Mapping of schistosomiasis and soil-transmitted helminthiasis in Ethiopia

Ethiopian Public Health Institute (EPHI), Federal Ministry of Health (FMOH), Schistosomiasis Control Initiative (SCI), Partnership for Child Development (PCD)

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1. Introduction

Ethiopia is the second most populous country in sub-Saharan Africa, behind only Nigeria, with an estimated population of 90 million people. In comparison to some of its neighbours it is relatively late in implementing large-scale schistosomiasis and STH treatment. However, in recent years political commitment has built significantly behind NTD control in Ethiopia. For example Ethiopia launched its national NTD Master Plan in July 2013 which sets out the intended aims and objectives of the programme to reach the WHO NTD 2020 goals. The Federal Ministry of Health (FMOH) have ambitious aims to scale-up treatment quickly against all NTDs, including schistosomiasis (SCH) and soil-transmitted helminthiasis (STH).

To enable this, the nationwide mapping of the distribution of SCH and STH was planned with the objectives of:

- Determining the district (woreda) level infection of SCH to guide treatment decisions
- Determining the district (woreda) level infection of STH to guide treatment decisions
- Understanding school-level WASH facilities and usage, and school-feeding needs to guide implementation and assist with integration and co-ordination (Results to be covered in a separate document).

The surveys were conducted by the **Ethiopian Public Health Institute** (EPHI, the technical arm of the FMOH) with technical and financial support from the Schistosomiasis Control Initiative (SCI) and the Partnership for Child Development (PCD).

The FMOH and EPHI took advantage of this extensive logistics platform to also collect invaluable information on the school-level water, sanitation and hygiene (WASH) infrastructure, and school-feeding requirements from all sites.

2. Methods

Ethical Statement

The study protocol was approved (ethical clearance received from) by the Scientific and Ethical Review Office (SERO) of EPHI. The Federal Ministry of Education (FMOE), as well as all regional Health and Education bureaux, were informed about the study and inputted to its design. Written informed consent was obtained from all participating schools' directors. Study participants were informed of the purpose of the study including its benefits, potential risks, study procedure and that participation in the study was voluntary. Verbal consent was obtained from all children included in the study.

Study setting

Ethiopia is divided into 9 regional states and 2 city administrations, which are further subdivided into 834 districts (or woredas). The study was conducted in every region in the country except Amhara regional state where prior mapping surveys has been undertaken in 2013 with support from The Carter Center, and in Addis Ababa. In this study, Tigray, Benushangul Gumuz, Oromia, Southern Nation Nationalities and Peoples, Gambella, and Harari regional states and Dire Dawa city Administration had district level mapping whereas zonal-mapping was conducted in Afar and Somali regional states as these were considered likely to have much lower levels of infection by the SCH / STH Mapping steering committee. The study was undertaken between December 2013 and March 2014.

School Selection and Sample Size

School selection and sample size calculations were conducted according to the World Health Organization (WHO) guidelines. Due to the known focal distribution of schistosomiasis and assuming that STH were distributed throughout the country the following sampling approach was employed.

In each woreda 10 schools were chosen with a probability proportions to size (PPS) approach where the likelihood of each school being selected was weighted by the number of enrolled pupils. From this list of ten schools the local teams were instructed to liaise with the woreda health bureau to choose five that were situated close to water bodies. The remaining five schools were used as reserves in case access to the selected schools proved impossible.

The sample frame for each woreda was a list of all primary schools in that woreda, as per the WHO guidelines.

Therefore, for the 535 woredas being surveyed this gave a total of **2,675 schools** to be included in the study. In each school 50 school-aged children, 25 male and 25 female students (2 boys and 2 girls as a reserve), were selected randomly using a lottery method. A total of **133,750 school-aged children** were targeted to be enrolled from all the sampled districts.

Training and Survey procedures

Over 180 technicians and parasitologists from around the country were trained on the necessary techniques before heading into the field. International experts from the Kenyan Medical Research Institute (Dr. Jimmy Kihara), the Ugandan Ministry of Health (Betty Nebatte), the SCI (Dr. Narcis

Kabatereine), and from the University of Ghent (Dr. Bruno Levecke) played a central role in the training.

