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Schistosomiasis prevalence in Zomba, Southern Malawi

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A large proportion of Malawi’s more than 13 million people live in rural areas where major livelihood activities include subsistence farming, irrigation and fishing. Therefore the villagers have contact with water, which exposes them to schistosomes. In this case study, surveys and parasitological investigations were conducted to determine the prevalence of schistosomiasis and to explore the relationship between disease prevalence and selected qualitative variables in five villages located in Zomba District in Lake Chilwa Basin. The study revealed a high prevalence, ranging from 23% in Machemba village to 49% in Mukhweya village. Children, 6–15 years old, were the most heavily infested (40%), and the 0–5 years group the least. A high prevalence was observed among school children (39%), and occupations such as irrigated farming (26%) and fishing (24%). Analyses at the 0.05 α-level revealed statistically significant associations between schistosomiasis prevalence and village of residence, age group and occupation type, but there was insufficient evidence to suggest a significant relationship with gender. Based on these findings, targeted awareness and mass treatment programmes were implemented in all the villages, and 9085 people were treated.

Keywords: schistosomiasis; Lake Chilwa Basin; Malawi; rainfall variability

Introduction

Schistosomiasis, commonly known as bilharzia, is a debilitating human disease caused by parasitic flat worms called schistosomes (*Schistosoma* spp.). Intermediate host snails thrive in tropical climates, and 90% of an estimated 230 million infection cases reported worldwide each year occur in Africa (WHO, 2012). Common intermediate host snails include *Bulinus* spp. and *Biomphalaria* spp. which prefer shallow fresh water, and the most common worms of medical concern are *Schistosoma mansoni*, *Schistosoma haematobium* and *Schistosoma japonicum* (Garfield, 1986). The geographical distribution of parasite species for the two main forms of schistosomiasis – intestinal and urogenital is shown in Table 1.

Infection often takes place when there is contact between humans and intermediate host snail-harbouring freshwater bodies such as lakes, ponds, streams and irrigation canals. *S. mansoni*, *S. haematobium* and *S. japonicum* are chiefly responsible for causing intestinal, genitourinary and hepatosplenic disease, respectively (Cetron et al., 1996; Gray, Ross, Li, & McManus, 2011; Stauffer et al., 2008). Bilharzia compromises peo-
people’s health, curtailing their participation in livelihood-sustaining activities. This reduces their resilience and capacity to adapt to natural environmental stressors, especially in areas like the Lake Chilwa Basin that are subject to frequent droughts and floods.

Extreme weather events such as floods and droughts are expected to increase across southern Africa due to climate change (IPCC, 2007), and so is the influence of these events on disease prevalence. Human health – climate change linkages are not the subject of this study, but these have been widely explored in the past decade (Githeko, Lindsay, Confalonieri, & Patz, 2000; Talla et al., 1990, Zhou et al., 2008). Climate change not only influences the geographical range and abundance of snail intermediate host species (Patz, Graczyk, Geller, & Vittor, 2000; Zhou et al., 2008), but it also increases bilharzia transmission through ecologic transformations that create favourable conditions for snail proliferation and increased human contact with snail and schistosome egg-infested waters (Utzinger, Zhou, Chen, & Bergquist, 2005; Yang, Vounatsou, Zhou, Tanner, & Utzinger, 2005).

In bilharzia endemic areas, well-intentioned climate change adaptation initiatives such as water development projects may also create conditions that favour the proliferation of bilharzia (N’Goran, Diabate, Utzinger, & Sellin, 1997; Olliver, Brutus, & Coy, 1999). A survey of literature shows a few prominent examples on the African continent. These include a reported increase in the abundance of snail hosts of bilharzia following the construction of irrigation projects in the Nile Delta (Garfield, 1986), dams in Senegal (Emmould, Ba, & Sellin, 1999; Talla et al., 1990) and an increase or introduction of new areas of urinary schistosomiasis following the construction of dams and irrigation projects meant to improve water security in Cameroon, Cote d’Ivoire, Ghana, Mali, Namibia, and Sudan (see Elias, Daffala, Lassen, Madsen, & Christensen, 1994; Hunter, Rey, Chu, Adecoulo-John, & Mott, 1993; Southgate, 1997). Other related examples are highlighted in studies by Chitsulo, Engels, Montresor, and Savioli (2000) in Malawi and Wilmott (1987) in middle and upper Egypt.

