Kenya National School Based Deworming Programme

Year 5 (2017) Impact Analysis

Technical Report Based on Data Collected Between 22nd January and 20th July 2017

23rd December, 2017

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Executive Summary

The impact of the Kenya national school-based deworming programme (KNSBDP) was monitored for five years (2012-2017) by conducting pre-post treatment intervention and repeated cross-sectional surveys. The specific objectives of the evaluation have been to understand the long-term impact on the prevalence and intensity of infection with Soil Transmitted Helminths (STH) and schistosomiasis as well as annual programme effectiveness in terms of reductions of infections.

This report is on the overall and year 5 results of the school-based deworming programme. In year 5, 199 schools were surveyed for endline assessment and 60 schools surveyed after the fifth mass drug administration (MDA). The year 5 results were then compared with those of subsequent years for trend of infection over the years.

Based on the baseline, midterm and endline surveys, the STH combined prevalence had dropped substantially from the initial level of 33.6% to 15.2% with a significant relative reduction (RR) rate of 54.9%. Similarly there was a significant drop in the specific species prevalence; *A. lumbricoides* from 20.7% to 11.1% (RR 46.7%), hookworm 15.2% to 1.3% (RR 91.6%), and *T. trichiura* 6.3% to 4.6% (RR 27.8%). There were also significant reductions in the pre- and post-MDA prevalence for each STH infections.

For the schistosome infections, there was a significant drop on *S. haematobium* from a baseline level of 18.0% to 3.9% at endline indicating a relative reduction of 78.2%. However, a similar drop was not witnessed for *S. mansoni* with an initial prevalence of 2.4% and dropped to 2.0% (RR 19.4%).

Treatment coverage for both STH and schistosome infections is also reported, in which it is noted that treatment for STH infections has been cconsistently carried out over five years in 28 counties including the 16 counties under M&E programme. Since the beginning of the programme, a total of 5,953,198 (81.3%), 6,405,645 (77.5%), 6,167,847 (83.0%), 6,418,934 (80.0%), and 5,973,386 (76.3%) children have been dewormed for STH infections in year 1, 2, 3, 4, and 5 respectively. However, treatment for schistosome infections has not been that consistent in all counties.

Key performance indicators (KPI) for overall and immediate infection prevalence reduction, and prevalence of moderate to heavy infection were used to assess the progress of the programme. For

any STH and schistosome infections, a target of 60% immediate reduction in prevalence was set and progress measured against this target as outlined in table A1.

The findings of the M&E programme after five rounds of MDA indicate that STH infections have continued to decline from baseline to endline with overall significant relative reduction of 54.9% for STH combined. Despite the staggered treatment for schistosome infections, there has been a significant decline in prevalence for any schistosome infection.

Comparison of POC-CCA and Kato-Katz techniques: Comparison was done between the traditional Kato-Katz technique and the more sensitive commercially available point-of-care circulating cathodic antigen (POC-CCA) test kit which detect schistosome antigen in urine since schistosome prevalence was becoming relatively low and the Kato-Katz sensitivity in low prevalence areas was increasingly getting inadequate. The results demonstrated that POC-CCA technique performed very well to detect *S. mansoni* in children and indeed it yielded prevalence which were 14-fold higher than those of Kato-Katz.

Implications: The immediate relative reductions reported are as expected in a national deworming programme and are an indication that the programme is doing well. While the evaluation was not powered to detect county-level changes, results at county level shows heterogeneity in programmatic impact and may merit much more intensive programmatic interventions to get to the goal of morbidity control and transmission break. It seems that, of the STHs, children are getting re-infected with *A. lumbricoides* very rapidly, eroding the gains made by MDA. Additionally, not covering other age groups and non-enrolled children is likely to be leaving reservoirs of infection in those groups. Although, the evaluation was not designed to look at levels of infection in those groups, but there are indications that younger children tend to have higher moderate-to-heavy infections.

Re-infections, especially with *Ascaris lumbricoides*, often occurs following MDAs. Other interventions such as provision of water, sanitation and hygiene (WASH) have to be introduced to sustain chemotherapeutic gains of MDA and to accelerate attainment of the transmission break point that could lead to possible elimination of STH as a public health problem.

Our results have also shown that POC-CCA is a more sensitive method than Kato-Katz technique in detection of *S. mansoni* infection in low prevalence areas.

Introduction

From the year 2012, the ministries of health and of education in Kenya started to deworm all school – age children who live in 66 districts (now sub counties) identified as having a high prevalence STH and schistosome infections to warrant MDA. The impact of the Kenya's school-based deworming programme, carried out in Western, Nyanza, Rift Valley and Coast regions, was monitored for five years and included pre-post intervention and repeated cross-sectional surveys as outlined in figure 1.

The repeat cross-sectional surveys were conducted in a representative, stratified, two-stage sample of schools across Kenya. Sub-counties stratification was based on both geography and anticipated infection prevalence. The programme contained two tiers of monitoring: i) a national baseline survey including 200 schools in 20 sub-counties which aims to establish an accurate national measurement of infection levels; ii) surveys conducted pre- and post-intervention (pre-post surveys), which monitor 60 of the 200 schools before and after the deworming activity to determine reduction in infections following MDA.

This report therefore presents the survey results of year five endline and post-MDA assessment surveys from 16 counties with comparison to previous surveys since baseline. However, one school from Homabay County was not surveyed during the endline assessment since the school had been shut down at the time of the survey.

Results

Overall 21,045 children with mean age of 9.6 years (2 – 20 years) were surveyed in the endline survey, and 6,280 children with mean age 9.4 years were surveyed during the post-MDA survey as shown in table 1. All the year 5 endline surveys were conducted approximately one year after year 4 MDA delivery and post-MDA surveys were conducted 14-37 days after the year 5 MDA delivery.