These technicians constituted 41 survey teams. Each team consisted of 3 laboratory technologists and 1 nurse who conducted the survey. The laboratory technologists took turns in sample preparation and slide reading and one senior technologist assigned as team leader and quality control slide reader. While the clinical nurse was responsible for collecting school and study participant information and providing treatment. Supervision was done conducted by 9 regional supervisors and 4 researchers from the Ethiopian Public Health Institute. In addition, 3 external supervisors from the Kenya Medical Research Institute and the Ugandan Ministry of Health – Vector Control Division were invited to monitor the overall mapping exercise. In total, 180 health professionals and researchers were involved in this survey. All data collectors and regional supervisors were selected and sent for training by their respective regions.

Data Collection

All data were collected using the LINKS® data collection system developed by the Task Force for Global Health, based in Atlanta, Georgia. This is an android-based application installed on smart phones used to record epidemiological data in the field. The operator was able to enter data and they were sent to LINKS system server in real-time or near-real-time when a network connection to allow supervision by the study coordinators.

School information was recorded at entry to the school, in discussion with the Director of the school. GPS co-ordinates were collected for each school to allow for geo-referencing and mapping.

Parasitological Data

Study participants were provided with 50ml screw cap plastic sample containers for urine and stool collection. Approximately 50 ml of urine was collected from each student and tested for the presence of blood in urine with Haemastix ® dipsticks. Where the Haemastix® results were positive for haematuria (recording either a +++, ++, +, or trace recording) these results were supplemented by urine filtration technique to verify *S. haematobium* infection. The results are expressed as the number of eggs per ten millilitres of urine. Collected stool samples were subjected to standard Kato-Katz method for *S. mansoni* and soil transmitted-helminthiasis diagnostics via the use of a single slide, and are expressed as the number of eggs per gram of faeces.

Quality Control

To ensure reliability of the data collected, a quality control mechanism was installed. In each school 10% of study participants (5 children per school) provided a second slide for quality control purposes. The survey team leader, who was a qualified laboratory technologist, was responsible for the reading of the secondary slides. Quality control slides were selected randomly from the 50 Kato-Katz slides prepared and read and results were recorded on a separate form in the Smart phone Application. During supervision rounds, each supervisor collected 10 % (1 slide) from the QC slides for further reading in the central laboratory. No significant difference in prevalence or intensity of infection was found in a comparison of these quality control slides (data not shown).

Statistical analysis

The average prevalence of infection was calculated for each district for both schistosomiasis infections, and for the combined STH infection. This was calculated using the crude prevalence across all schools in the district. Robust 95% confidence intervals were calculated for each district taking into account the clustering of infection observed at the school-level, and using the R software package.

Once the field surveys were completed, and to improve the rigor and the effectiveness of the mapping, SCI and PCD with partners from the London School of Hygiene and Tropical Medicine (Dr. Rachel Pullan), conducted in-depth training for EPHI and Federal Ministry of Health technicians on how to clean and analyze the data collected and how to use this to create worm prevalence and risk maps.

Combining data with The Carter Center-supported surveys

In a secondary analysis stage, and to provide the fullest picture possible of infection data from the current survey were combined with data from Amhara region which was kindly provided by The Carter Center.

3. Results and Discussion

In this study a total of 535 districts were surveyed, of a total in the country of 834. Samples from >125,000 school-aged children were examined for the presence of uro-genital and intestinal schistosomiasis species and for the main STH species.

Table 1 shows the breakdown of the endemicity of woredas for both SCH and STH. These have been classified using both the point prevalence and the 95% upper confidence interval for comparison.

Number of schistosomiasis endemic districts at different infection category				
	High risk (≥50%)	Medium risk (≥10% and <50%)	Low risk (≥1% and <10%)	Total
S.mansoni	5	57	164	226
***S.mansoni* (using 95% upper CI)**	42	90	94	226
Number of soil transmitted helminths at different infection category				
	High risk (≥50%)	Medium risk ≥20% and <50%)	Low risk ≥1% and <20%)	Total
Soil transmitted helminths	71	159	263	493
Soil transmitted helminths (using 95% upper CI)	178	162	153	493

Table 1. Endemic districts classified by infection category for schistosomiasis and soil transmitted helminths.

