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SHORT COMMUNICATION

A cross-sectional pilot household study of *Schistosoma mansoni* burden and associated morbidities in Lake Albert, Uganda

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Abstract

Objectives: Schistosomiasis is persistent in Lake Albert, Uganda, but local data are limited. This study aims to describe the local burden of moderate-to-heavy infection and associated morbidity in all ages and identify factors associated with these outcomes to guide further research.

Methods: This cross-sectional pilot study was conducted in July–August, 2022 in four village sites (Walukuba, Rwentale, Kyabarangwa and Runga) of the Praziquantel in Preschoolers (PIP) trial. Residents (approximately four per household) of any age of households of PIP participants were eligible, but individuals <10 years were only enrolled if no older individuals were available. Socio-demographic information, household location, single stool Kato-Katz and hepatic ultrasound results were obtained for a convenience sampled subset of trial households. The primary outcome, moderate-to-heavy infection (≥100 eggs per gram of faeces), was analysed using mixed-effects logistic regression, with a household random effect. Univariate analyses were used for the secondary outcome, periportal fibrosis (Niamey protocol ultrasound image pattern C–F).

Results: Of 243 participants with a median age of 22 (interquartile range 12–33) years from 66 households, 49.8% (103/207 with a Kato-Katz result) had moderate-to-heavy infection and 11.2% (25/224 with ultrasound data) had periportal fibrosis. Moderate-to-heavy infection clustered by household (intraclass correlation coefficient = 0.11) and, in multivariable analysis, varied by village (Walukuba vs. Kyabarangwa adjusted odds ratio [aOR] 0.11, 95% CI 0.02–0.71), was highest in participants aged 10–15 years (vs. 5–9 years aOR 6.14, 95% CI 1.61–23.38) and lower in those reporting praziquantel treatment in the past year (aOR 0.39, 95% CI 0.18–0.88).

Conclusions: In this setting, schistosome infection and morbidity are pervasive in all age groups. More intensive interventions are needed, for example more frequent praziquantel treatment, under investigation in the PIP trial and improved water and sanitation. More research is needed to understand local treatment barriers and optimal control strategies.

KEYWORDS
epidemiology, PIP trial, *Schistosoma mansoni*, schistosomiasis, Uganda

INTRODUCTION

Schistosomiasis affects an estimated 142 million people worldwide [1] with infection beginning during water contact

Sustainable Development Goal: Good Health and and Well-being; Clean Water and Sanitation.

when free-swimming cercariae penetrate the skin. Longstanding infection with *Schistosoma mansoni* can cause morbidity, including periportal fibrosis [2]. Transmission is highly focal, dependent on suitable environmental conditions for the intermediate host snail and human water contact behaviours [3–5]. Schistosomiasis is controlled principally by mass drug administration (MDA) of praziquantel. Traditionally targeted at school-aged children but more recently recommended in all ages over 2 years, MDA offers individuals treatment based on community prevalence without formal diagnosis [6].

The shoreside communities of Lake Albert, western Uganda, are persistent hotspots for *S. mansoni* where, despite several years of control, prevalence has remained high [7], estimated at ≥50% in both school-aged children and adults in Buliisa and Hoima districts [8, 9]. A 2019 study in 288 school-aged children in Buliisa recorded a moderate-to-heavy infection prevalence by Kato-Katz of 34.0% [10]. However, recent local estimates, especially in adults, are limited. Control programmes in Uganda are threatened by low MDA coverage [11] and high reinfection rates [12], and there is a need to characterise infection and morbidity burden in all ages, providing data on groups that may currently be excluded by programmes, including adults and preschool-aged children.

The Praziquantel in Preschoolers (PIP) trial is an ongoing phase II randomised controlled trial conducted amongst residents of Lake Albert fishing villages, aiming to understand the optimal treatment (praziquantel 40 mg/kg vs. 80 mg/kg, both either as a one-off dose or repeated after 6 months) of preschool-aged children with intestinal schistosomiasis [13]. All age groups are at risk of disease, and as global aims for schistosomiasis control broaden from an exclusive focus on school-aged children, the PIP trial setting provides an opportunity to investigate schistosomiasis burden in an accessible population of all ages. This cross-sectional pilot study in household members of PIP trial participants aims to describe the burden of *S. mansoni* moderate-to-heavy infection and associated periportal fibrosis and explore potential factors associated with these outcomes to generate hypotheses for future research that may help explain the ongoing high burden in these communities.