Soil Transmitted Helminths

STH year-on-year reduction in prevalence and mean intensity

During baseline survey, the combined STH prevalence was 33.6%, with *A. lumbricoides* most prevalent 20.7% followed by hookworm 15.2% and *T. trichiura* 6.3%. In the year 3 mid-term survey after two rounds of MDA, the overall STH prevalence dropped to 18.6%; with 13.8%, 2.4%, and 5.0% for *A. lumbricoides*, hookworms and *T. trichiura* respectively. Similarly, during the endline survey after five round of MDA, the STH combined prevalence further dropped to 15.2% with specific species prevalence also dropping to 11.1%, 1.3% and 4.6% for *A. lumbricoides*, hookworms and *T. trichiura* respectively. The overall relative reductions in prevalence from baseline to endline was 54.9% ($p<0.001$) with hookworm species showing the greatest reduction level of 91.6% ($p<0.001$) and the other two species recorded prevalence reduction of below 50%. Similarly, the baseline, mid-term and endline mean intensities with the overall relative reductions are as shown in table 2. The trend in prevalence of the STH infections for baseline, midterm and endline surveys is shown in figure 2.

Additionally, table 3 gives the pre- and post-MDA prevalence and mean intensity of infection for STH combined and specific species from year 1 to 5, and the associated overall relative reductions in prevalence and mean intensity of STH combined was 57.6% ($p<0.001$) and 45.3% ($p=0.004$) respectively.

Table 4 compare baseline, midterm and endline prevalence of infections for each county. After five rounds of MDA, only 3 counties reduced the prevalence of any STH infection by over 90%; Kilifi (baseline 32.7% to endline 2.4%, RR = 92.7%), Migori (baseline 22.3% to endline 2.2%, RR = 90.2%) and Mombasa (baseline 19.8% to endline 1.5%, RR = 92.3%), with only nine, three

and one county reducing hookworm, *A. lumbricoides* and *T. trichiura* prevalence by over 90% respectively.

STH immediate reductions in prevalence and mean intensity

a) Year 5 prevalence, mean intensity and relative reductions

In year 5, the combined STH pre-MDA prevalence was 14.1%; with *A. lumbricoides* 10.5% followed by *T. trichiura* 3.6% and hookworm 1.7%. Similarly, the pre-MDA mean intensity for specific species was highest for *A. lumbricoides* 940 epg followed by *T. trichiura* 11 epg and hookworm 7 epg. For post-MDA, the combined STH prevalence reduced to 3.0%; with *T. trichiura* being the most prevalent 2.0% with mean intensity of 5 epg followed by *A. lumbricoides* 0.8% with mean intensity of 79 epg and hookworm 0.6% with mean intensity of 3 epg. The prevalence of STH combined significantly reduced by 78.4% ($p<0.001$) immediately after year 5 MDA delivery, with *A. lumbricoides* showing the highest reduction of 92.8% ($p<0.001$) followed by hookworm 65.0% ($p<0.001$) and *T. trichiura* 43.8% ($p=0.001$).

After the fifth MDA round; Bungoma, Kericho, Kilifi, Migori, Mombasa and Taita Taveta counties had their prevalence for any STH reduced to ≤ 1%, with 13 counties reducing their hookworm prevalence to below 1%, and similarly 9 and 12 counties reduced their *T. trichiura* and *A. lumbricoides* prevalence to below 1% respectively. However, due to occurrence of re-infections, the infection levels in those counties are likely to shoot up after a while.

b) Prevalence and immediate relative reduction trend: Year 1 to 5

The overall prevalence of each specific species and STH combined has declined over the five years to below 3%. The immediate reductions in prevalence since baseline is as follows: For year 1 (STH combined: 73.5%, hookworm: 80.4%, *A. lumbricoides*: 88.2%, and *T. trichiura*: 20.3%), year 2 (STH combined: 68.5%, hookworm: 50.3%, *A. lumbricoides*: 85.5%, and *T. trichiura*: 48.5%), year 3 (STH combined: 60.8%, hookworm: 26.1%, *A. lumbricoides*: 77.7%, and *T. trichiura*: 24.1%), year 4 (STH combined: 68.5%, hookworm: 60.9%, *A. lumbricoides*: 87.3%, and *T. trichiura*: 11.6%) and year 5 (STH combined: 78.4%, hookworm: 65.0%, *A. lumbricoides*: 92.8%, and *T. trichiura*: 43.8%). Greater immediate reductions in prevalence were seen in years 1 and 5

as opposed to years 2, 3 and 4. The trend in prevalence of the STH infections since year 1 to 5 is shown in figure 3.

c) Prevalence of light, moderate and heavy intensity of infections: Year 1 to 5

The prevalence of both light, moderate and heavy infections have tremendously reduced since baseline with an overall relative reduction as follows: For STH combined (light: 90.1%, moderate: 94.0%, heavy: *increased*), for hookworm (light: 88.2%, moderate: 82.6%, heavy: 79.1%), for *A. lumbricoides* (light: 97.0%, moderate: 95.3%) and *T. trichiura* (light: 39.9%). However, there were no reductions in moderate and heavy infections for *T. trichiura*.

There was also a general declining trend in the prevalence of moderate to heavy intensity of infections from year 1 to year 5. At year 1 pre-MDA the STH combined prevalence of moderate to heavy infections was 8.4% (95%CI: 6.3-11.2) and after five rounds of MDA at year 5 post-MDA it reduced to 1.9% (95%CI: 1.5-2.5) translating to a significant relative reduction of 77.1% ($p<0.001$). The trend in prevalence of moderate to heavy intensity of STH infections since year 1 to 5 is shown in figure 3.

d) Re-infections since year 1 to 5

After one year of MDA delivery, the re-infection in prevalence for STH combined was 14.0% with *A. lumbricoides* showing the highest re-infection levels of 7.5%, followed by *T. trichiura* at 4.8% and hookworm at 3.9%. However, after five years of MDA delivery, the fifth year re-infection levels didn't reduce significantly with the STH combined re-infection in prevalence being 10.4% (*A. lumbricoides* was 6.7%, *T. trichiura* 3.7% and hookworm 1.4%). Similar re-infection pattern was seen for the mean intensity of STH infections.

Changes in STH prevalence and mean intensity of infections by regions

Changes in prevalence and mean intensity of STH infections were also assessed by the former regions (Coast, Nyanza, Rift Valley and Western) of Kenya.

