)

* Percentages for all marital status categories with exception of 'single' were calculated out of the 'all adults' (aged above 18 years) portion of the total sample size.

3. Results

3.1. Demographic and socio-economic characteristics of survey participants

In 2022, a total of 1964 participants were recruited to participate in the survey, with 1789 followed up in 2023 and 1908 in 2024 surveys. Out of these participants, majority (55.2 %) were from Mangochi and 44.8 % were from Nsanje and comprised of 55.7 % females and 44.3 % males. Over the three years, the leading demographic groups comprised of School-Aged Children (SAC) aged from 6 to 17 years (62.1 %), young adults aged from 18 to 24 years (16.4 %) and adults aged above 25 years (21.5 %), with their mean ages at 11, 20.2 and 34.2 years, respectively (range: 6–46). At the time of the surveys, 77.9 % of all participants were not married while 52.6 % of adult participants reported to be married. Sena (44.3 %) and Chewa (44.2 %); Christianity (93.5 %) followed by Islam (5.9 %) were predominant tribes and religions respectively. Many participants (73.5 %) attended primary level of education, while 19.9 % had never attended school. Farming (16.9 %) and small business enterprises (8.5 %) were reported as leading economic activities. Table 1 summarizes the demographic and socio-economic characteristics of the study participants in the study areas.

3.2. Knowledge about the Schistosoma spp. lifecycle, disease prevention, effects, and complications of schistosomiasis

To gauge how implementation of education and behaviour change activities has been adhered to, the respondents in the study were assessed on their levels of knowledge and understanding of what schistosomiasis is, the *Schistosoma* spp. life cycle, disease prevention, effects, and complications. Over the years, participants generally exhibited moderate to very low knowledge levels during the 2022 baseline survey, which subsequently progressed to low and moderate levels during 2023 and 2024 follow up surveys.

In 2022, moderate knowledge levels were observed when respondents were asked if they knew what schistosomiasis is; 65.5 % were able to correctly explain that it is a disease caused by small worms which infect a person when he or she gets into contact with infested water (Fig. 2B). When respondents were asked if they knew some of the signs or symptoms of schistosomiasis such as abdominal pain, fever, blood in urine (haematuria), blood in stool, painful urination, coughing, headache, body aches, rash, or abdominal swelling (ascites), a low score of 39.0 % was obtained (Fig. 2C), with very low levels of knowledge on how one can prevent contracting schistosomiasis (25.0 %) (Fig. 2D), what causes schistosomiasis (21.1 %) (Fig. 2E), how a healthy person can get infected with schistosomiasis (24.2 %) (Fig. 2F) and how schistosomiasis is transmitted from a sick person to a healthy person (21.1 %) (Fig. 2G). The deposition of *Schistosoma* spp. eggs in various human body organs usually cause some effects or complications which result in various degrees of organs harm, malfunction, or disability such as abdominal swelling (ascites), lesions in genital areas, paralysis, or seizures, to which a very low knowledge score 17.7 % of the respondents were able to correctly mention problems that can be caused if schistosomiasis is not treated (Fig. 2H). Further, individuals and communities living in endemic areas need to know and understand the importance of snail control interventions in eliminating local transmission foci, a very low score of 5.1 % was recorded for respondents correctly mentioning the snail as the intermediate host for schistosomiasis parasites (Fig. 2I). During subsequent follow up surveys, there was a general improvement trend observed in knowledge levels among the respondents. Moderate level scores were observed for what schistosomiasis is (62.4 % and 64.1 %), and on signs and symptoms for schistosomiasis; low scores were recorded on what causes schistosomiasis (43.5 %), how one can prevent contracting schistosomiasis (42.7 %), how a healthy person can get infected with schistosomiasis (36.4 %), how schistosomiasis is transmitted from a sick person to a healthy person (31.3 %), and problems schistosomiasis can cause if it is not treated (31.1 %). Respondents' knowledge of the snail as the intermediate host for schistosomiasis parasites remained very low despite obtaining an improved scores of 8.3 % and 18.5 % during follow up surveys. Fig. 2A-I depicts how the respondents answered selected knowledge questions regarding schistosomiasis and its life cycle during the 2022, 2023 and 2024 knowledge, attitudes and practices surveys.

3.3. Effect of education level, gender, age and district on the likelihood of having general knowledge of schistosomiasis

The results of the logit model on knowledge of schistosomiasis are set out in Table 2. The findings show that study participants in the reference group (Mangochi, females, Primary School-Aged [6 – 13 years], and no formal education) were 42.0 % less likely (OR = 0.58, 95 % CI [0.49–0.69]) to have general knowledge of schistosomiasis compared to individuals in other groups. Among participants in Nsanje, the odds of schistosomiasis knowledge were 11.1 % lower (OR = 0.89, 95 % CI [0.78, 1.00]) than those in Mangochi, albeit marginal statistical significance. In terms of gender, males had an 83.0 % higher likelihood (OR = 1.83, 95 % CI [1.61, 2.08]) of knowing about schistosomiasis compared to females, and this difference was statistically significant. For age groups, Secondary School-Aged (13–17 years) were nearly three times more likely (OR = 2.94, 95 % CI [2.44, 3.56]) to have knowledge of schistosomiasis than Primary School-Aged Children (6–13 years). Young adults (18–24 years) were three times more likely (OR = 3.80.14, 95 % CI [3.13, 4.65]), and Adults (≥ 25 years) were five times more likely (OR = 5.74, 95 % CI [4.74, 6.98]). These differences in odds by age group are statistically significant. Regarding education, participants with primary education were twice as likely (OR = 2.01, 95 % CI [1.73, 2.34]) to know compared to those with no formal education. Secondary education increases the likelihood of schistosomiasis knowledge fourfold (OR = 4.67, 95 % CI [3.01, 7.61]). Tertiary education indicated a 27 % higher likelihood (OR = 1.27, 95 % CI [0.63, 2.77]), albeit not statistically significant.

3.4. Effect of education level, gender, age and district on the likelihood of having accurate knowledge of schistosomiasis

The results of the logit model on correct knowledge of schistosomiasis are presented in Table 3. The findings show that respondents in the reference group (Mangochi, females, Primary School-Aged [6–13 years], and no formal education) had 1.96 odds for correct knowledge (OR = 1.96, 95 % CI [1.56–2.47]). Participants in Nsanje had 38 % higher odds (OR = 1.38, 95 % CI [1.19–1.61]) of having correct knowledge of schistosomiasis compared to those in Mangochi, and this difference was statistically significant. In terms of gender, males had 3 % lower likelihood (OR = 0.97, 95 % CI [0.83–1.12]) of having correct knowledge of schistosomiasis compared to females, albeit not statistically significant.

Regarding age groups, Secondary School-Aged participants (13–17 years) had 51 % higher odds (OR = 1.51, 95 % CI [1.23–1.86]) of having correct knowledge of schistosomiasis compared to School-Aged Children, with this difference being statistically significant. Young Adults (18–24 years) had 67 % higher odds (OR = 1.67, 95 % CI [1.35–2.07]) of having correct knowledge compared to School-Aged Children, also statistically significant. Adults (≥ 25 years) had 2.20 times higher odds (OR = 2.20, 95 % CI [1.79–2.70]) of having correct knowledge of schistosomiasis compared to School-Aged Children, a statistically significant result.

