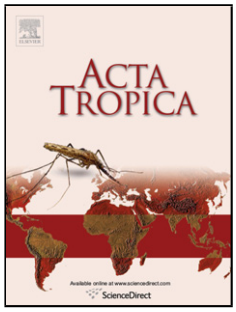

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The epidemiology of Schistosomiasis in Lango Region Uganda 60 years after Schwetz 1951: Can Schistosomiasis be eliminated through Mass Drug Administration without other supportive control measures?

Running title: The epidemiology of schistosomiasis in Lango region, Uganda,

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Graphical abstract

Main Research Highlights

- Lango region, the only known co-endemic for urinary and intestinal schistosomiasis.
- We present the epidemiology of schistosomiasis since 1951-2011 determined through stool and urine examinations and a restrospective records review.
- *S. haematobium* was quite low and confined to a few putative foci while a reverse trend observed for *S.mansoni.*
- Infection rates declined from the original prevalence of 28.2% in 1951 to just 2.48% by 2011.

Abstract.

Introduction: Lango region is the only known endemic region for urinary and intestinal schistosomiasis in Uganda. Although there has been no significant improvement in sanitation and safe water supply in the region over years, the endemicity and prevalence of *Schistosoma haematobium*, in particular, have declined, perhaps due to yearly mass treatment campaigns implemented since 2003.

Methods: We report the epidemiology of Urinary and Intestinal schistosomiasis in Lango since 1951-2011 determined through Microscopic examinations for *S.mansoni* and *S.haematobium* respectively. A retrospective data review from 195-2011 was done to establish the prevalence over the years in the region. We performed Poisson regression analysis to observe trends in epidemiology before and after control was initiated in 2002. In addition, malacological surveys were undertaken in 2007 to assess local transmission potential.

Findings: Contrary to earlier records, *S. haematobium* was low and confined to a few putative foci, with declined in infections from 28.2% in 1951 to 2.48% by 2011. Although this decline can be attributed to control, this was already much lower in 1967 than 1951, long before control interventions began suggesting that environmental changes may have made the habitat less suitable for the transmission of *S.haematobium*. Compared to the historical records *S.mansoni* prevalence first increased up immediately before control interventions in 2003, significantly declined ($p=<0.001$) until 2007. However, in 2007 and 2011 declined insignificant, ($p=0.656$). No snail has ever been isolated shedding *S.haematobium* cercariae but many *Bulinus* snail spp were found shedding *S.bovis* cercariae.

Conclusion: This suggests that a combination of environmental and mass treatment has had a significant impact on transmission in Lango region.

Keywords: **Urinary schistosomiasis, Intestinal schistosomiasis, Lango region, Uganda.**

Introduction

Schistosomiasis is a chronic parasitic disease of man caused by blood flukes of genus *Schistosoma.* It is an ancient disease detected in Egyptian mummies from 1198-1150 BC (Deelder et al., 1990). Estimated to afflict some 200 million people in 76 countries and a further 600 million are at risk of the infection, 85% of whom live in sub-Saharan Africa (WHO, 1998) with about 120 million having the symptomatic disease and 20 million suffer severe morbidity (WHO, 1993).

In sub-Saharan Africa, most cases of human schistosomiasis are caused by infections with *S. haematobium* or *S. mansoni*, which cause urinary or intestinal schistosomiasis respectively, and both forms of the disease exist in Uganda (Kabatereine et al., 2004b). *S. mansoni* infections are more common, especially in communities living near large water bodies such as Lakes Victoria, Albert, and Kyoga, along with the Albert Nile. The transmission has been reported to occur in irrigation schemes and paddy fields and in several valley dams in Uganda (Bukenya et al., 1994, Adriko et al., 2013). Country-wide estimated to infect 7 million Ugandans with 16.7 million at risk (Kabatereine et al., 2004a), with *S.haematobium* limited to central northern Lango region (Kabatereine, 2000).

Urinary schistosomiasis was first detected in Uganda in 1946 (Schwetz, 1951) and in 1967 (Bradley et al., 1967) in school Age children in Lango region. This remained a single district till the 1970s but currently comprised 8 districts of Apac, Kole, Oyam, Lira, Alebtong, Otuke, Amolatar and Dokolo. Prevalence was observed to be 25% in the 5-9years and 50% in 10-14 years (Bradley et al., 1967). High infections were observed in Abilonino and Teboke Primary Schools at 52% and 56%, respectively (Schwetz, 1951). However, since that study, no further

