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Intestinal schistosomiasis among preschool children along the shores of Lake Victoria in Uganda

A. Nalugwa[a,*], A. Olsen[b], M.E. Tukahebwa[c], F. Nuwaha[d]

[a] Child Health and Development Centre, College of Health Sciences, Makerere University, Uganda
[b] Department of Veterinary Disease Biology, University of Copenhagen, Denmark
[c] Neglected Tropical Diseases, Vector Control Division, Ministry of Health, Uganda
[d] Disease Control and Prevention, College of Health Sciences, Makerere University, Uganda

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ABSTRACT

Schistosomiasis, a disease caused by *Schistosoma* trematode parasites, affects hundreds of millions of people and accounts for more than 40% of the global health burden due to neglected tropical diseases. In Uganda, intestinal schistosomiasis is endemic in 73 out of 112 districts and about 55% of the population of 36 million individuals are at risk. There is scanty information on the status and burden of schistosomiasis in preschool children less than six years of age in Uganda. This study aimed to assess the status of *Schistosoma mansoni* infections in children aged 1–5 years in Uganda. *S. mansoni* prevalence and intensity of infection were examined in 3058 children from 5 districts along Lake Victoria shoreline, eastern Uganda. For each child one stool sample was collected on three consecutive days. The Kato–Katz technique was used to prepare stool smears on slides for microscopic examination. Short interviews with a standardized pre-tested questionnaire prepared in the local language (Lusoga) were administered to each caregiver to identify risk factors associated with *S. mansoni* infection. An overall *S. mansoni* prevalence of 39.3% (95% CI: 38.0–41.1%) was estimated out of the 3058 stool samples examined. The geometric mean intensity of *S. mansoni* among the infected children was 273 (95% CI: 241–305) eggs per gram of faeces. Both prevalence and intensity of infection increased linearly with age ($P < 0.0001$) and were highest in the age group 49–60 months. Majority (61%) of the children, especially in the age group 12–24 months (84.2%; 95% CI: 75.6–90.1%), were lightly infected. Short interviews with caregivers revealed that preschool children, 1–5 years old, get exposed to *S. mansoni* infested waters through bathing, playing or swimming. It is important that the Uganda national control programme for schistosomiasis takes preschool children into consideration and that health education on transmission of schistosomiasis is delivered to the endemic communities regularly.

1. Introduction

Schistosomiasis (commonly known as Bilharzia) is a disease caused by blood-fluke (trematodes) parasites of the genus *Schistosoma*. Schistosomiasis affects hundreds of millions of people and accounts for more than 40% of the global health burden due to neglected tropical diseases (Hotez and Kamath, 2009). The most prevalent form, intestinal schistosomiasis, is caused by *Schistosoma mansoni*, which infects an estimated 207 million people with more than 90% of the cases occurring in sub-Saharan Africa (Steinmann et al., 2006; Hotez and Kamath, 2009). The disease is distributed throughout Africa and endemic in 54 countries. In Uganda intestinal schistosomiasis is endemic in 73 out of 112 districts and about 55% of the population of 36 million individuals are at risk (Loewenberg, 2014). The disease is particularly severe in communities living along the shores of Lake Albert and the eastern part of Lake Victoria (Dunne et al., 2006; Kazibwe et al., 2010; Kabatereine et al., 2004, Standley et al., 2009; Stothard et al., 2009). *S. mansoni* infection is spread by freshwater snails of the genus *Biomphalaria* (Morgan et al., 2001) and Lake Victoria inhabits two vector species of *Biomphalaria*; *Biomphalaria choanophala* and *Biomphalaria sudanica*. Transmission occurs when schistosome larvae, cercariae, found in faecally contaminated freshwater, penetrate the human skin. Swimming, bathing and wading in contaminated water can, therefore, result in *S. mansoni* infection. In

* Corresponding author at: Child Health and Development Centre, College of Health Sciences, Makerere University, P.O. Box 6717, Kampala, Uganda. Tel.: +256 414541684.
E-mail addresses: allennalugwa@yahoo.co.uk, analugwa@chdc.mak.ac.ug (A. Nalugwa).