During baseline, the STH combined prevalence was 24.2% for Coast, 30.6% for Nyanza, 36.3% for Rift Valley and 38.6% for Western region. During endline, the prevalence dropped to 3.0%, 12.4%, 26.4% and 15.2% for Coast, Nyanza, Rift Valley and Western regions respectively. This

translated to an overall relative reduction in prevalence of 86.1% (p<0.001) for Coast, 78.3% (p<0.001) for Nyanza, 68.6% (p<0.001) for Rift Valley and 72.9% (p<0.001) for Western regions.

During baseline, the risk of getting hookworm infections were highest in Western region, (OR = 1.51, p<0.001) than the rest of the regions, with the risk of getting *T. trichiura* significantly common in R. Valley (OR = 1.58, p<0.001), however, *A. lumbricoides* infection was found to be significantly common in all the regions. After five years of MDA delivery, the risk of getting the hookworm infections reduced significantly in all the regions to OR < 1 with slightly higher odds of infection in Western region (OR = 0.95, p=0.760), however, the risk of *T. trichiura* increased in all the regions with Rift Valley region still leading (OR = 9.97, p<0.001).

Schistosomiasis

Stool samples were examined for *S. mansoni* infections in all the 16 counties in Western, Nyanza, Rift valley and Coast regions, while urine samples were examined for *S. haematobium* infections in 4 counties in the Coastal region with the overall and county infection levels shown in table 5.

Schistosomiasis year-on-year reduction in prevalence and mean intensity

Table 6 provides the overall prevalence, average intensity of infection and relative reductions from baseline to Y5 post-MDA. Baseline prevalence were in overall low with a prevalence of 2.4% with average intensity of 14 epg for *S. mansoni* and a prevalence of 18.0% with average intensity of 20 epg for *S. haematobium*. This dropped, after two years of programme implementation, to a prevalence of 1.7% with average intensity of 6 epg for *S. mansoni* and 7.9% with average intensity 7 epg for *S. haematobium* in the year 3 mid-term survey. After five rounds of MDA, the prevalence of *S. mansoni* was 2.0% with average intensity of 5 epg while prevalence of *S. haematobium* was 3.9% with average intensity of 4 epg. This translated to a non-significant prevalence reduction of 19.4% (p=0.061) for *S. mansoni* and a significant reduction of 78.2% (p=0.001) for *S. haematobium* from baseline to endline. The trend in prevalence of both schistosome infections for baseline, midterm and endline surveys is shown in figure 4 and 5.

Schistosomiasis immediate reductions in prevalence and mean intensity: Year 1-5

In year 5, the pre-MDA prevalence for *S. mansoni* and *S. haematobium* were 1.8% and 4.1% respectively with respective mean intensity of infections of 4 epg for each species, while for the post-MDA, the overall prevalence for *S. mansoni* and *S. haematobium* were 0.7% and 2.1% respectively with respective mean intensity of infections of each 2 epg. *S. mansoni* showed an immediate significant reduction in prevalence of 62.7% (p=0.049) but not for mean intensity 52.2% (p=0.232), whereas *S. haematobium* showed a significant reduction in both prevalence of 47.9% (p<0.001) and mean intensity of 56.1% (p=0.012), see table 5.

Despite the staggered treatment for schistosomiasis, after five years of programme implementation, the overall prevalence of *S. mansoni* has been reduced to zero levels in the following counties; Bomet, Kericho, Kwale, Migori, Nyamira and Taita taveta. The overall prevalence of *S. haematobium* has also been reduced to zero in Mombasa and Taita Taveta counties, see table 5.

Comparisons from year one to five of the pre- and post-MDA prevalence for any schistosome infections and for specific species show that prevalence has in overall reduced, see figure 6. Specifically, after five years the overall prevalence of any schistosome infection has significantly reduced by 59.3% (p=0.002) while the specific species has only significantly reduced by 77.1% (p=0.010) for *S. haematobium* but not for *S. mansoni* 0.1% (p=0.998) since year 1 to 5 pre-MDA. The immediate pre- and post-MDA significant reductions in prevalence for any schistosome infections was seen only in year 2 (RR = 56.0%, p=0.001), year 3 (RR = 42.9%, p=0.044) and year 5 (RR = 56.1%, p=0.005) but not in year 1 and 4.

The prevalence of light, moderate and heavy intensity of schistosome infections based on pre- and post-MDA schools from year 1 to 5. In overall, there has been an increase in prevalence of both light and heavy intensity of infections for *S. mansoni* from Y1 to Y5 pre-MDA with only moderate intensity of infection insignificantly decreasing 10.8% (p=0.548). Similarly, for *S. haematobium*, the overall prevalence of light and heavy intensity reduced significantly by 11.1% (p=0.014) and insignificantly by 73.4% (p=0.105) respectively. Figure 6 shows the trend in prevalence of moderate to heavy intensity of schistosome infections since year 1 to 5.

Re-infections in prevalence has significantly remained high for any schistosome infections since baseline, the re-infection rates for any schistosome infections were; 21.9%, 10.8%, 8.9% and 9.8%

after year 1, 2, 3 and 4 MDA deliveries respectively. The re-infection rates for *S. haematobium* has for the last four MDAs been high (between 4% – 7%) compared to those for *S. mansoni* (between 1% - 3%).

Changes in Schistosomiasis prevalence and mean intensity of infections by regions

Changes in prevalence and mean intensity of *S. mansoni* infection was also assessed by the former regions (Coast, Nyanza, Rift Valley and Western) of Kenya, with *S. haematobium* being examined only at the Coastal region.

During baseline, the *S. mansoni* prevalence was very low at 0% for Coast, 2.8% for Nyanza, 0.4% for Rift Valley and 4.2% for Western regions. At year five endline, the prevalence insignificantly increased to 0.1% and 0.5% for Coast and Rift Valley regions respectively but insignificantly dropped to 2.3% and 3.1% for Nyanza, and Western regions respectively.

The prevalence of *S. haematobium* was 14.8% at baseline in the Coast region which significantly dropped to 2.4% at year 5 endline assessment.

Generally, Western (OR = 10.38, $p<0.001$) and Nyanza (OR = 4.74, $p<0.001$) regions are still significantly highly likely to be prone to *S. mansoni* infection compared to the Coast or Rift Valley regions.