Schistosomiasis has been prevalent for over a century in the Southern African nation of Malawi (Chiotha, 1990). *S. haematobium* is highly prevalent in the southern part of the country, while *S. mansoni* predominates in the central plain and the northern regions. A few prevalence studies have been conducted in the past and it is important to note that the results vary widely among surveys, mainly because of the sampling methods applied, among other factors. For example, Phiri, Whitty, Graham, and Ssembatya-Luel (2000) focussed on children 3–15 years and their non-random hot spot survey revealed a significantly higher prevalence of helminthic infection in urban areas, compared to rural areas. Major risk factors cited included the presence of pools of water

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### Table 1. Geographical distribution of intestinal and urogenital schistosomiasis.

<table>
<thead>
<tr>
<th>Schistosomiasis</th>
<th>Geographical Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urogenital</strong></td>
<td><em>S. haematobium</em></td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td>Africa, the Middle East</td>
</tr>
<tr>
<td>Intestinal</td>
<td><em>S. mansoni</em></td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td>Africa, the Middle East, the Caribbean, Brazil, Venezuela, Suriname</td>
</tr>
<tr>
<td><em>S. japonicum</em></td>
<td>China, Indonesia, the Philippines</td>
</tr>
<tr>
<td><em>Schistosoma mekongi</em></td>
<td>Several districts of Cambodia and the Lao People’s Democratic Republic</td>
</tr>
<tr>
<td><em>Schistosoma guineensis</em> and related <em>S. intercalatum</em></td>
<td>Rain forest areas of central Africa</td>
</tr>
</tbody>
</table>

and sewage around houses, walking barefoot, low school attendance among children and mothers’ low level of education.

A random national survey conducted by Bowie, Purcell, Shaba, Makaula, and Perez (2004) involving primary school level children found a prevalence of 6.9% and 0.4% for *S. hematobium* and *S. mansoni*, respectively, and the perceived low prevalence was attributed to targeted treatment programmes at that time. In contrast, a high national schistosomiasis infection rate of 40–50% of the total Malawian population was reported by the 2004–2008 five-year National Plan of Action for the Control of Schistosomiasis and Soil transmitted Helminthes (National Statistical Office [NSO], 2008).

Bilharzia prevalence in Malawi also varies widely among locations. It was as high as 79–80% among primary school-going age groups in some parts of Lake Chilwa Basin (Zomba District Health Office [ZDHO], 2009), but only 10% for the same age groups in Blantyre city (Kapito-Tembo et al., 2009). Findings by Madsen et al. (2011) ranged from 21 to 73% urinary schistosomiasis prevalence among the lakeshore communities of Lake Malawi, but only 10 to 26% in inland villages. Despite this high prevalence in some locations and the debilitating nature of the disease, bilharzia generally remains neglected in Malawi, to the extent that it was not even mentioned in the recent Malawi Demographic and Health Survey Report (NSO, 2010). Consequently, very little health intervention efforts have been taken towards addressing the disease, until recent prioritisation efforts by stakeholders that include the media.

A recent proliferation of studies focusing on biological controls of intermediate snail hosts brings into focus the need for holistic approaches that incorporate several measures to combat schistosomiasis prevalence in endemic areas. For example, to compliment traditionally used measures such as repeated chemotherapy (Evers, Madsen, McKaye, & Stauffer, 2006), the contributions by Stauffer, Arnegard et al. (1997), Stauffer, Arnegard et al. (2006), Evers et al. (2006), Evers, Madsen, and Stauffer (2011) and Lundeba, Likongwe, Madsen, and Stauffer (2007, 2011) are devoted to reducing schistosomiasis transmission through an increased understanding of and promoting the conservation of intermediate snail predator fish species. To underscore the importance of additional measures such as biological controls, Madsen et al. (2011) argue that *S. haematobium* transmission became more prominent in post mid 1980s Malawi because overfishing had decimated the populations of intermediate snail host predating molluscivore fishes. In their 2010 Lake Malawi study, Madsen et al. (2011) recommended some bilharzia infection risk-reducing measures that include avoiding water contact in high risk transmission sites such as snail habitats, avoiding swimming in endemic areas, and diving around 200 m away from lake shorelines where intermediate host snail habitats like streams and ponds are concentrated. In Madsen and Stauffer (2011), a fishing ban of up to 100 m offshore along Lake Malawi shoreline villages is advocated for to allow populations of intermediate snail-predating fishes to increase. While discussing the potential of controlling hosts of parasitic diseases using fishes, Stauffer et al. (1997) also highlight the need to exercise caution in order to avoid an inadvertent introduction of exotic invasive species of biological controls.