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endemic areas, all ages with freshwater exposure are equally at risk of infection.

Several studies on the epidemiology of intestinal schistosomiasis in various parts of Uganda have tended to focus on school-age children (6–15 years of age) and adults in high-risk occupational groups like fishermen (Kabatereine et al., 2004, 2006; Odongo-Aginya et al., 2002; Tukahebwa et al., 2013). The Uganda national control programme for schistosomiasis has also focused on mass drug treatment of similar age groups, leaving out the preschool children (PSC) untreated. Recent studies from other endemic areas in Africa, Uganda inclusive, however, show that PSC are also at high risk of *S. mansoni* infection (Odogwu et al., 2006; Stothard et al., 2011). Children as young as 6 months have been found to be infected with *S. mansoni* (Sousa-Figueiredo et al., 2010) in Uganda.

There is still limited information on the prevalence and intensity of *S. mansoni* in PSC in Uganda. The aim of the present study was to investigate the occurrence and estimate the magnitude of *S. mansoni* infections and its associated risk factors among PSC with a broad coverage of Lake Victoria shoreline in eastern Uganda. This information will throw more light on the campaign to include PSC in the ongoing preventive chemotherapy of schistosomiasis in various endemic communities in Uganda.

2. Materials and methods

2.1. Study area and population

The study was carried out along the north-east shoreline of Lake Victoria, eastern Uganda (Fig. 1). Five districts previously studied and known to be endemic for schistosomiasis *mansoni* with reference to school-age children and adults (Odogwu et al., 2006; Sousa-Figueiredo et al., 2010; Tukahebwa et al., 2013) were surveyed; these include; Bugiri, Buikwe, Jinja, Mayuge and Namayingo. A random sample of 35 communities was selected from the five districts from a list of fishing communities using a table of random numbers. Farming and fishing are the major activities carried out by most people living on the shoreline. All children in the age bracket (1–5 years) who were present on the days of survey were included in the study, with consent of caregivers.

2.2. Survey of risk factors

Short interviews with a standardized pre-tested questionnaire prepared in the local language (Lusoga) were administered to each parent or caregiver to identify risk factors associated with *S. mansoni*. The questionnaire consisted of variables including caregivers' knowledge, attitudes and practices towards schistosomiasis, how long they have lived in the communities, sanitary facilities, frequency of water contact and reasons for water contact (questionnaire submitted in supplementary material).

2.3. Sample collection and detection of S. mansoni

This study was conducted from December 2012 to March 2013. Following community sensitization on the ongoing study and written consent, caregivers whose children were to participate in the study were given orientation on how to handle and submit the stool samples of their children. Stool containers (polythene sheets) labelled with the child's identification number and name were given out to the respective parents. For each child one stool sample was collected on three consecutive days. The Kato–Katz technique was used to prepare stool smears on slides for microscopic examination (Katz et al., 1972). Two slides were prepared and examined for each sample; totalling six slides for each child. A small amount of faeces was pressed through a fine nylon or steel screen to remove large debris, the sieved stool filled into a 41.7 mg hole in a template placed on a slide. The specimen on the slide was covered by a piece of cellophane soaked in glycerol with malachite green used as a cover slip. The two faecal smears were each examined under a microscope and eggs on each slide were counted and recorded by two different experienced field technicians. To ensure the accuracy of the egg counts a 10% of the slides from each field technician were chosen at random and re-read by a senior technician. There were no discrepancies.

2.4. Ethical consideration

The study was approved by the Research and Ethics Committee, College of Health Sciences, Makerere University, and cleared by the Uganda National Council of Science and Technology. Permission to conduct the study in the region was obtained from the President's office/Residential District Commissioner. At the beginning of the study, caregivers were explained the objectives of the study in the local language and were asked to decide the participation of their children. Written consent was provided for each child by their parents/caregivers for inclusion in the study.