Comparison of infection prevalence among early childhood (ECD) and older children

According to the design of the M&E programme, six classes (i.e. one ECD class and classes 2-6) in each survey school was targeted for sample collection. Comparison of infections prevalence among ECD and older children revealed that ECD children are more likely to be infected with STH infections compared to the older children (OR = 1.22, $p<0.001$) but less likely to be infected with any schistosome infections (OR = 0.81, $p=0.003$). The comparison of prevalence for both STH and schistosome infections among ECD and older children is outlined in table 7.

Treatment coverage

Annual deworming for STH has been carried out consistently for the last five years in 28 counties and all the 16 counties included in the M&E programme were appropriately covered for treatment. Since baseline in 2012, a total of 5,953,198; 6,405,645; 6,167,847; 6,418,934; and 5,973,386 children have been dewormed for STH in year 1, 2, 3, 4, and 5 in all the 28 counties, with overall treatment coverage of 81.3%, 77.5%, 83.0%, 80.0%, and 76.3% respectively. The STH treatment coverage for each county is shown in figure 7.

However, the annual deworming for schistosomiasis using praziquantel has not been consistent and covered fewer counties especially those monitored by the M&E programme. In year 1, only 5 out of the 28 counties received praziquantel drug with approximately 191,318 children (average coverage of 104%) being dewormed; in year 2, only 16 out of the 28 counties received treatment with approximately 890,459 children (average coverage of 84.7%) getting dewormed; in year 3, only 2 of 28 counties received praziquantel reaching only 79,038 children (average coverage of 81.7%); in year 4 and 5, 15 of 28 counties were treated for each of the two years for schistosomiasis covering approximately 556,638 and 519,232 children with average coverage of 73.4% and 65.6% respectively. The schistosomiasis treatment coverage for each county is shown in figure 8.

Comparison of POC-CCA and Kato Katz results in evaluating *Schistosoma mansoni* infection

The prevalence of *S. mansoni* infection was calculated with one Kato-Katz technique and compared with one POC-CCA technique. The observed prevalence using POC-CCA technique was 26.5% during pre-treatment and 21.4% during post-treatment compared to those observed when using Kato-Katz technique of 4.9% and 1.5% for pre- and post-treatment respectively. The observed prevalence for both pre- and post-treatment of *S. mansoni* infection using POC-CCA technique were significantly higher ($\chi^2 = 135.58$, $p<0.001$) than those observed using Kato-Katz technique. The number of children who were positive and those negative for each of the diagnostic methods is shown in table 8, while table 9 compares the observed *S. mansoni* prevalence using the two techniques by county.

The analysis showed an overall kappa index of k=0.11, p<0.001 with interrater agreement of 77.1% indicating a very slight agreement between the two methods. The kappa index and interrater agreement between the two diagnostic methods for each county is shown in table 9.

Table 10 shows the Kato-Katz performance measures of sensitivity, specificity, and positive and negative predictive values. With the results from POC-CCA taken as the gold standard, Kato-Katz technique was found to be significantly lower in sensitivity both at pre- and post-treatment, Sn=12.5% and Sn=5.2% respectively, McNemar test χ^2_m = 782.0, p<0.001. However, its specificity was significantly higher both at pre- and post-treatment, Sp=97.9% and Sp=99.5% respectively, McNemar test χ^2_m = 34.0, p<0.001.

Discussion

STH infections

The results showed a general decline in the prevalence and intensity of STH infections from baseline to endline as well as significant yearly reductions in the infections. The results shows that the programme has greatly reduced the STH infections particularly for hookworm but not to a level where it is no longer a public health concern (less than 1% prevalence), hence the need to incorporate other interventions alongside the preventive chemotherapy to accelerate this decline and perhaps achieve elimination.

These results showed that the single-dose oral albendazole given to the school children is efficacious against *A. lumbricoides* and hookworm but not *T. trichiura*, notwithstanding the higher rate of re-infection for *A. lumbricoides*. From these results, the programme should consider either increasing the frequency of MDA or using drug combination to control *trichuriasis* infection since single-dose oral albendazole currently administered by the programme has little effect [1,2].

The five-year results indicate a modest drop on the STH combined prevalence of moderate to heavy intensity of infection with *trichuriasis* showing almost no change. However, the within-year reduction of moderate to heavy infection for any STH was always above 73.9%. This shows that the programme has managed to reduce the morbidity associated with STH infections using

preventive chemotherapy alone but that gain was constantly reversed by the higher re-infection levels and lack of additional interventions.

Our results noted higher re-infection rates particularly for *A. lumbricoides* compared to other species, this finding is supported by other studies [3,4]. This potentially warrants further exploration into the factors causing the re-infection, and probably need for frequent anthelmintic drug administration to maximize the benefit of preventive chemotherapy.

The programme recorded greater reduction levels in STH infections in the Coastal region, followed by Nyanza region, Western, and Rift Valley. From the results, higher chances of getting *A. lumbricoides* infection is still spread across the four regions; however, despite reduction in risk associated with hookworm and *T. trichiura* infections over the five years, we still established a higher risk of hookworm infection in Western region and higher odds of *trichuriasis* infection in Rift Valley region. We therefore call for detailed research into the continued likelihood of spread of these particular species in those specifc regions.

The variations in the infections observed in the counties are likely to be due to specific epidemiological situation, geographical heterogeneity, initial prevalence levels/worm burden, different transmission intensities, as well as differing treatment coverage, drug uptake and compliance.

We established that parasite infections for any STH were more prevalent in younger (ECD) children than the older ones, underscoring the inadequate deworming delivered to this group. To meet the WHO target of controlling, eradication or elimination of STH infections by the year 2020, we therefore recommend that the programme be scaled up to cover the non-enrolled children, the adult population and pre-school children since they could act as reservoir for infection.

Schistosome infections

Treatment for both schistosome infections i.e. *Schistosoma mansoni* and *Schistosoma haematobium*, has not been consistent and was coupled with low coverage. This low coverage in treatment of schistosome infections has complicated the comparison of the observed prevalence and mean intensity over the five years of the programme monitoring. This challenge notwithstanding, the programme has reduced the prevalence of schistosome infections.