Several intervention efforts have been initiated in the past few years in Malawi, in addition to national programmes such as the National Plan of Action for the Control of Schistosomiasis and Soil transmitted Helminthes. An example is the Lake Chilwa Basin Climate Change Adaptation Programme, a five-year programme under which this case study was conducted, supported by the Royal Norwegian Embassy. The goal of the programme is to secure the livelihoods of 1.5 million people in the Lake Chilwa Basin in southern Malawi (LEADSEA, 2010). This is being accomplished by implementing
basin-wide climate change adaptation initiatives in order to enhance the capacity of communities to adopt sustainable livelihood and natural resource management practices.

In this case study, we apply a general random sampling survey framework and statistical analyses to assess bilharzia prevalence and its relationship with selected qualitative variables in Lake Chilwa Basin. Previous schistosomiasis surveys in Malawi have focussed on issues ranging from prevalence in rural women (Kjetland et al., 1996), national level distribution, prevalence and intensity of infection (Bowie et al., 2004), and transmission in lakeshore villages and inland villages (Madsen et al., 2011). Our study is unique because it explores the interrelationship between schistosomiasis prevalence and people’s livelihoods in a basin that is of national importance due to its abundant natural resources. This is essential in adding knowledge to multisectoral approaches that are essential for the holistic control of schistosomiasis in a historically endemic area. The Lake Chilwa Basin makes an excellent case study because it is one of the largest schistosomiasis transmission sites in the country, together with the Lake Malawi Basin (Chiotha, 1990). The following research questions are investigated: (1) to what extent is schistosomiasis prevalent in the Zomba District in the Lake Chilwa Basin? (2) what is the nature of interrelationships between schistosomiasis infection cases and activities that sustain people’s livelihoods in the study area? (3) Is there any association between schistosomiasis prevalence and variables such as gender, age and location?

Methods

Prevalence surveys and parasitological investigations were conducted in Zomba District in Lake Chilwa Basin, southern Malawi (Figure 1). The district has a total population of

![Figure 1. Map of bilharzia study villages in Zomba District.](image)
nearly 600,000 people, more than half (52.6%) of whom are 18 years or younger; a population density of 230 persons per km²; and experienced a population growth rate of 2% per year over the last decade (NSO, 2008). Its agricultural economy is dominated by maize production for both subsistence and marketing. Other major crops include tobacco and coffee, solely cultivated as cash crops.

Ethics approval
The process for testing schistosomiasis was done with the consent of all survey participants, following detailed explanations about the procedure to them. Consent from the District Commissioner and Chiefs was sought before the bilharzia control activities began, as they are the administrative authorities under whose mandate our study area falls in the district. Consent from the District Education Manager was also sought, since the surveys included schools. In addition, clearance for the study was obtained from the Ministry of Health through the Zomba District Health Office.

Prevalence surveys
Through the Lake Chilwa Basin Climate Change Adaptation Programme, 65 villages and 29 schools were identified as S. haematobium hotspot areas. Random number tables were used to carry out basic simple random sampling of five villages (Mukhweya, Machemba, Masala, Lamusi I and Maluwa) and five primary schools (Mitole, Mikundi, Khuluvi, Nazitimbe and Muluma) from the hotspot areas. The surveys were conducted over a three-month period from September to November 2011, resulting in the participation of all 483 respondents from the selected villages and primary schools. Simple random sampling was applied in this study mainly because of its low cost of application, and due to little available advance knowledge of the population. Data from simple random sampling tends to be free of classification errors, in addition to producing results that are simple to interpret under different study conditions. Prevalence of each group was calculated as the proportion of the sum of moderately and severely infected people to the total number of participants representing that group, and overall prevalence was computed by comparing total number of infected participants to the total sample size for this study.