METHODS

Sample size was estimated for the main outcome, moderate-to-heavy infection, using unadjusted logistic regression in the *powerMediation* R package. At an alpha value of 0.05 and assuming an unexposed and exposed prevalence of *S. mansoni* infection of 76% and 49%, respectively, for the exposure variable of treatment in the past year with praziquantel (at a prevalence of 42%) [14], a sample size of 200 would have 80% power to detect this difference, after correcting for household cluster sampling using a design effect of 2.0.

This cross-sectional study took place in four fishing villages adjacent to Lake Albert where participants in the PIP trial live (Figure 1a) from 27th July to 10th August 2022. Households were eligible for enrolment if they included a PIP trial participant (preschool-aged child) whose trial follow-up visit fell within the study period. PIP trial participants themselves were not recruited. Convenience sampling was used to recruit one household member (often mothers) during participant visits to the research station in Bugoigo. With the aim of recruiting approximately four participants per household, additional residents were enrolled by convenience sampling during subsequent village visits. Residents of any age were eligible but, to capture a range of burden characteristics, individuals under 10 years were only recruited when there were insufficient numbers of older residents available to make up four participants per household.

After obtaining informed written consent (signature or thumbprint, parents on behalf of participants younger than 18 years—all households contained at least one adult to consent on behalf of children) in the local language, Alur, questionnaires were administered in Open Data Kit [15] using portable electronic devices. These captured socio-demographics, water contact behaviours and schistosomiasis treatment history. GPS coordinates were recorded outside each household. A single stool sample was collected from each participant, transported to the research station in Bugoigo and duplicate smears quantified by an experienced laboratory technician (AW) within 48 h of collection, using the Kato-Katz technique [6, 16]. A hepatic ultrasound was completed on-site in temporary examination rooms during village visits by a radiographer experienced in the diagnosis of schistosomiasis morbidity (VA). Periportal fibrosis was defined as an image pattern of C, D, E or F (distinct liver parenchyma patterns suggestive of increasingly severe fibrosis), according to the Niamey protocol [17]. Surveys, stool samples and ultrasounds took place within the given study dates.

The main outcome was moderate-to-heavy *S. mansoni* infection (mean eggs per gram of faeces [EPG] ≥ 100). Primary exposure variables were reported water contact types (involvement in fishing or agriculture on flooded land), participant estimates of water contact duration (whether participants spent, on average, less or more than 1 h at the lake per visit) and frequency (on average, how many times per day the participant visited the lake), praziquantel treatment in the past year (whether the participant received and swallowed a praziquantel tablet in the preceding 12 months) and shortest Euclidean distance from household to lakeshore (calculated using Google satellite images) [18]. As PIP participants themselves were not recruited, recent treatment was likely to be in the context of MDA. The participant age variable was discretised into five categories (preschool-aged children [<5], two categories of school-aged children [5–9 and 10–15], 16–30 and ≥30) to capture the possible non-linear relationship between age and higher-intensity infections noted in previous research [19]. Periportal fibrosis on hepatic ultrasound was a secondary outcome; the same exposure variables were examined as for the main outcome, with the addition of mean EPG.