2.5. Data analysis

Data were entered in EpiData software version 3.1 (EpiData Association; Odense, Denmark) and double-checked against the original data sheets. Data analysis was performed using Stata/IC release 12.0 (StataCorp; College Station, TX, USA). *S. mansoni* infection was defined as the presence of one or more eggs in at least one of the six Kato–Katz thick smears examined. Prevalence and intensity of *S. mansoni* infection were determined in frequencies and eggs per gram of stool (epg), respectively. Intensity of infection was calculated by multiplying the mean for the six slides by a factor of 24 to obtain eggs per gram stool. The eggs were found to be over dispersed and was thus log-transformed and intensities reported as geometric mean intensity (GMI) of epg among infected children and classified as light (1–99 epg), moderate (100–399 epg), and heavy infections $\geq$400 epg (Montresor et al., 1998; World Health Organization, 1993). Various proportions of interest were calculated and comparisons made using the Pearson χ^2 test. Univariate logistic regression analysis was used to assess the association between each risk factor and *S. mansoni* infection using chi square test. Crude and adjusted ORs (odds ratio) and CIs (confidence interval) were also calculated (Fleiss, 1981). To determine the independent risk factors associated with infection, multiple logistic regression analysis was performed using adjusted odd ratio at 95% confidence interval (Breslow and Day, 1980). All variables that showed significant difference with $P < 0.2$ in the univariate analyses were used to develop the multiple logistic regression "STEPWISE" models. *P*-values of less than 0.05 were considered statistically significant.

3. Results

3.1. S. mansoni prevalence and intensity of infection

A total number of 3058 children (1–5 years of age), 1513 girls and 1545 boys, were examined for *S. mansoni* infection. The overall prevalence of *S. mansoni* was 39.3%and varied significantly among districts ($\chi^2 = 9.97$; $P = 0.041$); highest in Jinja district (53.4%) and lowest in Bugiri district (35.0%). The prevalence also varied significantly ($\chi^2 = 387.206$; $P = 0.0001$) among the study communities within the districts; ranging from 0% in Sityohe and Kwomutumba to 66.7% in Lugala. The prevalence of schistosomiasis increased linearly with increasing age in girls ($\chi^2 = 207.7$; $P = 0.0001$) and boys ($\chi^2 = 219.4$; $P = 0.0001$) (Table 1 and Fig. 2). The overall GMI among

