Time to change implementation units for mass drug administration against schistosomiasis in Uganda: Evidence from Communities levels data validation and its implication in planning

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ABSTRACT

Uganda started implementing mass drug administration against schistosomiasis in 2003, with district used as an implementation unit. This resulted into misclassification of communities into wrong risk levels, under-or-over treatment and over request of praziquantel (PZQ) drugs. The objective of the current study was to reviewing the community data available at World Health Organization/ESPEN database to understand the status of schistosomiasis and identify pockets with infection. The decision tree assessment tool was used to analyzed schistosomiasis epidemiological data of 7501 communities. Before validation, the schistosomiasis endemicity status of 79 % of communities was not known. After validation, 58.6 %, 22.6 % and 16.3 % of communities were not endemic, had low and moderate endemicity status. Of 2362 communities classified having high endemicity using a district as implementation unit, 41.6 %, 12.7 % and 17.3 % of them were not endemic, had low and moderate endemicity, while only 22.7 % had high endemicity. Using the new treatment guidelines, 2,875,006 school aged children were adequately treated, 18,235 were under-treated and 2,250,013 were over treated. The results show a considerable change in endemicity status when communities were used as an implementation unit compared to district. Thus, the country control programme is recommended to use communities as implementation unit.

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1. Background/Introduction

Uganda is within the East African region and is among the countries endemic for schistosomiasis (Emmanuel et al., 2008; Booth et al., 2004; Kabatereine et al., 1996; Tukahebwa et al., 2004; McCullough, 1972; Brooker et al., 2009). Schistosomiasis infection was noted in the country since 1902 and both *Schistosoma mansoni* and *Schistosoma haematobium* are present in the country (Emmanuel et al., 2008). *S. mansoni* is widely distributed and occurs mostly in large water bodies (lakes and rivers) (Emmanuel et al., 2008; Booth et al., 2004; Tukahebwa et al., 2004; Kabatereine et al., 2004a), whereas *S. haematobium* is highly focal and occurs only in few areas, mostly restricted to Lake Kyoga (Adriko et al., 2018a; Adriko et al., 2018b). In Uganda, intestinal schistosomiasis is endemic in 67 % of the districts (95/146) whereas urogenital schistosomiasis is endemic in 2.9 % (4/146) of the total districts (Emmanuel et al., 2008; Kabatereine et al., 2004b). In total, 95 districts of 146 are endemic for schistosomiasis (Emmanuel et al., 2008; Kabatereine et al., 2004b). In 1995, all of the Uganda's 19.2 million people were estimated to be at risk of infection for schistosomiasis, with the national prevalence estimated at 31.9 % (Chitsulo et al., 2000). Todate, 55 % (19,000 people) of the 16.7million people are estimated to be at risk, with seven million people are estimated to be infected with schistosomiasis (Adriko et al., 2018c).

Uganda was one of the first African countries to launch a national-scale schistosomiasis and intestinal helminths control programme in 2003. The National Bilharzia and Worm control programme in Uganda was established in 2003 (Kabatereine et al., 2006a) and coordinated by the Vector Control Division (VCD) of the Uganda Ministry of Health, with support from the Schistosomiasis Control Initiative (SCI) (Kabatereine et al., 2006a). The programme is run vertically, implemented by districts using school teachers and volunteers known as community drug distributors (CDDs). The aim of the schistosomiasis control to date has been to control morbidity. The delivery strategy is through mass annual anthelmintic treatment targeted at school-aged children and high-risk groups in the endemic areas using praziquantel (PZQ) drug to treat schistosomiasis and albendazole drug to treat soil-transmitted helminths (STH) infection. The earlier intervention focused on school-and-community-based mass drug administration in one sub-county in each of the 18 most affected districts (Kabatereine et al., 2006a). The national Control Programme also included basic health education training and information on how behavioural changes can reduce transmission (Kabatereine et al., 2006a).

In 2004, a total of 1.4 million people were treated in 18 of then 38 endemic districts and in 2005, three million people were treated in 23 districts (Kabatereine et al., 2006a). In the same period, to scale-up treatment, health centre-based treatment was introduced in 11 of the 38 endemic districts? (Kabatereine et al., 2006a). In 2006, two million people were treated in 27 of the 28 endemic districts (Kabatereine et al., 2006a; Kabatereine et al., 2006b). Mass drug administration campaigns were scaled-up between 2010 and 2012, with the national coverage recorded at 33 %, 18 % and 19 % respectively in 2010, 2011 and 2012 (Fleming et al., 2009; Loewenberg, 2014; Lai et al., 2015)(WHO:PCT Databank). Following implementation of the initial control activities under the support of SCI from 2004 to 2008, the national prevalence dropped to 20.4 % in 2003 and to 15.9 % in 2010 (Kabatereine et al., 2006a; Kabatereine et al., 2006b). In 2012, the national prevalence dropped further to 9.1 % (Lai et al., 2015). The impact of MDA using praziquantel drug were also noted on schistosomiasis related morbidities in children and adult (WHO, 2011; Kabatereine et al., 2007). From 2014, efforts to control schistosomiasis (Fleming et al., 2009) were intensified by the government of Uganda in collaboration with partners (SCIF, 2020). Todate, the National Schistosomiasis and Worm control programme has implemented 16 rounds of treatment (VCD-MOH programme unpublished report). The national coverage of MDA increased from 22 % in school aged children (SAC) in 2014 to 62 % in 2019 (https://espen.afro.who.int/countries/uganda). In adult, the national coverage increased from 32 % in 2014 to 42 % in 2018 (https://espen.afro.who.int/countries/uganda). At the same period, the geographical coverage of implementation unit (IUs) requiring preventive chemotherapy increased from 44 % in 2014 to 80 % in 2019 (https://espen.afro.who.int/countries/uganda).