Prevalence values obtained in this study are only estimates of the true population parameters derived from data collected from samples. Therefore confidence intervals (CIs) at the 95% confidence level were calculated to show how bilharzia prevalence estimates from the samples compared with the true population prevalence. The 95% confidence intervals were calculated using the procedure described below. For each group proportion, the maximum error of estimate for the true population proportion ($p$) is depicted by Equation (1):

$$E_{max} = Z_{\alpha/2} \sqrt{\frac{pq}{n}}$$

where $E_{max}$ maximum error of estimate and $Z_{\alpha} = 1.96$ at the 95% level of confidence.

For a group of size $n$ with $X$ total number of infected respondents, the infected and uninfected sample proportions are defined by Equations (2) and (3) respectively.

$$\hat{p} = \frac{X}{n}$$

$$\hat{q} = 1 - \hat{p}$$
The proportion confidence interval is represented by the following formula:

$$\hat{p} = 1 - \hat{q}$$

(3)

where $\hat{p}$ = population proportion. The confidence intervals for each group prevalence proportion were computed using Minitab statistical software. For each group, this proportion confidence interval is valid provided the criteria that $np \geq 5$ and $nq \geq 5$ are both met.

Parasitological investigations

Survey participants responded to a previously prepared questionnaire that individual details such as name, age, gender and occupation, among other variables. This was followed by the collection of urine specimens and analyses using the standard filtration technique (Bowie et al., 2004; Madsen et al., 2011). The urine specimens were also inspected for macrohaematuria (visible signs of haematuria) – and dipsticks used to check for micro-haematuria. Egg counts for *S. haematobium* were made per 10 ml of urine and centrifuging was performed, followed by cell counting using microscopes. Communities were mobilised through a drama troupe that provided a performance on the theme of bilharzia to raise awareness about the disease. The drug Praziquantel was administered on all infected people, under the close supervision of health personnel from the Zomba District Health Office.

Chi-square test of independence

Chi-square tests for independence were conducted using Statistical Package for the Social Sciences (SPSS) software. A chi-square test of independence is appropriate for testing the association between two or more categorical variables, where the interest is determining whether the observed breakdown of people over various categories fits some expected breakdown (Jackson, 2006). The goal of the chi-square tests was to determine if there was any association between schistosomiasis prevalence and the following four major qualitative variables at the 0.05 alpha ($\alpha$) level: gender, village of residence, occupation and age group. For each variable, the chi-square ($\chi^2$) was calculated using Equation (4) under the null hypothesis that there is no association between schistosomiasis prevalence and the variable under consideration.

$$\chi^2 = \sum_{i} \sum_{j} \left( \frac{O_{ij} - E_{ij}}{E_{ij}} \right)^2$$

(4)

where $\chi^2$ = chi-square statistic, $R$ = number of rows, $C$ = number of columns, $O_{ij}$ = observed frequency for the cell in the $i$th row and $j$th column, $E_{ij}$ = expected frequency for the cell in the $i$th row and $j$th column, calculated using Equation (5),

$$E_{ij} = \frac{f_i f_j}{N}$$

(5)

$f_i$ = marginal frequency for the $i$th row, $f_j$ = marginal frequency for the $j$th column, and $N$ = total number of participants in the study.

The chi-square analyses carried out under the assumptions that: (1) samples used are independent and random, (2) total number of subjects used is at least 20 so that the null
distribution of the statistic is approximately chi-square, (3) each two variables being
analysed are independent of one another and (4) no expected frequency is equal to zero.

Results and discussion

Overall prevalence of schistosomiasis among survey participants in Zomba District

The total number of participants consisted of 248 males and 235 females. Overall mean
prevalence was 37% among males, 31% among females and 34% among all the 483
participants (Table 2). Confidence intervals (CI) for each group and for the total number
of participants are also shown in Table 2. According to these results, one can be 95%
confident that the true population prevalence level in the study area is between 29.9%
and 38.4%.

Table 3 presents the results of a chi-square analysis carried out to investigate
whether there was any association between gender and schistosomiasis prevalence,
under a null hypothesis that there is no association between gender and bilharzia preva-
ience. At the 0.05 $\alpha$-level, the results yielded a test statistic of $\chi^2(1, N = 483) = 1.953,$
and $p$-value = 0.162. Since $p > \alpha$, there is insufficient evidence to reject the null
hypothesis. There is therefore no statistically significant association between gender and
schistosomiasis prevalence in this study. A test of the strength of the association using
Phi and Cramer’s V confirmed a very weak relationship between gender and bilharzia
prevalence in Zomba District (Table 3).