The reduction in prevalence for both schistosome infections has been similarly varying by region and county. The results pointed out a significantly higher risk of *S. mansoni* infection in Nyanza and Western regions compared to other regions. Despite the inconsistent treatment schedule witnessed throughout the programme, our results are inconcurrent with data seen in other countries which have reported 'hot spots' or areas of persistent re-infection despite intensive treatment.

Further, we also noted that schistosome infections were less prevalent among younger (ECD) children than the older counterparts, OR = 0.18, p=0.003, indicating a likelihood of a more serious schistosomiasis problem among the adult population.

Comparison of CCA and Kato-Katz in evaluating *Schistosoma mansoni* infection

The Kato-Katz technique has long been the mainstay technique in schistosomiasis diagnosis in endemic areas. However, several studies have now documented a poor Kato-Katz sensitivity in evaluating *Schistosoma mansoni* especially in areas with lower rates of transmission [7–9]. Since our programme has been running for five years and has managed to reduce schistosome infections to substantially lower levels as indicated by Kato-Katz results, we found it worthwhile during the endline surveys to explore the relationship between results of the stool-based Kato-Katz technique and the urine-based POC-CCA technique for *S. mansoni*. This would inform decision-making by the programme in changing from Kato-Katz to POC-CCA technique in its effort to control or interrupt transmission of schistosomiasis.

From the results, *S. mansoni* prevalence from POC-CCA technique were significantly higher than those from Kato-Katz technique and indeed 5-fold higher during pre-trreatment and 14-fold higher during post-treatment. Similar findings were reported by Kittur *et. al.* [7] in his systematic literature review where he noted that whenever the *S. mansoni* prevalence was above 50% by Kato-Katz then Kato-Katz and POC-CCA results yielded essentially the same prevalence. However, whenever the prevalence is below 50% by Kato-Katz then the POC-CCA prevalence was between 1.5 and 6-fold higher and could increase further as prevalence by Kato-Katz decreased.

Using POC-CCA as the gold standard, the stool-based Kato-Katz technique had extremely low sensitivity during both pre- and post-treatment, but however had higher specificity. In overall, the results demonstrated a slight interrater agreement between the two techniques.

Like previous studies [8,10] have found, we conclude that the POC-CCA technique is an effective screening tool for *S. mansoni* infections in areas of low prevalence, and should be used alongside Kato-Katz examinations. The POC-CCA method was more sensitive and upto 14-fold accurate than Kato-Katz method. It was also easy to use and less time consuming.

Methods of Analysis

Infection prevalence and average intensity of infections were calculated for STH combined and separately for each specific species including schistosome infections using STATA 14. Intensity of infections was defined according to WHO guidelines [11]. Confidence intervals (CIs) for prevalence and average intensity of infections were obtained using binomial and negative binomial regression models, respectively, adjusting for school clustering.

Relative reductions in prevalence and average intensity of infections were estimated by binomial regression and negative binomial regression, respectively, taking into account school clusters and the likelihood ratio test (LRT) p-values obtained using multivariable mixed effects models with random intercepts for schools and counties implemented in R software. Graphs were developed using the ggplot package implemented in R software [12].

During the year five surveys, a selected number of schools were surveyed during pre- and post-MDA to compare the performance of POC-CCA and Kato-Katz techniques in evaluating *Schistosoma mansoni* infection with the view to inform the program decision-making in changing diagnostic technique. The Kato-Katz performance measures were calculated and compared with POC-CCA results, as the gold standard, at 95%CIs for sensitivity (Sn), specificity (Sp), positive predictive values (PPV), negative predictive values (NPV), and kappa score. Specificity and sensitivity were determined using 2x2 contingency tables and compared using the McNemar's chi-square test. PPV and NPV were determined using the weighted generalized score chi-square test for paired data [13]. Exact binomial 95%CIs were calculated for each measure listed above. Agreement between the diagnostic methods was determined by calculating kappa statistics with 95%CIs. Kappa values were interpreted according to Landis and Koch classification [14].

Conclusion

We note that drug therapy alone is only a short term measure of reducing worm infection and re-infection. In fact, several studies suggest that in all but low transmission settings, the treatment of school-aged children alone is unlikely to drive transmission to a level where the parasites cannot persist [15]. Long-term control measures lie in concomitantly improving the quality of WASH education in schools. It is therefore recommended that post year five the programme should incorporate integrated control approaches emphasizing on health education and WASH interventions alongside the current preventive chemotherapy to drive transmission to a level where the parasites cannot persist.

Our results have shown that the current single-dose albendazole being administered by the programme is not very effective in controlling *T. trichuira,* and we therefore suggest that either the programme to increase drug administration frequency or use drug combination to effectively control the transmission of *trichuriasis* infection. Possibly, the programme can also consider conducting detailed studies to accurately measure drug efficacy and to detect potential emergence of drug resistance to albendazole and praziquantel.

The results revealed a significantly higher levels of STH infections among the ECD children compared to the older ones indicating that most of these infections are harboured by the non-enrolled or pre-school children. The programme should therefore be extended to cover both non-enrolled and pre-school children as well as the adult population, to ensure coverage of the entire population.

Our results found that the Kato-Katz technique is extremely of low sensitivity in areas of low prevalence, and as a result the programme should convert from Kato-Katz to POC-CCA technique in an effort to effectively control schistosomiasis. The POC-CCA uses urine instead of stool, results can be available immediately and the cost of POC-CCA is either equivalent to or less than Kato-Katz depending on bulk pricing of the cassettes purchased [7,16]. However, because the exisiting guidelines for schistosomiasis control programmes are based on Kato-Katz, the programme may need to use POC-CCA alongside Kato-Katz technique.