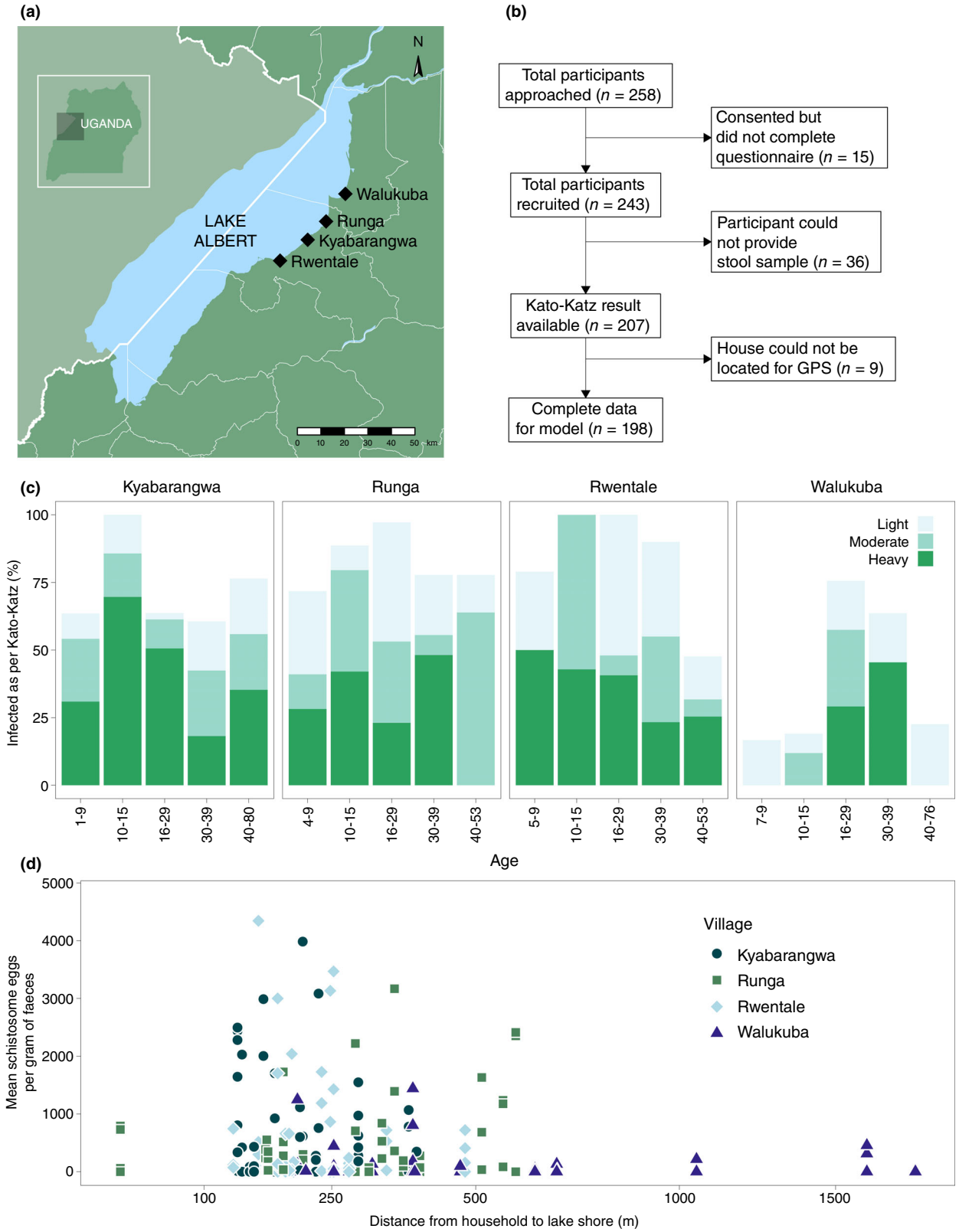

FIGURE 1 (a) Study site map. The four studied fishing villages, situated in Hoima and Buliisa districts, are amongst the study sites of the Praziquantel in Preschoolers trial. (b) Study flow chart for the moderate-to-heavy infection outcome. (c) *Schistosoma mansoni* infection intensity by single Kato-Katz, stratified by village and age group. (d) Household distance to lake and mean eggs per gram of faeces (EPG). Points represent individual participants, and the same distance has been assigned to all household members. One outlier with a distance of 348.4 m and a mean EPG of 7392 is not shown. The x-axis is shown on the square root scale.

TABLE 1 Study participant characteristics ($N = 243$).

