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Theme:

**The Control and Elimination of Preventive
Chemotherapy Neglected Tropical Diseases
(PC/NTDs) in Nigeria: Strategy for meeting the
WHO 2030 Elimination goals**

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Application of the novel ESPEN schistosomiasis community Data Analysis tool to refocus Preventive Chemotherapy intervention for schistosomiasis Control and Elimination in Nigeria.

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Abstract

The control and elimination of schistosomiasis in Nigeria with preventive chemotherapy (PC) require precise mapping of disease endemicity. We used a novel ESPEN schistosomiasis community data analysis tool developed by WHO/ESPEN to disaggregate LGA epidemiological data from 4,773 locations across Nigeria for the period 2000-2018 into ward-level endemicity data. We derived schistosomiasis endemicity for 6,188/9,684(63.9%) wards in the country. The proportion of non-endemic wards compared to the non-endemic LGAs increased from 2,533 (26.2%) to 3,320 (34.3%), and the number of endemic wards requiring PC dropped from 7,151 (73.85%) to 6,364 (65.7%). In addition, the number of persons requiring PC treatment increased from 39,652,252 to 41,196,352 individuals of which 16,478,341 (40.0%) are school-age children. The people requiring PC treatment based on new WHO treatment guidelines increased from 39,652,252 to 53,989,872 individuals, of which 18,896,462 (35.0%) are school-aged children and 35,093,410 (65.0%) are adults. These results demonstrate the usefulness of the ESPEN schistosomiasis community analysis tool for strategic planning to refocus and redirect intervention to endemic wards in need of PC towards the interruption of transmission and elimination of schistosomiasis in Nigeria.

Keywords: schistosomiasis, data analysis tool, control, elimination, Nigeria

Introduction

Schistosomiasis is a neglected tropical disease

caused by a parasitic flatworm (*Class Trematoda*) called *Schistosoma* and is targeted for elimination as a public health problem by the year 2030 [1]. It was

estimated that 241.3 million people required treatment for schistosomiasis in 2020, with more than 90% of them living in sub-Saharan Africa, 133.3 million of whom were school-aged (5-14 years) children [2]. Three species are endemic in Nigeria namely: *Schistosoma mansoni* and *Schistosoma intercalatum* which cause intestinal schistosomiasis, and *Schistosoma haematobium* which causes urogenital schistosomiasis [3]. It is estimated that around 29 million people [4,5] are infected in Nigeria, representing 14% of the global burden [6]. People are infected when they come in contact with freshwater from rivers, streams, and ponds, harbouring the infected larva called cercaria which develops in freshwater snails [7]. School-aged children (SAC) are the most-high risk group and therefore the target of preventive chemotherapy [8]. However, it is now widely recognized that other groups such as pre-school-aged children [9] and adults are infected and act as reservoirs, thereby rendering the entire community members at risk [10].

The presence of schistosomiasis in Nigeria dates to pre-independence times, with historical maps and data reporting *S. haematobium* infection in the country [11]. A comprehensive distribution map of *S. haematobium* and *S. mansoni* with locations of reported cases in Nigeria was first published in 1984 [12]. It was not until 1988 that a national schistosomiasis control programme was established, due to growing interest in the control of the disease [13]. Due to the lack of funding, only limited surveys and control activities were implemented until 2000 when several non-governmental organizations (NGOs) started to support the implementation of nationwide mapping surveys for onchocerciasis, lymphatic filariasis, and soil-transmitted helminthiasis [13-16]. These nationwide mapping surveys were later used to produce model-based geostatistical estimates of transmission risk and population affected [17]. From this modelling exercise, it was estimated that 11.3 million school-aged children were infected by any schistosome species in Nigeria. A later and follow-up study updated the estimates to 22.6 million SAC, and 45.5 million total population requiring annual preventive chemotherapy (PC) treatment with praziquantel (PZQ) in Nigeria [18].

Following the London Declaration on NTDs, where 22 development partners and pharmaceutical companies pledged to sustain, expand, and extend access to the supply of PZQ for as long as it is needed

for the control of schistosomiasis by 2020 [19], provided an opportunity for scaling up control activities by providing epidemiological data necessary for planning and starting PC treatment with praziquantel in Nigeria [20]. Consequently, between 2013-2018, a nationally coordinated epidemiological mapping of schistosomiasis was carried out in schools in 19 States and the Federal Capital Territory (FCT) using the WHO mapping protocol [21]. The mapping exercise provided prevalence estimates and risk classification at the LGA level (second administrative level), in which 582 out of 774 LGAs were found endemic for schistosomiasis. Schistosomiasis risk classification put

- (I) 279 LGAs as low risk (10 prevalence) requiring treatment of SAC once in 2 years;
- (ii) 293 LGAs as moderate risk (10-49% prevalence) requiring treatment of SAC once a year; and
- (iii) 10 LGAs as high risk (50% prevalence) requiring treatment for SAC and adults once a year, while
- (iv) 191 LGAs as non-endemic [21].

The mapping results estimated that a total of 139,645,032 people lived in schistosomiasis at-risk areas in 2017, where 41,033,925 SAC and 1,396,203 adults would require regular treatments with PZQ [21]. In 2020, the National Control Programme delivered 9,558,570 and 6,636,532 treatments to the SAC and adult populations respectively, representing 55% of SAC and 73% of adults requiring PC in the country were treated [22]. A recent modelling study has shown strong evidence of the positive impact of scaling up PC interventions with PZQ on schistosomiasis prevalence among SAC in Nigeria; prevalence decreased by 44.9% in 2011-2014 and 67.1% in 2015-2019, compared to baseline prevalence (2000-2010) [23].

The overall strategic plan for morbidity control is to achieve and maintain 100% geographic coverage and achieve and maintain at least 75% therapeutic coverage of eligible populations. To reach these goals, necessary for the elimination of the disease by 2030, more targeted and precise interventions are needed. Schistosomiasis transmission has been seen to be focal, meaning variable transmission intensity may concur within an outlined implementation area [10]. Therefore, defining treatment strategies based on averaged prevalence for large areas may lead to

overestimating and underestimating treatment needs. This fact has led to a shift in the current treatment strategies focused on ‘district-level’ interventions to a community-centred strategy, which will help allocate treatment to where it is needed thereby reducing the treatment gap and preventing over-or undertreatment [24].

The available repository of geolocated epidemiological data has allowed us to disaggregate LGA data to a lower geographical level, ward level, without necessarily leading to costly remapping exercises. This paper documents the procedure, processes, and outcome of using the ESPEN schistosomiasis community Data Analysis Tool (https://espen.afro.who.int/system/files/content/resources/Schistosomiasis_Data_analysis_tool_-_User_Guide_%28V1_20190916_English%29.pdf) for the disaggregation of existing schistosomiasis LGA endemicity classification into ward-level endemicity in Nigeria.

Materials and Methods

Study Area

Nigeria, located in West Africa, is the most populous country in Africa. The country is administered through 36 States, FCT, and 774 LGAs. The population of Nigeria is estimated to be 206,139,587 million inhabitants in 2020 (<https://data.worldbank.org/indicator/SP.POP.TOTL?locations=NG>). The health system is decentralized, comprising primary health care (PHC) facilities in the communities and general hospitals at the LGA level. There is at least one federal or state-owned tertiary health institution in each state capital. There are 226,900 public and private primary schools with a total enrolment of 27,889,387 pupils and an average of 122 pupils per school (https://ubec-static.s3.amazonaws.com/media/data/COMPENDIUM_OF_PUBLIC_AND_PRIVATE_SCHOOLS_BASIC_EDUCATION_PROFILE_INDICATORS_IN_N_jTSHIwI.xlsx).