Of 535 districts surveyed, 226 were found to be endemic for SCH and 493 districts endemic for STH (Table 1). There were 5 high and 57 medium endemcity districts for SCH. Among endemic districts for STH, 71 districts were high and 159 were medium endemcity. The distribution of infection among the regions is displayed in Table 2.

Region	No. Districts surveyed	No. *S. mansoni* positive Districts	No. STH positive Districts
Afar	**16**	**3**	**10**
Benishangul-Gumuz	**21**	**19**	**21**
Dire Dawa	**1**	**1**	**1**
Gambella	**12**	**12**	**12**
Harari	**9**	**6**	**4**
Oromiya	**269**	**98**	**255**
SNNPR	**154**	**62**	**154**
Somali	**7**	**3**	**7**
Tigray	**46**	**34**	**41**
TOTAL	**535**	**238**	**505**

Table 2. Endemic SCH and STH districts by region

Schistosomiasis infection was found to be almost exclusively that of intestinal schistosomiasis (caused by *S. mansoni*). Although infection with *S. haematobium* was present in some areas it was very focally distributed and mostly found in Somali region (Table 3).

Region	*No. positive* school age children	*No. Sampled* school age children	*Prevalence*
Afar	***27***	***2,333***	***1.2%***
Benishangul-Gumuz	***11***	***5,176***	***0.2%***
Dire Dawa	***0***	***1,643***	***-***
Harari	***0***	***1,714***	***-***
Oromiya	***29***	***45,577***	***0.1%***
SNNPR	***21***	***33,795***	***0.1%***
Somali	***218***	***1,697***	***12.9%***
Tigray	***7***	***11,464***	***0.1%***
TOTAL	***313***	***103,339***	***0.3%***

Table 3. *Schistosoma haematobium* infection prevalence by region

Figure 1 below displays a map of the location of the schools used in the survey, as well as the school-level infection with SCH (Figure 1a) and STH (Figure 1b).

Figure 2 below displays a map of the woreda (district) level prevalence for both SCH (Figure 2a) and STH (Figure 2b). In this figure the colours represent the endemicity bands as recommended by the WHO which determine the treatment approach.

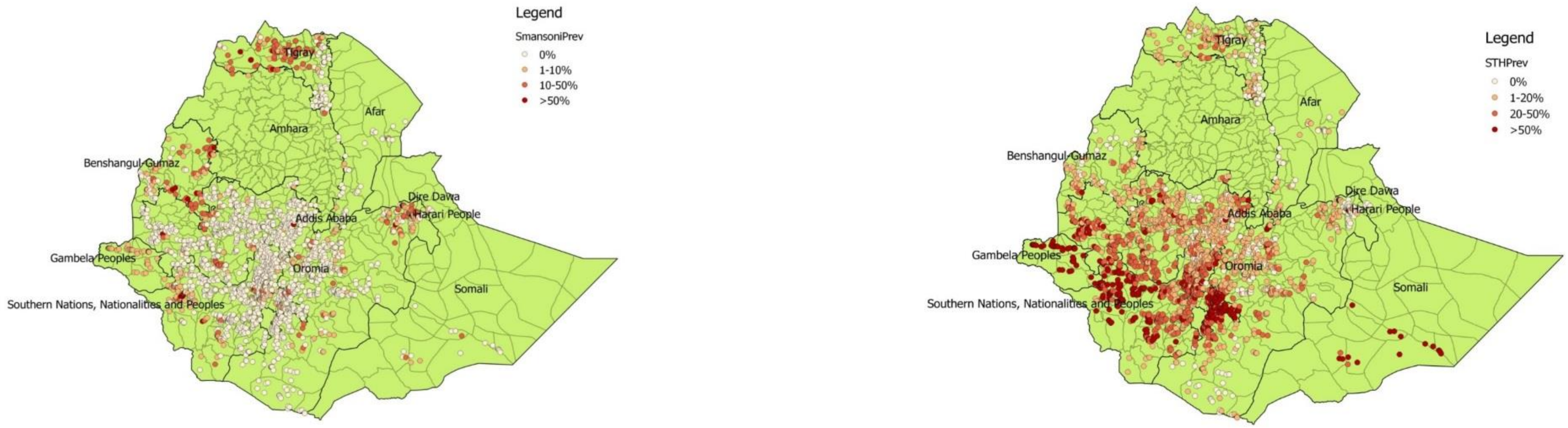

Figure 1. School-level prevalence by school of a) *Schistosoma mansoni* and b) soil-transmitted helminthiasis in Ethiopia.