References

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Appendix

Table 1: Number of schools and children examined by County in year 5

County	Pre-MDA		Post-MDA	
	Number of schools	Number of children	Number of schools	Number of children
BOMET	12	1,296	3	319
BUNGOMA	10	1,048	3	320
BUSIA	18	1,916	6	637
HOMA BAY*	23	2,458	6	628
KAKAMEGA	20	2,108	6	637
KERICHO	12	1,278	3	320
KILIFI	10	1,040	3	307
KISII	12	1,264	3	318
KISUMU	10	1,069	3	316
KWALE	18	1,857	6	615
MIGORI	8	834	3	312
MOMBASA	8	850	3	315
NAROK	10	1,054	3	322
NYAMIRA	10	1,061	3	318
TAITA TAVETA	10	1,058	3	277
VIHIGA	8	854	3	319
Total	199	21,045	60	6,280

*One school in Homabay County was not surveyed since the school had been shut down at the time of the survey

Table 2: Year-on-year overall prevalence (%), average intensity (epg) of infection and relative reductions (%) based on 172 schools

Survey	STH Combined	Hookworm	*A. lumbricoides*	*T. trichiura*
Prevalence, % (95%CI)				
Baseline	33.6 (31.2-36.2)	15.2 (13.2-17.4)	20.7 (18.3-23.5)	6.3 (5.0-8.0)
Midterm	18.6 (16.4-21.0)	2.4 (1.8-3.2)	13.8 (12.0-15.9)	5.0 (3.7-6.8)
Endline	15.2 (13.1-17.6)	1.3 (1.0-1.6)	11.1 (9.3-13.2)	4.6 (3.4-6.1)
Relative Reduction (Baseline – Endline)	54.9 (p<0.001)	91.6 (p<0.001)	46.7 (p<0.001)	27.8 (p<0.001)
Average Intensity, epg (95%CI)				
Baseline	2012 (1698-2385)	62 (48-78)	1914 (1601-2288)	36 (11-122)
Midterm	1141 (962-1352)	9 (5-16)	1113 (936-1324)	19 (12-30)
Endline	1088 (898-1318)	11 (5-21)	1059 (872-1286)	18 (11-29)
Relative Reduction (Baseline – Endline)	45.9 (p<0.001)	82.9 (p<0.001)	44.7 (p<0.001)	50.1 (p<0.001)

Table 3: Pre- and Post-MDA prevalence (%), average intensity (epg) of infection and relative reductions (%) based on 59 schools

Survey	STH combined	Hookworm	*A. lumbricoides*	*T. trichiura*
Y1 pre-MDA Prevalence (%):	33.2 (29.4-37.4)	16.5 (13.3-20.4)	19.5 (15.3-24.8)	5.5 (3.8-7.9)
Av. Intensity (epg):	1750 (1304-2349)	63 (44-90)	1678 (1234-2281)	10 (5-18)
Y1 post-MDA Prevalence (%):	8.8 (6.6-11.7)	3.2 (2.2-4.8)	2.3 (1.6-3.2)	4.4 (2.8-7.0)
Av. Intensity (epg):	127 (85-190)	7 (4-12)	108 (68-171)	12 (4-34)
Y2 pre-MDA Prevalence (%):	19.1 (15.7-23.3)	4.5 (2.9-6.9)	12.6 (9.7-16.4)	5.2 (3.3-8.1)
Av. Intensity (epg):	1109 (828-1487)	18 (9-34)	1078 (797-1459)	14 (6-32)
Y2 post-MDA Prevalence (%):	6.0 (4.5-8.0)	2.2 (1.4-3.6)	1.8 (1.1-3.0)	2.7 (1.8-4.1)
Av. Intensity (epg):	90 (55-147)	4 (2-8)	82 (48-138)	5 (2-9)
Y3 pre-MDA Prevalence (%):	16.4 (13.2-20.3)	2.4 (1.5-3.9)	12.8 (9.8-16.7)	3.1 (2.0-4.8)
Av. Intensity (epg):	935 (679-1288)	6 (3-11)	921 (667-1273)	8 (4-15)
Y3 post-MDA Prevalence (%):	6.4 (4.8-8.6)	1.8 (1.1-3.0)	2.9 (1.7-4.8)	2.3 (1.5-3.8)
Av. Intensity (epg):	130 (87-196)	6 (3-12)	119 (77-185)	6 (3-12)
Y4 pre-MDA Prevalence (%):	15.9 (12.6-20.1)	2.6 (1.8-3.7)	11.9 (8.9-15.8)	3.8 (2.4-6.1)
Av. Intensity (epg):	1180 (842-1655)	34 (12-96)	1126 (796-1594)	20 (7-62)
Y4 post-MDA* Prevalence (%):	5.9 (4.3-8.2)	1.1 (0.6-1.8)	1.9 (1.1-3.0)	3.8 (2.5-5.8)
Av. Intensity (epg):	131 (62-279)	3 (1-5)	116 (52-261)	12 (7-23)
Y5 pre-MDA Prevalence (%):	14.1 (10.8-18.4)	1.7 (1.1-2.6)	10.5 (7.7-14.5)	3.6 (2.2-5.7)
Av. Intensity (epg):	958 (683-1342)	7 (3-15)	940 (668-1322)	11 (4-31)
Y5 post-MDA Prevalence (%):	3.0 (1.9-4.8)	0.6 (0.3-1.1)	0.8 (0.5-1.2)	2.0 (1.0-3.8)
Av. Intensity (epg):	88 (54-143)	3 (1-10)	79 (47-133)	5 (2-12)
Relative Reduction	PR: 57.6 (p<0.001)	89.7 (p<0.001)	45.9 (p<0.001)	35.4 (p=0.009)
(Y1pre-MDA to Y5pre-MDA)	IR: 45.3 (p<0.001)	88.8 (p<0.001)	44.0 (p<0.001)	*Increase

* Y4 post-MDA survey was based on 48 schools

Table 4: Baseline, midterm and endline prevalence % and relative reduction (RR) from baseline to endline by county: 172 schools