	n (%)		
Characteristics	**Overall ($N = 243$)**	**Female ($N = 161$)**	**Male ($N = 82$)**
Sex			
Female	161 (66.3)	-	-
Male	82 (33.7)	-	-
Age, years			
Median (IQR)	22 (12–33)	24 (13–33)	17 (9.25–32)
<5	8 (3.3)	3 (1.9)	5 (6.1)
5–9	35 (14.4)	19 (11.8)	16 (19.5)
10–15	43 (17.7)	25 (15.5)	18 (22)
16–29	81 (33.3)	63 (39.1)	18 (22)
≥30	76 (31.3)	51 (31.7)	25 (30.5)
Village			
Runga	60 (24.7)	41 (25.5)	19 (23.2)
Kyabarangwa	64 (26.3)	41 (25.5)	23 (28.0)
Rwentale	63 (25.9)	41 (25.5)	22 (26.8)
Walukuba	56 (23.0)	38 (23.6)	18 (22.0)
Household size			
Median (IQR)	7 (5–8)	7 (5–8)	6 (5–8)
Residence time, years			
Median (IQR)	9 (4–20)	9 (4–19)	9 (4–20)
Occupation			
In school	61 (25.1)	32 (19.9)	29 (35.4)
Stays at home	43 (17.7)	40 (24.8)	3 (3.7)
Fishing	26 (10.7)	1 (0.6)	25 (30.5)
Trading	67 (27.6)	67 (41.6)	0 (0)
Other	46 (18.9)	21 (13.0)	25 (30.5)
Religion			
Protestant	65 (26.7)	40 (24.8)	25 (30.5)
Catholic	94 (38.7)	62 (38.5)	32 (39.0)
Muslim	7 (2.9)	5 (3.1)	2 (2.4)
Pentecostal	27 (11.1)	19 (11.8)	8 (9.8)
Other	50 (20.6)	35 (21.7)	15 (18.3)
Education			
None	53 (21.8)	40 (24.8)	13 (15.9)
Primary	111 (45.7)	84 (52.2)	27 (32.9)
Secondary	18 (7.4)	5 (3.1)	13 (15.9)
Currently in school	61 (25.1)	32 (19.9)	29 (35.4)
Socioeconomic status			
Poorest	23 (9.5)	12 (7.5)	11 (13.4)
Middle	133 (54.7)	91 (56.5)	42 (51.2)
Richest	87 (35.8)	58 (36)	29 (35.4)
Lake contact frequency			
Less than twice per day	42 (17.3)	16 (9.9)	26 (31.7)
Twice or more per day	201 (82.7)	145 (90.1)	56 (68.3)
Lake contact duration per visit ($N = 241$)			
≤60 min	121 (50.2)	79 (49.7)	42 (51.2)
>60 min	120 (49.8)	80 (50.3)	40 (48.8)

TABLE 1 (Continued)

Characteristics	*n* (%)		
	Overall ($N = 243$)	**Female ($N = 161$)**	**Male ($N = 82$)**
Lake contact activities			
Bathing	103 (42.4)	53 (32.9)	50 (61.0)
Collecting water	195 (80.2)	148 (91.9)	47 (57.3)
Swimming/playing	46 (18.9)	16 (9.9)	30 (36.6)
Washing clothes	163 (67.1)	131 (81.4)	32 (39.0)
Involved in fishing			
No	155 (63.8)	121 (75.2)	34 (41.5)
Yes	88 (36.2)	40 (24.8)	48 (58.5)
Involved in agriculture on flooded land			
No	189 (77.8)	120 (74.5)	69 (84.1)
Yes	54 (22.2)	41 (25.5)	13 (15.9)
Distance from household to lake, metres ($N = 234$)			
Median (IQR)	242 (178–384)	236 (179–384)	248 (177–373)
School attendance ($N = 78$)[a]			
No	18 (26.1)	10 (27.0)	8 (25.0)
Yes	51 (73.9)	27 (73.0)	24 (75.0)
Receipt of praziquantel ($N = 235$)[b]			
Ever	177 (75.3)	126 (79.7)	51 (66.2)
Past year	87 (37.0)	56 (35.4)	31 (40.3)
Past 3 months	40 (17.0)	23 (14.6)	17 (22.1)
Kato-Katz *S. mansoni* result ($N = 207$)			
EPG, arithmetic mean (SD)	534.8 (957.5)	513.0 (813.0)	573.9 (1178.8)
Any positive (≥ 0.5 EPG)	147 (71.0)	96 (72.2)	51 (68.9)
Light (0.5–99 EPG)	44 (21.3)	27 (20.3)	17 (23.0)
Moderate (100–399 EPG)	36 (17.4)	23 (17.3)	13 (17.6)
Heavy (≥ 400 EPG)	67 (32.4)	46 (34.6)	21 (28.4)
Hepatic ultrasound result ($N = 224$)			
Periportal fibrosis (image pattern C, D, E or F)	25 (11.2)	14 (9.1)	11 (15.7)
Image pattern A	192 (85.7)	135 (87.7)	57 (81.4)
Image pattern B	7 (3.1)	5 (3.2)	2 (2.9)
Image pattern C	12 (5.4)	6 (3.9)	6 (8.6)
Image pattern D	10 (4.5)	6 (3.9)	4 (5.7)
Image pattern E	3 (1.3)	2 (1.3)	1 (1.4)

Note: Missing values: lake contact duration: 2 (0.8%), distance from household to lake: 9 (3.7%), school attendance: 9 (11.5%), Kato-Katz: 36 (14.8%), hepatic ultrasound: 19 (7.8%). All other variables had no missing values.