Schistosomiasis Control in Nigeria

Schistosomiasis intervention is coordinated by National Schistosomiasis and Soil-Transmitted Helminthiasis Control Programme, within the Federal Ministry of Health, Abuja. In each state, there is a local or international development partner supporting the implementation of PC: Evidence Action in Ogun, Oyo and Rivers States; Helen Keller International (HKI) in Katsina, Bornu, Adamawa and Akwa Ibom States; Amen Health Foundation in Osun

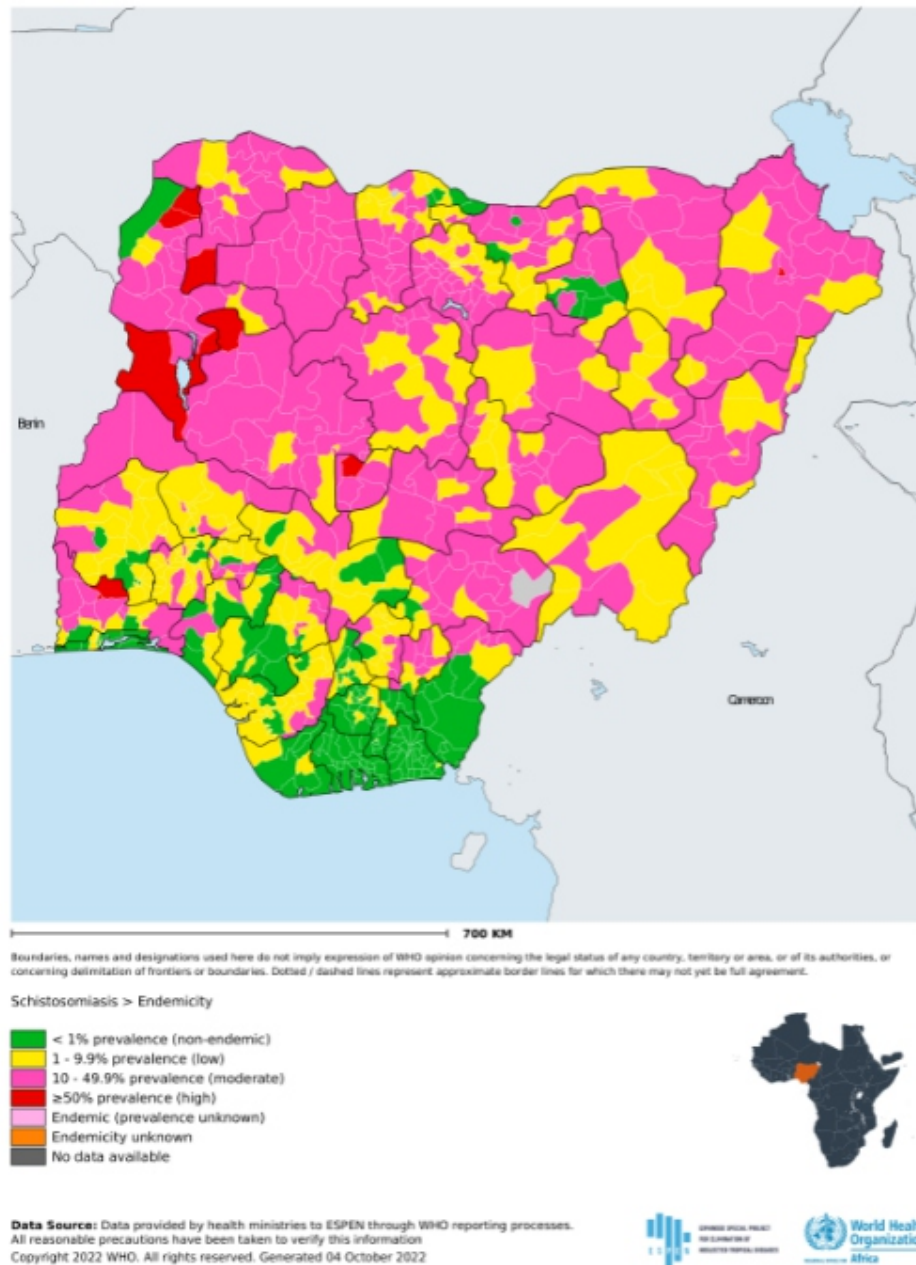
and Gombe States; Sightsavers in Sokoto, Kebbi, Zamfara, Kaduna, Kwara, Kogi, and Benue State; Mission to Save the Helpless (MITOSATH) in Niger, Bauchi, Taraba, Ekiti, Lagos and Ondo States; The Carter Centre (TCC) in Plateau, Nasarawa, Anambra, Enugu, Imo, Abia, Delta and Edo States; Christoffel Blinden Mission (CBM) and Health and Development Support (HANDS) in FCT, Kano, Jigawa, and Yobe States; Research Triangle Institute (RTI) International through ENVISION and ActEast Projects in Cross River State. Bayelsa is the only State in the country without a partner. Based on the Schistosomiasis transmission risk, school-based interventions are implemented at the LGA level based on the endemicity classification as shown in Figure 1.

Sources of the Epidemiological Dataset

The epidemiological dataset used in this analysis was mostly derived from national surveys carried out in primary schools in Nigeria between 2000 and 2018. The main goal of the surveys was to provide evidence-based data for advocacy, funding, and support of PC with praziquantel. The initial survey began in 2000 to 2012, for schistosomiasis (*S. haematobium*) in Plateau and Nasarawa States supported by the Carter Center and States Ministries of Health [25]. The other States, such as Ekiti, and Ondo States also conducted some surveys during this period, except for Ogun State, where historical published data was deemed sufficient for estimating baseline prevalence. A nationally coordinated extensive survey was conducted by FMOH, in collaboration with State Ministries of Health and NGOs using trained field workers in 19 states and FCT from 2013-2015 [20]. The survey used standard protocols developed by WHO for rapid mapping of schistosomiasis infection in schools, collection of urine and stool samples, and laboratory work-up [26]. Samples collected from children were assessed for haematuria using the Combi-9 reagent strip and then examined for eggs in 10ml urine by filtration for *S. haematobium* infection. *S. mansoni* eggs’ presence in stool was assessed using sedimentation or the Kato-Katz technique, with duplicate Kato-Katz thick smears prepared from fresh stool samples; one per participant [26]. Five schools were visited per LGA, in which 50-55 pupils of both sexes, 5-16 years old, from each school were surveyed. The consultants and supervisors verified laboratory results to ensure consistency in sample preparation and examination [21]. Data were collected at 4,773 locations across Nigeria. All epidemiological data were compiled and

Figure 1: Current Status of Schistosomiasis endemicity in Nigeria by LGA as of 2021 (Source Nigeria | ESPEN (who.int))

Nigeria (2021)
 Status of Schistosomiasis Elimination



uploaded to the WHO/ESPEN database. Only Mobar LGA in Bornu State (north-eastern Nigeria) was not surveyed due to security challenges. These surveys were supplemented with historical data submitted to WHO/AFRO, downloaded from the Global Atlas of

Helminth Infections (GAHI), and provided by the Schistosomiasis Control Initiative Foundation (SCIF).