In terms of education level, respondents with primary education had 6 % lower odds (OR = 0.94, 95 % CI [0.77–1.15) of having correct knowledge of schistosomiasis compared to those with no formal education. However, this difference was not statistically significant. In contrast, secondary education was associated with 51 % higher odds (OR = 1.51, 95 % CI [1.04–2.22]) of having correct knowledge of schistosomiasis compared to no formal education, a statistically

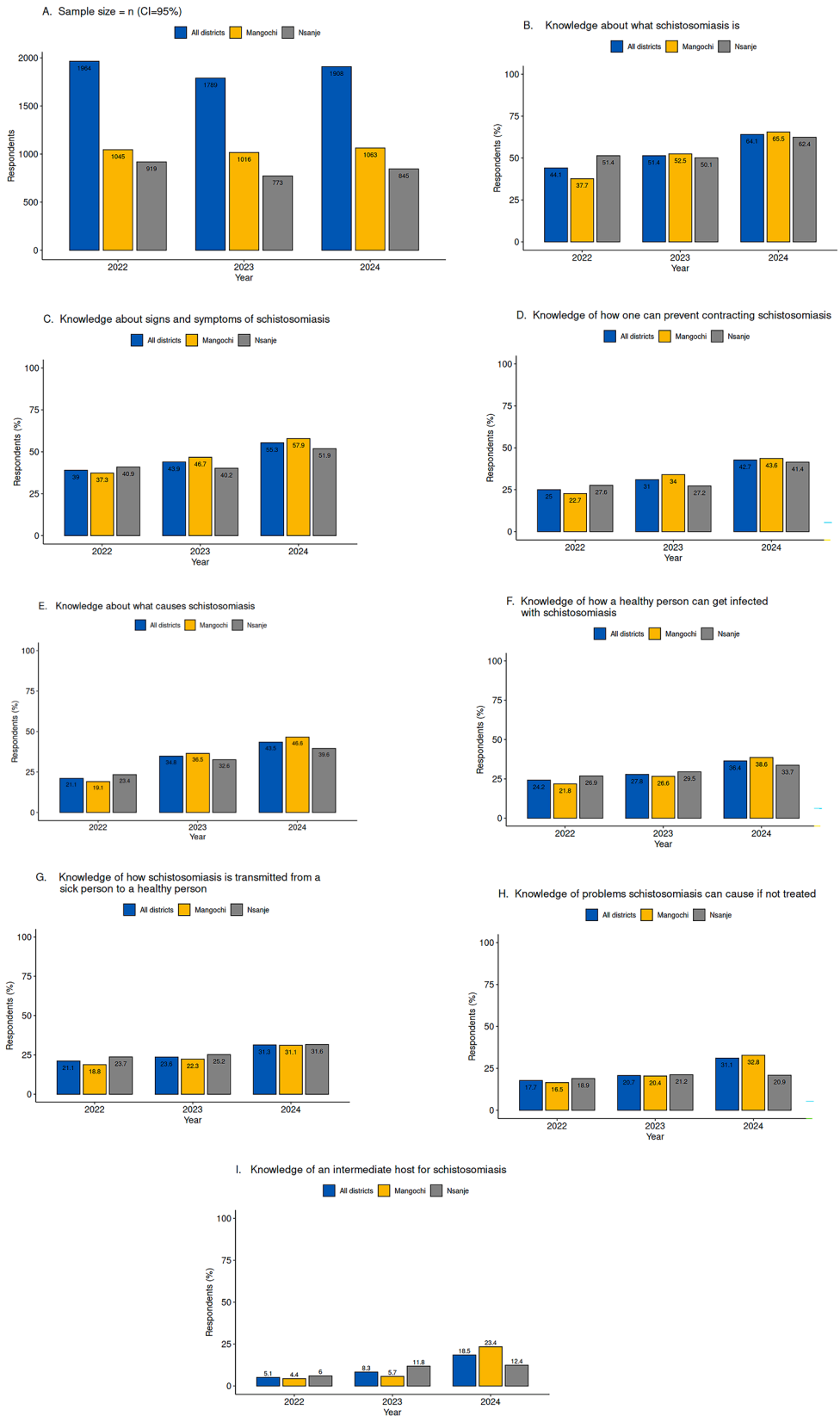


Fig. 2. (A) Sample sizes = N (CI = 95 %); (B-I) How the respondents answered selected knowledge questions related to schistosomiasis and its life cycle over three years according to study areas.

Table 2
Effect of education level, gender, age and district on the likelihood of having general knowledge of schistosomiasis.

	Odds Ratio	95 % Confidence Interval
(Intercept)	0.58	0.49, 0.64
Nsanje	0.89	0.78, 1
Male	1.83	1.61, 2.08
Secondary School-Aged (13 –17)	2.94	2.44, 3.56
Young adults (18 – 24)	3.80	3.13, 4.65
Adults (≥ 25)	5.74	4.74, 6.98
Primary education	2.01	1.73, 2.34
Secondary education	4.67	3.01, 7.61
Tertiary education	1.27	0.63, 2.77

(Intercept)	−0.541***
	(0.085)
District: Nsanje	−0.121+
	(0.063)
Gender: Male	0.604***
	(0.065)
Age group: Secondary School-Aged (13 - 17)	1.079***
	(0.096)
Age group: Young Adults (18 - 24)	1.336***
	(0.101)
Age group: Adults (≥ 25)	1.747***
	(0.098)
Education: Primary	0.698***
	(0.077)
Education: Secondary	1.542***
	(0.236)
Education: Tertiary	0.237
	(0.373)
Num.Obs.	5661
AIC	6168.59
BIC	6228.357
Log.Lik.	−3075.292
F	78.033
RMSE	0.43

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3
Effect of education level, gender, age and district on the likelihood of having accurate knowledge of schistosomiasis.

	Odds Ratio	95 % Confidence Interval
(Intercept)	1.96	1.56, 2.47
Nsanje	1.38	1.19, 1.61
Male	0.97	0.83, 1.12
Secondary School-Aged (13 –17)	1.51	1.23, 1.86
Young Adults (18 – 24)	1.67	1.35, 2.07
Adults (≥ 25)	2.20	1.79, 2.70
Primary education	0.94	0.77, 1.15
Secondary education	1.51	1.04, 2.22
Tertiary education	0.84	0.38, 2.13

(Intercept)	0.673***
	(0.116)
District: Nsanje	0.325***
	(0.076)
Gender: Male	−0.035
	(0.076)
Age group: Secondary School-Aged (13 - 17)	0.409***
	(0.106)
Age group: Young Adults (18 - 24)	−0.510***
	(0.109)
Age group: Adults (≥ 25)	0.786***
	(0.105)
Education: Primary	−0.058
	(0.104)
Education: Secondary	0.412*
	(0.193)
Education: Tertiary	−0.177
	(0.435)
Num.Obs.	3995
AIC	4371.146
BIC	4427.781
Log.Lik.	−2176.573
F	15.134
RMSE	0.43

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Note: Numbers in brackets denote (Standard Error).

significant result. Tertiary education showed 16 % lower odds (OR = 0.84, 95 % CI [0.38–2.13]) of having correct knowledge, albeit not statistically significant.

3.5. Prevalence and intensity of urogenital schistosomiasis infections after deliveries of zero, one-annual and biannual community-wide mass drug administration

In 2021, the year preceding the commencement of the study there was no MDA implemented in all study sites by the NSCP. The overall prevalence of urogenital schistosomiasis obtained in 2022 was 43.6 %, which subsequently increased to 44.1 % in 2023 despite the delivery of an annual community-wide MDA as part of the study. In 2024, the rate decreased to 27.0 % after delivery of two rounds of MDA, biannually (Fig. 3B). A comparison between the individual districts shows that Mangochi had the highest prevalence of 51.5 % in 2022 which steadily decreased to 43.1 % and 31.7 % in 2023 and 2024 respectively, while Nsanje had a prevalence of 34.3 % in 2022 which increased to 45.4 % in 2023 despite delivery of MDA and then decreased to the rate of 20.7 % in 2024, after delivery of MDA biannually. Mangochi registered the highest prevalence of urogenital schistosomiasis at 51.5 % in 2022 and 31.7 % in 2024 than Nsanje at 34.3 % and 20.7 % respectively, while Nsanje had the highest prevalence of urogenital schistosomiasis at 45.4 % in 2023 than Mangochi at 43.1 %. Both Mangochi and Nsanje registered the highest prevalence of heavy-intensity infections (12.2 %) in 2022, and (12.7 %) in 2023 respectively. These trends observed in overall prevalence rates and specifically in each district are mirrored in corresponding average rates for macrohematuria 3.9 % (range: 2.9 %−4.7 %), microhematuria 27.5 % (range: 20.5 %−36 %), light- 28.4 % (range: 13. %−39.3 %) and heavy 9.9 % (range: 7.0 %−12.7 %) intensity infections observed over the years in all study districts. Furthermore, for example in 2022, 10.5 % of all participants had heavy intensity infections which subsequently increased to 11.4 % in 2023 before decreasing to 7.7 % in 2024. Similar patterns were observed in rates for other diagnostic parameters of macrohematuria, microhematuria and light intensity infections for both districts jointly and individually. While the overall prevalences of urogenital schistosomiasis, macrohematuria, microhematuria, light and heavy intensity infections generally decreased over the years, the overall proportion of those with heavy-intensity infections in both districts depicted an increasing trajectory from 24.1 % in 2022, to 25.9 % and 28.4 % in 2023 and 2024 respectively (Fig. 3B).