The noted increases in geographical and national coverage have resulted into decline in prevalence of schistosomiasis in some districts of Uganda. The significant decline can be noted at individual communities' level rather than at the current implementation unit, the district. Alternatively, the observed changes in prevalence means that the endemicity status of communities rather than the district have changed, therefore to ensure an efficient allocation of resources and target only the population in need of treatment, it is important for the programme to change its implementation strategy from using district level data, to use data disaggregated at community levels. This process requires a review of the communities' data and risk of transmission at community levels. WHO/AFRO has provided a tool for schistosomiasis communities data optimization. This current study focuses on validating these data from Uganda using assessment tool.

2. Methodology

2.1. Study setting

Uganda is within the East African region and is divided into four regions, Central, Eastern, Northern and Western. The country has a total of 146 districts, which are divided into counties and sub-counties, which are further subdivided into parishes/wards and villages. In total, Uganda has 7501 communities (counties or sub-counties). Schistosomiasis is endemic in 67 % (95/146) districts of Uganda. Planning and implementation of schistosomiasis control activities are organized at the district level, the district is an implementation unit (IU).

2.2. Validation of the Uganda workbook

2.2.1. Data availability and analysis

Between 2018 and 2020, all countries in the African region were supported to collect all available schistosomiasis epidemiology

data, in order to enrich the schistosomiasis database for better decision making. In addition, current demographic data presented at the lowest demographic level possible was obtained from the relevant government departments. During workshops organized by ESPEN in 2018, data teams entered all their available epidemiological and demographic information into the WHO/AFRO schistosomiasis community's data optimization tool (workbook) and applied the decision tree presented in the tool to determine communities' level endemicity categories. The workbook was then presented to wider stakeholders within the NTD programme in Uganda and district level managers for validation. The final validated workbook was used to apply for medicines through the WHO donation programme in 2020.

The data preparation into the WHO/AFRO communities involved filling in the input data worksheets with the available datasets for the analysis. Four worksheets were selected: - demographic data worksheet, epidemiological data worksheet, JRSM data worksheet, and the neighbouring subunits worksheet. The Joint Request for Selected Medicine (JRSM) data worksheet included data extracted from the latest Joint Application Package (JAP) submitted by the country and is used in the decision tree to inform the current implementation strategy for the communities.

For data quality check, data were categorised into three groups (i) data which were collected after 2004 using appropriate diagnostic technique, number of examined individuals and positive cases were reported and the sample size was adequate (ii) Data were collected between 2000 and 2004 using appropriate diagnostic technique, number of individual examined and positive cases were reported and sample size was adequate and (iii) Data were collected either before 2000 or after 2000 with poor quality (diagnostic methods not reported, number of individuals examined and number of positive cases not reported). Data which fulfilled criteria described in category one and two, were considered superior, and placed in quality grade one and two respectively, for further analysis. Those in category three, were only used in the absence of quality level one or two. The unit of analysis was a community (implementation unit, in the case of Uganda, the communities/county/sub-county) and from the data, various indicators were calculated as shown in the Table 1 below.

For the determination of the communities' final endemicity levels, the Decision Tree was used. Despite the use of the decision tree to categorise endemicity of the communities, the National Neglected Tropical Diseases Control Programme manager and the country NTD team were involved in validating the analysis and classification of the communities.

Table 1
The implementation units from which the various the data indicators were calculated.