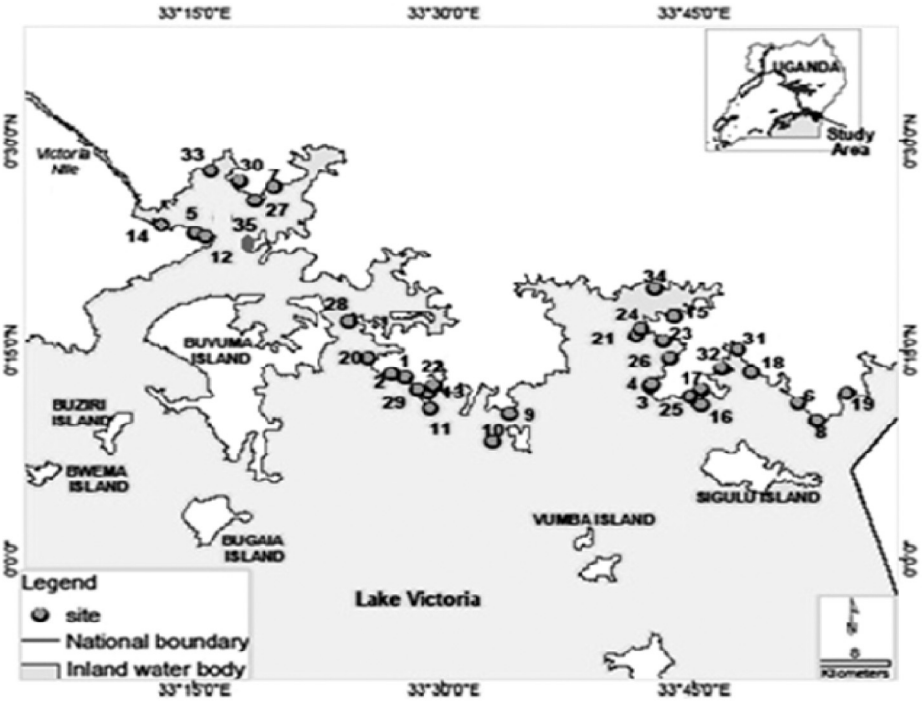

Fig. 1. Map showing study sites along the shores of Lake Victoria, eastern Uganda: 1 – Bukagabo A; 2 – Bukagabo B; 3 – Bumeru A; 4 – Bumeru B; 5 – Busana; 6 – Busiro; 7 – Busuyi; 8 – Buyondo; 9 – Bwondha; 10 – Gori Island; 11 – Kabuka; 12 – Kalindi; 13 – Kayanja; 14 – Kikondo; 15 – Kwomutumba; 16 – Lubango A; 17 – Lubango B; 18 – Lufudo; 19 – Lugala; 20 – Malindi; 21 – Maruba; 22 – Masaka; 23 – Matiko; 24 – Mpanga; 25 – Mulwanda; 26 – Musoli; 27 – Musoli A; 28 – Namoni; 29 – Nango; 30 – Ntinkalu; 31 – Sidome; 32 – Sityohe; 33 – Wairaka; 34 – Wakawaka; 35 – Kisiima Island.

the infected children in the study population was 272.7 epg (95% CI: 240.9–304.5 epg). The intensity increased linearly with age (1 df, F – 42.3, P = 0.0001) in both girls and boys; lowest in age group 12–24 months and highest in age group 49–60 months (Table 1 and Fig. 2). Geometric mean intensity of infection differed significantly (P = 0.017) between girls 387.0 (95% CI: 301.7–472.4) and boys 489.4 (95% CI: 392.1–586.7) in age group 49–60 months (Table 1).

The overall proportions of lightly, moderately and heavily infected children were 60.7%, 21.8% and 17.5%, respectively (Table 2). Age group 12–24 months showed the highest level of