A comparison of prevalence of urogenital schistosomiasis in terms of gender of participants revealed that highest prevalences were recorded among males in 2022 (45.1 %) and in 2023 (66.4 %) than among females (Fig. 3C). Primary School-Aged Children aged from 6 to 13 years (43.8 %) followed by Secondary School-Aged Children aged from 14 to 24 years (41.6 %), PreSchool-Aged Children aged from 2 to 5 years (30.1 %), Young Adults aged from 18 to 24 years (18.9 %) and Adults aged 25 and above years (16.8 %) were the leading age groups afflicted by the infection in 2022. In 2023, Secondary School-Aged Children (46.1 %), PreSchool-Aged Children (45.4 %) and Primary School-Aged Children (45.2 %) and in 2024 Preschool-Aged Children (40.0 %) were the two most infection afflicted age groups (Fig. 3D). Furthermore, the findings revealed that proportionally, the participants who attained primary (44.8 %), tertiary (50.0 %) and none (31.7 %) levels of education in 2022, 2023 and 2024 respectively were the highest infected although primary level (46.1 %) can replace tertiary level in 2023 due to inadequate sample size (Fig. 3E). Fig. 3A-E shows how prevalences and intensity of urogenital schistosomiasis infections changed over three years period according to study sites, gender, age group and education level of participants after deliveries of zero in 2021, one-annual in 2022 and

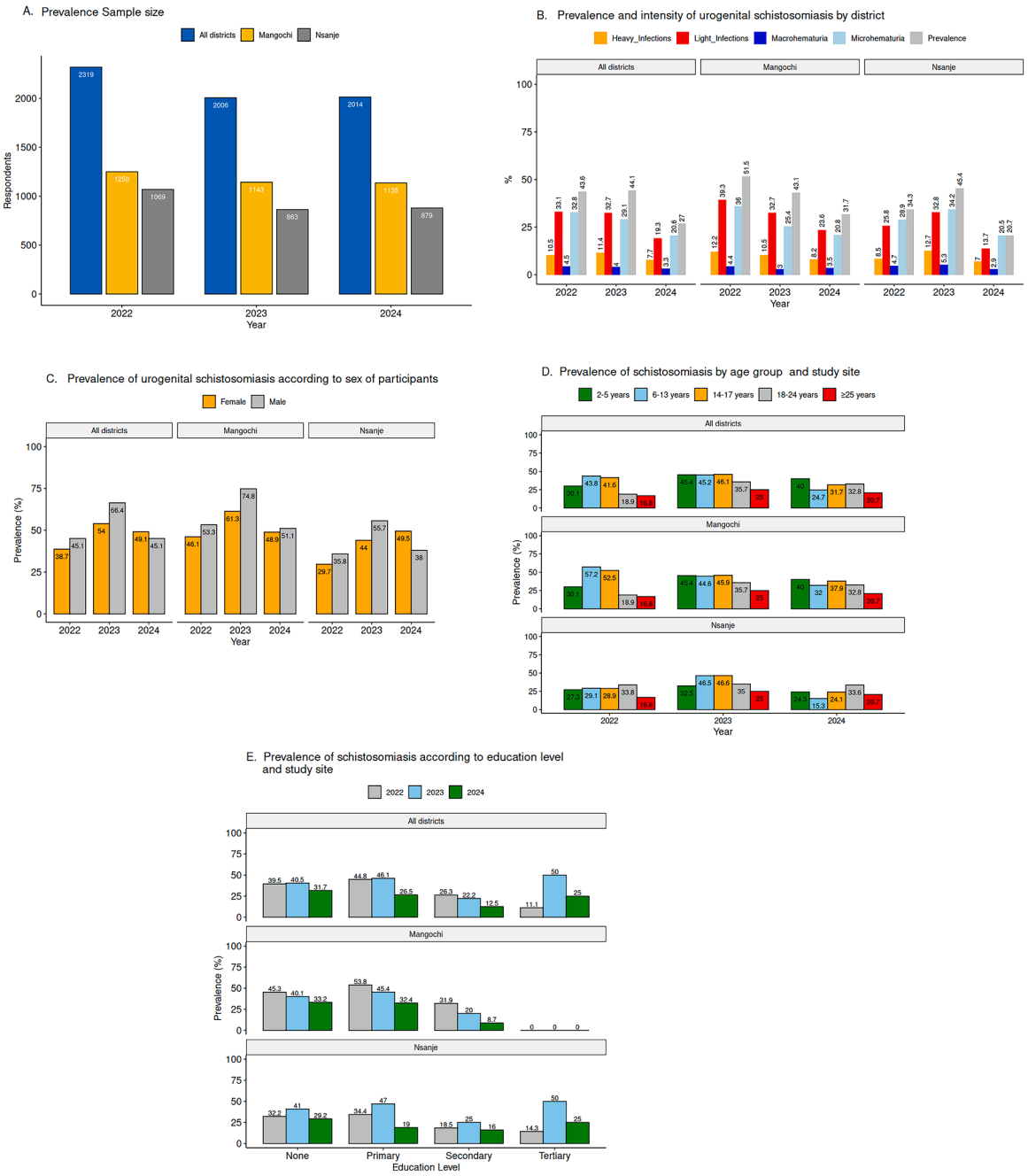


Fig. 3. Sample sizes = *N* (CI=95 %) (A), prevalence and intensity of urogenital schistosomiasis infections (B), prevalence of urogenital schistosomiasis according to gender (C), age groups (D) and education level (E) of participants over three years and according to study sites after delivery of zero, one-annual and biannual community mass drug administration.

biannual in 2023 and 2024 community-wide MDA.

3.6. Respondents' attitudes and practices related to treatment of at-risk population groups for control of schistosomiasis

Generally, in both districts, over half of the respondents 59.7 % in 2022, 65.8 % in 2023 and 71.3 % in 2023 believed that schistosomiasis is treatable by drugs. Similarly, 56.0 % in 2022, 64.1 % in 2023 and 73.1 % in 2024 admitted having suffered from the disease at some point in time for which 45.6 %, 54.5 % and 69.3 % respectively said had received drugs for treatment. When the respondents were specifically asked if they recently received drugs for treatment of schistosomiasis, majority of them (53.4 %) in 2022, (72.0 %) in 2023, and (86.6 %) in 2024 answered affirmatively indicating an increasing trend. Many respondents 55.1 % in 2022, 65.1 % in 2023 and 54.2 % in 2024 indicated that they received the drugs within one year ago. The drugs were mostly obtained from community (42.4 %) in 2022, increasing to 65.2 % in 2023 and 75.9 % in 2024; followed by those who said they received from school (41.8 %), which decreased to 25.4 % and 18.3 % respectively. Community-based health workers (53.4 %) and facility-based health workers (38.9 %) in 2022, changing to 84.8 % and 7.6 % in 2023, and 75.8 % and 21.7 % in 2024 respectively, were the main dispensers of the drugs.

About a quarter of the respondents (24.3 %) in 2022, 31.3 % in 2023 and 43.7 % in 2024 indicated that they had experienced some problems after taking the drugs for which drowsiness/dizziness (50.2 %),

abdominal pain (21.1 %) and fever/sweating (10.6 %) in 2023; 40.4 %, 23.6 % and 8.7 % in 2023; and 47.9 %, 20.1 % and 11.1 % in 2024 and respectively were the most frequently mentioned problems. About half of the respondents (48.9 %) reported that at least a member of their household received drugs for schistosomiasis within the past year, and only 37.7 % in 2022 were of opinion that schistosomiasis drugs were readily accessible in their villages, which increased to 43.9 % in 2023 and 51.6 % in 2024. When the districts were specifically compared, respondents in Mangochi generally scored higher than those in Nsanje in all treatment related questions. Table 4 summarizes respondents' attitudes and practices towards treatment for control of schistosomiasis as revealed in the study areas during the three yearly surveys.