Indicators	Variables calculated	Formula/narration
Past prevalence	Prevalence calculated by the site data of the Past quality. District level calculation: It is the average prevalence of all site prevalence of the most recent year and the Past diagnostic methods Subdistrict level: It is the highest prevalence of all site prevalence of the most recent year and the Past diagnostic methods	Site prevalence: the site prevalence if not already calculated is calculated as below: -Number of people positives/Number of people examined *100 District Prevalence (DP): - (Total positives) / (Total examined) * 100 Prevalence of the subdistrict (SDP): Highest site prevalence among all sites (in the highest quality group) in the communities-based on parasitological technique/results
Year of Past prevalence	Year of the Past prevalence of the district or communities	
Diagnostic methods of the Past prevalence	Diagnostic methods of the Past prevalence of the district or communities	For calculation of prevalence, the following diagnostic tests results were used: - Kato Katz technique, Urine filtration technique, Urine sedimentation technique, blood in urine (BIU), dipstick and point-of-care circulating cathodic antigen test
Number of sites of the Past prevalence	Number of sites used for the calculation of the Past prevalence of the district or communities	Based on the parasitological or clinical laboratory methods
Endemicity by the Past prevalence	Endemicity category determined by the Past prevalence of the communities or district (The endemicity category is determined as recommended in the WHO guidelines	Non-endemic, Low prevalence (<10 %), Moderate prevalence (10 %–49 %) High prevalence (50 % and above)
School Aged Children (SAC) needing preventive chemotherapy (PC)	Total number of school age children living in an endemic area classified low, moderate, or high risk	Low prevalence (<10 %), Moderate prevalence (10 %–49 %) High prevalence (50 % and above)
Adult needing PC	Number of adults needing treatment in an endemic area classified moderate, or high risk	Low risk: no adult treatment is recommended Moderate risk: 20 % of the total adult population in the sub district or district High risk: All he adult population in the sub district or district
Drug estimates	The number of drugs needed is calculated by multiplying the population to be treated by a factor that depends on the age. This factor is 2.5 for school age children and 3 for adults	The dose by treatment is 2.5 tablets per SAC and 3 tablets per adult.
Treatment adequacy	Comparison of preventive Chemotherapy (PC) regimen at district level compared to sub district level	No change in strategy: the treatment strategy does not change from district implementation to community's implementation Adequate: No change in preventive chemotherapy (PC) regimen Under treatment: PC regimen at district level is lower than PC regimen suggested by communities' analysis. Over treatment: PC regimen at district level is higher than PC regimen suggested by communities' analysis

3. Results

3.1. Demographic characteristics

Uganda has four provinces which have a total of 146 implementation units (districts) and a total of 7501 sub-implementation units (communities). The country has a total population of 42,856,905 people, of these 29.4 % are school aged children. Table 2 shows other demographic characteristics of Uganda.

3.2. Endemicity status of district and communities in Uganda

Table 3 present the results of the decision tree algorithm to assign schistosomiasis endemicity to communities', districts implementation unit, using the drug request documents and the WHO/AFRO risk assessment tool which combines information from qualitative environmental risk assessment, local knowledge by health professionals, reported clinical cases, laboratory data at local health facilities, existence of snail hosts and GIS risk maps. Of the total 7501 wards, 16.5 %, 23.7 % and 33.2 % were classified using the sub-implementation unit, district as implementation unit and JRSM documents. The remaining 26.6 %, were categorise using the WHO/AFRO risk assessment tool.

The implementation units were further classified based on the regions using the similar approach described above (Table 3). Using the sub-implementation unit, the Eastern (17.2 %) and the Northern (24 %) had the highest number of sub-implementation unit. However, based on JRSM, the Northern (30.6 %), Central (39 %) and Western (40.8 %) regions had the highest number of implementation units requiring drug (Table 4).

Lastly, the sub-implementation units (communities') were classified based on the WHO endemicity criteria. Overall, 9.4 % and 7.3 % of the sub-IUs had moderate and high endemicity levels (Table 5). Majority of the sub-IUs with moderate and high endemicity levels were located in the Northern and Central regions.

3.3. Changes in the endemicity status of sub-implementation units compared to district level implementation unit

Fig. 1: shows changes in the schistosomiasis endemicity status when sub-IUs (communities') are used as the implementation unit compared to the district. Similar information is presented in Table 6. When categorization of endemicity status was done at district as IUs, 1762 sub-IUs were classified as low endemic areas, however using the sub-IUs (communities'), 46.7 % of these were classified as non-endemic (Table 6). Similarly, using the district as IUs, of 1145 district IUs categorise to have moderate endemicity, 31.7 %, 41.2 % and 23.9 % were categized as non-endemic, low and moderate endemic areas using the communities (Table 6a and 6b). On the other hand, using the district as an implementation unit, a total of 2362 communities were categorised to have high endemicity. However, when categorization was done using the sub-IUs (communities'), 41.6 %, 12.7 %, 16.7 % and 22.7 % were categorised into non-endemic, low, moderate and heavy endemic (Table 6a and 6b).

3.4. Projection of school-aged children and adult living in communities' and their level of risk

Overall, a total of 5,143,254 school aged children were estimated to be living in areas with different endemicity level of schistosomiasis (Table 7). Of these, 27 % and 20 % live in communities with moderate and high endemicity for schistosomiasis. Majority of the adult population live in areas with high endemicity for schistosomiasis (Fig. 2).

3.5. Comparison of the population requiring medicine by district as an implementation unit versus communities as an implementation unit

In general, the results indicate a significant variation in the communities' requiring treatment is the district is used as an implementation unit (Table 8). There was a discrepancy of 44.7 % of the number of communities' requiring treatment when the district is used as an implementation unit. Similarly, there was a discrepancy of 35.1 % of the total number of school children requiring treatment when the district is used as an implementation unit. Importantly, there was a variation of 35.1 % with a total of 2,315,950 extra praziquantel tablets requested when the district was used as an implementation unit.