follow-up surveys were conducted in this region until the start of the Uganda National Bilharzia Control Programme in 2003, thus highlighting the importance of this study. It's likely that the high disease endemicity continued until after annual mass treatment campaign was initiated in 2005. What is now clear is that *S.haematobium* seems to have been successfully controlled to a level where it is no longer of public health importance (Kabatereine et al., 2007). Intestinal schistosomiasis was first detected in Lango in 1967 (Bradley et al., 1967) with a low prevalence below 5%. However, by 1990, *S.mansoni* was becoming a serious public health concern in the region. However, the snail-schistosome positivity rate has never been high (Schwetz, 1951, Bradley et al., 1967). In this paper, we document the prevalence of schistosomiasis from 1951, 2007 and 2011 and the gold standard syringe filtration method in Lango region of central northern Uganda. Following the 2001 World Health Assembly resolution 54.19 (WHO, 2002), Uganda initiated a national bilharzia and worm control programme in 2003 (Kabatereine et al., 2007) that first targeted high-moderate transmission foci near large Lakes and along river Nile. Lango region, though not in a such a location, was among the priority areas because it is the only area in the country where both urogenital and intestinal schistosomiasis co-occur (Kabatereine et al., 2004a, Kabatereine et al., 2007). The control strategy of mass treatment with praziquantel supported by health education messages for behaviour change targeted anyone 5 years and above or over 90cm in height according to the WHO guidelines (Montresor et al., 2001, Sousa-Figueiredo et al., 2010). The control was vertical between 2003 and 2007 and thereafter integrated into the larger NTD control programme riding over child health days. Lango region is situated in central northern Uganda that experienced political insurgency from 1980s-2006.

Surveillance of vector snail dynamics and infection levels is vital and can provide an early warning of the possibility of an increase in transmission, thus all human water contact sites

were surveyed for infection and sampled snails catalogued. No particular snail species has ever been isolated from shedding human schistosome cercariae in the Lango region.

2. Materials and Methods

2.1. Study area and population

This study was carried out in the former Lango District previously described by (Schwetz, 1951), a region affected by the Lord's Resistance Army insurgency stretching from the early 1990s to 2007.

Figure I: Showing the Location of Study areas in Lango region

<**Please insert figure I**>

2.2.Urine and stool specimen collection for parasitological examinations

From 1952-2002, the prevalence of *S.mansoni* and *S.haematobium* was retrospectively reviewed from published literature from Lango sub-region. A total of 27-schools and 3-high risk communities, 22-schools and 8-communities were surveyed in 2007 and 2011 respectively in the districts of Apac, Kole, Oyam, Lira, Alebtong, Otuke, Amolatar and Dokolo. The study sites were stratified into different ecological zones and later randomly selected from the historically-known *S.haematobium* hot spots in the region. Coordinates of the study sites were taken using a handheld GPS system (e-Trex, Garmin, USA).

Before collection of urine and stool samples, the purpose was explained to head teachers and pupils and political leaders and then later to the communities that took part in the study. Informed consent was obtained from all the adults who took part in the study. The parents and guardians were requested to provide consent for their children aged 5-17 years while children aged 8-14 years were also requested to provide an informed assent to participate in the study. The participation in the study was voluntary. Thereafter, all individuals who fulfilled the

inclusion criteria were given urine and stool containers and requested to provide a single day's specimen between 10.00-15.00 hours corresponding to peak schistosome egg excretion period (Ndyomugyenyi and Minjas, 2001).

2.3.Specimen examinations

About 20 ml of urine were collected and tested for the presence of microhaematuria (cryptic blood in urine) using reagent strips (Hemastix©, Bayer, Germany). The amount of blood in urine was scored semi-quantitatively as negative, trace, +, ++ or +++, as the scores are believed to correspond qualitatively to presence and intensity of *S.haematobium* infection (Wilkins et al., 1979). For confirmation of the infection, a syringe filtration method (Peters et al., 1976) was used to detect eggs in each urine sample ,first thoroughly mixing the urine by agitation from which a 10ml urine sample was slowly forced through a nylon filter membrane of 8-µm pore size (Nucleopore, Pleasanton, CA) held on a swinnex filter holder. After filtration, the nylon membrane was placed on a microscope glass slide, moistened with a drop of physiological saline and examined for schistosome eggs (WHO, 2002). For *S.mansoni* infections, stool samples were processed using Kato-Katz double thick smears (Katz et al., 1972) using a 41.7 mg template and duplicate smears examined under a microscope according to WHO guidelines (WHO, 2002).

2.4. Malacological surveys

In 2007, Snail surveys were conducted in the vicinity of each school surveyed for *Bulinus* and *Biomphalaria* snail species following guidelines described elsewhere(Madsen., 1985) and taken to a central field laboratory for morphological identification using field keys (Kristensen, 1987). Cercariae were identified under the dissection microscope (x40) using identification keys (Frandsen and Christensen, 1984). A number of water chemistry parameters were also

collected during the malacological surveys in 2007. These were included in regression models to identify factors which might be relevant to predicting the presence/absence or abundance of trematode intermediate host species.