3.7. Respondents' access to safe water, sanitation, and hygiene services, freshwater body and livestock contacts practices

Generally, most participants (91.3 %) in 2022, 95.5 % in 2023 and 99 % in 2024 used a borehole or pipes as sources of drinking water (Fig. 4B). Similarly, it was noted that 93.8 % in 2022, 87 % in 2023 and 94.6 % in 2024, of the respondents in both districts used a latrine to urinate or defecate (Fig. 4C). However, in terms of borehole or pipe water use comparison, Nsanje has higher rates at 96.5 % in 2022, 98.8 % in 2023 and 99.7 % in 2024 than Mangochi at 86.7 %, 92.9 % and 98.5 % respectively. It was revealed that in both districts, many respondents were living >30 min (25.4 %), 22.9 %, and 5 to 10 min (30.7 %) walking distances to reach a freshwater body in 2022, 2023 and 2024

Table 4
Respondents' attitudes and practices towards treatment for control of schistosomiasis according study sites and years.

Question that was asked to respondents	Number (%) of respondents who answered affirmatively to attitudes and practices related question								
	Mangochi			Nsanje			All districts		
	2022	2023	2024	2022	2023	2024	2022	2023	2024
1. Sample size N	1,045 (53.2)	1,016 (56.8)	1,063 (55.7)	919 (46.8)	773 (43.2)	845 (54.3)	1,964 (100)	1,789 (100)	1,908 (100)
2. Is schistosomiasis treatable by drugs?	621 (59.4)	713 (70.2)	774 (72.8)	552 (60.1)	465 (60.2)	586 (69.3)	1,173 (59.7)	1,178 (65.8)	1,360 (71.3)
3. Have you ever suffered from schistosomiasis?	643 (61.5)	710 (69.9)	845 (79.5)	456 (49.6)	436 (56.8)	550 (65.1)	1,099 (56.0)	1,146 (64.1)	1,395 (73.1)
4. If yes, did you get drugs for treatment of schistosomiasis?	579 (55.4)	639 (62.9)	821 (77.2)	317 (34.5)	336 (43.5)	502 (59.4)	896 (45.6)	975 (54.5)	1,323 (69.3)
5. Are schistosomiasis drugs readily accessible in this village?	514 (49.2)	500 (49.2)	632 (59.4)	227 (24.7)	285 (36.9)	353 (41.8)	741 (37.7)	785 (43.9)	985 (51.6)
6. Have you recently received drugs for schistosomiasis?	688 (65.8)	822 (80.9)	963 (90.4)	361 (39.3)	467 (60.4)	689 (81.5)	1,049 (53.4)	1,289 (72.0)	1,652 (86.6 %)
7. If yes, when did you recently receive the drugs for schistosomiasis?									
• Within the past week	14 (2.0)	4 (0.5)	28 (2.9)	14 (3.9)	14 (3.0)	16 (2.3)	28 (2.7)	18 (1.4)	44 (2.7)
• Within one month ago	60 (8.7)	42 (5.1)	455 (47.2)	75 (20.8)	32 (6.8)	153 (22.2)	135 (12.9)	74 (5.7)	608 (36.8)
• Within one year ago	443 (64.4)	480 (58.4)	402 (41.7)	135 (37.4)	359 (76.9)	493 (71.5)	578 (55.1)	839 (65.1)	895 (54.2)
• Over one year ago	103 (15.0)	206 (25.1)	55 (5.7)	96 (26.6)	28 (6.0)	16 (2.3)	199 (19.0)	234 (18.1)	71 (4.3)
• Do not remember	68 (9.9)	90 (10.9)	23 (2.4)	41 (11.4)	34 (7.3)	11 (1.6)	109 (10.4)	124 (9.6)	34 (2.1)
8. Where did you get the drugs from?									
• Health facility	33 (4.8)	43 (5.2)	16 (1.7)	118 (32.7)	70 (15.0)	79 (11.5)	151 (14.4)	113 (8.8)	95 (5.7)
• Community	328 (47.7)	553 (67.3)	791 (82.1)	117 (32.4)	287 (61.5)	463 (67.2)	445 (42.4)	840 (65.2)	1,254 (75.9)
• School	317 (46.1)	220 (26.8)	156 (16.2)	122 (33.8)	108 (23.1)	146 (21.2)	439 (41.8)	328 (25.4)	302 (18.3)
• Store or grocery	4 (0.6)	3 (0.4)	0	2 (0.5)	1 (0.2)	1 (0.1)	6 (0.6)	4 (0.3)	1 (0.1)
• Other	6 (0.9)	3 (0.4)	0	2 (0.5)	1 (0.2)	0	8 (0.8)	4 (0.3)	0
9. Who dispensed the schistosomiasis drugs to you?									
• Facility health worker	250 (36.3)	37 (4.5)	145 (15.1)	158 (43.8)	61 (13.1)	213 (30.9)	408 (38.9)	98 (7.6)	358 (21.7)
• Community health worker	367 (53.3)	705 (85.8)	781 (81.1)	193 (53.5)	388 (83.1)	471 (68.4)	560 (53.4)	1,093 (84.8)	1,252 (75.8)
• Community volunteer	58 (8.4)	74 (9.0)	37 (3.8)	8 (2.2)	17 (3.6)	3 (0.4)	66 (6.3)	91 (7.1)	40 (2.4)
• Other	13 (1.9)	6 (0.7)	0	2 (0.5)	1 (0.2)	2 (0.3)	15 (1.4)	7 (0.5)	2 (0.1)
10. Did you experience any problems after taking schistosomiasis drugs?	186 (27.0)	292 (35.5)	517 (53.7)	69 (19.1)	111 (23.8)	205 (29.7)	255 (24.3)	403 (31.3)	722 (43.7)
11. If yes, what problems did you experience after taking schistosomiasis drugs? *									
• Abdominal pain	45 (23.2)	74 (25.3)	126 (24.4)	9 (13.0)	20 (18.0)	19 (9.3)	55 (20.7)	95 (23.6)	145 (20.1)
• Nausea/vomiting	15 (7.7)	26 (8.9)	65 (12.6)	6 (8.7)	5 (4.5)	21 (10.2)	21 (7.9)	30 (7.4)	86 (11.9)
• Allergy/rash	1 (0.5)	4 (1.4)	5 (1.0)	0	2 (1.8)	0	1 (0.4)	6 (1.5)	5 (0.7)
• Drowsiness/dizziness	105 (54.1)	120 (41.1)	199 (38.5)	28 (40.6)	43 (38.7)	147 (71.7)	135 (50.9)	163 (40.4)	346 (47.9)
• Fever/sweating	12 (6.2)	21 (7.2)	71 (13.7)	17 (24.6)	14 (12.6)	9 (4.4)	28 (10.6)	35 (8.7)	80 (11.1)
• Others	16 (8.2)	47 (16.1)	51 (9.9)	9 (13.0)	27 (24.3)	9 (4.4)	25 (9.4)	74 (18.4)	60 (8.3)

* Respondents were allowed to mention multiple responses.

respectively (Fig. 4D). A comparison of the districts individually, in Nsanje more respondents (32.5 %) in 2022 took longer times of >30 min to reach a water body than in Mangochi (19.1 %), while more respondents in Mangochi (29.8 % and 17.5 %) took longer times of >30 min than in Nsanje (13.7 % and 11.5 %) in 2023. Many participants have lived close to the source of freshwater for over 5 years (59.6 %) in 2022, 22.1 % in 2023 and 67.6 % in 2024 (Fig 4E). The respondents (36.3 %) in 2022 reported to have visited a water body more than once in a day, which increased to 38.4 % in 2023 and 41.3 % in 2024 with Nsanje and Mangochi averages at 41.5 % and 36.5 % respectively (Fig. 4F).