Table 2
Total number of districts, communities, and the country population number.

Variable	Number
Number of provinces	4
Number of IUs (districts)	146
Number of sub-IUs (communities)	7501
Total Population	42,856,905
Number of school age children	12,579,425
Number of adults	22,192,579

Table 3
Categorization of wards using the decision tree algorithm for Uganda.

Total number of wards	1. Use sub-IU endemicity	2. Use IU endemicity	3. Use JRSM endemicity	4. Use highest adjacent endemicity	5. Need further assessment	6. Other methods
7501(100 %)	1239 (16.5 %)	1780(23.7 %)	2487(33.2 %)	0	0	1995(26.6 %)

Table 4
Categorization of implementation units by regions in Uganda using the decision tree algorithm for Uganda.

Region	1. Use sub-IU endemicity	2. Use IU endemicity	3. Use JRSM endemicity	4. Use highest adjacent endemicity	5. Need further assessment	6. Other methods	Total
Central	240 (15.7)	360 (23.5)	597 (39.0)	0	0	335 (21.9)	1532 (100)
Eastern	400 (17.2)	556 (23.9)	572 (24.6)	0	0	799 (34.3)	2327 (100)
Northern	396 (24.0)	522 (31.6)	505 (30.6)	0	0	228 (13.8)	1651 (100)
Western	203 (10.2)	342 (17.2)	813 (40.8)	0	0	633 (31.8)	1991 (100)
Total	1239 (16.5)	1780 (23.7)	2487 (33.2)	0	0	1995 (26.6)	7501 (100)

Table 5
Endemicity status of communities in Uganda.

Regions	Endemicity status of sub-implementation units				
	Not endemic	Low	Moderate	High	Total
Central	979 (64.7)	244 (16.1)	127 (8.4)	162 (10.7)	1512 (100)
Eastern	1151 (50.6)	846 (37.2)	134 (5.9)	145 (6.4)	2276 (100)
Northern	594 (38.8)	469 (30.6)	335 (21.9)	134 (8.7)	1532 (100)
Western	1671 (84.0)	135 (6.8)	89 (4.5)	95 (4.8)	1990 (100)
Total	4395 (60.1)	1694 (23.2)	685 (9.4)	536 (7.3)	7310 (100)

Key: non-endemic (0 %), low (prevalence <10 %), moderate (10 %–49 %) and high (50 % and above).

3.6. Communities with under treatment and over treatment when using the district is used as an implementation unit

Table 9 present the findings on the number of communities' which had either under treatment or over treatment when the district was used as an implementation unit. All the 823 communities' which were not required to received treatment received treatment rounds. These communities were classified as low endemic areas using the district as an implementation unit. However, using the communities as an implementation unit, all these communities were categorised as non-endemic. Similarly, of the 1691 areas categorised to have moderate endemicity using the district as an implementation unit, received treatment. When using communities has an implementation unit, 58.1 % (983 sub-IUs) and 17.7 % (300 sub-IUs) were categorised as non-endemic and with low endemicity (Table 9). Only 12.2 % (408) of these communities qualified for treatment (Table 9). Again, 50 % of the communities were under treated when the district was used as an implementation unit.

3.7. Treatment adequacy for targeted population

Overtreatment was noted in a total of 867,000 individuals who were classified living in moderate endemicity using the district as an implementation unit (Table 10). Using the communities as IUs, all these individuals were classified in low endemicity requiring no treatment. Similarly, of 1,383,013 individuals targeted for treatment using the district as an IUs, 42.8 % (591,928) of them were categorised into low endemicity, when the communities were used as IUs and did not require treatment. On the other hand, of 18,235 individuals classified to be living in non-endemic areas using the district as IUs, 72 % of them were undertreated/missed treatment when classification was done using communities as IUs (Table 10). These individuals were classified to be living in moderate endemicity areas.