2.5.Ethical considerations

All children found positive for schistosomiasis were treated with praziquantel Distocide® 600 mg, Shin Poong Pharmaceuticals, Seoul Republic of Korea, 40 mg/kg body weight. Regardless of infection status, one tablet of albendazole (Alzental® 400mg) was given to each child for treatment of intestinal worms. This study was approved by the Vector Control Division Research Ethics Committee and Ugandan National Council of Science and Technology and formed part of the monitoring and surveillance activities of the Ugandan National Control Programme as approved by the NHS-LREC of Imperial College London (application 03.36).

2.6.Data analysis

The data were first tabulated on paper reporting sheets then entered into the computer and analyzed using commercial statistical software (SPSS/PC+; SPSS Inc., Chicago, IL) and R version 2.5.2 (Ihaka R. and Gentleman R., 1996). Prevalence and confidence intervals were calculated using the binomial distribution and multivariate logistical regressions were carried out using generalized mixed models for categorical response variables and linear models for continuous response variables. A Poisson regression model was constructed to explore the existence of a trend in the active schistosomiasis cases found in Lango sub-region; pre-intervention (1952-2002) and post-intervention (2003-2011). The model was constructed as follows: $y_i=a+bt_i$……I where y is the prevalence of a disease for each year and t is the time in years for either pre or post interventions. In the model, ***a*** is the intercept and ***b*** is the slope.

Coefficient b is a parameter of interest in trend analysis. The statistical significance of *b* is an indication of the existence of an increase or decrease in the trend of the measured variable over time. The increase/decrease is determined by the sign "+/-" respectively. The robustness of the model was based on a log-likelihood ratio with a $P<0.005$. Water chemistry parameters collected during malacological surveys in 2007 and altitude data were included in a regression model to identify factors relevant to predicting the presence/absence or abundance of trematode intermediate host species.

Results

*3.1.*Prevalence of schistosomiasis in Lango from 1951-2011.

Generally, *S.mansoni* has become more prevalent and endemic than urinary schistosomiasis. The comparisons of *S. haematobium* prevalence data by survey site both in 2007 and 2011 as detected by either haemastix or urine filtration test. Only 8/1877 people examined in 2011 by the filtration test were positive corresponding to a prevalence of 0.43% (95% CI = 0.2 - 0.8). Only 12 children were co-infected with both *S.mansoni* and *S.haematobium* (Hemastix if trace results were considered positive) corresponding to 0.65% (95% CI = 0.34-1.14). However, the number drops to 7 if trace results are considered negative, which is 0.38% (95% CI = 0.15-0.78). Unfortunately, there was lack of agreement between the haemastix results and data collected using the urine filtration technique, the Kappa indices being extremely low at 0.08 and 0.10 leading to a conclusion that the concordance between the two methods was actually very poor. As such, this was taken as an evidence that other conditions, such as menstruation or bladder infections, which can often increase the risk of blood in urine in females, may be confounding the diagnosis of *S. haematobium* in the 2007 and 2011 surveys, leading to perceived greater prevalence of *S. haematobium* than was actually the case. Also counter-intuitively, the odds ratio for age of the 2007 data was greater than one, indicating a positive relationship between infection risk and increasing age (OR =1.05; 95% CI = 1.04-1.06). The

significant relationships between *S. haematobium* infection and sex/age were the same whether trace Hemastix results were considered positive or negative, and which is very unusual for a school age group of 10 to 15 years. Usually, the prevalence of *S. haematobium* infection is at a climax in the age group 10 to 15 (Tchuem Tchuente et al., 2003, Atupele et al., 2009). Thus in this study, the filtration technique results were taken to be the true current situation of the disease in Lango.

3.2.S. haematobium and coinfection with S. mansoni.

S.haematobium infection rates as detected by the two tests, a generalized linear model (GLM) looking at factors influencing the binomial prevalence of *S. haematobium* infection as diagnosed by haemastix was carried out. Age, sex, and knowledge were all included in the model as explanatory variables and only age was significant ($p < 0.0001$). The odds ratio was 0.81 (95% CI = 0.72-0.90), indicating that the risk of infection decreased with increasing age. Only age and sex were available to use as explanatory variables and they were significant in the GLM; $p = 0.001$ and $p < 0.0001$, respectively). The odds ratio for sex was 1.70 (95% CI =1.23-2.36), and males were the baseline, indicating greater risk in females. Also counter-intuitively, the odds ratio for age of the 2007 data was greater than one, indicating a positive relationship between infection risk and increasing age (OR =1.05; 95% CI = 1.04-1.06). The significant relationships between *S.haematobium* infection and sex/age were the same whether trace haemastix results were considered positive or negative, and which is very unusual for a school age group of 10 to 15 years. Usually, the prevalence of *S. haematobium* infection is at a climax in the age group 10 to 15 (Tchuem Tchuente et al., 2003, Atupele et al., 2009). Thus in this study, the filtration technique results were taken to be the true current situation of the disease in Lango. The *S.haematobium* results shows significant decrease of infection in 2011 compared to historical data 28.2% (21.3–35.1) by (Schwetz, 1951) and 12.3% (8.3–16.3) by

(Bradley et al., 1967), (p <0.0001), Not only did the prevalence of *S. haematobium* decrease but also the number of sites where positive cases were found also decreased. For example, in 1951, 5/6 schools surveyed had positive cases (Schwetz, 1951) compared to only 2/30 in 2011 (Fig.1). Furthermore, each site with positive cases had prevalence generally above 20% in the 1950s'.