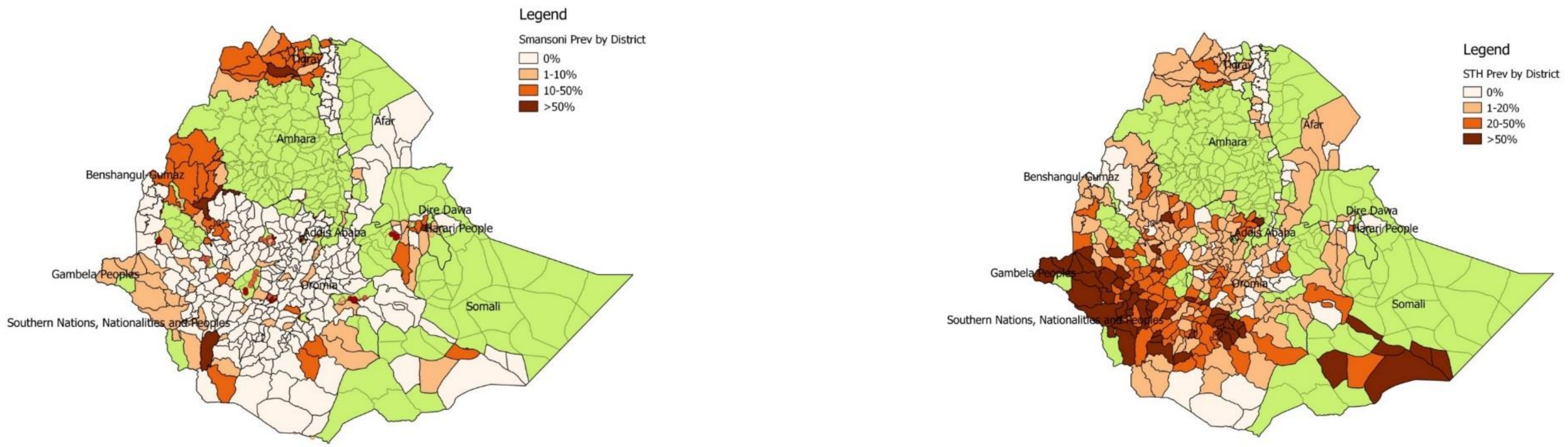

Figure 2. Woreda (district)-level prevalence of a) *Schistosoma mansoni* and b) soil-transmitted helminthiasis in Ethiopia.

Combining data with The Carter Center-supported surveys

Data were kindly provided by The Carter Center for levels of infection with *S. mansoni* and STH infection from Amhara region. Earlier in 2013 The Carter Center had implemented an integrated trachoma / SCH / STH community-based treatment protocol in the region.

The results from both surveys are displayed below in Figure 3.