Table 11 summarizes the number of school aged children adequately treated and missed treatment in all the sub-IUs in Uganda when the district was used as an IUs compared to the use of communities as IUs. Overall, 18,235 and 2,250,013 school aged children missed treatment and were unnecessary treated. There was also an under-estimation of treatment and over estimation of targeted population as shown in the Table 11. These data are categorised by regions of Uganda in Table 12. The Eastern (38.5 %) and Northern (32.6 %) region had the highest number of the SAC who were adequately treated where the Central region had the highest number of SAC who were undertreated (Table 12). The highest number of over treatments of SAC were observed in Eastern (38.2 %) and Northern (30.9 %) regions. These regions had also the highest percentage of excess PZQ tablets requested at 27.6 % and 34.5 % (Table 12).
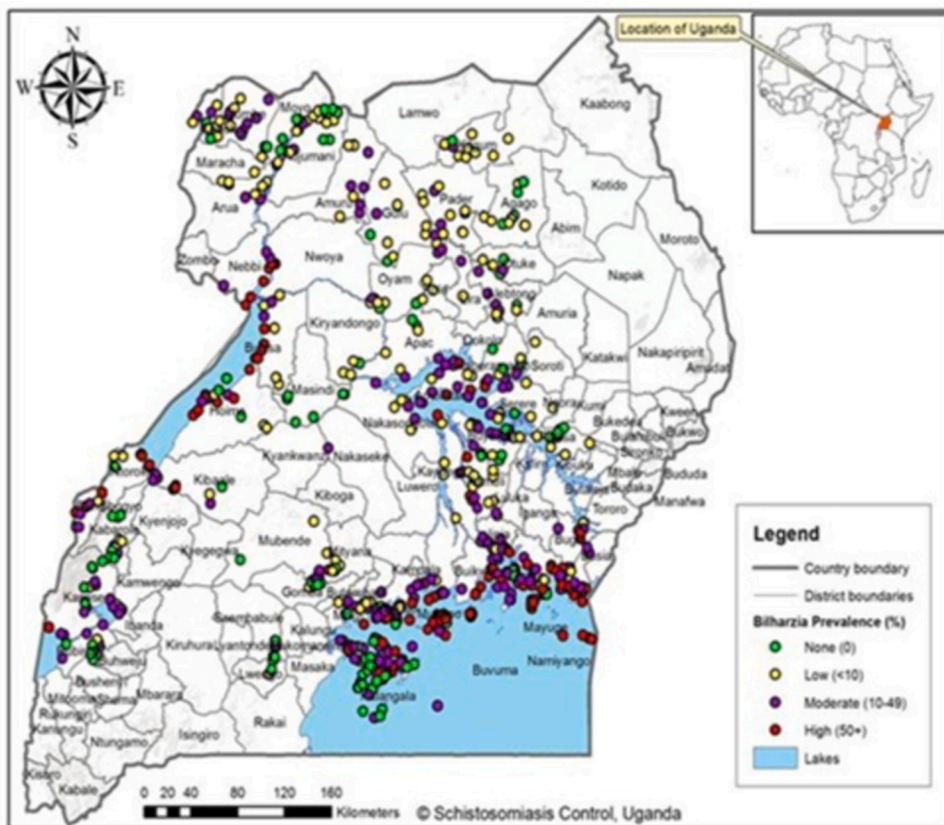
Fig. 1. Geographical Current distribution Schistosomiasis in Uganda.

Table 6a
Changes in endemicity category of communities compared to district level implementation.

Endemicity category by district level implementation		Endemicity category by community's level implementation			
Categories	Popn	Not endemic	Low	Moderate	High
Not endemic	2232	2226	3	3	0
Low	1762	823	919	0	0
Moderate	1145	363	472	274	0
High	2362	983	300	408	536
Total	7501	4395	1694	685	536

3.8. Before and after validation of communities' and population requiring treatment

Table 13 summarizes the total number of communities of Uganda and their schistosomiasis endemicity status before validation. Of the total 7501 communities, 404 (5.4 %), 729 (9.7 %) and 444(5.9 %) were categorised as not endemic, low, and moderate endemicity. The endemicity status of 5924 communities was not known. Before validation, a total of 2,537,230 (SAC = 944,184 and adult = 1,593,046) required treatment. After validation, 4395 (58.6 %), 1694 (22.6 %), 1221 (16.3 %) were not endemic, low, and moderate endemicity (Table 14). Overall, a total of 2,424,460 and 4,031,741 SAC and adult required treatment.

4. Discussion

Review and validation of the Uganda workbook and other documents available at WHO/ESPEN has given an opportunity to understand the changes which have occurred in the country after over 15 years of MDA and the importance of using communities versus districts has an implementation unit for planning and executing MDA. The findings indicate that the use of a district as an UIs resulted into a misclassification of the infection risk levels of communities/wards which translated into underestimation or overestimation of the number of people requiring preventive chemotherapy, the number of PZQ tablets requested for the MDA campaigns and in-country budgeting for the MDA exercise. For instance, before validation, Uganda had a total of 7501 communities but schistosomiasis endemicity status was known for only 21 % (5.4 %-not endemic, 9.7 %-low endemicity and 5.9 %-moderate endemicity) of the

Table 6b

Projected changes in endemicity category within district level when the classification is by district the implementation unit in Uganda.

Endemicity category by community's level implementation	Number	Percentage (%)
Classified as Not endemic at District level implementation ($N = 2232$)		
Not endemic	2226	99.7
Low	3	0.1
Moderate	3	0.1
High	0	0.0
Classified as Low at District level implementation ($N = 1762$)		
Not endemic	823	46.7
Low	919	52.2
Moderate	0	0.0
High	0	0.0
Classified as Moderate at District level implementation ($N = 1145$)		
Not endemic	363	31.7
Low	472	41.2
Moderate	274	23.9
High	0	0.0
Classified as High at District level implementation ($N = 2362$)		
Not endemic	983	41.6
Low	300	12.7
Moderate	408	17.3
High	536	22.7

Table 7

Number of sub-IUs by endemicity categories and related populations in Uganda.