Prevalence and severity of infection by village

A total of 57 out of 483 participants from the five different villages had severe
schistosomiasis infection. Prevalence in the five villages ranged between 23% in
Machemba and 49% in Mukhweya village (Table 4). The table also shows the calcu-
lated CIs for the true prevalence level in each village. These CIs vary between villages,
depending on the number of survey participants and the proportion of positive bilharzia
cases. Villages with the highest prevalence (Mukhweya and Lamusi) also had the largest
number of severe infection cases. The former village is located in a wetland area that
has irrigation canals. These villagers are frequently in contact with contaminated water
as they engage in farming activities. Lamusi village is located close to the Likangala
River and also has a network of irrigation canals. In addition to farming, communities
use water from the irrigation canals for activities such as washing (Figure 2), bathing
and swimming. Similarly, Masala Village (prevalence 30%) is also located in a wetland
area where irrigated farming is practised. Maluwa village is located on Chisi
Island within Lake Chilwa, and the majority of people tested there were fishermen who

Table 2. Overall prevalence among survey participants.

<table>
<thead>
<tr>
<th>Severity of infection</th>
<th>Total infected</th>
<th>Total number of participants</th>
<th>Prevalence ($p$) (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>156</td>
<td>92</td>
<td>248</td>
<td>31.1% &lt; $p$ &lt; 43.1%</td>
</tr>
<tr>
<td>Moderate</td>
<td>59</td>
<td>73</td>
<td>235</td>
<td>25.1% &lt; $p$ &lt; 37.0%</td>
</tr>
<tr>
<td>Severe</td>
<td>33</td>
<td>165</td>
<td>483</td>
<td>29.9% &lt; $p$ &lt; 38.4%</td>
</tr>
<tr>
<td>Total</td>
<td>318</td>
<td>165</td>
<td>483</td>
<td></td>
</tr>
</tbody>
</table>

*aSeverity of infection scale: 0 (Negative); 1–9 (Moderate); 10–800 (Severe).*
spend long hours in contact with water in the lake. Although Maluwa village had the lowest number of participants (85) compared to the other four villages, its prevalence (28%) and number of severe infections are comparable to the highly irrigating villages. Machemba village had the lowest prevalence and least number of severe infections (Figure 3). It is not located in a wetland area and does not have irrigation canals, although some irrigation occurs through the use of treadle pumps.

Given the village characteristics in Table 4, we further explored the relationship between schistosomiasis prevalence and village of residence. The chi-square analysis results are presented in Table 5, based on the null hypothesis that there is no association between village of residence and bilharzia prevalence. The results were statistically significant ($\chi^2_{(4, N = 483)} = 19.15$, $p$-value = 0.001). We therefore rejected the null hypothesis and concluded that there is an association between village of residence and schistosomiasis prevalence in the study area. A measure of the strength of association between these two variables using Phi and Cramer’s V tests confirmed the presence of a moderately strong, statistically significant relationship (Table 5).
Prevalence and severity of infection by occupation

The school-going population was found to have highest prevalence (39%, 95% CI: 33.5% < p < 44.3%) and the highest recorded number of severe cases (42 out of 57) among all occupations. This was mainly attributed to the nature of their recreational activities. Over the duration of this study, school children were frequently observed swimming in the irrigation canals, rivers and nearby lake for recreation. Farmers and fishermen (Figure 4) had prevalence levels of 26% (95% CI: 18.0% < p < 33.7%) and
24% (95% CI: 10.5% < \( p \) < 38.1%) respectively (Figure 5) – attributed mainly to their livelihood activities that require frequent and long periods in contact with water. Participants drawn from various other smaller occupations had a combined prevalence of 27% (95% CI: 4.3% < \( p \) < 49%), although there were fewer participants in this combined category in comparison to other major occupations.