Abbreviations: EPG, eggs per gram; IQR, interquartile range; SD, standard deviation.

[a]School attendance restricted to participants aged 5–15 years.

[b]Receipt of praziquantel restricted to participants aged 5 years and older.

Principal component analysis was used to create a socioeconomic status variable. From a total of 26 variables collected at the household level, seven with the highest loadings (>0.25 or <−0.25) in the first component were retained for a new component: mud flooring, cement flooring, radio ownership, absence of all listed household assets (bicycle, car, radio, electricity or phone), presence of household mother with primary education, use of the lake for drinking water and use of other sources for drinking water (full list of variables considered, definitions and loadings in Data S1). The first component captured 37.2% of the variability in these seven variables and scores were discretised into terciles, to create a socioeconomic status variable, applied to all household residents.

A mixed-effects binomial generalised linear model fit in the *lme4* package in R was used to assess factors associated with moderate-to-heavy infection compared to no or light infection, with a household random effect. Variable selection used the change-in-estimate approach, checking for important changes in adjusted odds ratios (±10%) of primary exposure variables with each addition of other variables (full

TABLE 2 Associations of participant characteristics with moderate-to-heavy *Schistosoma mansoni* infection ($N = 198$).

	n (%)				
	No/light infection ($N = 100$)	**Moderate-to-heavy infection ($N = 98$)**	**Estimate[a]**	**95% confidence interval**	***p* value[b]**
Fixed effects					
Sex					
Female	62 (48.8)	65 (51.2)	*Reference*	-	0.8
Male	38 (53.5)	33 (46.5)	0.89	0.35, 2.23	
Age, years					
< 5	4 (66.7)	2 (33.3)	0.29	0.03, 2.94	0.014[c]
5–9	18 (56.2)	14 (43.8)	*Reference*	-	
10–15	9 (28.1)	23 (71.9)	6.14	1.61, 23.38	
16–29	29 (45.3)	35 (54.7)	0.99	0.21, 4.68	
≥30	40 (62.5)	24 (37.5)	0.53	0.11, 2.58	
Village					
Kyabarangwa	21 (41.2)	30 (58.8)	*Reference*	-	0.082[c]
Rwentale	20 (43.5)	26 (56.5)	0.81	0.28, 2.36	
Runga	23 (42.6)	31 (57.4)	0.43	0.13, 1.35	
Walukuba	36 (76.6)	11 (23.4)	0.11	0.02, 0.71	
Education					
None	27 (60.0)	18 (40.0)	*Reference*	-	0.17[c]
Primary	38 (43.7)	49 (56.3)	2.10	0.73, 6.03	
Secondary	12 (75.0)	4 (25.0)	0.59	0.11, 3.02	
Currently in school	23 (46.0)	27 (54.0)	0.77	0.18, 3.25	
Socioeconomic status					
Poorest	4 (28.6)	10 (71.4)	*Reference*	-	0.61[c]
Middle	52 (45.6)	62 (54.4)	0.45	0.08, 2.53	
Richest	44 (62.9)	26 (37.1)	0.60	0.08, 4.49	
Receipt of praziquantel in past year					
No	54 (43.9)	69 (56.1)	*Reference*	-	0.024
Yes	46 (61.3)	29 (38.7)	0.39	0.18, 0.88	
Distance from household to lake, 100 s metres					
Mean (SD)	3.9 (3.4)	3 (2.4)	1.06	0.88, 1.26	0.55
Lake contact frequency					
Less than twice per day	23 (67.6)	11 (32.4)	*Reference*	-	0.43
Twice or more per day	77 (47.0)	87 (53.0)	1.51	0.55, 4.16	
Lake contact duration per visit					
≤60 min	55 (58.5)	39 (41.5)	*Reference*	-	0.09
>60 min	45 (43.3)	59 (56.7)	1.97	0.89, 4.34	
Involved in fishing					
No	61 (48.4)	65 (51.6)	*Reference*	-	0.97
Yes	39 (54.2)	33 (45.8)	0.98	0.37, 2.61	
Involved in agriculture on flooded land					
No	70 (45.5)	84 (54.5)	*Reference*	-	0.34
Yes	30 (68.2)	14 (31.8)	0.62	0.23, 1.65	
Random effect					
Household[d]			0.32		
Residual intraclass correlation					
Household			0.09	0.00, 0.32	