Endemicity categories of communities'	Number of communities'	Number of school age children	Number of adults
Not endemic	4395 (58.6)	0	0
Low	1694 (22.6)	2,718,794 (52.9)	0
Moderate	685 (9.1)	1,388,635 (27.0)	457,911 (20.8)
High	536 (7.1)	1,035,825 (20.1)	1,742,190 (79.2)
Total	7501 (100)	5,143,254 (100)	2,200,101 (100)
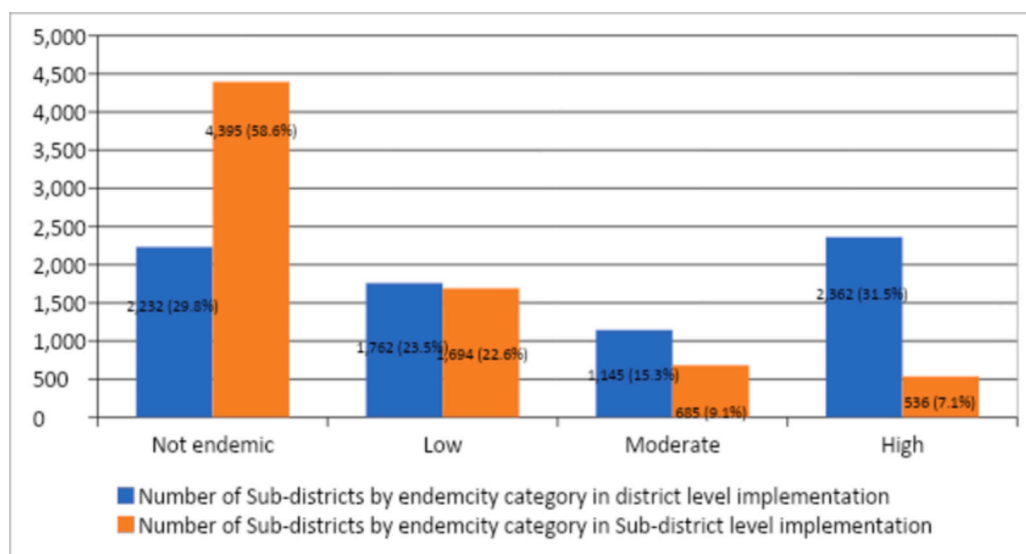
Fig. 2. Comparison of number of communities' and their endemicity categorised using district as an implementation unit and communities has an implementation unit.

communities. After validation, the endemicity status of 97.5 % of the communities was known, with 58.6 % (4395) were noted to not endemic, 22.6 % (1694) had low endemicity and 16.3 % (1221) had moderate endemicity. Similar picture was noted in the population required preventive chemotherapy, before validation, a total of 2,537,230 people (944,184 school aged children and 1,593,046 adult) were indicated to require preventive chemotherapy. After validation, 6,456,201 people (2,424,460 school aged children and 4,031,741 adults) required preventive chemotherapy. The gaps observed in the risk level of communities and the number of people

Table 8

Comparison of target population and medicines by district implementation versus community's implementation.

Variable	District level implementation	Communities level implementation	Variation
Number of Communities	5269	2915	−2354 (−44.7 %)
School age children requiring treatment	3,562,789	2,636,409	−926,380 (−35.1 %)
PZQ Estimates	8,906,972	6,591,022	−2,315,950 (−35.1 %)

Table 9

Number of communities' with under treated and over treated in district level implementation by endemicity category.

Preventive Chemotherapy strategy adequacy	District level implementation		Communities level implementation			
			Communities endemicity category			
			Not endemic	Low	Moderate	High
Adequate Treatment	Not endemic	2226 (100)	2226 (100)	0	0	0
	Low	919 (100)	0	919 (100)	0	0
	Moderate	274 (100)	0	0	274(100)	0
	High	536 (100)	0	0	0	536(100)
	Total	3955(100)	2226(56.3)	919 (23.2)	274(6.9)	536(13.6)
Under Treatment	Not endemic	6 (100)	0	3 (50.0)	3 (50.0)	0
	Low	0	0	0	0	0
	Moderate	0	0	0	0	0
	High	0	0	0	0	0
	Total	6(100)	0	3 (50.0)	3 (50.0)	0
Over Treatment	Not endemic	0	0	0	0	0
	Low	823(100)	823(100)	0	0	0
	Moderate	835(100)	363(43.5)	472(56.5)	0	0
	High	1691(100)	983(58.1)	300(17.7)	408 (24.1)	0
	Total	3349(100)	2169(64.8)	772(23.1)	408 (12.2)	0
	Grand total	7310(100)	4395(60.1)	1694(23.2)	685(9.4)	536 (7.3)

Table 10

Treatment adequacy for target populations by endemicity categories.