Disaggregation to Ward-Level Endemicity Data

WHO/ESPEN decision tree algorithm was used to assign endemic data to the wards. WHO/ESPEN tool for disaggregation of district-level schistosomiasis prevalence is an MS Excel-based application and has been provided with macros that automatically reassign the available survey data to the selected administrative level and implement the decision tree algorithm after having entered the necessary data: community-level survey data, demographics and reported LGA endemicity [27]. Briefly, the tool reassigns the community-level surveys to a ward-level, based on their geolocation or manually using local knowledge of the community's location. If there are more than one data point (survey sites) with varied prevalence values within a ward, the highest endemicity value is assigned to the ward. Where there is no survey data available for determining ward-level schistosomiasis endemicity for areas already implementing MDA, the tool allows for deciding if to continue MDA using the reported LGA level endemicity, estimated endemicity for adjacent wards, or LGA level endemicity as reported in the most recent JRSM submission. In the circumstance of non-availability of this information, other methods such as similar environmental conditions to classified wards and recent prevalence data from literature can be used to assign endemicity category to allow a decision on whether MDA should be continued pending further mapping. WHO/ESPEN organized training workshops to train national programmes and data managers on the use of the schistosomiasis community data analysis tool and to validate the final ward-level reassignment of schistosomiasis endemicity.

New WHO recommended PC Treatment Guidelines.

The new WHO treatment guidelines recommend the following treatment strategy: in endemic communities with *Schistosoma* spp. infection <10% continue the intervention at the same or reduced frequency, where there has been a programme of regular PC, or use a clinical approach of test-and-treat where no regular PC has yet been implemented; in endemic communities with schistosomiasis prevalence $\geq 10\%$, the programme should deliver annual PC with a single dose of PZQ at $\geq 75\%$ treatment coverage; and in endemic communities with schistosomiasis prevalence $\geq 10\%$, that demonstrate lack of an appropriate response to annual PC, despite adequate treatment coverage ($\geq 75\%$), the programme should pursue implementing two PC rounds per year. PC treatments are to be

extended to all age groups from 2 years old, including adults, pregnant women after the first trimester and lactating women [28]. The new treatment guidelines were used to produce estimates of SAC and adult population requiring PC at different administrative levels (state, LGA and wards).

Results*General Description: Country Division And Demographics*

In Nigeria, there are 9,684 wards distributed across the 774 LGAs, up until now considered implementation units (IUs), and 37 states including FCT. The total population is 197,791,762, of which school-aged children (SAC) are 55,381,729 (28.0%) and adults 102,851,741 (52.0%).

Categorization of Ward-level Schistosomiasis Endemicity

The existing 9,684 wards were categorized using the decision tree algorithm for schistosomiasis endemicity reassignment (Figure 2). Schistosomiasis risk transmission at the ward level was mostly determined based on LGA level endemicity, 6,188 out of 9,684 wards (63.9%) wards. For 3,368 (34.8%) wards, endemicity was established based on the reassignment of available prevalence surveys and in 128 (1.3%) wards, the reported IU level endemicity at the latest JRSM submission was used.

Table 1 shows the distribution of wards categorization by states according to the decision tree. Except for some wards in Anambra, Borno, Imo, and Ogun States, all the ward data were derived from either LGA endemicity or ward endemicity. JRSM endemicity data was used for the categorization of 68 (25.9%) of the wards in Ogun State, 35 (10.6%) of the wards in Anambra State; 15 (3.6%) of the wards in Imo State, and 10 (3.2%) of the wards in Borno State.

Distribution of Population Requiring Treatment Based on Ward-level Endemicity.

The population requiring PC treatment for schistosomiasis is 46.9M of which 37.5M (79.9%) are school-aged children (SAC) and 9.4M (20.0%) are adults (Table 2). Akwa Ibom, Imo, Lagos and Rivers States have no adult population requiring treatment. A total of 3,320 wards are non-endemic. While the categorization of endemicity for PC implementation at the ward level, in locations with schistosomiasis shows that a total of 252 (2.6%) of the wards are in the high endemic category, 2,981 (30.8%) in moderate endemic category and 3,131

Figure 2: Methods used for disaggregation of LGA level endemicity data to Ward level endemicity data.