In the districts, both goats and cattle (25.9 %), goats only (20.3 %) and cattle only (8.1 %) are the most common livestock which respondents live and frequently get in contact with (Fig. 4G). In 2022, many respondents in both districts reported that they lived near and frequently got in contact with goats (20.2 %) followed by both cattle and goats (8.7 %), which changed to cattle and goats (30.7 %) and other livestock (18.8 %) in 2023, and cattle and goats (28.2 %) and goats (26.9 %) in 2024. Fig. 4A-G summarizes the findings on respondents' access to WASH services, freshwater bodies and livestock contact practices.

4. Discussions

Our study has found that while people's knowledge and understanding of what schistosomiasis is, is satisfactory (≥ 50 % – ≤ 70 %), knowledge of its life cycle, prevention, effects, and complications in the study areas were unsatisfactory because they mostly range from moderate (≥ 30 % – ≤ 50 %) to very low (≤ 30 %) scores during the three years. This is somewhat disappointing when set against the large-scale ambitions and national context of schistosomiasis control in Malawi. Low and very low results were obtained when respondents from both study districts were asked about other aspects related to the life cycle, prevention, effects, and complications of schistosomiasis, implying that the importance of information, education and communication activities is not well appreciated by the programme implementers in the districts. These low results are like other studies found in Malawi (Kapito-Tembo et al., 2009; Makaula et al., 2022; Mthawanji et al., 2023; Lubanga et al., 2024) and other countries (Alemu et al., 2024; Anyolitho et al., 2022; Barrow et al., 2020; Maseko et al., 2018; Riaz et al., 2023; Santos et al., 2023; Yohana et al., 2022). These low and very low knowledge levels about schistosomiasis obtained in Malawi, and other countries, are therefore posing a hurdle towards the global efforts to eliminate schistosomiasis as a public health problem. The importance of imparting adequate and correct information to empower people to play their part in the prevention, control and elimination of schistosomiasis cannot therefore be downplayed (Feng et al., 2023). However, it was observed that the knowledge levels obtained in study areas at baseline were mostly increasing in subsequent years. These increasing trends in knowledge are attributable to intensive community sensitization activities, participants' reading our information leaflets and feedback sessions regularly carried out in communities as part of the study.

Comparatively, in answering the survey questions, respondents in Nsanje exhibited better knowledge, understanding of the effects and complications of schistosomiasis than respondents in Mangochi. Additionally, the current study indicates that: (1) Increased likelihood of having general knowledge of schistosomiasis is associated with being male, being older, and having higher education levels. (2) Correct or accurate knowledge of schistosomiasis is higher among those in Nsanje, younger adults, and older individuals, while secondary education level is associated with higher knowledge levels. On the other hand, gender and primary or tertiary education level did not have significant impacts on correct knowledge. Despite respondents in Mangochi demonstrating higher levels of general knowledge, respondents in Nsanje showed higher levels of correct knowledge, with secondary education being a key determinant. Of note, gender and primary or tertiary education level did not significantly influence correct knowledge. The implications of these findings highlight the need for tailored public health interventions to address gaps in both general and correct knowledge of schistosomiasis e.g. the need to educate young females and perhaps educating earlier in schools so that those without secondary education can improve their knowledge of schistosomiasis. While general knowledge is associated with gender, age, and education level, correct knowledge critical for effective behavior change is influenced more by specific educational attainment.

The study has also found that parasitological assessments using urine filtration and other diagnostic techniques, overall prevalences of urogenital schistosomiasis, macrohematuria, microhematuria, light- and heavy-intensity infections oscillated over the three years. Specifically for each study site, the study found prevalences of urogenital schistosomiasis of 51.5 % in 2022 which decreased to 43.1 % in 2023 and 31.7 % in 2024 in Mangochi; and 34.3 % in 2022, which increased to 45.4 % in 2023 before decreasing to 20.7 % in 2024 in Nsanje. While overall prevalences of urogenital schistosomiasis were 43.6 % in 2022, 44.1 % in 2023 and 27.0 % in 2024, heavy-intensity infections which is used as a proxy for measuring extent of morbidity in a population, were 10.5 % in 2022, subsequently increased to 11.4 % in 2023 before decreasing to 7.7 % in 2024. For prevalences of heavy-intensity infections, Mangochi reported 12.2 % in 2022 which decreased to 10.5 % in 2023 and 8.2 % in 2024, while in Nsanje, heavy-intensity infections were at 8.5 % in 2022, which increased to 12.7 % in 2023 before decreasing to 7.0 % in 2024. The general decreases in the prevalence of urogenital schistosomiasis, macrohematuria, microhematuria, light- and heavy-intensity infections rates observed among study participants in the two districts might be explained by availability of treatment through an annual MDA. However, the increase in prevalence of urogenital schistosomiasis, macrohematuria, microhematuria, light- and heavy-intensity infections observed in Nsanje in 2023 despite the delivery of MDA in 2022 can be attributed to the findings that most people in Nsanje (41.5 %) visited a freshwater body more than once in a day than their counterparts in Mangochi (36.5 %), which increased the chances of getting reinfected with the parasites. We have been tracking infection dynamics in snails over the same period and have noticed some general trends, e.g. increase in the number of infected *Bulinus globosus* intermediate hosts snails at a nearby surveillance sites, during our quarterly environmental (E01 – E12) surveys for which a manuscript on snail information is in preparation.

These rates of heavy-intensity infections obtained in this study are still high considering that the target of eliminating schistosomiasis as a public health problem (<1 % heavy-intensity infections) will soon come to an end in 2030. The prevalence of urogenital schistosomiasis, macrohematuria, microhematuria, light- and heavy-intensity infections rates obtained in study areas are categorized as moderate according to WHO, necessitating delivery of annual MDA (WHO, 2022) although according to the NSCP in Malawi, these areas were within traditional areas not among those planned for MDA in years 2021 to 2024 during our study implementation. The change by the NSCP from using district-wide to smaller traditional areas (sub-districts) as implementation units for MDA delivery (Makaula et al., 2022) risks leaving out some isolated hotspot areas with high prevalence rates from annual MDA based on average low prevalence rates obtained by the NSCP in the traditional areas. Our parasitological prevalence, macrohematuria, microhematuria, light- and heavy-intensity infections results for urogenital schistosomiasis obtained in this study have pointed to existence of isolated hotspot areas within the designated smaller implementation units in both districts. These findings are like what other recently carried out studies within Malawi, in Chikwawa (Chiepa et al., 2024), Karonga, Rumphi and Nkhata Bay (Mthawanji et al., 2023) districts revealed that prevalences of urogenital schistosomiasis among school children averaged 35.0 % despite ongoing control efforts by the NSCP.

As part of HUGS study, the annual community-wide MDA was delivered in 2022/2023 while two MDA campaigns were delivered in 2023/2024 biannually. While implementation of a single annual MDA in 2022/2023 decreased prevalence and heavy-infection rates in