PC strategy adequacy	District level implementation		Sub-IU level implementation			
			Sub-IU Endemicity Category			
			Not endemic	Low	Moderate	High
Adequate Treatment	Not endemic	0	0	0	0	0
	Low	1,254,803 (100)	0	1,254,803 (100)	0	0
	Moderate	584,378 (100)	0	0	584,378 (100)	0
	High	1,035,825 (100)	0	0	0	1,035,825 (100)
	Total	2,875,006 (100)	0	1,254,803 (43.6)	584,378 (20.3)	1,035,825 (36.0)
Under Treatment	Not endemic	18,235 (100)	0	5063 (27.8)	13,172 (72.2)	0
	Low	0	0	0	0	0
	Moderate	0	0	0	0	0
	High	0	0	0	0	0
	Total	18,235 (100)	0	5063 (27.8)	13,172 (72.2)	0
Over Treatment	Not endemic	0	0	0	0	0
	Low	0	0	0	0	0
	Moderate	867,000 (100)	0	867,000 (100)	0	0
	High	1,383,013 (100)	0	591,928 (42.8)	791,085 (57.2)	0
	Total	2,250,013 (100)	0	1,458,928 (64.8)	791,085 (35.2)	0
	Grand total	5,143,254 (100)	0	2,718,794 (52.9)	1,388,635 (27.0)	1,035,825(20.1)

Table 11

Treatment adequacy of Sub-IUs in previous IU level implementation Vs Sub-IU level.

Number of sub-IUs	SAC adequately treated	SAC missing treatment	SAC unnecessary treated	Under estimations gaps	Over estimations excess
7501	2,875,006	18,235	2,250,013	20,642	2,348,805

before and after validation of the Uganda workbook shows (i) the importance of periodic review of the in-country data after repeated rounds of MDA (ii) the importance of using communities as an IUs rather the district as an IUs which has a number of limitations and (iii) the importance of having a living workbook for schistosomiasis endemic countries.

Table 12
Treatment adequacy of Sub-IUs in previous IU level implementation Vs Sub-IU level by province.

Region	Number of Ward	SAC adequately treated	SAC under treated	SAC over treated	Under treatment gaps in PZQ	Over treatment excess in PZQ
Central	1532	518,739	18,235	431,778	20,642	545,731
Eastern	2327	1,108,186	0	861,053	0	647,786
Northern	1651	938,014	0	694,752	0	810,987
Western	1991	310,067	0	262,430	0	344,301
Total	7501	2,875,006	18,235	2,250,013	20,642	2,348,805

Uganda is one of the first African countries to launch a national-scale schistosomiasis control in 2003 (Fenwick et al., 2009). Mass drug administration has been a key intervention against schistosomiasis in Uganda and repeated rounds of MDA have resulted in changes in the prevalence and intensities of schistosomiasis, which translate to changes in the schistosomiasis endemicity status of the district as an IUs. It is clear that the changes in endemicity status can vary within a single district or community. Thus, using the district as IUs to define the endemicity status of communities can lead to misclassification of wards/counts. A noted change in the endemicity status of communities was observed when the communities were used as IUs. Over 50 % of the communities was noted to be not endemic for schistosomiasis and the country had no any communities which had high endemicity. In addition, considering the recent release of treatment guidelines by WHO (WHO, 2022), the country will have an additional of 22.6 % (1694 with prevalence <10 %) communities which will not require treatment rounds and only 16.3 % (1221) requiring only one round of treatment. These results will have a significant impact on the country's request for PZQ tablets to reduce drug wastage, reduce the in-country budget for MDA implementation and monitoring and finally, will allow the national control programme to implement a highly focused MDA targeting only communities remaining with pockets of infection (Tchuenté et al., 2017).

Among the disadvantages of using the district as an IUs is undertreatment and overtreatment which is simply translated into wastage of medicine. The current analysis and the consideration of the new treatment guidelines (WHO, 2022) will help Uganda overcome the problem of undertreatment and overtreatment. This will allow the country to plan for the delivery of a highly focused treatment plan by delivering drugs to the most needed areas. In addition, the country will have space to deliver drug to the most at-risk population of adult and pre-school aged children. The analysis has further shown that, a total of 6,546,201 people (2,424,460 school aged children and 4,031,741 adult) require preventive chemotherapy and are living in areas categorised by the new treatment guidelines requiring at least one round of treatment. It is worthwhile to note that the discrepancy observed between the two-implementation unit, the district, and the sub-district, arises from comparing the number of those at risk when the prevalence threshold was aggregated at a higher level, the district IU versus the population estimated to be at risk when the prevalence was disaggregated to smaller sub-units, the sub-district IU. The analysis identified the gaps which were previously not addressed. However, the difference in the number of people requiring the treatment from the two IU, does not imply an increased need for resources because the target districts remain the same, but it does indeed indicate a higher need for donation of PZQ drug. Furthermore, in this analysis is important to note that the population requiring treatment increased at sub-district analysis due to the more granular analysis, again this does not imply a higher logistical demand.