County	STH combined				Hookworm				A. lumbricoides				T. trichiura			
	Y1 baseline	Y3 midterm	Y5 endline	RR (%)	Y1 baseline	Y3 midterm	Y5 endline	RR (%)	Y1 baseline	Y3 midterm	Y5 endline	RR (%)	Y1 baseline	Y3 midterm	Y5 endline	RR (%)
Overall	33.6	18.6	15.2	54.9*	15.2	2.4	1.3	91.6*	20.7	13.8	11.1	46.7*	6.3	5.0	4.6	27.8*
BOMET	29.7	23.3	18.1	39.1*	0.2	0.1	0.1	49.9	27.9	20.9	15.2	45.5*	3.9	5.7	4.5	+
BUNGOMA[$]	49.5	10.9	7.3	85.2*	44.0	1.8	0.9	98.0*	30.7	9.7	6.6	78.6*	0.8	0	0.2	73.5*
BUSIA	36.1	25.7	16.9	53.3*	20.9	3.1	2.7	87.1*	14.4	15.1	7.2	49.9*	12.5	14.1	10.1	18.9
HOMA BAY	30.3	16.4	11.5	62.0*	14.7	5.2	2.7	81.9*	17.3	11.4	7.8	55.2*	5.8	2.9	2.9	50.4*
KAKAMEGA	31.4	15.9	9.8	68.8*	23.1	0.8	0.5	97.7*	23.1	15.0	9.3	59.6*	0.7	0.7	0.3	61.1
KERICHO	29.2	16.7	21.0	27.9*	5.7	0.1	0.2	97.2*	24.5	14.6	18.1	26.1*	4.7	4.0	4.8	+
KILIFI	32.7	5.4	2.4	92.7*	30.9	3.2	1.4	95.6*	1.2	0.6	0.3	72.4	1.9	2.2	1.0	44.9
KISII	46.8	26.2	23.7	49.4*	11.1	1.4	0.9	92.1*	39.7	25.4	22.8	42.4*	1.3	1.1	1.0	26.9
KISUMU	17.4	4.7	4.0	76.8*	8.4	0.5	0.7	92.2*	7.8	2.4	1.8	77.0*	4.1	2.0	2.0	51.6
KWALE	29.6	15.6	4.7	84.0*	25.8	13.5	3.1	87.9*	0.7	0.6	0	100*	6.0	3.0	1.9	68.3*
MIGORI	22.3	2.1	2.2	90.2*	20.1	0.7	0.4	98.2*	3.4	1.4	1.7	49.4	0.7	0.1	0.2	65.1
MOMBASA	19.8	3.0	1.5	92.3*	7.4	0.7	0	100*	1.5	0	0	100*	17.3	2.3	1.5	91.2
NAROK	53.0	39.7	43.1	18.7*	5.0	0.8	1.2	75.0*	29.3	20.3	19.7	32.7*	30.2	26.6	28.6	5.1
NYAMIRA	31.6	19.1	17.6	44.4*	1.9	0.4	0.1	95.1*	27.6	18.8	17.4	37.0*	3.1	0.5	0.4	87.6*
TAITA TAVETA	2.8	0.3	0.3	88.7*	0	0.3	0	0	0.9	0	0	100*	1.9	0	0.3	83.0*
VIHIGA	50.2	35.9	32.8	34.7*	16.0	1.8	2.2	86.1*	44.4	33.9	30.0	32.5*	9.9	7.2	6.7	32.2

Table 5: Schistosomiasis: Year 5 pre- and post-MDA prevalence % (95%CI) by county, based on 59 schools

County	*S. mansoni*			*S. haematobium*		
	Y5 Pre-MDA	**Y5 Post-MDA**	**RR (%)**	**Y5 Pre-MDA**	**Y5 Post-MDA**	**RR (%)**
Overall	1.8 (0.6-5.1)	0.7 (0.3-1.3)	62.7*	4.1 (1.5-11.3)	2.1 (0.7-6.2)	47.9*
BOMET	0	0	0	-	-	-
BUNGOMA	0	1.0 (0.1-6.9)	+	-	-	-
BUSIA	10.9 (2.3-50.8)	1.6 (0.7-3.7)	85.1*	-	-	-
HOMA BAY	0.6 (0.1-2.7)	1.9 (1.0-3.7)	+	-	-	-
KAKAMEGA	1.0 (0.3-3.3)	1.9 (0.3-13.4)	+	-	-	-
KERICHO	0	0	0	-	-	-
KILIFI	0.3 (0.1-2.2)	0	100*	2.4 (0.4-16.1)	1.0 (0.1-7.4)	59.0*
KISII	0.3 (0-2.3)	0	100*	-	-	-
KISUMU	6.9 (2.3-20.6)	1.3 (0.5-3.5)	81.0*	-	-	-
KWALE	0	0	0	9.0 (3.2-24.9)	4.8 (1.7-13.7)	46.5*
MIGORI	0	0	0	-	-	-
MOMBASA	0.4 (0-3.8)	0	100*	0	0	0
NAROK	0.9 (0.9-0.9)	0	100*	-	-	-
NYAMIRA	0	0	0	-	-	-
TAITA TAVETA	0	0	0	0	0	0
VIHIGA	0.9 (0.9-1.0)	0.3 (0-2.2)	66.6	-	-	-

[+] indicates an increase in prevalence between Y5 pre- and post-MDA

Table 6: Schistosomiasis: Overall prevalence, average intensity of infection and relative reductions

Survey	**Any Schistosome**	***S. mansoni***	***S. haematobium***
Y1 baseline* Prevalence (%):	37.9 (27.4-52.5)	2.4 (1.5-4.1)	18.0 (13.0-24.9)
Av. Intensity (epg):	20 (11-39)	14 (5-41)	20 (11-39)
Y1 post-MDA Prevalence (%):	**	2.4 (1.3-4.4)	**
Av. Intensity (epg):	**	28 (10-79)	**
Y2 pre-MDA Prevalence (%):	15.4 (7.6-30.9)	2.7 (0.9-8.1)	6.3 (3.2-12.5)
Av. Intensity (epg):	5 (2-11)	16 (3-72)	5 (2-11)
Y2 post-MDA Prevalence (%):	6.8 (3.2-14.1)	0.6 (0.1-2.6)	4.6 (2.0-10.4)
Av. Intensity (epg):	4 (2-8)	2 (0-9)	4 (2-8)
Y3 mid-term* Prevalence (%):	20.6 (12.3-34.6)	1.7 (0.8-3.6)	7.9 (3.8-16.2)
Av. Intensity (epg):	7 (3-16)	6 (2-16)	7 (3-16)
Y3 post-MDA Prevalence (%):	8.5 (4.8-15.1)	0.8 (0.4-1.5)	5.6 (2.6-12.8)