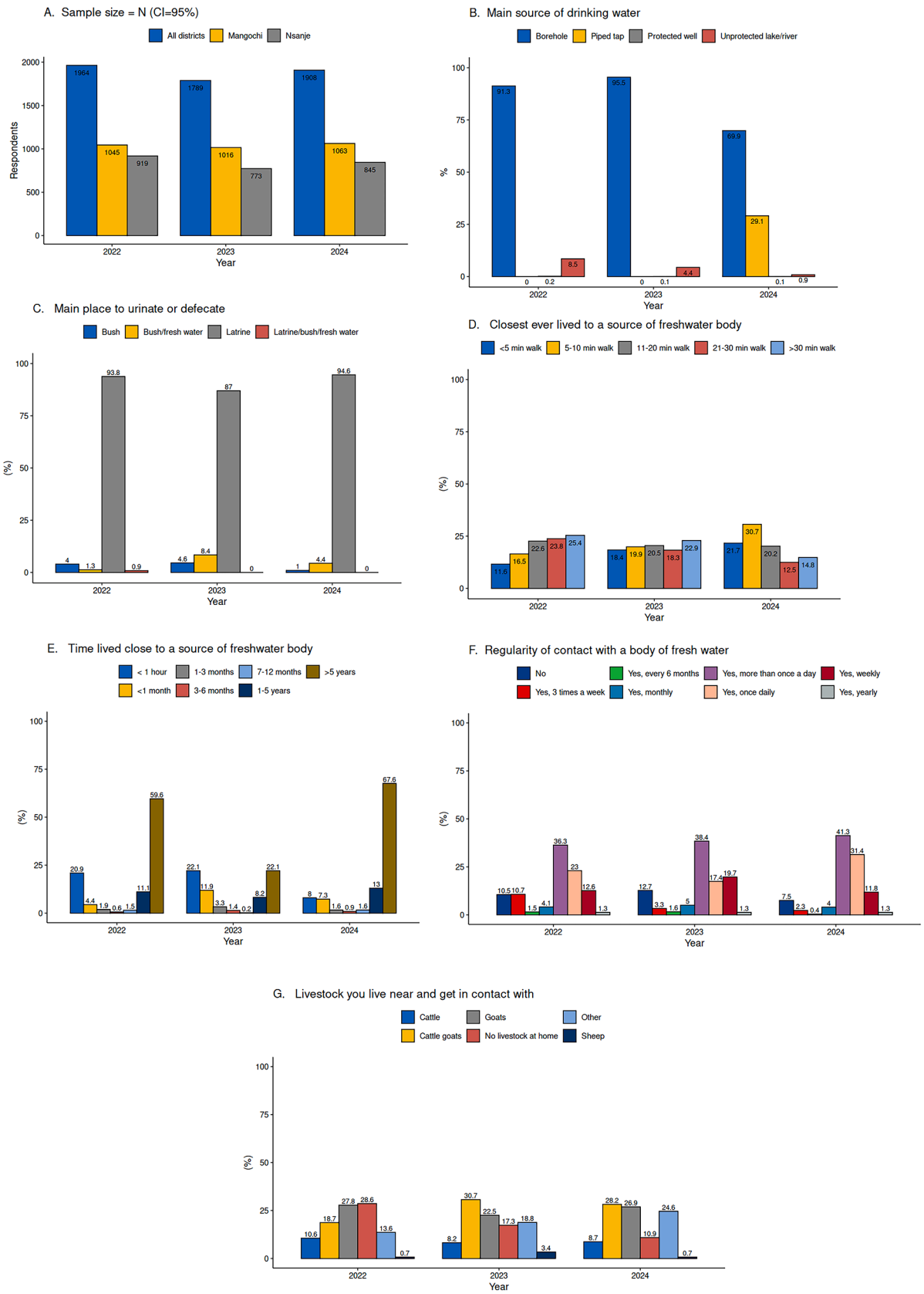


Fig. 4. Sample size = *N* (CI=95 %) (A), how respondents answered selected questions related to safe water (B), sanitation, and hygiene (C), freshwater (D-F) and livestock (G) contact practices over three years.

Mangochi, the opposite was observed in Nsanje, necessitating a change to implementation of two MDA biannually in 2023/2024 resulting in decreases in prevalence and heavy-infection rates in both districts. This change in MDA strategy supports the WHO recommendations requiring delivery of biannual MDA to all at-risk population groups in endemic areas with prevalence of *Schistosoma* spp. infection ≥10 % that demonstrates lack of appropriate response to annual preventive chemotherapy, despite adequate treatment coverage (≥75 %) (WHO, 2022). The findings of this study have also exposed that despite continued availability of treatment through consistent delivery of MDA in the study areas, moderate prevalence and heavy infections prevailed meaning that provision of treatment alone without implementation of other complementary interventions will not help towards the attainment of the goal of eliminating schistosomiasis as a public health problem. This study has also validated the increased MDA coverage rates in Malawi when 45.6 % in 2022, 54.5 % in 2023) and 69.3 % in 2024, of those who admitted having suffered from the disease at some point in time said had received drugs for treatment. The high treatment coverage rates reported in this study have to some extent been catalyzed by existence of several enabling factors as reported by the majority of respondents that received treatment within one year ago. Notably, some of these factors are increases in availability of treatment from within the respondents' communities (42.4 %, 65.2 % and 75.9 %) and community-based health workers (53.4 %, 84.8 % and 75.8 %) dispensing treatment which enhanced easy availability and accessibility of drugs especially during the MDA campaign periods. Despite the obtained high treatment coverage rates in the study areas, however, accessibility of drugs beyond the designated annual campaign periods is a hurdle as only 37.7 % in 2022, 43.9 % in 2023 and 51.6 % in 2024, of respondents indicated that drugs were readily accessible in their villages. There is, therefore, a need for implementers to consider adoption of other community-based treatment avenues like community-directed intervention to make drugs easily available and accessible to people, especially in isolated and hotspot areas (Makaula et al., 2024).

Our study has also found that there is a disproportionate variation in coverage among certain demographic sections of the population with mainly males (43.2 %) as opposed to females (56.8 %), School-Aged Children (62.7 %), Adults (20.0 %) and Young Adults (17.3 %) who received treatment. Probable reasons for observed low coverage among these groups could be that MDA was carried out at the time when most males and older people were away to fields or perhaps the respondents did receive treatment but were not specifically made aware that it was for schistosomiasis. These observed variations necessitate the need for the implementers to consider appropriate times during MDA planning. This study has also documented that incidence of some problems such as drowsiness/dizziness (50.9 %, 40.4 % and 47.9 %), abdominal pain (20.7 %, 23.6 % and 20.1 %) and fever/sweating (10.6 %, 8.7 % and 11.1 %) after taking drugs are likely deterrents of delivery of treatment in the study areas (Makaula et al., 2022).

The WHO recommends that in endemic areas, activities to promote access to adequate WASH infrastructure, freshwater snail control and environmental management should be implemented along with other interventions (WHO, 2022). The study has found that although in both districts, access to WASH facilities is satisfactory with majority of people using a borehole or piped as a source of drinking water (91.3 %, 95.5 % and 99.2 %) and use a latrine to urinate or defecate (93.8 %, 87 % and 94.6 %), many people still visit and contact the water bodies as often to carry out other chores. Further, no snail control and environmental management activities are implemented in the study areas. This therefore means that in the study areas transmission is perpetuated since the water bodies harbour snails which also serve as intermediate hosts for schistosomiasis parasites. Moreover, this study has found that many respondents in both districts reported that they lived near and frequently got in contact with livestock like goats, sheep and cattle which also use the same freshwater sources frequented by the people. Since these livestock get infected with schistosomiasis parasites, they act as reservoirs and hosts for zoonotic schistosomiasis thereby continuing the transmission cycle in the areas (Juhász et al., 2024a & 2024b). As people and livestock with schistosome parasitic infections still visit and pollute freshwater bodies, it underscores the fact that transmission is more a behavioural than WASH availability issue therefore calling for One Health approach and increased behaviour change and communication efforts by the programme implementers in the districts (WHO, 2022; Juhász et al., 2024b). People living in communities close to freshwater bodies harboring snails should be targeted with a key behaviour change message of not defaecating or urinating in water to avoid passing on parasites thereby perpetuating the transmission life cycle. Further, the persistent moderate prevalence of urogenital schistosomiasis and heavy-intensity infections despite repeated deliveries of MDA in the investigated areas could be attributed to the fact that people living in these areas were dependent on nearby freshwater bodies for domestic and occupational chores in the process they may get exposed to infection or reinfection by parasites. There is therefore a need for health authorities to consider these isolated hotspot areas when planning for delivery of MDA in all endemic areas to avoid recrudescence of the disease and reversal of gains towards attainment of the goal of eliminating schistosomiasis as a public health problem.

While this study has confirmed that School-Aged Children followed by PreSchool-Aged Children are the most affected groups, the mostly school-based approach of MDA delivery used by the NSCP is reaching only the former group while completely sidelining other affected out of school groups within the endemic communities. Considering that MDA, is the mainstay of the national control programme in Malawi and has been ongoing for over a decade these findings cast a shadow over the likelihood of eliminating schistosomiasis as a public health problem in the country. This therefore a case for intensification of implementation of other complementary interventions for elimination of schistosomiasis as also recommended by WHO (WHO, 2022). The NSCP should also consider adoption of short-term biannual MDA deliveries in hotspot areas as the case was in Nsanje where implementation of an annual MDA did not reduce infection rates, more so in absence of implementation of any disease transmission control interventions in Malawian districts.