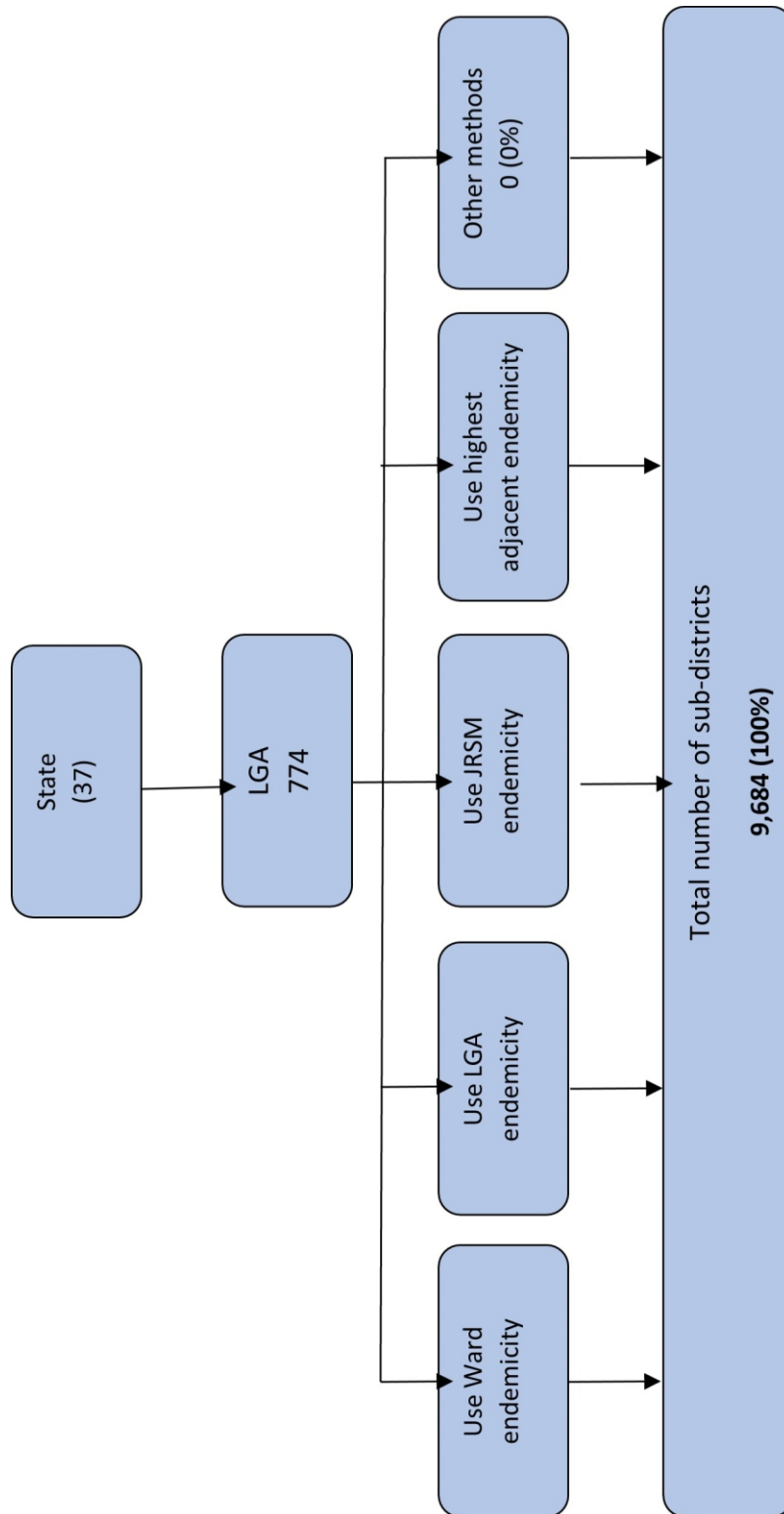


Table 1: Distribution of Wards Categorization Methods by State

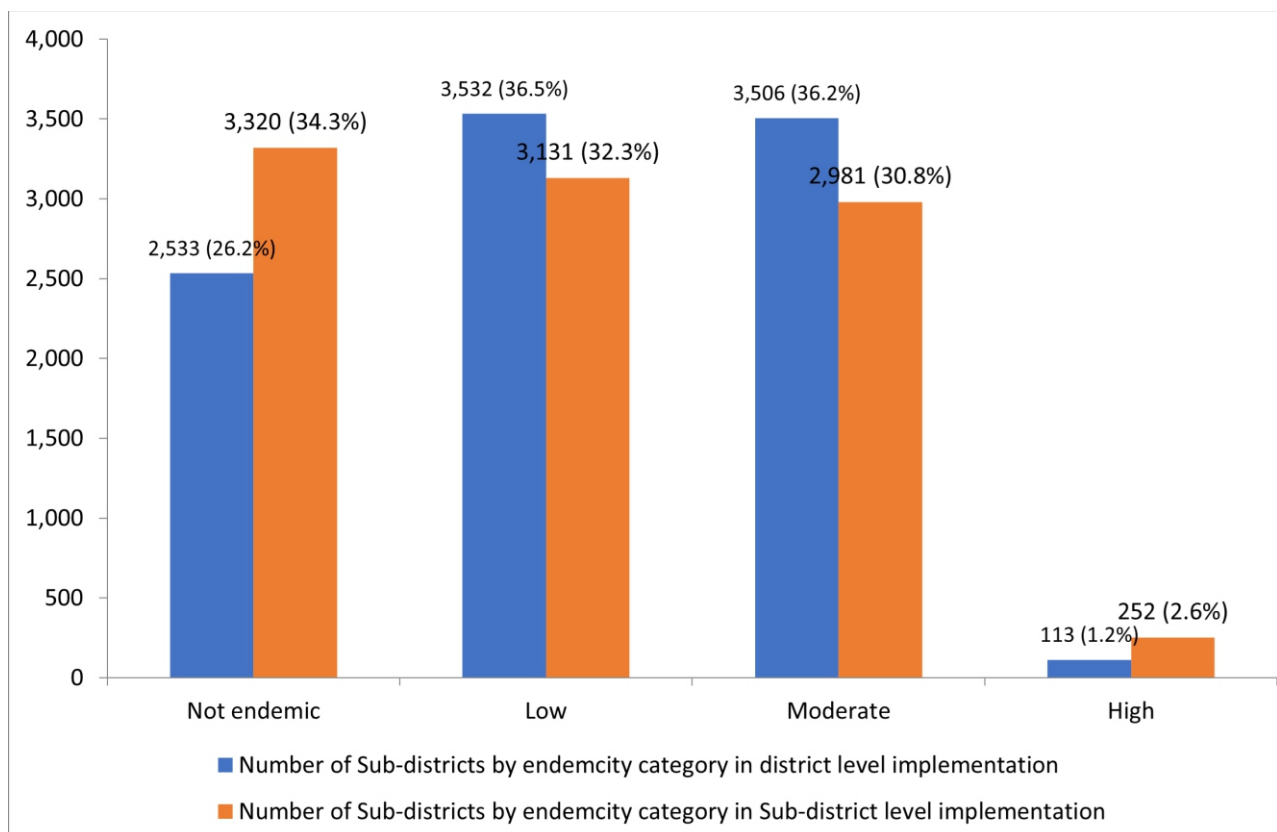
State	1. Use sub-IU endemicity	2. Use IU endemicity	3. Use JRSM endemicity	Total
ABIA	107 (38.8)	169 (61.2)	0	276 (100)
ADAMAWA	90 (39.6)	137 (60.4)	0	227 (100)
AKWA IBOM	122 (36.4)	213 (63.6)	0	335 (100)
ANAMBRA	90 (27.4)	204 (62.0)	35 (10.6)	329 (100)
BAUCHI	92 (28.3)	233 (71.7)	0	325 (100)
BAYELSA	30 (28.6)	75 (71.4)	0	105 (100)
BENUE	91 (32.6)	188 (67.4)	0	279 (100)
BORNO	59 (19.0)	241 (77.7)	10 (3.2)	310 (100)
CROSS RIVER	83 (42.1)	114 (57.9)	0	197 (100)
DELTA	141 (51.6)	132 (48.4)	0	273 (100)
EBONYI	82 (26.7)	225 (73.3)	0	307 (100)
EDO	100 (51.8)	93 (48.2)	0	193 (100)
EKITI	53 (29.6)	126 (70.4)	0	179 (100)
ENUGU	69 (20.2)	273 (79.8)	0	342 (100)
FCT	24 (38.7)	38 (61.3)	0	62 (100)
GOMBE	38 (33.3)	76 (66.7)	0	114 (100)
IMO	166 (39.7)	237 (56.7)	15 (3.6)	418 (100)
JIGAWA	120 (41.8)	167 (58.2)	0	287 (100)
KADUNA	103 (40.4)	152 (59.6)	0	255 (100)
KANO	194 (40.0)	291 (60.0)	0	485 (100)
KATSINA	164 (45.4)	197 (54.6)	0	361 (100)
KEBBI	83 (36.9)	142 (63.1)	0	225 (100)
KOGI	99 (40.7)	144 (59.3)	0	243 (100)
KWARA	72 (36.9)	123 (63.1)	0	195 (100)
LAGOS	82 (21.8)	295 (78.2)	0	377 (100)
NASSARAWA	79 (53.7)	68 (46.3)	0	147 (100)
NIGER	139 (49.1)	144 (50.9)	0	283 (100)
OGUN	15 (5.7)	180 (68.4)	68 (25.9)	263 (100)
ONDO	56 (27.2)	150 (72.8)	0	206 (100)
OSUN	119 (33.7)	234 (66.3)	0	353 (100)
OYO	138 (39.3)	213 (60.7)	0	351 (100)
PLATEAU	112 (34.5)	213 (65.5)	0	325 (100)
RIVERS	97 (30.4)	222 (69.6)	0	319 (100)
SOKOTO	87 (35.7)	157 (64.3)	0	244 (100)
TARABA	68 (40.5)	100 (59.5)	0	168 (100)
YOBE	55 (30.7)	124 (69.3)	0	179 (100)
ZAMFARA	49 (33.3)	98 (66.7)	0	147 (100)
Total	3,368 (34.8)	6,188 (63.9)	128 (1.3)	9,684 (100)

(32.3%) in the low endemic category. The 252 high endemic wards are in 28 (75.7%) out of 37 States. Seven States (Niger=42, Ogun=37, Kebbi=27, Sokoto=23, Borno=16, Zamfara=12 and FCT Abuja=10) account for 66.2% of high-risk wards in the country. For the state-by-state distribution of ward transmission risk and population of school-age children and adults requiring PC (Table 2).

Changes in Ward Endemicity Categories from LGA-level Implementation

Figure 3 provides information on the changes in ward endemicity categorization after disaggregation. The number and proportion of non-endemic wards increased from 2,533 (26.2%) to 3,320 (34.3%). Likewise, the number of low endemic wards decreased from 3,532 (36.5%) to 3,131 (32.3%), and that of moderate endemic wards equally decreased from 3506 (36.2%) to 2981 (30.8%). However, the

Figure 3: Comparison of endemicity categories at IU level implementation vs endemicity categories at sub-district level (N=9684)



number of high endemic wards increased from 113(1.2%) to 252 (2.6%). Following disaggregation 787 (23.7%) new non-endemic wards and 139(55.2%) new high endemic wards have been identified (Table 3). The variation between low and moderate endemic wards was 12.8% and 17.6% respectively.