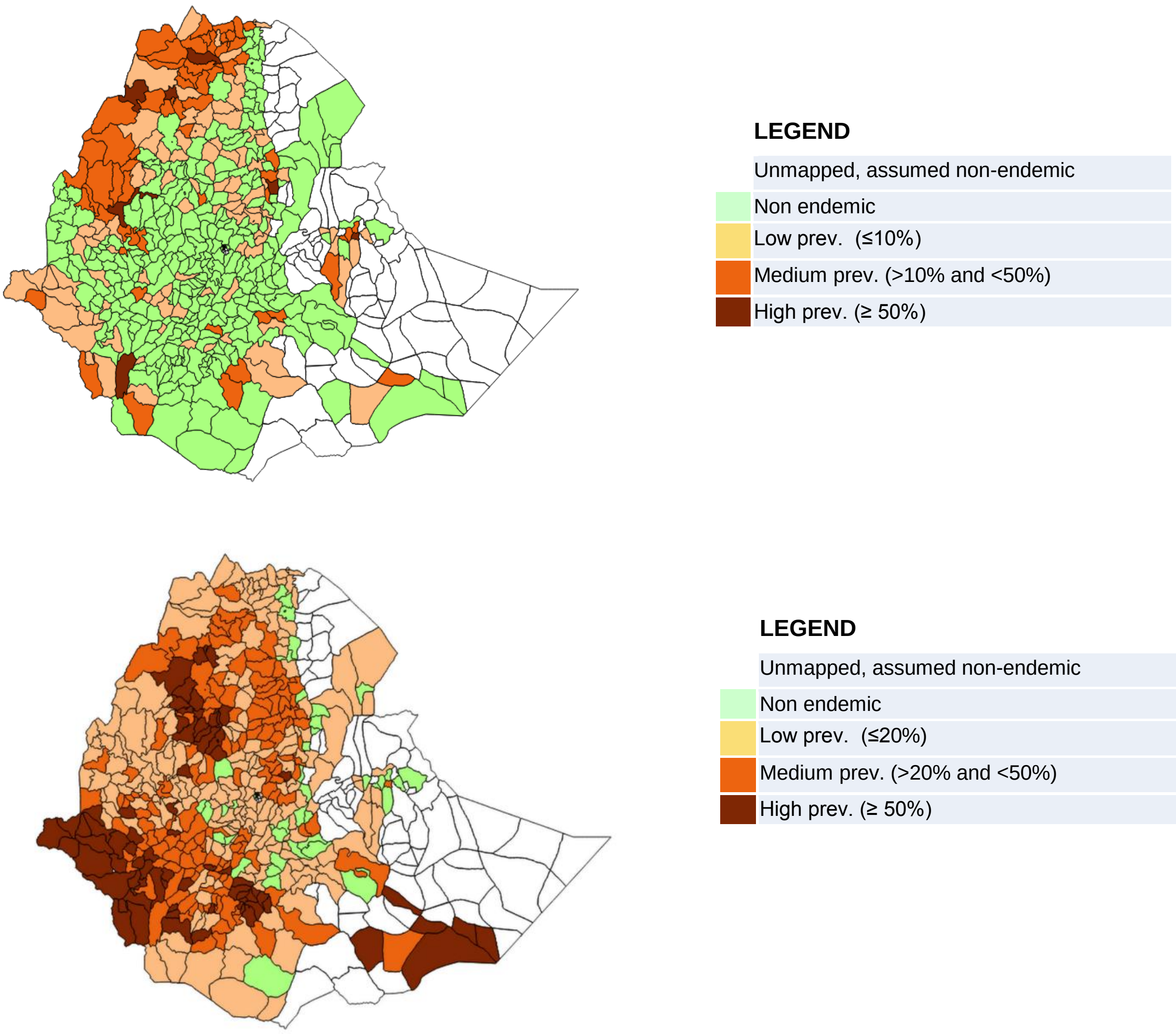

Figure 3. Combined data from EPHI and The Carter Center showing the distribution of a) SCH infection and b) STH infection categorised according to WHO guidelines

The results from these combined surveys demonstrate that in Ethiopia both schistosomiasis and STH are endemic. The intestinal form of schistosomiasis is widely distributed while the uro-genital form is thought to be restricted to foci in the rift valley region.

The summary results from the combined surveys are displayed in Table 4 below.

Infection	High	Medium	Low	Uninfected	To be Determined	Endemic Woredas[1]	Woredas Requiring Treatment[2]
STH	242	179	162	26	220	803	641
Schistosomiasis	47	120	130	312	220	517	517

Table 4. Categories of infection endemicity of STH and schistosomiasis in Ethiopia.

The results from the national NTD mapping are being used by the **Federal Ministry of Health** and partners to set the direction of schistosomiasis and STH treatment programmes, as well as school health and nutrition programmes. For the sake of planning those woredas that are yet to be mapped have been assumed to be of moderate infection for both schistosomiasis and STH, and therefore require annual treatment against STH and biennial treatment against schistosomiasis. Therefore, the most up to date information available is that **517 woredas require treatment against schistosomiasis and 641 require treatment against STH**.

There are estimated to be at least **55.9 million** people living in schistosomiasis endemic areas, comprising 5.0 million pre-school children, 17.7 million school-aged children, and 30.5 million adults.