The strength of our study is the involvement of large population-based cohort which was followed up over three consecutive years period to understand complexities surrounding transmission and control of urogenital schistosomiasis in two southern Malawi districts. The novel aspect of the paper is the tracking of infection dynamics against the KAP variables in the format: zero MDA => first KAP, baseline survey, first MDA => second KAP, first follow-up survey, second MDA, third MDA => third KAP, second follow-up survey, fourth MDA. Our annual in-depth urogenital schistosomiasis prevalence, macrohematuria, microhematuria, light-, heavy-intensity infections and KAP surveys have shed light on how communities may or may not accept and respond to current efforts of the NSCP as they aim to eliminate schistosomiasis as a public health problem by year 2030. Whilst the NSCP operates under the auspices of the WHO 2022 recommendations, our detailed findings are likely reflective of other communities within Malawi where public health campaigns are centrally implemented by the NSCP through the District Health Offices.

5. Conclusions

Overall prevalences of urogenital schistosomiasis, macrohematuria, microhematuria, light-, and heavy-intensity infections oscillated within the moderate category in both districts during three yearly surveys despite sustained delivery of MDA. While knowledge of what schistosomiasis is, delivery of treatment and adequate access to WASH infrastructures are satisfactory in the study areas, no matching efforts are being carried out towards increasing community's knowledge and awareness about other aspects of its life cycle, reduction of contacts with freshwater bodies, snail control and environmental management to stop transmission of schistosomiasis parasites. In addition to treatment and

WASH provision, it is essential to engage individuals and communities, improving their understanding of the lifecycle, causes, symptoms and zoonotic potential of the disease. The implications of these findings highlight the need for tailored public health interventions to address gaps in both general and correct knowledge of schistosomiasis to bring about necessary and positive behaviour changes among people in endemic areas. We therefore concluded that implementation of these additional interventions is needed to more effectively control and potentially eliminate schistosomiasis in Malawi.

Abbreviations

CI Confidence Interval
HUGS Hybridisation in UroGenital Schistosomiasis
KAP Knowledge, Attitudes and Practices
KUHeS Kamuzu University of Health Sciences
KUREC KUHeS Research Ethics Committee
LMICs Low- and Middle-Income Countries
LSTM Liverpool School of Tropical Medicine
MDA Mass Drug Administration
NSCP National Schistosomiasis Control Programme
NTD Neglected Tropical Disease(s)
OR Odds Ratio
PSAC PreSchool-Aged Children
SAC School-Aged Children
WASH Water, Sanitation and Hygiene
WHO World Health Organization

Funding

This work is funded by the Wellcome Trust and National Institute for Health Research (NIHR) through a Joint Investigator Award, grant number WT 220,818/Z/20/Z.

Data availability

The datasets generated and analyzed for this study can be made available by contacting the corresponding author.

Supplementary materials

S1 supplementary file 1: A structured knowledge, attitudes, and practices (KAP) survey questionnaire used in the study

S2 supplementary file 2: Participant information leaflet (PIL) used in the study

S3 supplementary file 3: Participant consent/assent forms used in the study

CRediT authorship contribution statement

Peter Makaula: Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Clinton Nkolokosa:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Formal analysis. **John Archer:** Writing – review & editing, Software, Methodology. **Gladys Namacha:** Writing – review & editing, Supervision, Project administration, Data curation. **Priscilla Chammudzi:** Writing – review & editing, Supervision, Data curation. **Donales R. Kapira:** Writing – review & editing, Supervision, Data curation. **David Lally:** Writing – review & editing, Supervision, Data curation. **Bessie P. Ntaba:** Writing – review & editing, Supervision, Resources. **Ruth Cowlishaw:** Writing – review & editing, Resources, Investigation. **Angus M. O'Ferrall:** Writing – review & editing, Methodology, Data curation. **Sam Jones:** Writing – review & editing, Resources, Project administration, Data curation. **Lucas J. Cunningham:** Writing – review & editing, Methodology, Formal analysis. **Sarah Rollason:** Writing – review & editing, Supervision, Data curation. **Alexandra Juhász:** Writing – review & editing, Supervision, Investigation. **Henry Chibowa:** Writing – review & editing, Supervision. **Victor Kumfunda:** Writing – review & editing, Conceptualization. **Bright Mainga:** Writing – review & editing, Supervision, Data curation. **Gilbert Chapweteka:** Writing – review & editing, Supervision. **Waleke Khumalo:** Writing – review & editing, Supervision. **John Chiphwanya:** Writing – review & editing, Supervision. **James E. LaCourse:** Writing – review & editing, Supervision, Methodology, Formal analysis. **Sekeleghe A. Kayuni:** Writing – review & editing, Supervision, Methodology, Investigation, Data curation, Conceptualization. **J. Russell Stothard:** Writing – review & editing, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Janelisa Musaya:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that no competing interests exist.

Acknowledgments

We acknowledge the support received from the District Commissioners, Directors of Health and Social Services, District Medical Officers, District Environmental Health Officers, District Schistosomiasis Coordinators, Management and staff of Mangochi and Nsanje District Councils; the Assistant Environmental Health Officers, Health Centre officer in-charges and Health Surveillance Assistants of Mpondasi and Tengani Health Centres; the Headteachers and teachers of Samama and Mthawira Primary Schools; Research Assistants, all community leaders and members who participated in the study. Mr. Andrew Nguluwe, of the NSCP, for the unwavering support rendered to the study. We are grateful to the MSc. Research students from LSTM for their help with laboratory work: 2022 - Ffion Doull, Lewis Field, James Hardaker, James Lee and Morgan McKee; 2023 – Lennon Turner and Christine Rice; and 2024 – Lilly Atkins, Fatma Ahmed, Guilleary Deles, Jordan White and Abgail Cawley.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.actatropica.2025.107692.

Data availability

Data will be made available on request.

References

Alemu, G., Nibret, E., Amor, A., Munshea, A., Anegagrie, M., 2024. Knowledge, attitude and practice towards intestinal schistosomiasis among school-aged children and adults in Amhara Regional State, northwest Ethiopia. A cross-sectional study. Trop Med Health 52, 23. https://doi.org/10.1186/s41182-024-00584-6.

Anyolitho, M.K., Poels, K., Huyse, T., Tumusiime, J., Mugabi, F., Tolo, C.U., Masquillier, C., Nyakato, V.N., 2022. Knowledge attitudes and practices regarding schistosomiasis infection and prevention: a mixed-methods study among endemic communities of western Uganda. PLoS Negl Trop Dis 16 (2), e0010190. https://doi.org/10.1371/journal.pntd.0010190.

Barrow, A., Badjie, M., Touray, J., Kinteh, B., Nget, M., Touray, E., Kinteh, S.L.S., Sillah, S.O., Darboe, L., Jallow, Y., Badjan, M., Gaye, M., Jatta, S.P.S., 2020. Knowledge, attitude, and practice of provincial dwellers on prevention and control of schistosomiasis: evidence from a community-based cross-sectional study in the Gambia. J. Trop. Med. https://doi.org/10.1155/2020/2653096. Article ID 2653096.

Buonfrate, D., Ferrari, T.C.A., Adegnika, A.A., Stothard, J.R., Gobbi, F.G., 2025. Human schistosomiasis. Lancet 405, 658–670. https://doi.org/10.1016/S00140-6736(24)02814-9.

Chiepa, B., Mbewe, R., Stanton, M.C., Kapumba, B., Kambewa, E., Kaunga, L., Chiphwanya, J., Mzilahowa, T., Jones, C.M., Stothard, J.R., 2024. A baseline epidemiological survey for malaria and schistosomiasis reveals an alarming burden in primary schools despite ongoing control in Chikwawa District, southern Malawi. Curr Res Parasitol V. Dis. 5, 100183. https://doi.org/10.1016/j.crpvbd.2024.100183.