Figure II: shows Trend analyses of schistosomiasis cases reported for years 1951-2011 in Lango Region.

<***Please insert figure II***>

The highest recorded site prevalence by (Schwetz, 1951) was 68.8% (52.7–84.8) and 51.6% (39.2–64.1) by (Bradley et al., 1967), compared to 11.3% (4.7-21.9) in Acandyang community in 2011, (Table I) and this difference was highly significant, (p <0.0001).

Table I: shows *S.mansoni* and *S.haematobium* co-infections in Lango region.

<***Please insert table I***>

Overall, the trends of *S.haematobium* before intervention showed a decrease over the time period (b=-0.06, *P*=0.02) but slightly increased during post interventions phase (*b*=0.77 *P*=0.05) (Table II).

Table II: shows the trends of Schistosomiasis Prevalence in Lango region.

<**Please insert table II**>

3.3.Schistosoma mansoni

Table III shows the pre-control prevalence data in 7 communities in 2000 in comparison to the post-intervention follow up surveys either in 2007 or 2011 or both. Both the pre-control

and the follow–up surveys used Kato Katz technique (Katz et al., 1972) for stool survey. There was a tremendous decrease in the overall infection rate from 62.35% in 2000 to 11.84%, in 2007, and this decrease was significant (P <0.01). Overall, the trends of *S.mansoni* showed an apparent increase over a time period before intervention (b= 0.07, P<0.01), and decreased significantly after initiation of control interventions (b= -0.2, P<0.01). However, when restricted to the shared sites between 2007 and 2011, the change in prevalence was low and insignificant (table 4). Although difficult to compare prevalence between time points where the surveys utilized different diagnostic techniques, *S. mansoni* was rather a common infection before the control and was found in all sites surveyed in 2000 (Table III) and in 6/9 sites in 2011, (Table III). This observation when compared to records in the fifties and sixties (Schwetz, 1951, Bradley et al., 1967).

Table III: shows the comparison of *S. mansoni* infection rates between the pre-control Period in 2000 and the post control era either in 2007 or in 2011 or on both years and Comparing *S. mansoni* prevalence in sites surveyed both in 2007 and 2011 in the Lango

<***Please insert table III***>

3.4.Malacological survey in 2007

A total of 2002 snails were collected of which 1084 (54.0%) were *Biomphalaria* and 918 (46.0%) were *Bulinus* as shown in table IV. Overall figure was relatively low compared to old records in the pre-1967 period and none of the *Biomphalaria* snails shed human schistosome cercariae, However, 6(1.2%) *Bulinus nasutus* snails from Apac were shedding schistosome cercariae which were later genotyped by PCR and identified as *Schistosoma bovis*.

Table IV: shows the total number of Biomphalaria spp and Bulinus collected and Infection status with Schistosome cercariae by the district in 2007

<***Please insert table IV***>

4. Discussion

Despite the poor sanitary conditions and limited safe water the people continue to live under, the results of this study demonstrate a significant decline of schistosomiasis prevalence in the Lango region, a remote rural area of Uganda. Thus these observations were contrary to the general expectations where boys are more likely to be infected than females (Bradley et al., 1967, Saotoing et al., 2011, Atupele et al., 2009, Biu et al., 2009). Both *S. haematobium* and *S. mansoni* prevalence were significantly lower than the pre-control levels, ($p < 0.0001$). However, *S. mansoni* was widespread while *S. haematobium* was limited to just a few foci; quite opposite to the historical records for *S.haematobium* rather than *S. mansoni*. The tremendous decline occurred from 2003-2007, $p < 0.0001$ when control was vertical. But when the analysis was limited to the shared sites (table 4; 2007-2011) the change in prevalence was slow and insignificant $p = 0.656$. Furthermore, *S.haematobium* haemastix prevalence had significantly reduced from 1967-2007 ($p < 0.0001$), however by 2011, returned to the 1967 level $p = 0.150$.