For the 4,031,741 adults requiring treatment, the analysis was based on the WHO guidelines that recommend treating all at risk persons in areas where the prevalence of schistosomiasis exceeds 10 %. While no communities were classified as having "high endemicity," in Uganda, the large number of adults requiring preventive chemotherapy reflected the inclusion of moderately endemic areas where adults still need treatment, as per WHO's threshold for mass drug administration. The data showing over 50 % of communities as non-endemic is accurate after district-level disaggregation, but the large adult population needing treatment comes from those moderate-endemicity areas. On the other hand, the increased the number of people requiring preventive chemotherapy, especially adults and the reduced number of communities requiring treatment, the country can be in track to achieve the required minimum treatment coverage of 75 % as recommended by the WHO (WHO, 2002). The impact of repeated MDA has been demonstrated in Africa (Kokaliaris et al., 2022), with a reduction of prevalence of 60 %, gives a clear way forward that the continent is on the right track to achieve the 2030 vision (WHO, 2020). These results call for the inclusion of other supplementary measures such as provision of clean water, improved sanitation, and hygiene.

5. Limitation

Even though the assessment tool has provided useful information about the need for changing of implementation units, from district to communities and the milestone the country has reached in fighting against schistosomiasis, there are limitations which are worthwhile to mention. Parasitological data used in the analysis tool were based on a single stool and urine samples, which can lead to under estimation of the true prevalence and intensity of infection (Berhe et al., 2007). The use of the prevalence data of adjacent geographical area to estimate the prevalence of the nearby geographical area may have led to either underestimation or overestimation of the true prevalence. Thus, verification of each of the endemic communities is highly recommended.

6. Conclusion

The assessment tools have clearly demonstrated that, Uganda has reduced the number of communities requiring preventive

Table 13
Number of sub-units by PC regimen and targeted populations before validation.

Region	Total No. of communities	Total population	Not endemic			<10 % (No PC)			≥ 10 % (1 round/year)			≥ 10 % (2 rounds/year)			Unknown		
			No. of communities'	No. of SAC	No. of adults	No. of communities	No. of SAC	No. of adults	No. of communities	No. of SAC	No. of adults	No. of communities	No. of SAC	No. of adults	No. of communities	No. of SAC	No. of adults
Central	1532(100)	457,912 (100)	93 (6.1)	0	0	16,410.7)	0	0	68 (4.4)	147,346 (32.2)	310,566 (67.8)	0	0	0	1207(78.8)	0	0
Eastern	2327(100)	1,061,412 (100)	75 (3.2)	0	0	265(11.4)	0	0	170 (7.3)	413,932 (39.0)	647,480 (61.0)	0	0	0	1817(78.1)	0	0
Northern	1651(100)	779,194 (100)	96 (5.8)	0	0	217(13.1)	0	0	155(9.4)	300,741 (38.6)	478,453 (61.4)	0	0	0	1183(71.7)	0	0
Western	1991(100)	238,712 (100)	140 (7.0)	0	0	83(4.2)	0	0	51(2.6)	82,165 (34.4)	156,547 (65.6)	0	0	0	1717(86.2)	0	0
Total	7501(100)	2,537,230 (100)	404 (5.4)	0	0	729(9.7)	0	0	444(5.9)	944,184 (37.2)	1,593,046 (62.8)	0	0	0	5924 (79.0)	0	0

Table 14
Number of communities by PC regimen and targeted populations after validation.

Region	Total No. of communities	Total population	Not endemic			<10 % (No PC)			≥ 10 % (1 round/year)			≥ 10 % (2 rounds/year)		
			No. of communities	No. of SAC	No. of adults	No. of communities	No. of SAC	No. of adults	No. of communities	No. of SAC	No. of adults	No. of communities	No. of SAC	No. of adults
Central	1532 (100)	1,581,209 (100)	979 (63.9)	0	0	244 (15.9)	0	0	289 (18.9)	534,346 (33.8)	1,046,863 (66.2)	0	0	0
Eastern	2327 (100)	1,694,186 (100)	1151 (49.5)	0	0	846 (36.4)	0	0	279 (12.0)	667,989 (39.4)	1,026,197 (60.6)	0	0	0
Northern	1651 (100)	2,248,158 (100)	594 (36.0)	0	0	469 (28.4)	0	0	469 (28.4)	888,196 (39.5)	1,359,962 (60.5)	0	0	0
Western	1991 (100)	932,648 (100)	1671 (83.9)	0	0	135 (6.8)	0	0	184 (9.2)	333,929 (35.8)	598,719 (64.2)	0	0	0
Total	7501 (100)	6,456,201 (100)	4395 (58.6)	0	0	1694 (22.6)	0	0	1221 (16.3)	2,424,460 (37.6)	4,031,741 (62.4)	0	0	0

chemotherapy and the tools have further demonstrated the gaps when using the district as implementation unit versus using the community as implementation unit. There are more advantages of using the communities in planning and implementation of mass drug administration which will reduce wastage of drugs, financial resources and allow the control programme to implement a focused mass drug administration targeting the most in need communities in order to achieve the elimination goals.

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Declaration of generative AI and Ai-Assisted Technologies

The author declare that there was no use of generative AI and AI-assisted technologies during the writing process and submission of the manuscript.

Ethical standards

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CRediT authorship contribution statement

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Declaration of competing interest

The authors declare that there are no conflicts of interest in the authorship of this publication.

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Appendix A. Supplementary data

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