[a]Estimates are adjusted (for all other variables in the table) odds ratios for fixed effects, variance for random effects and intraclass correlation coefficient for residual intraclass correlation.
[b]*p* values calculated using Wald test unless otherwise stated.
[c]*p* value calculated using likelihood ratio test.
[d]57 household units.

list of exposure variables in Data S1) [20]. This study was not powered to detect interactions. Additionally, a null model containing the outcome and random effect only with no covariates estimated an intraclass correlation coefficient (ICC), to assess for household clustering of moderate-to-heavy infection. A sensitivity analysis assessed consistency of results by repeating these methods with the outcome reference group as solely uninfected (i.e. those with light infection were excluded from the analysis). Due to small event numbers, analysis of the periportal fibrosis outcome was restricted to univariate analyses. Analyses were conducted using R version 4.3.0 and Quantum GIS version 3.22.

Ethical approval was obtained from the London School of Hygiene and Tropical Medicine MSc Research Ethics Committee (27029) and the Uganda Virus Research Institute Research Ethics Committee (RGPM190101). Participants were informed of their infection status and those infected were treated with a single dose of praziquantel 40 mg/kg.

RESULTS

Of 258 individuals approached for participation, 243 (94.2%) were recruited from 66 households with a median of 4 participants per household (interquartile range [IQR] 3–4, range 1–8). A flow chart of participant recruitment and data completeness is shown in Figure 1b. The median age of participants was 22.0 (IQR 12–33, range 1–80) years and 161 (66.3%) were female (Table 1; Figure S1). Due to participant availability, 32 households (48.5%) had at least one participant younger than 10 years.

A Kato-Katz result was available for 207/243 (85.2%) participants, of whom 147 (71.0%) were positive for *S. mansoni* infection and 103 (49.8%) had moderate-to-heavy infection (70.1% of those infected). Overall, the proportion of participants with moderate-to-heavy infection was similar between males and females and highest in individuals aged 10–15 years. However, in Walukuba, where the proportion of moderate-to-heavy infection overall was lower, individuals aged 16–29 years had the highest proportion of moderate-to-heavy infection (Figure 1c; Table 2).

Amongst participants aged ≥5 years, 37.0% (87/235) reported taking praziquantel in the past year, but this varied by village from 22.0% (13/59) in Runga to 55.4% (31/56) in Walukuba. The proportion of participants with moderate-to-heavy infection was 38.0% in those reporting praziquantel in the past year compared to 57.0% in those who did not.

Mean distance from household to lake varied from 220 m (132–395 m) in Kyabarangwa to 658 m (203–1794 m) in Walukuba (Table 1), and there was no strong evidence for correlation between distance to lake and mean EPG (Pearson correlation coefficient $r = -0.13$, $p = 0.066$, Figure 1d).

In multivariable analysis, individuals aged 10–15 years had higher odds of moderate-to-heavy infection compared to those aged 5–9 years, while participants from the village of Walukuba had lower odds of moderate-to-heavy infection compared to those from Kyabarangwa. The odds of moderate-to-heavy infection were lower in those who reported recent praziquantel treatment (Table 2). There was no evidence for an association between any water contact variables or distance to the lake and moderate-to-heavy infection.

In the null model, 11% (ICC = 0.11, 95% confidence interval [CI] 0.00–0.25) of the variance in moderate-to-heavy infection could be explained by clustering at the household level, compared to 9% (0.09, 95% CI 0.00–0.40) after adjustment with the inclusion of fixed effects.

Similar results were seen in the multivariable sensitivity analysis using no infection as the reference group (Table S3), but with higher clustering of moderate-to-heavy infection by household in the null model (ICC = 0.21, 95% CI 0.02–0.41).