A comparison of the target population and PCT requirement shows a variation in the number of

wards implementing PC of 787, whereas the number of SAC requiring PZQ treatment increased from 15,860,901 to 16,478,541 representing a variation of 617,640 (3.7%). Likewise, the PZQ estimate has increased from 39,652,252 to 41,196,352 representing a variation of 1,544,100 (3.7%) additional tablets at ward-level implementation (Table 4).

Treatment Adequacy and Variation From LGA to Ward IU by Endemicity Category

The number of wards under and over-treated versus LGA IU by endemicity category is shown in Table 5. The analysis showed 161 (28.4%) wards formerly classified as non-endemic at LGA IU were reclassified to low endemicity at Ward IU level after disaggregation. Likewise, 249 (95.4%) wards classified as low endemic at LGA IU are now classed as moderate endemic at Ward IU and 12 (4.6%) wards as high endemic. This reclassification resulted in PC under-treatment in 422 Wards at LGA level implementation. Concerning the over-treatment, 780 (100%) wards considered previously as low-endemic and were receiving treatment are now classified as non-endemic at ward level implementation. Likewise, 645 wards classified as moderate endemic under LGA level implementation have been reclassified as 168 (26.0%) non-endemic and 477 (74.0%) as low-endemic respectively for ward level implementation. Again, 18 wards hitherto classified as high endemic at LGA level implementation were reclassified as 2 (11.1%) as low and 16 (88.9%) as moderate, respectively. Adequacy in PC treatment was established in 7,674 wards regardless of whether it is LGA- or Ward-level implementation (Table 5).

Treatment Adequacy according to the Target Population

Table 6 shows the treatment adequacy by population comparing implementation at the LGA level with the Ward level. The results indicate that 1,098,631 targeted populations hitherto living in non-endemic wards at the LGA level are now eligible for PC treatment at low endemicity. Furthermore, 1,664,715 persons under moderate PC treatment at the LGA level, were reduced to 1,588,958 persons with the remaining 75,757 persons to benefit from high endemic PCT at the Ward level. For over-treatment, 151,580 persons treated under high endemicity PCT at the LGA level will now be treated at low endemicity (12,088 persons) and moderate endemicity (139,492) at the Ward level, respectively. Table 7 shows variation in treatment adequacy of Ward IUs in previous LGA level implementation by each state. There were issues of under-treatment in all the states resulting in 3,718,680 school-aged children being under-treated. Likewise, over-treatment was established in 28 out of 37 States with a total of 1,377,185 school-aged children over-treated (Table 7).

Categorization of Ward and Targeted Population requiring PC based on 2022 WHO Treatment Guidelines.

Table 8 shows the categorization of wards and targeted populations requiring PC based on the 2022 World Health Organization guidelines on the control and elimination of human schistosomiasis. Three thousand one hundred and thirty-one (32.3) low endemic wards (<10%) were categorized as no longer requiring PC, while 3,233 (33.4%) endemic wards with $\geq 10\%$ required an annual single dose of PC. No ward for the analysis is qualified for 2 rounds/years. Out of a total population of 53,989,872 persons requiring PC, 18,896,462 (35.0%) are SAC and 35,093,410 (65.0%) are adults. Akwa Ibom, Imo, Lagos and River States have zero population requiring PC (Table 8).

Discussion

Schistosomiasis is a focal disease whose transmission is dependent on open surface water resources where there are active or passive water contact activities in endemic communities. Over the years, PC implementation has been organized at the LGA level. This was based on WHO mapping guidelines which recommended LGA as the IU [8]. As countries shift from schistosomiasis control to elimination, it is important to re-strategize and ensure the achievement of WHO NTD 2030 road maps, which now target Schistosomiasis for elimination.

The Ward-level analysis data presented here, will provide the Nigerian Schistosomiasis Control Programme with the data for a more targeted delivery of praziquantel PC, maximized human and material resources, effective application and usage of drugs, and financial resources [24]. This will also improve community participation as IU are more realistic and interventions closer to benefiting communities. A total of 787 wards new non-endemic wards have been identified from the analysis, suggesting the curbing of drug wastage that has been ongoing and unknown to programme managers. As these communities located in the identified wards may no longer receive PC, it will reduce programming costs, such as annual training, mobilization and logistic to deliver PC. However, these new non-endemic wards will require impact assessment and validation to confirm their negative status.

The new WHO treatment guidelines recommend PC only in endemic communities where the infection prevalence is $\geq 10\%$ for all age groups from 2 years

old, including adults, pregnant women after the first trimester and lactating women, to control morbidity and advance towards elimination [28]. Thus, Akwa Ibom, Imo, and Lagos States in which all endemic wards are of low endemicity (<10%) and where there has been PC treatment, may either continue with PC intervention or reduced PC frequency towards interruption of transmission. Consequently, Rivers State, with new low endemic wards, and where PC has not commenced should use a clinical approach of test and treat, instead of PC targeting a population to maintain the no PC status of the State. All the endemic wards in the country now require an annual single dose of PC, until an impact assessment is carried out to assess PC intervention.

These changes in the reclassification of endemicity categories at Ward level implementation, and the new WHO guidelines, are likely to affect praziquantel requisition by wards, as a more precise reorganization of wards requiring PC treatment has been achieved with this analysis. For instance, there are increases in the number of SAC population requiring treatment and PZQ tablets requisition at Ward IU compared to LGA level IU. Nevertheless, the elimination of under-treatment or over-treatment has been achieved with this analysis tool thereby freeing up PZQ to be moved from locations not needed to be used at locations where it is needed. Although, there are 18,896,462 SAC requiring PC treatment in Nigeria, in which an estimated 10.5 million are not attending school [29], therefore, the innovative strategy of reaching out-of-school children during school-based PC to improve coverage to $\geq 75\%$ is required.

It is believed that the change from LGA IU to Ward IU will facilitate the implementation of the new WHO PC treatment guideline on the control and elimination of human schistosomiasis. Moving to Ward IU will provide the platform to reach all age groups and assess the impact of intervention without any additional resources or cost to Programme Managers.

Recent analysis showed that PC for schistosomiasis has effectively reduced schistosomiasis morbidity over the years from 2000 to 2019 [23], thus our analysis should encourage Programme Managers to consolidate these gains using community endemicity data for better targeting of intervention, coupled with other interventions such as snail control and improve water, sanitation, and hygiene (WASH) towards the

elimination of schistosomiasis in Nigeria.

The Schistosomiasis community analysis tool has been useful in disaggregation of LGA level endemicity data to Ward level for intervention thus saving the country from embarking on costly re-mapping exercise. Validation of the new ward endemicity data is ongoing in the country.

Conclusion

These results demonstrate the usefulness of the WHO/ESPEN schistosomiasis community data analysis tool for strategic planning to refocus and redirect intervention to endemic wards/communities in need of PC towards the control and elimination of schistosomiasis in Nigeria. It equally has huge implications for medicines requisition and allocation of human and logistic resources for treatment distribution.