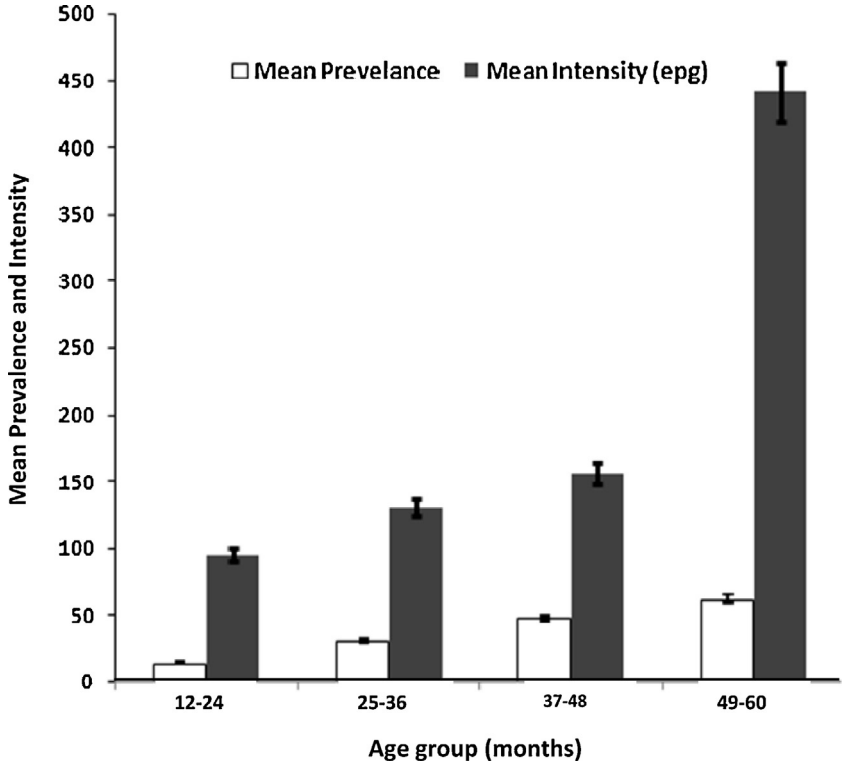

Fig. 2. Prevalence and intensity of *Schistosoma mansoni* infection by age group; error bars show 95% confidence limits.

Table 1
Schistosoma mansoni infection prevalence (%) and geometric mean intensity (GMI) among infected children by sex and age.

Sex/age (months)	Infected children	Prevalence (95% CI)	GMI in epg (95% CI)
Girls			
12–24	57	14.7 (11.5–18.6)	101.9 (52.4–151.4)
25–36	120	29.7 (25.4–34.4)	117.6 (82.7–152.5)
37–48	143	45.7 (40.2–51.2)	177.7 (128.6–226.9)
49–60	253	61.9 (57.0–66.5)	387.0 (301.7–472.4)
Total girls	**573**	**37.9 (35.5–40.3)**	**250.0 (208.2–291.8)**
Boys			
12–24	44	12.5 (9.5–16.4)	85.6 (34.0–137.2)
25–36	119	32.9 (28.2–37.9)	142.8 (100.8–184.8)
37–48	184	49.3 (44.3–54.4)	138.5 (109.7–167.3)
49–60	283	61.7 (57.1–66.0)	489.4 (392.1–586.7)
Total boys	**630**	**40.8 (38.3–43.3)**	**293.3 (245.9–340.6)**
Overall	**1203**	**39.3 (37.6–41.1)**	**272.7 (240.9–304.5)**

light infections, while age group 49–60 months showed the highest level of heavy infections (Table 2).

3.2. Risk factors associated with S. mansoni infection

The majority (93.0%) of the caregivers interviewed were aware of the existence of intestinal schistosomiasis in their communities but 84.0%were ignorant of how the disease is transmitted and its related symptoms. The study results show that children from households which have lived in the village for more than 5 years had a significantly higher prevalence of schistosomiasis; 41.7%, 43.4% and 47.0% among households which had lived for 5–9 years, 10–14 years, 15+ years respectively compared to 32.5% among households that lived less than 5 years. Further analysis with multiple logistic regression model (Table 3) revealed that children who were born from village had significantly higher odds of having schistosomiasis when compared to those not borne in the village (AOR = 1.5; 95% CI: 1.1–2.0).

Older children were more likely to get infected; 2.2 times (95% CI: 1.5–3.3), 5.3 (95% CI: 3.6–7.8) and 7.2 times (95% CI: 5.0–10.4) among 25–36 months, 37–48-months and 49–60 months respectively than their young counter parts aged 12–24 months old. Children who go with parents/caregivers or by themselves to the lake had higher odds of having schistosomiasis compared to their counterparts who do not go to the lake (AOR = 1.8; 95% CI: 1.3–2.6). Significantly higher odd of having schistosomiasis were identified among children who spent a long period (>1 h) in the lake, 2.4 times (95% CI: 1.6–3.6) compared to those who stay at lake for less than 5 min. Children who bathe and play/swim (Fig. 3) in the infested lake water were more likely to get infected (bathe: AOR = 2.4; 95% CI: 1.9–3.1; play/swim: AOR = 2.4; 95% CI: 1.9–3.2) than those who do not bathe, play or swim in the lake. Sex of child and distance of home from the lake both had no significant association of *S. mansoni* infection in preschool children.