Of 224 participants assessed with a hepatic ultrasound, 25 (11.2%) had image pattern evidence of periportal fibrosis (image pattern C and above). In unadjusted analyses, increasing age, involvement in fishing and lower mean EPG were associated with higher odds of periportal fibrosis (Table S4; Figure S2).

DISCUSSION

This study focused on a high-burden population. Analyses suggested that higher-intensity infections clustered by household and that age, village and lack of recent treatment were associated with increased odds of moderate-to-heavy *S. mansoni* infection. Unadjusted analyses suggested that odds of periportal fibrosis were associated with increasing age, fishing and lower mean EPG.

A previous study found clustering of *S. mansoni* infection risk between adult and child household pairs, but did not compare results unadjusted and adjusted for covariates [21]. In the current study, low-level household clustering of moderate-to-heavy infection may be partly explained by shared treatment access, water contact behaviours or availability of sanitation facilities, especially given the decrease in ICC after adjustment. This may be important for targeting interventions to high-risk populations.

A potential explanation for the different age distribution of moderate-to-heavy infection in one village, Walukuba, is that as school-based control efforts have succeeded here in reducing the burden in children, the peak has shifted to adults. If this is true, it highlights the importance of targeting all age groups with interventions.

The adolescent age peak in moderate-to-heavy infection is consistent with previous studies [5, 19, 21]. The lack of association with sex or water contact variables, however, is unlike some previous studies [5, 21, 22], and may suggest that the exceptionally high local transmission means any and all water contact is risky. Additionally, it is difficult to accurately capture water contact exposure, given the variability in risk of exposure to cercariae at different water contact sites.

Possible explanations for the lack of association between distance to lake and infection, contrary to several previous studies [5, 21, 23], are the smaller distances involved (most individuals live close to the lake and therefore exposure risk is similar), the model adjustment for village, which itself was associated with distance to lake, and a lack of alternative sources of water.

Although participants reporting recent praziquantel had lower odds of moderate-to-heavy infection, the burden in this group was high, which may indicate rapid reinfection and/or treatment failure and be an indication for more frequent treatment. Praziquantel efficacy may wane over time with repeated distribution [24] and cure rates can be low, especially in higher-intensity infections [25]. While the current recommended MDA approach locally is biannual treatment targeted to school-aged children and older adults, recent praziquantel shortages have meant MDA has been intermittent. The PIP trial will provide insights into how different dose intervals may impact treatment response in young children. Regular, higher coverage MDA in all age groups, as well as improvements to water supply and sanitation, will be necessary to reduce transmission and morbidity. This may require targeting specific villages, neglected community members and those at higher risk of periportal fibrosis.

Several limitations must be considered when interpreting these results. The relatively small sample size and certain effect sizes that were smaller than assumed mean this pilot study was not powered to detect associations between outcomes and all exposure variables. However, this study will hopefully provide a base on which to perform larger studies. Convenience sampling of individuals that were available for participation led to an oversampling of mothers and lower numbers of males. However, our results did not suggest a gender-based difference in infection. Given households contained a PIP trial participant who was *S. mansoni* infected at trial enrolment, the study population may also be biased towards a higher infection risk. As the sample was non-representative, with a higher proportion of older, female individuals than the general population, and household participants likely to be more similar to each other compared to a simple random sample, findings are not easily generalisable. The older study population may have underestimated moderate-to-heavy infection but overestimated periportal fibrosis. Sampling of multiple residents of single households did allow us to explore clustering of burden, and the mixed-effects analyses explicitly accounted for this effect. Finally, the low sensitivity of a single Kato-Katz [26] may have underestimated lower-intensity infections, which could have biased estimates towards the null.

WHO schistosomiasis elimination targets [27] are ambitious in these communities with high exposure to contaminated water, and intensified control measures will be required. These could include community-wide MDA as opposed to school-based approaches that only capture a limited group at risk, allowing others to experience morbidity and perpetuate the transmission cycle. Biannual treatment may also be required.

This pilot study has identified several knowledge gaps. Firstly, local research is needed to understand barriers to treatment access, given the low reported coverage. Is this an issue of medication availability, population compliance with MDA or are certain groups being systematically missed? Secondly, this study has highlighted the high burden of higher-intensity infections, including in individuals reporting recent praziquantel use, reinforcing the need for research comparing alternative strategies, a key aim of the PIP trial.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data supporting the conclusions of this article will be shared on reasonable request to the corresponding author.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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