Declarations

Ethical Consideration and Informed Consent

The work presented here is derived from an in-depth analysis of schistosomiasis infection survey data obtained from the Federal Ministry of Health (FMoH) of Nigeria between 2000-2019. Ethical clearance, informed consent procedures, and treatment were according to FMoH guidelines and recommendations. The data are aggregated and do not contain identifiable individual or household-level information. Thus, no specific ethical approval was required for the secondary analysis presented here.

Authors' Contributions

NOJ, JSM, ANM, EUF, wrote the first draft of the manuscript. NOJ, JSM, ANM, SS, MES, NBO, OC, OFO, participated in and supervised in-country field surveys and primary data collection, processing, and submission to WHO. AS, VB, CJ, ZH and MPN performed the data extraction and statistical analysis. WPN, CJ and EUF revived the manuscript and provided important intellectual content. KB, JSM and EUF accessed and verified all the data in the study. All authors approved the final version of the paper before submission. The authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

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Conflicts of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Data

The epidemiology and population data used in this study are available and can be downloaded at the ESPEN Data portal https://espen.afro.who.int/system/files/content/resources/Schistosomiasis_Data_analysis_tool_-_User_Guide%28V1_20190916_English%29.pdf

Abbreviations

PC – Preventive Chemotherapy
 IU – Implementation Unit
 LGA – Local Government Area
 PZQ – Praziquantel
 WHO/EPSEN - WHO Expanded Special Project for the Elimination of Neglected Tropical Diseases
 MDA - Mass Drug Administration
 PCT - Preventive Chemotherapy and Treatment
 SAC - School Aged Children
 JRSM - Joint Request for Selected PC Medicine
 NGDO - Non-Governmental Donor Organisation

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Table 2: Distribution of ward endemicity by State and Population requiring treatment.

State	Population		Ward Endemicity Category						
	Total Population requiring PC	SAC Population	Adult Population	Not Endemic			Endemic		
				Low	Moderate	High	Low	Moderate	High
ABIA	146,575 (100)	145427 (99.2)	1148 (0.8)	243 (88.0)	32 (11.6)	1 (0.4)	0	276 (100)	
ADAMAWA	1,513,113 (100)	1197923 (79.2)	315190 (20.8)	10 (4.4)	83 (36.6)	131 (57.7)	3 (1.3)	227 (100)	
AKWA IBOM	88,892 (100)	88892 (100)	0 (0.0)	310 (92.5)	25 (7.5)	0	0	335 (100)	
ANAMBRA	601,596 (100)	599546 (99.7)	2050 (0.3)	209 (63.5)	117 (35.6)	3 (0.9)	0	329 (100)	
BAUCHI	1,862,263 (100)	1424567 (76.5)	437696 (23.5)	80 (24.6)	74 (22.8)	164 (50.5)	7 (2.2)	325 (100)	
BAYELSA	262,475 (100)	259779 (99.0)	2696 (1.0)	68 (64.8)	36 (34.3)	1 (1.0)	0	105 (100)	
BENUE	2,125,989 (100)	1572965 (74.0)	553024 (26.0)	20 (7.2)	68 (24.4)	182 (65.2)	9 (3.2)	279 (100)	
BORNO	2,448,911 (100)	1633825 (66.7)	815086 (33.3)	3 (1.0)	67 (21.6)	224 (72.3)	16 (5.2)	310 (100)	
CROSS RIVER	508,144 (100)	395896 (77.9)	112248 (22.1)	129 (65.5)	25 (12.7)	39 (19.8)	4 (2.0)	197 (100)	
DELTA	607,500 (100)	595328 (98.0)	12172 (2.0)	166 (60.8)	103 (37.7)	4 (1.5)	0	273 (100)	
EBONYI	850,651 (100)	666482 (78.3)	184169 (21.7)	62 (20.2)	69 (22.5)	172 (56.0)	4 (1.3)	307 (100)	
EDO	574,215 (100)	540438 (94.1)	33777 (5.9)	104 (53.9)	74 (38.3)	15 (7.8)	0	193 (100)	
EKITI	752,466 (100)	602955 (80.1)	149511 (19.9)	77 (43.0)	51 (28.5)	48 (26.8)	3 (1.7)	179 (100)	
ENUGU	1,106,635 (100)	1051191 (95.0)	55444 (5.0)	66 (19.3)	230 (67.3)	45 (13.2)	1 (0.3)	342 (100)	
FCT	798,754 (100)	551800 (69.1)	246954 (30.9)	1 (1.6)	14 (22.6)	37 (59.7)	10 (16.1)	62 (100)	
GOMBE	1,053,762 (100)	873391 (82.9)	180371 (17.1)	6 (5.3)	54 (47.4)	52 (45.6)	2 (1.8)	114 (100)	
IMO	249,697 (100)	249697 (100)	0 (0.0)	346 (82.8)	72 (17.2)	0	0	418 (100)	
JIGAWA	1,874,610 (100)	1537347 (82.0)	337263 (18.0)	29 (10.1)	128 (44.6)	128 (44.6)	2 (0.7)	287 (100)	
KADUNA	2,923,488 (100)	2337324 (79.9)	586164 (20.1)	8 (3.1)	92 (36.1)	150 (58.8)	5 (2.0)	255 (100)	
KANO	4,237,005 (100)	3536840 (83.5)	700165 (16.5)	19 (3.9)	218 (44.9)	233 (48.0)	15 (3.1)	485 (100)	
KATSINA	2,238,797 (100)	1785695 (79.8)	453102 (20.2)	81 (22.4)	98 (27.1)	179 (49.6)	3 (0.8)	361 (100)	
KEBBI	1,727,371 (100)	1154468 (66.8)	572903 (33.2)	24 (10.7)	40 (17.8)	134 (59.6)	27 (12.0)	225 (100)	
KOGI	464,080 (100)	404426 (87.1)	59654 (12.9)	167 (68.7)	52 (21.4)	23 (9.5)	1 (0.4)	243 (100)	
KWARA	964,398 (100)	784604 (81.4)	179794 (18.6)	34 (17.4)	98 (50.3)	61 (31.3)	2 (1.0)	195 (100)	
LAGOS	1,637,800 (100)	1637800 (100)	0 (0.0)	238 (63.1)	139 (36.9)	0	0	377 (100)	
NASSARAWA	787,195 (100)	632954 (80.4)	154241 (19.6)	24 (16.3)	57 (38.8)	60 (40.8)	6 (4.1)	147 (100)	
NIGER	2,350,696 (100)	1507639 (64.1)	843057 (35.9)	9 (3.2)	48 (17.0)	184 (65.0)	42 (14.8)	283 (100)	
OGUN	1,746,851 (100)	1216338 (69.6)	530513 (30.4)	32 (12.2)	80 (30.4)	114 (43.3)	37 (14.1)	263 (100)	
ONDO	863,322 (100)	661359 (76.6)	201963 (23.4)	111 (53.9)	54 (26.2)	32 (15.5)	9 (4.4)	206 (100)	
OSUN	1,240,800 (100)	1140962 (92.0)	99838 (8.0)	71 (20.1)	231 (65.4)	49 (13.9)	2 (0.6)	353 (100)	
OYO	1,791,356 (100)	1652906 (92.3)	138450 (7.7)	88 (25.1)	194 (55.3)	67 (19.1)	2 (0.6)	351 (100)	
PLATEAU	852,617 (100)	754066 (88.4)	98551 (11.6)	122 (37.5)	129 (39.7)	73 (22.5)	1 (0.3)	325 (100)	
RIVERS	56,317 (100)	56317 (100)	0 (0.0)	312 (97.8)	7 (2.2)	0	0	319 (100)	
SOKOTO	1,948,558 (100)	1421777 (73.0)	526781 (27.0)	8 (3.3)	88 (36.1)	125 (51.2)	23 (9.4)	244 (100)	
TARABA	770,512 (100)	696533 (90.4)	73979 (9.6)	37 (22.0)	98 (58.3)	31 (18.5)	2 (1.2)	168 (100)	
YOBE	1,108,025 (100)	900502 (81.3)	207523 (18.7)	4 (2.2)	68 (38.0)	105 (58.7)	2 (1.1)	179 (100)	
ZAMFARA	1,847,438 (100)	1270557 (68.8)	576881 (31.2)	2 (1.4)	18 (12.2)	115 (78.2)	12 (8.2)	147 (100)	
Total	46,982,874 (100)	37540516 (79.9)	9442358 (20.1)	3,320 (34.3)	3,131 (32.3)	2,981 (30.8)	252 (2.6)	9,684 (100)	

Table 3: Changes in Schistosomiasis Transmission Risk of Ward IUs compared to LGA IU implementation.