The major drawback of this study covering a period of 60 years was the difficulty to compare prevalence between time points especially since different diagnostic techniques were applied and compared. The 2011 surveys utilized the highly sensitive filtration and the Kato Katz techniques (Niels Ørnbjerg Christensen. et al., 1984) for *S.haematobium* and *S.mansoni* respectively, the concentration technique applied for both *S.mansoni* and *S.haematobium* by (Bradley et al., 1967) while (Schwetz, 1951) applied the direct smears technique which is generally poor method for schistosomiasis examination (Niels Ørnbjerg Christensen. et al., 1984). The 2007 *S.haematobium* survey utilized an indirect haemastix method for *S. haematobium*. Nevertheless, we believe the decreasing trends reported here is a true evaluation of schistosomiasis epidemiology over the 60 year period. The diagnostic techniques applied during the historical era were less sensitive compared to those used from 2000 onwards and

thus if the decrease had not occurred one would naturally have expected the historical prevalence to be lower rather than the reverse since less sensitive techniques were applied. Using the highly sensitive filtration technique in 2011, only 8/1877(0.43%; 95% CI = 0.18-0.84) were positive for *S.haematobium* eggs. This was lower than reported in earlier studies (Schwetz, 1951, Bradley et al., 1967). However, both the 2007 and 2011 surveys utilized the haemastix method and the shared sites between the two surveys showed that 2011 had a significantly higher infection rate than 2007 ($p < 0.0001$). It is possible that in earlier studies, the low prevalence figures were attributable to the insensitivity of technique they applied and thus several cases might have been missed. The 2007 and 2011 surveys utilized Kato Katz method while (Schwetz, 1951) used the direct thick smear technique and (Bradley et al., 1967) applied the stool sedimentation technique. Only 1/22 surveyed in 2007 and 2011 had a prevalence of 0.8% and 0.4% respectively for a single *S.haematobium* positive case. This was extremely low when compared to the historical records that had 12.0% (Schwetz, 1951, Bradley et al., 1967).

In this study, it was noted that the sensitivity of the haemastix technique in detecting positive haematuria associated with *S.haematobium* cases was rather poor when compared to the filtration technique. Results from this study and indeed from unpublished records at VCD suggest that there has been a major shift from *S.haematobium* to *S.mansoni* (Chaine and Malek, 1983) but not clearly understood what caused such a drift. One contributing factor might be *S.haematobium* responded more to regular mass treatment with praziquantel than *S.mansoni.* Indeed when children were asked if they had ever swallowed praziquantel, 77.2% answered affirmatively. The difference in prevalence between 1951 and 1967 is statistically significant, according to Fisher's exact test ($p < 0.01$). This suggests that environmental changes may have made the habitat less suitable for the transmission of *S.haematobium*, independent of the control program. It is important to note that *S.mansoni* infection levels had even been higher

especially from 1992-2000 before yearly mass treatment campaign was initiated in 2005. (Schwetz, 1951) never detected a single case of *S. mansoni* while the highest record of the disease according to (Bradley et al., 1967) was 4% at Abiya (Oyam district) and 53% at Paranga which though reported under the Lango study is actually situated in Acholi region (Bradley et al., 1967). The *S.mansoni* proliferation is due to the transformation of relevant ecological factors such as the construction of numerous valley dams especially in the 1950s-1960s (Kabatereine et al., 2004a). The changes in agricultural practices of paddy rice growing favouring *Biomphalaria* against *Bulinus* snails.

A lot of effort has been invested in snail studies in Lango region but to date, the exact *Bulinus* species responsible for *S.haematobium* transmission in the region are not fully known. (Schwetz, 1951) using the morphological characteristics just named *Bulinus Physopsis* (Table IIb) which is synonymous with a wide range of *Bulinus africanus* group and *Bulinus Pygrophysa*(*Bulinus forskalii* group) thus historical identification does not help to differentiate the responsible vectors. The compatibility of these snail populations with local *S. haematobium* is also enigmatic but it is worthy of note that they are likely compatible with *S.bovis* as well as with local *B.forskalii/bavayi* group, which helps to better reveal the actual transmission zone of this parasite in Uganda (Stothard et al., 2004). Furthermore, the problem is exacerbated by patchy and overdispersed *S.haematobium* foci and with very low infection rates explaining why none of the collected snails in the 2007 survey was found shedding *S.haematobium* cercariae. It seems transmission by positive snails is very constrained; persisting in a handful of water contact sites thus the difficulty, even from the historical data (Schwetz, 1951, Bradley et al., 1967). Future studies might be rewarding if sporocyst rate rather than cercarial shedding and snail PCR analysis is utilized.

Conclusions

There is a need for reviewing the existing guidelines, tools and methods to align them with transmission rather than morbidity control and fortunately the current WHO draft resolution 65.19 is geared to transmission control (WHO, 2002). Certainly, these results are exciting because they suggest that elimination of schistosomiasis is possible in some isolated foci in Uganda despite the low per capita income and unsanitary conditions they continue to live under. It is, therefore, encouraging that WHO is changing its resolution from morbidity control to transmission control and that targeted snail control can be achieved especially in areas where transmission is mainly on small water bodies.