STH infections are distributed very widely in the country (Figure 2 bottom). The estimated number of people living in STH endemic areas is **88.1 million**, comprised of 7.8 million pre-school-aged children, 27.9 million school-aged children, and 48.1 million adults. The number of individuals living in areas qualifying for STH-treatment (areas that have low infection do not currently qualify for MDA treatment) is **72.8 million**, comprised of 6.5 million pre-school children, 23.1 million school-age children, and 39.7 million adults)

The findings showed that **421** woredas warrant mass drug administration (MDA) for soil-transmitted helminthes (STH), and **297** for schistosomiasis (SCH). It is estimated that 24.9 million annual treatments are required for STH and 9.9 million treatments for schistosomiasis (Table 5).

The number of SAC requiring treatment against either schistosomiasis or STH is **25.6 million**. The number of individuals receiving treatment will vary by year as areas with either moderate (10-50% prevalence) or low (<10% prevalence) infection with schistosomiasis will receive treatment every other year.

Table 6 below outlines the targeted number of treatments across all five years of the programme. This assumes the programme achieves a staged increase in coverage of enrolled and non-enrolled children. The programme will aim to implement at total of **99.9 million** treatments across the five years of the programme.

[1] For the sake of planning, currently unmapped woredas are assumed to require annual treatment
[2] The WHO does not currently recommend MDA against STH for low infected areas

Region	Enrolled SAC	Non-enrolled SAC	Total SAC
Addis Ababa	813,137	152,584	965,721
Afar	216,997	201,109	418,106
Amhara	4,322,690	1,997,032	6,319,723
Benishangul Gumuz	187,720	127,246	314,966
Dire Dawa	98,770	32,573	131,343
Gambella	108,551	25,628	134,179
Harari	48,534	16,964	65,498
Oromia	5,213,443	3,446,761	8,660,204
SNNPR	3,700,537	2,173,331	5,873,869
Somali	799,865	596,060	1,395,925
Tigray	1,003,596	329,201	1,332,797
Total	**16,513,841**	**9,098,490**	**25,612,331**

Table 5. Number of school-aged children requiring treatment against either schistosomiasis or STH in each region of Ethiopia.

All Children	Y1	Y2	Y3	Y4	Y5	TOTAL
Oromia	4,254,758	5,216,413	6,287,666	6,389,149	7,921,097	30,069,084
Tigray	785,617	507,488	902,835	568,719	1,061,192	3,825,852
Afar	182,858	217,437	264,256	282,070	347,220	1,293,841
Amhara	3,441,721	4,891,840	5,641,814	5,696,676	6,837,488	26,509,540
Somali	659,505	772,535	868,586	964,638	1,110,057	4,375,320
Beni.Gumuz	153,514	109,696	196,832	134,886	248,696	843,624
SNNPR	2,992,736	5,355,925	5,928,774	6,443,771	7,368,619	28,089,825
Gambella	83,976	173,078	180,766	188,455	207,511	833,785
Harari	38,097	30,774	56,222	34,710	66,428	226,232
Addis Abeba	625,112	640,370	663,258	686,145	751,215	3,366,099
Dire Dawa	77,335	75,357	85,478	84,494	100,514	423,178
TOTAL	13,295,230	17,990,914	21,076,487	21,473,712	26,020,037	99,856,380

Table 6. Total number of treatments per year and per region against both schistosomiasis and STH across the five years of the programme

The results from the WASH and school-feeding surveys will be presented elsewhere. In summary, only 44% of schools had a water source within the school compound and only 15% of these had water connected to the school building.

Next steps:

In order to complete the national picture of distribution EPHI have secured funding from WHO-AFRO and the Bill and Melinda Gates Foundation to conduct further mapping in the regions of Somali and Addis Ababa. These regions were excluded from the original mapping surveys as they were believed to harbour little helminthic infection. However, higher than expected infection levels were identified in these regions in the original mapping which has prompted further, refinement mapping.

In addition, this opportunity is being taken to re-map the region of Amahara, which was mapped in 2013 with support from The Carter Center using an integrated trachoma, STH, and intestinal schistosomiasis approach. Surveys will be conducted here in order to collect information on the distribution of *S. haematobium* infection, as well as reconfirming the figures for *S. mansoni* and STH. These surveys are being undertaken between March and May 2015 and will be presented at that time.