Fig. 3. Children playing and fetching water at Wakawaka landing site along Lake Victoria shoreline , Bugiri district.

4. Discussion

The present study investigated the status of intestinal schistosomiasis in PSC (1–5 years of age) in Uganda and the results clearly demonstrate that children in this age bracket living along water bodies are at high risk of *S. mansoni* infection. Prevalence of *S. mansoni* infection (39.3%) in PSC reported in this study compares favourably with findings of previous studies in Uganda (Odogwu et al., 2006; Sousa-Figueiredo et al., 2010) and other sub-Saharan *S. mansoni* endemic countries. The infection rate estimated in PSC in this study reveals the magnitude of the health burden of intestinal schistosomiasis on the Lake Victoria shoreline and Uganda in general. Previous studies in Uganda have presented higher prevalence in school-age children >5 years and adults (Kabatereine et al., 2004; Odongo-Aginya et al., 2002; Tukahebwa et al., 2013). This presents a high risk of infection to preschool children living along Lake Victoria shoreline, hence the notable rate of infection observed in this study.

Considering responses of caregivers of PSC interviewed, indication is that these children are exposed to infection through lake water mainly by bathing and playing. Caregivers reported taking their children with them to the lake when carrying out routine domestic activities like fetching water, washing clothes and utensils, buying and cleaning fish. The caregivers find it convenient to either bathe the children direct in lake water or in a basin carried for washing before going back home. The older children (3–5 years) also get a chance to bathe and play in the shallow water while waiting to go home. Notably, most PSC stay with no clothes on during most of the day (Fig. 3), exposing their entire bodies to the infested water. Caregivers fetch and carry water back home and this can also be a source of infection if children are bathed in it within 24 h before the cercariae become too weak to penetrate. The rate of schistosomiasis infection in the PSC noted in this study is also attributed to the community general knowledge, practices and attitudes towards schistosomiasis. The majority of caregivers were aware of the existence of the disease in their communities but unfortunately many

Table 2
Proportions of egg counts according to infection levels, Light (1–99 epg), moderate (100–399 epg) and heavy infections (≥400 epg), among infected children by age groups.

Age group (months)	Light (epg %) 95% CI	Moderate (epg %) 95% CI	Heavy (epg %) 95% CI	*N*
12–24	84.2 (75.6–90.1)	10.0 (5.4–17.5)	5.9 (2.7–12.7)	101
25–36	72.4 (66.4–77.7)	18.4 (14.0–23.9)	9.2 (6.1–13.6)	239
37–48	64.0 (58.5–69.0)	25.4 (20.9–30.4)	10.7 (7.8–14.6)	327
49–60	49.1 (44.8–53.3)	23.3 (19.9–27.1)	27.6 (24.0–31.6)	536
Overall	**60.7 (57.9–63.4)**	**21.8 (19.5–24.2)**	**17.5 (15.5–19.8)**	**1203**

Table 3
Multivariate analysis of factors associated with *S. mansoni* infection among preschool children (1–5 years old).