Conflict of interest

None of the authors have conflict of interest.

SUMMARY

We present a 60 year epidemiological history of schistosomiasis studies and control in the Lango region of central northern Uganda since 1951 to 2011, as determined through stool and urine examinations for *S.mansoni* and *S. haematobium,* respectively. The region is comprised of 8 districts namely: Apac, Kole, Oyam, Lira, Alebtong, Otuke, Amolatar and Dokolo. A retrospective review of various records from 1951 to 2011 was carried to find out the number of cases examined and the number positive for both *S.mansoni* and *S.haematobium* over time.

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Legends

Figure 1: shows the Prevalence of Schistosomiasis in Lango region

Figure II: shows Trend analyses of schistosomiasis cases reported for years 1951-2011 in Lango Region.

Figure 1: Prevalence of Schisistosomiasis in Lango region

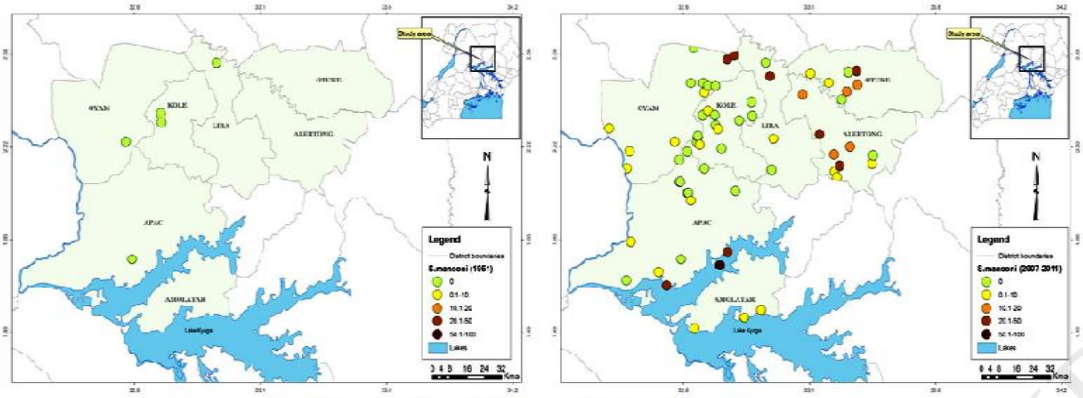

Figure A: Distribution of *S.mansoni* in Lango Region

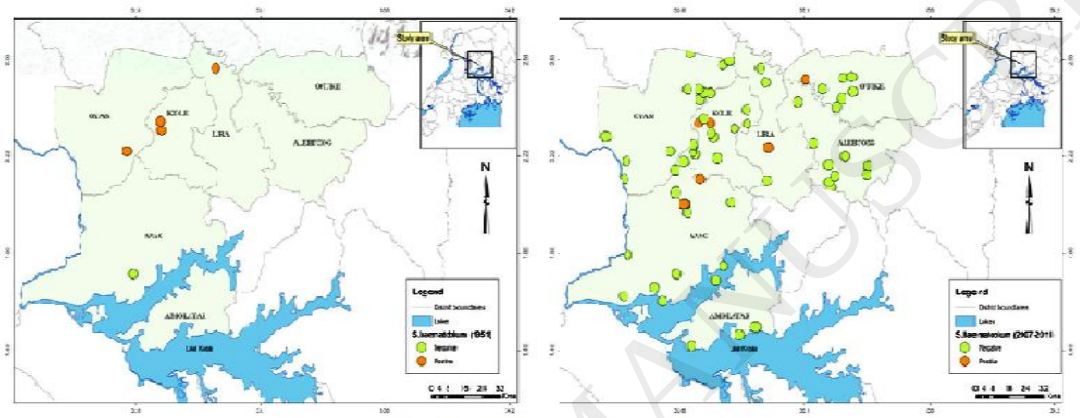

Figure B: Distribution of *S.haematobium* in Lango Region

Figure II: Trend analyses of schistosomiasis cases reported for years 1951-2011 in Lango Region.