A chi-square analysis was conducted at the 0.05 \( \alpha \)-level of significance to determine if there was any association between schistosomiasis prevalence and occupation. The results of the test, based on the null hypothesis that there is no association between the two variables are presented in Table 6. The analysis yielded a test statistic of \( \chi^2 = 65.633 \) with degrees of freedom \( df = 3 \) and a p-value of \( p = 0.0000 \) (much smaller than \( \alpha \)). Since \( p < \alpha \), there is sufficient evidence to reject the null hypothesis and

<table>
<thead>
<tr>
<th>Village of residence</th>
<th>Prevalence</th>
<th>Lamusi</th>
<th>Machemba</th>
<th>Maluwa</th>
<th>Masala</th>
<th>Mukhweya</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Observed count</td>
<td>40</td>
<td>23</td>
<td>23</td>
<td>30</td>
<td>49</td>
<td>165</td>
</tr>
<tr>
<td></td>
<td>Expected count</td>
<td>34.2</td>
<td>34.2</td>
<td>28.4</td>
<td>34.2</td>
<td>34.2</td>
<td>165</td>
</tr>
<tr>
<td>Negative</td>
<td>Observed count</td>
<td>60</td>
<td>77</td>
<td>60</td>
<td>70</td>
<td>51</td>
<td>318</td>
</tr>
<tr>
<td></td>
<td>Expected count</td>
<td>65.8</td>
<td>65.8</td>
<td>54.6</td>
<td>65.8</td>
<td>65.8</td>
<td>318</td>
</tr>
<tr>
<td>Total</td>
<td>Observed count</td>
<td>100</td>
<td>100</td>
<td>83</td>
<td>100</td>
<td>100</td>
<td>483</td>
</tr>
<tr>
<td></td>
<td>Expected count</td>
<td>100</td>
<td>100</td>
<td>83</td>
<td>100</td>
<td>100</td>
<td>483</td>
</tr>
</tbody>
</table>

Pearson \( \chi^2 = 19.15 \), \( \varphi = 0.199 \), Cramer’s V = 0.199, df = 4, \( p = 0.001 \).

Figure 4. Boat landing site for fishermen at the edge of Lake Chilwa. Freshwater snail species found at this site included *Bulinus globosus*, *Lanistes*, and *Melanoides* (Photo credit: J. Russell Stothard).
conclude that there is an association between schistosomiasis prevalence and occupation type in the study area. Phi and Cramer’s V tests confirmed a statistically significant, moderately strong relationship (Table 6).

**Prevalence and severity of infection by age group**

The 0–5 year age group had the lowest prevalence of 20% (95% CI: 4.3% < \( p < 35.7\% \)), arising from only five moderate infections in 25 participants (Figure 6). The highest prevalence of 40% (95% CI: 34.6% < \( p < 46.0\% \)) was observed among the 6- to 15-year olds (114 out of 283 infected, with 44 severe cases). All these are school-going children whose major recreational activity is swimming in the irrigation canals. The 16 years and above age group with a prevalence of 26% (95% CI: 19.8% < \( p < 32.8\% \)) are the working class engaged in major water using livelihood activities in the area, among them fishing and irrigated farming.

A chi-square analysis was conducted to examine the relationship between bilharzia prevalence and the age groups of participants in the study area. The results from the test at the 0.05 level of significance and using a null hypothesis that there is no association between the two variables are tabulated in Table 7. Since \( \chi^2(2, N = 483) = 11.77 \) and

<table>
<thead>
<tr>
<th>Prevalence</th>
<th>Schooling</th>
<th>Farming</th>
<th>Fisherman</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Observed count</td>
<td>121</td>
<td>0</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Expected count</td>
<td>86.3</td>
<td>33.3</td>
<td>10.3</td>
<td>4.2</td>
</tr>
<tr>
<td>Negative</td>
<td>Observed count</td>
<td>190</td>
<td>120</td>
<td>28</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Expected count</td>
<td>224.7</td>
<td>86.7</td>
<td>26.7</td>
<td>10.8</td>
</tr>
<tr>
<td>Total</td>
<td>Observed count</td>
<td>311</td>
<td>120</td>
<td>37</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Expected count</td>
<td>311</td>
<td>120</td>
<td>37</td>
<td>15</td>
</tr>
</tbody>
</table>

Pearson \( \chi^2 = 65.633, \phi = 0.369, \) Cramer’s V = 0.369, df = 3, \( p = 0.00000. \)
$p = 0.003$, which is less than, there is sufficient evidence to reject the no association hypothesis. Thus, we can conclude from this study that bilharzia prevalence and age group are associated.