Variable	COR (95% CI)	*p*-value	AOR (95% CI)	*p*-value
Child born in village (ref: no)				
Yes	1.6 (1.2–2.1)	0.01*	1.5 (1.1–2.0)	0.02**
Sex of child (ref: girl)				
Boy	1 (0.8–1.3)	0.68 ns		
Age of the child (months) (ref: 12–24)				
49–60	8.3 (5.8–11.9)	0.01*	7.2 (5.0–10.4)	0.01**
37–48	6.3 (4.3–9.1)	0.01*	5.3 (3.6–7.8)	0.01**
25–36	2.5 (1.7–3.7)	0.01*	2.2 (1.5–3.3)	0.01**
Distance of home from the lake (ref: <5 km)				
Near (5 km)	0.9 (0.7–1.2)	0.45 ns		
Far (5–10 km)	0.6 (0.4–1)	0.05 ns		
Very far (>10 km)	0.5 (0.1–2)	0.35 ns		
Child goes to the lake (ref: no)				
Yes	1.9 (1.4–2.6)	0.01*	1.8 (1.3–2.6)	0.01**
Duration at the lake (ref: <5 min)				
Very long period of time (>1 h)	3.6 (2.5–5.2)	0.01*	2.4 (1.6–3.6)	0.01**
Long time (15 min–1 h)	2.0 (1.4–2.9)	0.01*	1.5 (1.0–2.3)	0.04**
Short time (5–15 min)	1.9 (1.2–2.9)	0.01*	1.7 (1.1–2.8)	0.02**
Water contact activity (ref: fishing)				
Bathe	2.5 (2.0–3.2)	0.01*	2.4 (1.9–3.0)	0.01**
Play/swim	3.5 (2.8–4.4)	0.01*	2.4 (1.9–3.2)	0.01**

NB: COR, crude odds ratio; AOD, adjusted odds ratio; CI, confidence interval; ns, not significant at $P \geq 0.05$.
* Significant at ($P < 0.05$).
** $P < 0.01$.

did not know how the disease is acquired, neither its symptoms. On the other hand, many communities having no other source of clean water other than the contaminated lake continue to inevitably and unknowingly expose their children to infested lake waters.

Comparison of schistosomiasis prevalence among age groups showed that PSC aged 37–60 months had the highest rate of infection. Notably, the present study shows higher *S. mansoni* infection of 37.3% in Bwondha compared to 25% reported in the same community by a previous study (Odogwu et al., 2006). The age difference in children from the two studies explains the difference in the rate of infection. Children age 3–5 years in the present study were at higher risk of infection due to their frequent water contact behaviour than the young ones (<3 years) in the previous study (Odogwu et al., 2006). This is also attributable to the duration of exposure which is longer in the older children who have lived more years to acquire infection. This also explains why children in this study showed a relatively higher (39.3%) overall *S. mansoni* infection rate compared to 16.0% showed in children <3 years (Sousa-Figueiredo et al., 2010) from Lake Victoria. This report is in line with findings in other studies (Ekpo et al., 2012; Garba et al., 2010; Mutapi et al., 2011; Odogwu et al., 2006) that older children in any given schistosomiasis endemic area are at higher risk of infection than the much younger ones. In contrast, however, previous studies in Bugoto (along Lake Victoria shore) and Bugoigo (along Lake Albert shore), both showed higher infection rate in young children age <3 years, 85.7% (Odogwu et al., 2006) and 44.3% (Sousa-Figueiredo et al., 2010) respectively. This could be due to water contact activities and duration of exposure to infection which differ from one locality to another. Perhaps, some communities, where infection is high, engage in high-risk activities like bathing their children in infested waters. Secondly, when carrying out other activities like cleaning and drying fish at the lake side some caregivers spend longer time at the lake. This exposes children who go with them to the lake to more infections than those who stay for a shorter time.

In this study, boys and girls have the same rate of infection. In contrast, *S. mansoni* infections in school-age children were found higher in girls (22%) compared to boys (18.4%) in a study carried out in Ethiopia (Essa et al., 2012). Other studies have, however, indicated that *S. mansoni* infection is more common in boys than in girls (Assefa et al., 2013; Imran et al., 2014; Kabatereine et al., 2004). The argument is that girls carry out the house hold activities like washing and fetching water which exposes them to infested waters, but for short periods, while boys swim in the water and engage in fishing which lead to repeated and long-time exposure to infection. Preschool children (1–5 years), on the other hand, irrespective of sex, display almost similar water contact activities and many are actually passively infected when being washed or when accompanying their caregivers to the lake.