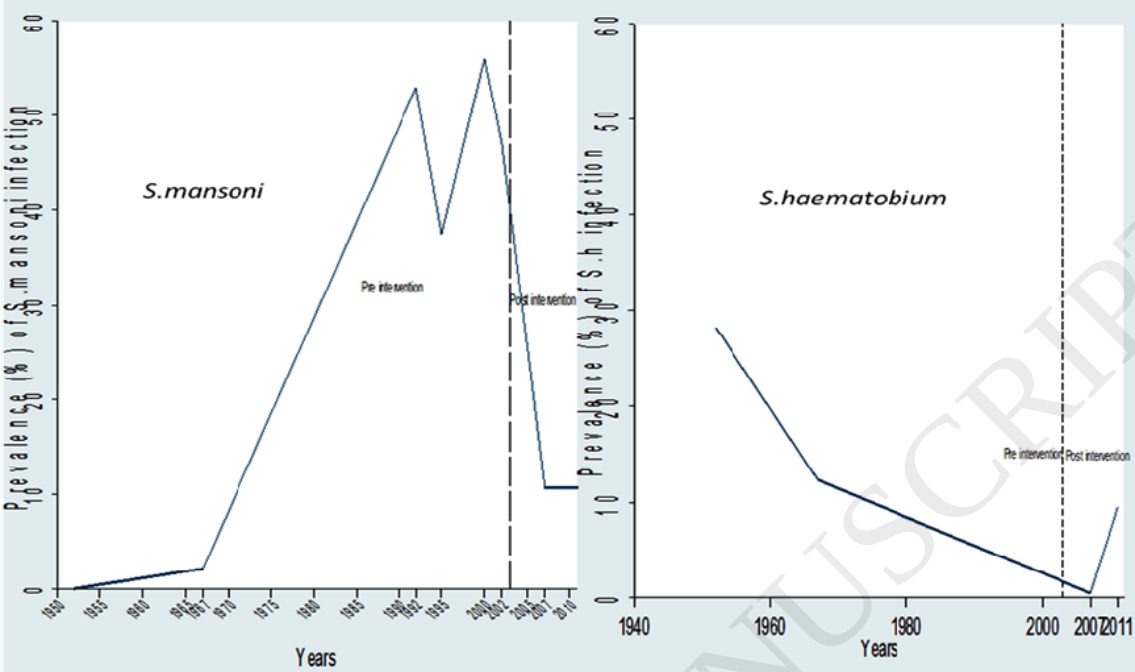

Table I: shows *S.mansoni* and *S.haematobium* co-infections in Lango region. The ***** *refers to sites in which children were surveyed at the primary school in 2007 verses in the community and ***** *refers to sites in which children were surveyed in the community in 2077 verses at the primary school in 2011.*

Table II: shows the trends of Schistosomiasis Prevalence in Lango region.

Table III: shows the comparison of *S. mansoni* infection rates between the pre-control period in 2000 and the post control era either in 2007 or in 2011 or on both years and directly comparing *S. mansoni* prevalence in sites surveyed both in 2007 and 2011 in the Lango region. The results of sites surveyed only once either in 2007 or in 2011 are not shown. * refers to sites in which children were surveyed at the primary school in 2007 verses in the community in 2011 while ** refers to sites in which children were surveyed in the community in 2007 verss at the primary school in 2011.

Table IV: shows the total number of Biomphalaria spp and Bulinus collected and infection Status with Schistosome cercariae by the district in 2007

Table I: *S.mansoni* and *S.haematobium* co-infections in Lango region

Table II: Direct comparisons of *S. haematobium* prevalence in sites surveyed both in 2007 and 2011 using haemastix and direct comparison of Hemastix and urine filtration techniques in 2011 alone. Note in 2007, urine filtration technique was not employed

.						
	2007		**2011**			
Site	**Sample size**	**Haemastix trace=Neg % Prevalence**	**Sample size**	**Haemastix trace = positive % Prevalence**	**Haemastix trace = negative % Prevalence**	**Urine filtration % Prevalence**
Abilonono**	20	0.00(0.00-16.84)	67	19.40(10.76-30.89)	5.97(1.65-14.59)	0.00(0.00-5.36)
Abilonono_2**	20	0.00(0.00-16.84)				
Acandyang_A com*	116	0.00(0.00-3.13)	62	20.97(11.66-33.18)	11.29 (4.66-21.89)	11.20(4.70-21.9)
Acandyang_A2 com*	60	0.00(0.00-5.96)				
Aleka	30	0.00(0.00-11.57)	69	1.45(0.04-7.81)	0.00(0.00-5.21)	0.00(0.00-5.20)
Alenga	30	0.00(0.00-11.57)	63	12.70(5.65-23.50)	3.17(0.39-11.00)	0.00(0.00-5.69)
Atigolwok	31	12.90(3.63-29.83)	65	27.69(17.31-40.19)	10.77(4.44-20.94)	0.00(0.00-5.51)
Atigolwok com*	120	1.67(0.20-5.89)				
Awali com*	90	0.00(0.00-4.02)	64	4.69(0.98-13.09)	4.69(0.98-13.09)	0.00(0.00-5.60)
Barodilo**	20	90.00(68.30-98.77)	62	3.23(0.39-11.17)	3.23(14.22-36.74)	0.00(0.00-5.78)
Barodilo_2**	20	0.00(0.00-16.84)				
Ebule com*	120	0.00(0.00-3.03)	66	4.55(0.95-12.71)	4.55(0.95-12.71)	0.00(0.00-5.43)
Ogogoro com*	118	0.00(0.00-3.08)	60	0.00(0.00-5.96)	0.00(0.00-5.96)	0.00(0.00-5.96)
Teboke	20	0.00(0.00-16.84)	65	32.31(21.23-45.05)	9.23(3.46-19.02)	0.00(0.00-5.51)
Teboke_2	20	0.00(0.00-16.84)				
Wansolo com*	120	0.00(0.00-3.03)	63	1.59(0.04-8.53)	1.59(0.04-8.53)	0.00(0.00-5.690)
Atar	-	-	64	7.81(2.59-17.30)	4.69(0.98-13.09)	1.56(0.04-8.40)
TOTAL	**955**	**2.51(1.61-3.72)**	**770**	**11.43(9.18-13.68)**	**4.94(3.40-6.47)**	**1.04(0.32-7.57)**