De Leo, G.A., Stensgaard, A., Sokolow, S.H., N'Goran, E.K., Chamberlin, A.J., Yang, G., Utzinger, J., 2020. Schistosomiasis and climate change. BMJ 371, m4324. https://doi.org/10.1136/bmj.m4324.

Feng, J., Wang, X., Zhang, X., Hu, H., Xue, J., Cao, C., Xu, J., Yang, P., Li, S., 2023. Effect of health education on schistosomiasis control knowledge, attitude, and practice after schistosomiasis blocking: results of a longitudinal observational study in the field. Trop. Med. Infect. Dis. 8, 267. https://doi.org/10.3390/tropicalmed8050267.

Juhász, A., Makaula, P., Cunningham, L.J., Jones, S., Archer, J., Lally, D., Namacha, G., Kapira, D., Chammudzi, P., LaCourse, E.J., Seto, E., Kayuni, S.A., Musaya, J., Stothard, J.R., 2024a. Revealing bovine schistosomiasis in Malawi: connecting human and hybrid schistosomes within cattle. One Health 19, 100761. https://doi.org/10.1016/j.onehlt.2024.100761.

Juhász, A., Makaula, P., Cunningham, L.J., Field, L., Jones, S., Archer, J., Mainga, B., Lally, D., Namacha, G., Kapira, D., Chammudzi, P., LaCourse, E.J., Nkolokosa, C., Seto, E., Kayuni, S.A., Musaya, J., Stothard, J.R., 2024b. Revealing caprine schistosomiasis and its one health importance in Malawi: a molecular epidemiological investigation augmented with a praziquantel treatment and GPS animal tracking pilot sub-study. One Health 19, 100918. https://doi.org/10.1016/j.onehlt.2024.100918.

Kapito-Tembo, A.P., Mwapasa, V., Meshnick, S.R., Samanyika, Y., Banda, D., Bowie, C., Radke, S., 2009. Prevalence, distribution and risk factors for *Schistosoma hematobium* infection among school children in Blantyre, Malawi. PLoS Negl Trop Dis 3 (1), e361. https://doi.org/10.1371/journal.pntd.0000361.

Kobo Toolbox, 2022. Powerful and intuitive data collection tools to make an impact. https://www.kobotoolbox.org.

Kokaliaris, C., Garba, A., Matuska, M., Bronzan, R.N., Colley, D.G., Dorkenoo, A.M., Ekpo, U.F., Fleming, F.M., French, M.D., Kabore, A., Mbonigaba, J.B., Midzi, N., Mwinzi, P.N.M., N'Goran, E.K., Polo, M.R., Sacko, M., Tchuenté, L-A.T., Tukahebwa, E.M., Uvon, P.A., Yang, G., Wiesner, L., Zhang, Y., Utzinger, J., Vounatsou, P., 2022. Effect of preventive chemotherapy with praziquantel on schistosomiasis among school-aged children in sub-Saharan Africa: a spatiotemporal modelling study. Lancet Infect Dis 1, 136–149. https://doi.org/10.1016/S1473-3099(21)00090-6.

Lubanga, A.F., Bwanali, A.M., Munthali, L.E., Mphepo, M., Chumbi, G.D., Kangoma, M., Matola, Y., Kaonga, B., Moyo, C.S., 2024. Exploring the role of community involvement in reducing the burden of schistosomiasis and other neglected tropical diseases in Malawi: where are we in the fight against neglected tropical diseases? Res Rep Trop Med 15, 51–58. https://doi.org/10.2147/RRTM.S448425.

Macias, Y.F., Glasauer, P., 2014. Guidelines For Assessing Nutrition-Related knowledge, Attitudes and Practices – KAP Manual. Rome, Food and Agriculture Organization of the United Nations. https://www.fao.org/3/i3545e/i3545e05.pdf (accessed 14 January 2024).

Makaula, P., Kayuni, S.A., Mamba, K.C., Bongololo, G., Funsanani, M., Juziwelo, L.T., Musaya, J., Furu, P., 2024. Mass drug administration campaigns: comparing two approaches for schistosomiasis and soil-transmitted helminths prevention and control in selected southern Malawi districts. BMC Health Serv Res 24, 11. https://doi.org/10.1186/s12913-023-10489-5.

Makaula, P., Kayuni, S.A., Mamba, K.C., Bongololo, G., Funsanani, M., Musaya, J., Juziwelo, L.T., Furu, P., 2022. An assessment of implementation and effectiveness of mass drug administration for prevention and control of schistosomiasis and soil-transmitted helminths in selected southern Malawi districts. BMC Health Serv Res 22, 517. https://doi.org/10.1186/s12913-022-07925-3.

Makaula, P., Sadalaki, J.R., Muula, A.S., Kayuni, S., Jemu, S.K., Bloch, P., 2014. Schistosomiasis in Malawi: a systematic review. Parasit Vectors 7, 570. http://www.parasitesandvectors.com/content/7/1/570.

Maseko, T.S.B., Mkhonta, N.R., Masuku, S.K.S., Dlamini, S.V., Fan, C.K., 2018. Schistosomiasis knowledge, attitude, practices, and associated factors among primary school children in the Siphofaneni area in the Lowveld of Swaziland. J. Microbiol Immunol Infect. 51, 103e109. https://doi.org/10.1016/j.jmii.2015.12.003.

Mthawanji, R., Nyondo, C., Chisale, M., Mkoola, K., 2023. Prevalence and risk factors of urinary schistosomiasis in northern Malawi – An assessment of mass drug administration and community perceptions of the disease. BMJ Glob. Health. 8 (10), A1–A131. https://doi.org/10.1136/bmjgh-2023-EDC.294.

R Core Team, 2024. R: A language and Environment For Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Riaz, S., Ahmed, H., Kiani, S.A., Afzal, M.S., Simsek, S., Celik, F., Wasif, S., Bangash, N., Naqvi, S.K., Zhang, J., Cao, J., 2023. Knowledge, attitudes and practices related to neglected tropical diseases (schistosomiasis and fascioliasis) of public health importance: a cross-sectional study. Front. Vet. Sci. 10, 1088981. https://doi.org/10.3389/fvets.2023.1088981.

Santos, A.J.d., Lima, S.V.M.A., Sousa, A.F.L.d., Santos, A.V.d., Santos, I.G.d.A., Santos, M. B., Feitosa, Santos V.L.C., Santos, A.d.d., Primão, J.C.M., Andrade, D.d., Silva, J.R.S., 2023. Knowledge, attitude and practices towards the prevention of *schistosomiasis mansoni* in an endemic area of Alagoas, Northeast Brazil. Trop. Med. Infect. Dis. 8, 34. https://doi.org/10.3390/tropicalmed8010034.

Webster, B.L., Alharbi, M.H., Kayuni, S., Makaula, P., Halstead, F., Christiansen, R., Juziwelo, L., Stanton, M.C., LaCourse, E.J., Rollinson, D., Kalua, K., Stothard, J.R., 2019. Schistosome interactions within the *Schistosoma haematobium* Group, Malawi. Emerg Infect Dis 25 (6), 1245–1247. https://doi.org/10.3201/eid2506.190020.

World Health Organization (WHO), 2020. Ending the Neglect to Attain the Sustainable Development Goals: a Road Map For Neglected Tropical Diseases 2021–2030. World Health Organization, Geneva. https://www.who.int/publications/i/item/9789240052932.

World Health Organization (WHO), 2022. Guideline On Control and Elimination of Human Schistosomiasis. World Health Organization, Geneva. https://www.who.int/publications/i/item/9789240041608.

World Health Organization (WHO), 2024. Global Report On Neglected Tropical Diseases 2024. World Health Organization, Geneva. https://iris.who.int/handle/10665/376667.

Yohana, C., Kinung'hi, S.M., Nyundo, B.A., Rambau, P.F., Bakuza, J.S., 2022. Knowledge, attitudes and practices on urinary schistosomiasis-related morbidity among communities in Itilima District, Tanzania. Tanz. J. Sci. 48 (4), 875–885. https://doi.org/10.4314/tjs.v48i4.14.