Transmission Risk	Number of LGAs by endemicity category in district-level implementation	Number of Wards by endemicity category in Sub-district level implementation	Change
Not endemic	2,533	3,320	+787 (23.7)
Low	3,532	3,131	-401 (12.8)
Moderate	3,506	2,981	-525 (17.6)
High	113	252	+139 (55.2)
Total	9,684	9,684	

Table 4: Comparison of target population and drug quantities between District level implementation and sub-district level implementation

	LGA level implementation	Ward level implementation	Variation
Number of Ward School-age children requiring treatment	7,151	6,364	-787 (-11.0%)
PZQ Estimates	15,860,901	16,478,541	617,640 (3.7%)
	39,652,252	41,196,352	1,544,100 (3.7%)

Table 5: Number of Sub Districts with under-treatment and over-treatment vs Districts IU by endemicity category

PC strategy adequacy	District level implementation	Sub-districts level implementation				
		Sub-district endemicity category				
		Not endemic	Low	Moderate	High	
Adequate Treatment	Not endemic	2,372 (100)	2,372 (100)	0	0	0
	Low	2,491 (100)	0	2,491 (100)	0	0
	Moderate	2,716 (100)	0	0	2,716 (100)	0
	High	95 (100)	0	0	0	95 (100)
	Total	7,674 (100)	2,372 (30.9)	2,491 (32.5)	2,716 (35.4)	95 (1.2)
Under Treatment	Not endemic	161 (100)	0	161 (100)	0	0
	Low	261 (100)	0	0	249 (95.4)	12 (4.6)
	Moderate	145 (100)	0	0	0	145 (100)
	High	0	0	0	0	0
	Total	567 (100)	0	161 (28.4)	249 (43.9)	157 (27.7)
Over Treatment	Not endemic	0	0	0	0	0
	Low	780 (100)	780 (100)	0	0	0
	Moderate	645 (100)	168 (26.0)	477 (74.0)	0	0
	High	18 (100)	0	2 (11.1)	16 (88.9)	0
	Total	1,443 (100)	948 (65.7)	479 (33.2)	16 (1.1)	0
Grand total	9,684 (100)	3,320 (34.3)	3,131 (32.3)	2,981 (30.8)	252 (2.6)	

Table 6: Number of targeted populations with under-treatment and over-treatment at Sub-district IU compared to District IU by endemicity category.

PC strategy adequacy	IU 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	14,750,797 (100)	0	14,750,797 (100)	0	0
	Moderate	15,536,700 (100)	0	0	15,536,700 (100)	0
	High	600,221 (100)	0	0	0	600,221 (100)
	Total	30,887,718 (100)	0	14,750,797 (47.8)	15,536,700 (50.3)	600,221 (1.9)
Under Treatment	Not endemic	1,098,631 (100)	0	1,098,631 (100)	0	0
	Low	1,664,715 (100)	0	0	1,588,958 (95.4)	75,757 (4.6)
	Moderate	955,334 (100)	0	0	0	955,334 (100)
	High	0	0	0	0	0
	Total	3,718,680 (100)	0	1,098,631 (29.5)	1,588,958 (42.7)	1,031,091 (27.7)
Over Treatment	Not endemic	0	0	0	0	0
	Low	0	0	0	0	0
	Moderate	2,782,538 (100)	0	2,782,538 (100)	0	0
	High	151,580 (100)	0	12,088 (8.0)	139,492 (92.0)	0
	Total	2,934,118 (100)	0	2,794,626 (95.2)	139,492 (4.8)	0
Grand total	37,540,516 (100)	0	18,644,054 (49.7)	17,265,150 (46.0)	1,631,312 (4.3)	

Table 7: Treatment adequacy variation observed with Ward level compared to LGA level implementation.

State	Number of Ward	SAC adequately treated	SAC under-treated	SAC over-treated	Under treatment gaps in PZQ	Over-treatment excess in PZQ
ABIA	276	89,831	55,596	0	44,632	0
ADAMAWA	227	986,685	101,660	109,578	62,697	46,569
AKWA IBOM	335	16,989	71,903	0	59,319	0
ANAMBRA	329	568,462	31,084	0	23,436	0
BAUCHI	325	1,290,026	76,980	57,561	69,935	24,467
BAYELSA	105	148,156	111,623	0	89,186	0
BENUE	279	1,292,781	103,741	176,443	114,632	74,986
BORNO	310	1,419,911	85,498	128,416	84,148	88,619
CROSS RIVER	197	269,433	69,264	57,199	64,628	24,309
DELTA	273	392,971	102,279	100,078	77,376	42,535
EBONYI	307	529,582	109,116	27,784	64,113	11,807
EDO	193	346,683	68,158	125,597	44,052	53,376
EKITI	179	569,603	21,212	12,140	21,718	5,159
ENUGU	342	929,951	2,965	118,275	3,706	50,268
FCT	62	506,226	8,199	37,375	6,102	24,339
GOMBE	114	799,010	63,726	10,655	38,906	4,528
IMO	418	124,640	125,057	0	103,173	0
JIGAWA	287	1,132,652	249,342	155,353	122,580	66,024
KADUNA	255	1,904,231	266,145	166,948	147,381	70,951
KANO	485	3,110,387	211,391	215,062	164,029	91,401
KATSINA	361	1,592,127	121,878	71,690	66,401	30,467
KEBBI	225	933,561	76,019	144,888	74,019	118,202
KOGI	243	313,035	60,942	30,449	52,999	12,940
KWARA	195	709,395	42,558	32,651	27,654	13,877
LAGOS	377	1,342,517	295,283	0	243,610	0
NASSARAWA	147	375,147	58,892	198,915	43,019	84,541
NIGER	283	1,154,898	154,823	197,918	188,320	115,180
OGUN	263	1,144,400	71,938	0	89,922	0
ONDO	206	475,780	168,554	17,025	167,538	7,237
OSUN	353	1,051,041	74,159	15,762	48,373	6,700
OYO	351	1,440,614	191,642	20,650	98,608	8,776
PLATEAU	325	502,751	11,210	240,105	6,137	102,044
RIVERS	319	0	56,317	0	46,462	0
SOKOTO	244	1,137,620	129,522	154,635	121,279	65,722
TARABA	168	564,208	63,547	68,778	32,722	29,232
YOBE	179	730,092	94,293	76,117	49,735	32,350
ZAMFARA	147	992,322	112,164	166,071	140,204	70,579
Total	9,684	30,887,718	3,718,680	2,934,118	2,902,751	1,377,185

Table 8: Number of wards and targeted population by state requiring PC based on WHO new treatment guidelines.