### Table 7. Prevalence and age group cross tabulation results.

<table>
<thead>
<tr>
<th>Prevalence</th>
<th>Age group</th>
<th>0–5 years</th>
<th>6–15 years</th>
<th>16+ years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Observed count</td>
<td>5</td>
<td>114</td>
<td>46</td>
<td>165</td>
</tr>
<tr>
<td></td>
<td>Expected count</td>
<td>8.5</td>
<td>96.7</td>
<td>59.8</td>
<td>165</td>
</tr>
<tr>
<td>Negative</td>
<td>Observed count</td>
<td>20</td>
<td>169</td>
<td>129</td>
<td>318</td>
</tr>
<tr>
<td></td>
<td>Expected count</td>
<td>16.5</td>
<td>186.3</td>
<td>115.2</td>
<td>318</td>
</tr>
<tr>
<td>Total</td>
<td>Observed count</td>
<td>25</td>
<td>283</td>
<td>175</td>
<td>483</td>
</tr>
<tr>
<td></td>
<td>Expected count</td>
<td>25</td>
<td>283</td>
<td>175</td>
<td>483</td>
</tr>
</tbody>
</table>

Pearson $\chi^2 = 11.77$, $\varphi = 0.156$, Cramer’s $V = 0.156$, df = 2, $p = 0.003$.

### Conclusion

This study revealed high prevalence levels of schistosomiasis that are interrelated to people’s basic livelihood activities in the Zomba District of the Lake Chilwa Basin. Irrigated farming and fishing – two major livelihood activities that enhance people’s resilience to drought and highly variable rainfall in the basin, are also the major occupations associated with high bilharzia prevalence levels. Children of school going age in the basin are especially vulnerable to infection due to frequent recreational swimming in untreated water bodies. Infections of bilharzia are naturally tied to villages or locations where specific livelihood activities are occurring (Table 4). Therefore it is not surprising to observe a statistically significant association between prevalence and village of residence. The study findings also revealed a statistically insignificant association between gender and bilharzia prevalence, indicating that prevalence cases in the study area are not likely being influenced by differences in livelihood activities between males and females.
The statistically significant association between bilharzia prevalence and major variables analysed in this study has important practical and policy implications. Although the list of major variables considered in this study is by no means exhaustive, the findings highlight the need for targeted treatment interventions for groups such as school-going children and water-related occupations. Awareness and mass treatment programmes were implemented in the Zomba District villages following this study, and these crucial measures are complimentary to the implementation of the national strategy for the control of schistosomiasis in Malawi.

As highlighted elsewhere in this study, some schistosomiasis endemic parts of Africa have reported increased prevalence levels as an unintended consequence of increased reliance on water-related livelihood activities, as people try to cope with highly variable and unreliable rainfall patterns. An important future area of study therefore involves demonstrating how changes in livelihood activities in these communities will impact schistosomiasis prevalence in the medium to long term. Such a long-term prevalence study can also consider other important variables such as land use and other ecological changes that we did not assess, using findings from this and other related studies for baseline information.

The findings presented in this case study are subject to a certain level of uncertainty arising from methodological limitations as well as assumptions used. For example, it is not clear how previous schistosomiasis control efforts may have impacted the results, as these could not be quantified at the time this study was carried out. Prevalence survey results tend to differ between studies, depending on the sampling methods used, and statistical calculations such as confidence intervals are depended on the size of sample under consideration. The chi-square test used to assess the relationship between two categorical variables assumes an independent random sample and two variables that are independent of one another. Further, the chi-square test does not provide much information on the strength of a relationship and this limitation necessitated the use of additional measures to test the strength of association, such as Phi and Cramer’s V applied in this study.

Schistosomiasis can be cheaply treated with a single dose of the drug Praziquantel. Despite the relatively low treatment costs, experiences in this endemic study region show that the re-infection rate is high, requiring two repeated treatments, or as frequent as every six months to lower the prevalence of the disease (Clerinx & Van Gompel, 2011). Funding limitations continue to hamper treatment efforts in Malawi, and more concerted efforts are required from all sectors to mobilise financial resources for combating the disease. Evidence from this study has demonstrated that targeted treatment interventions are urgently required, focussing on complete villages and highly vulnerable groups such as school-going children, and occupations associated with long hours of water contact in endemic regions. Such targeted measures should be part of a holistic package of prevalence reducing measures, including the continued exploration of potentially important options involving biological controls of intermediate host snails.

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