Table II: Trends of Schistosomiasis in Lango region.

	b-coefficient	**95% CI**	**Statistical significance**
S.mansoni			
Pre-intervention (1952-2003)	0.07	0.05 - 0.09	<0.01
Post-intervention (2003-2011)	-0.2	-0.27 - -0.12	<0.01
S.haematobium			
Pre-intervention (1952-2003)	-0.06	-0.1 - -0.01	0.02
Post-intervention (2003-2011)	0.77	0.01 - 1.53	0.05

Table III: The comparison of *S. mansoni* infection rates between the pre-control period in 2000 and the post control era either in 2007 or in 2011 or on both years and directly comparing *S. mansoni* prevalence in sites surveyed both in 2007 and 2011 in the Lango region

Between pre-control period in 2000 and Post control in 2007, or in 2011 or on both								**Between 2007 and 2011**				
	2000 (Before control)		**2007**		**2011**				**2007**		**2011**	
Study site	**Sample size**	**%prevalence (95%CI)**	**sample size**	**%prevalence (95%CI)**	**Sample size**	**%prevalence (95%CI)**	**P value**	**Site**	**Sample size**	**% Prevalence (95% CI)**	**Sample size**	**% Prevalence (95% CI)**
Opir	65	75.38(64.90-85.86)	240	2.50(0.52-4.48)	-	-	*<0.001*	Abilonino*	20	0(0.00-16.84)	67	1.49(0.04-8.04)
Agweng	59	49.15(36.40-61.91)	-	-	56	42.86(29.71-56.78)	*0.498*	Aleka	16	56.25(29.88-0.25)	67	43.28(31.22-55.96)
Ogogoro	56	64.28(51.74-76.84)	240	12.92(08.67-7.20)	60	11.67(4.82-22.57)	*<0.001*	Alenga	13	0(0.00-24.71)	61	1.64(0.04-8.80)
Aloi	59	44.07(31.40-56.74)	120	33.33(24.90-41.77)	-	-	*0.162*	Atar	18	0(0.00-18.53)	62	0(0.00-5.78)
Awali	62	66.13(54.35-77.91)	120	10.00(4.63-15.37)	64	17.19(8.90-28.68)	*<0.001*	Atigolwok	28	0(0.00-12.34)	60	0(0.00-5.96)
Abako	59	62.71(50.37-75.05)	180	21.67(15.64-2768)	61	18.03(9.36 - 29.98)	*<0.001*	Baradilo*	19	0(0.00-17.65)	62	3.23(0.39-11.17)
Abarlor	65	73.85(63.16-84.52)	240	2.92(0.78-5.04)	52	15.38 (5.58-25.19)	*<0.001*	Ebulecom**	27	3.70(0.09-18.97)	66	3.03(0.37-10.52)
All	**425**	**62.35 (57.75-66.96)**	**1140**	**11.84 (9.97-3.72)**	**293**	**3.75 (1.58-59.31)**	***<0.001***	Teboke	20	0(0.00-16.84)	64	0(0.00-5.60)
								Wansolo	55	69.09(55.19-0.86)	59	49.15(35.89-2.50)

Table IV: the total number of Biomphalaria spp and Bulinus collected and their infection status with Schistosome cercariae by the district in 2007

District	Total number of sites visited	*B. sudanica*		*B. Pfeifferi*		*B. forskalii*		*B. globosus*		*B. tropicus*		*B. nasutus*		*B. africanus*	
		Total collected	% HC	Total collected	% HC	Totals	% HC	Total	% HC	Totals	% HC	Totals	% shedding non human Schistosome cercariae	Totals	% HC
Apac	22	286	0	544	0	98	0	0	-	30	0	469	1.2	0	-
Dokolo	8	1	0	23	0	39	0	0	-	117	0	45	0	0	-
Lira	11	104	0	10	0	4	0	0	-	61	0	0	-	0	-
Oyam	11	10	0	106	0	29	0	0	-	18	0	8	0	0	-
Total	**52**	**401**	**0**	**683**	**0**	**170**	**0**	**0**	**-**	**226**	**0**	**522**	**1.2**	**0**	**-**