State	Total population requiring PC			Not endemic				<10% (No PC treatment)				≥10% (1 round/year PC)			
	Total number of sub-districts	Total population	requiring PC	Number of sub-districts	Number of SAC	Number of adults	Number of sub-districts	Number of SAC	Number of adults	Number of sub-districts	Number of SAC	Number of adults	Number of sub-districts	Number of SAC	Number of adults
ABIA	276 (100)	8,829 (100)	243 (88.0)	0	0	0	32 (11.6)	0	0	1 (0.4)	3,090 (35.0)	5,739 (65.0)			
ADAMAWA	227 (100)	2,154,555 (100)	10 (4.4)	0	0	0	83 (36.6)	0	0	134 (59.0)	754,099 (35.0)	1,400,456 (65.0)			
AKWA IBOM	335 (100)	0	310 (92.5)	0	0	0	25 (7.5)	0	0	0	0	0			
ANAMBRA	329 (100)	15,772 (100)	209 (63.5)	0	0	0	117 (35.6)	0	0	3 (0.9)	5,520 (35.0)	10,252 (65.0)			
BAUCHI	325 (100)	2,937,466 (100)	80 (24.6)	0	0	0	74 (22.8)	0	0	171 (52.6)	1,028,115 (35.0)	1,909,351 (65.0)			
BAYELSA	105 (100)	20,739 (100)	68 (64.8)	0	0	0	36 (34.3)	0	0	1 (1.0)	7,259 (35.0)	13,480 (65.0)			
BENUE	279 (100)	3,276,840 (100)	20 (7.2)	0	0	0	68 (24.4)	0	0	191 (68.5)	1,146,894 (35.0)	2,129,946 (65.0)			
BORNO	310 (100)	3,721,188 (100)	3 (1.0)	0	0	0	67 (21.6)	0	0	240 (77.4)	1,302,413 (35.0)	2,418,775 (65.0)			
CROSS RIVER	197 (100)	662,228 (100)	129 (65.5)	0	0	0	25 (12.7)	0	0	43 (21.8)	231,784 (35.0)	430,444 (65.0)			
DELTA	273 (100)	93,633 (100)	166 (60.8)	0	0	0	103 (37.7)	0	0	4 (1.5)	32,772 (35.0)	60,861 (65.0)			
EBONYI	307 (100)	1,274,354 (100)	62 (20.2)	0	0	0	69 (22.5)	0	0	176 (57.3)	446,019 (35.0)	828,335 (65.0)			
EDO	193 (100)	259,813 (100)	104 (53.9)	0	0	0	74 (38.3)	0	0	15 (7.8)	90,934 (35.0)	168,879 (65.0)			
EKITI	179 (100)	974,111 (100)	77 (43.0)	0	0	0	51 (28.5)	0	0	51 (28.5)	340,941 (35.0)	633,170 (65.0)			
ENUGU	342 (100)	392,610 (100)	66 (19.3)	0	0	0	230 (67.3)	0	0	46 (13.5)	137,414 (35.0)	255,196 (65.0)			
FCT	62 (100)	1,227,313 (100)	1 (1.6)	0	0	0	14 (22.6)	0	0	47 (75.8)	425,559 (35.0)	797,754 (65.0)			
GOMBE	114 (100)	1,223,740 (100)	6 (5.3)	0	0	0	54 (47.4)	0	0	54 (47.4)	428,309 (35.0)	795,431 (65.0)			
IMO	418 (100)	0	346 (82.8)	0	0	0	72 (17.2)	0	0	0	0	0			
JIGAWA	287 (100)	2,456,647 (100)	29 (10.1)	0	0	0	128 (44.6)	0	0	130 (45.3)	859,825 (35.0)	1,596,822 (65.0)			
KADUNA	255 (100)	4,034,273 (100)	8 (3.1)	0	0	0	92 (36.1)	0	0	155 (60.8)	1,411,997 (35.0)	2,622,276 (65.0)			
KANO	485 (100)	4,358,164 (100)	19 (3.9)	0	0	0	218 (44.9)	0	0	248 (51.1)	1,525,353 (35.0)	2,832,811 (65.0)			
KATSINA	361 (100)	3,366,751 (100)	81 (22.4)	0	0	0	98 (27.1)	0	0	182 (50.4)	1,178,361 (35.0)	2,188,390 (65.0)			
KEBBI	225 (100)	2,682,686 (100)	24 (10.7)	0	0	0	40 (17.8)	0	0	161 (71.6)	938,940 (35.0)	1,743,746 (65.0)			
KOGI	243 (100)	385,674 (100)	167 (68.7)	0	0	0	52 (21.4)	0	0	24 (9.9)	134,986 (35.0)	250,688 (65.0)			
KWARA	195 (100)	1,250,514 (100)	34 (17.4)	0	0	0	98 (50.3)	0	0	63 (32.3)	437,682 (35.0)	812,832 (65.0)			
LAGOS	377 (100)	0	238 (63.1)	0	0	0	139 (36.9)	0	0	0	0	0			
NASSARAWA	147 (100)	937,266 (100)	24 (16.3)	0	0	0	57 (38.8)	0	0	66 (44.9)	328,043 (35.0)	609,223 (65.0)			
NIGER	283 (100)	3,613,291 (100)	9 (3.2)	0	0	0	48 (17.0)	0	0	226 (79.9)	1,264,654 (35.0)	2,348,637 (65.0)			
OGUN	263 (100)	1,853,522 (100)	32 (12.2)	0	0	0	80 (30.4)	0	0	151 (57.4)	648,733 (35.0)	1,204,789 (65.0)			
ONDO	206 (100)	762,627 (100)	111 (53.9)	0	0	0	54 (26.2)	0	0	41 (19.9)	266,919 (35.0)	495,708 (65.0)			
OSUN	353 (100)	597,723 (100)	71 (20.1)	0	0	0	231 (65.4)	0	0	51 (14.4)	209,206 (35.0)	388,517 (65.0)			
OYO	351 (100)	1,002,537 (100)	88 (25.1)	0	0	0	194 (55.3)	0	0	69 (19.7)	350,890 (35.0)	651,647 (65.0)			
PLATEAU	325 (100)	739,066 (100)	122 (37.5)	0	0	0	129 (39.7)	0	0	74 (22.8)	258,674 (35.0)	480,392 (65.0)			
RIVERS	319 (100)	0	312 (97.8)	0	0	0	7 (2.2)	0	0	0	0	0			
SOKOTO	244 (100)	2,571,031 (100)	8 (3.3)	0	0	0	88 (36.1)	0	0	148 (60.7)	899,860 (35.0)	1,671,171 (65.0)			
TARABA	168 (100)	516,780 (100)	37 (22.0)	0	0	0	98 (58.3)	0	0	33 (19.6)	180,871 (35.0)	335,909 (65.0)			
YOBE	179 (100)	1,462,468 (100)	4 (2.2)	0	0	0	68 (38.0)	0	0	107 (59.8)	511,860 (35.0)	950,608 (65.0)			
ZAMFARA	147 (100)	3,155,661 (100)	2 (1.4)	0	0	0	18 (12.2)	0	0	127 (86.4)	1,104,486 (35.0)	2,051,175 (65.0)			
Total	9,684 (100)	53,989,872 (100)	3,320 (34.3)	0	0	0	3,131 (32.3)	0	0	3,233 (33.4)	18,896,462 (35.0)	35,093,410 (65.0)			

*Where impact assessment shows persistence prevalence despite >=75% treatment coverage