A greater proportion (60.7%) of the children had light intensity infection and this was prominent (84.2%) in the 12–24 months. Heavy intensity infection common in school-age children and adults (Kabatereine et al., 2004; Tukahebwa et al., 2013) was observed in a small proportion (17.5%) of children but highest (27.6%) in the 49–60 months old. The high proportion of light intensity can be attributed to a shorter time of exposure to infection and thus reduced worm burden and less egg excretion in preschool children. However, overall mean intensity of infection (272.7 epg) reported in this study is surprisingly higher than what has been reported in school children and adults in Uganda. Tukahebwa and co-authors reported an overall intensity of 236.2 epg for a fishing community composed of school-age children (aged 7–19 years) and 20–40+ years adults (Tukahebwa et al., 2013). In a similar study, school-age children (>6 years), showed intensity of infection 219.6 epg (Kabatereine et al., 2004). The comparable infection intensity among PSC with older children and adults could be due to the fact that PSC are not part of the schistosomiasis control programme and have never been treated since their first infection. The accumulated and high infection rates reveal high vulnerability and early *S. mansoni* infection in PSC. Children generally have higher prevalence and intensities of infection than adults, which reflect a lower acquisition of worms in adulthood. This lower acquisition is probably a combination of reduced exposure to infection and age-dependent changes in innate resistance or acquired immunity. In the present study, the age-prevalence and age-intensity curves are steadily increasing indicating that acquired immunity has not been effective yet. Children can acquire their first infection at the age of

5months (Stothard et al., 2011), but it is not clear whether such an early infection has an impact on the acquired immunity later in life.

Additionally, children in the age group 49–60 months displayed a higher infection intensity than their younger counter parts and this is probably due to the fact that older children frequently go to the lake shore to play and fetch water as reported elsewhere (Ekpo et al., 2012). These children spend more time in the infested lake water compared to their young ones, thus increasing the exposure time for infection of *S. mansoni*. It is evident in this study that children who spend more than 5 min at the lake are more likely to be infected than those who spend less time at the lake. Another reason for this higher intensity in the oldest age group is the build-up of worm loads with age as the life-span of *S. mansoni* worms is approximately 3–6 years (Anderson, 1987). If these children are not treated for the *S. mansoni* infections they are likely to have a cumulative intensity over years.

Moreover, intensity of infection was significantly higher in boys (489.4 epg) than in girls (387 epg) and this can be partly attributed to duration of exposure; boys tend to play and spend more time in the lake water than girls of the same age. In this explanation emphasis is put on age group 49–60 months who can go to the lake by themselves and in the company of an older sister or brother. However, sex hormones have also been implicated as one of the most important host factors that control the onset, establishment and pathogenesis of schistosomiasis (Escobedo et al., 2005). There has been found a bias towards males in the susceptibility to and severity of several parasitic diseases explained by influence of the male sex hormone, testosterone, on the immune system (Bernin and Lotter, 2014). Testosterone is said to decrease antibody production (McClelland and Smith, 2011) and thus prevents excessive immune responses (Gaillard, 1994) compared to female hormones which promote anti-inflammation (Degu et al., 2002). Unfortunately, the current knowledge on the existence of such a male bias in schistosomiasis is inconclusive (Bernin and Lotter, 2014). Furthermore, it must be expected that if such a bias exists it is most likely that it will be developed after the onset of puberty and not obvious already in the preschool child.

In conclusion, our findings show that preschool-aged children 1–5 years on the northern Lake Victoria shoreline of Uganda are at high risk of intestinal schistosomiasis infection as much as are school-age children and adults. There is urgent need to expand epidemiological studies to PSC in endemic communities and consider the inclusion of children of all ages in the national schistosomiasis control preventive strategies, to avoid long-term health consequences of infection in the PSC. If left untreated, these children can be potential source of continuous re-infection in endemic communities where successful control programmes have been implemented. Finally, endemic communities should be educated and constantly reminded of the dangers of improper water contact activities which lead to acquiring schistosomiasis.

Competing interests

The authors declare that they have no competing interests.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.actatropica.2014.11.014.

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