Av. Intensity (epg):	2 (1-3)	1 (1-2)	1 (0-3)
Y4 pre-MDA Prevalence (%):	9.4 (3.6-24.4)	1.8 (0.5-5.9)	3.0 (0.7-12.8)
Av. Intensity (epg):	3 (1-18)	6 (1-26)	3 (1-18)
Y4 post-MDA[$] Prevalence (%):	8.8 (4.2-18.7)	1.2 (0.4-3.5)	5.3 (1.9-14.7)
Av. Intensity (epg):	6 (1-25)	4 (1-13)	2 (1-7)
Y5 endline* Prevalence (%):	19.1 (11.7-31.1)	2.0 (1.2-3.2)	3.9 (1.7-9.0)
Av. Intensity (epg):	4 (1-11)	5 (3-10)	4 (1-12)
Y5 post-MDA Prevalence (%):	4.8 (2.5-9.2)	0.7 (0.3-1.3)	2.1 (0.7-6.2)
Av. Intensity (epg):	2 (1-5)	2 (1-4)	2 (1-5)
Relative Reduction (baseline to endline)	PR: 49.6 (p<0.001) IR: 79.7 (p=0.008)	PR: 19.4 (p=0.061) IR: 61.7 (p=0.002)	PR: 78.2 (p=0.001) IR: 81.4 (p=0.011)

*Y1 baseline, Y3 mid-term and Y5 endline were based on 172 schools while pre-post surveys were based on 59 schools, except [$]Y4 post-MDA survey which was based on 48 schools

Table 7: Comparison of infection prevalence among ECD and older children

Year/survey	Number sampled (percent)	STH combined prevalence	Any schistosomiasis prevalence	Prevalence of STH combined moderate to heavy intensity	Prevalence of any schistosomiasis moderate to heavy intensity
Year 1: Baseline					
ECD children	0	0	0	0	0
Older children	3193(100%)	32.7 (29.2-36.5)	25.9 (16.4-40.8)	6.2 (4.5-8.6)	2.8 (1.3-6.4)
Year 1: Post-MDA					
ECD children	903 (15.7%)	9.0 (6.3-12.8)	*	1.1 (0.6-2.2)	1.1 (0.4-2.9)
Older children	4865 (84.3%)	9.1 (6.8-12.1)	*	0.8 (0.5-1.3)	1.5 (0.7-3.4)
Year 2: Pre-MDA					
ECD children	267 (16.5%)	10.9 (5.1-23.2)	3.7 (1.4-10.4)	1.1 (0.4-3.2)	1.5 (0.6-3.6)
Older children	1347 (83.5%)	11.4 (6.1-21.2)	6.9 (3.6-13.3)	0.4 (0.2-1.3)	2.8 (1.4-5.7)
Year 2: Post-MDA					
ECD children	-	-	-	-	-
Older children	-	-	-	-	-
Year 3: Midterm					
ECD children	3439 (16.3%)	19.9 (17.4-22.7)	13.8 (9.0-21.1)	8.6 (7.1-10.4)	1.3 (0.7-2.6)
Older children	17624 (83.7%)	15.6 (13.7-17.9)	12.9 (8.4-19.9)	5.2 (4.3-6.2)	1.3 (0.7-2.4)
Year 3: Post-MDA					
ECD children	1026 (16.7%)	7.6 (5.3-10.9)	7.5 (3.7-15.1)	1.6 (0.9-2.8)	0.2 (0-0.8)
Older children	5136 (83.3%)	6.1 (4.5-8.3)	8.8 (4.9-15.6)	0.6 (0.3-0.9)	0.3 (0.2-0.5)
Year 4: Pre-MDA					
ECD children	1011 (16.3%)	21.2 (16.3-27.4)	7.8 (3.1-19.7)	10.4 (7.6-14.2)	2.2 (1.0-4.6)
Older children	5183 (83.7%)	15.0 (11.9-18.9)	9.9 (3.7-26.3)	6.2 (4.6-8.4)	2.0 (0.9-4.4)
Year 4: Post-MDA					
ECD children	824 (16.6%)	6.8 (4.5-10.2)	6.8 (3.1-14.7)	0.6 (0.2-1.7)	0.4 (0.1-1.1)
Older children	4143 (83.4%)	5.6 (4.0-7.8)	9.0 (4.2-19.4)	0.7 (0.3-1.3)	1.0 (0.4-2.5)
Year 5: Endline					

ECD children	3424 (16.5%)	17.3 (14.8-20.2)	7.8 (4.4-14.1)	10.5 (8.8-12.4)	2.8 (1.9-4.2)
Older children	17386 (83.6%)	12.7 (10.9-14.9)	9.5 (6.2-14.6)	6.0 (5.0-7.2)	2.2 (1.6-3.0)
Year 5: Post-MDA					
ECD children	1033 (16.7%)	5.1 (3.5-7.4)	6.4 (2.9-14.1)	3.2 (2.1-4.8)	2.9 (1.8-4.7)
Older children	5147 (83.3%)	2.6 (1.5-4.3)	4.5 (2.3-8.8)	1.7 (1.3-2.3)	1.8 (1.3-2.5)

Table 8: Comparative evaluation of the POC-CCA and the Kato-Katz parasitologic examination for the diagnosis of *S. mansoni* infection

Diagnostic Technique		**Kato-Katz stool examination**								
		Pre-treatment			**Post-treatment**			**Overall**		
		Positive	**Negative**	**Total**	**Positive**	**Negative**	**Total**	**Positive**	**Negative**	**Total**
CCA urine examination	**Positive**	60	419	479	20	363	383	80	782	862
	Negative	27	1255	1282	7	1409	1416	34	2664	2698
	Total	87	1674	1761	27	1772	1799	114	3446	3560

Table 9: Comparison of *S. mansoni* prevalence using CCA and Kato-Katz techniques among school aged children

County	**No. of schools (No. of children)**		**Kato Katz**			**CCA**			**Kappa Statistics (Agreement %)**
	Pre-MDA	**Post-MDA**	**Pre-MDA**	**Post-MDA**	**RR**	**Pre-MDA**	**Post-MDA**	**RR**	
Overall	**18 (1921)**	**18 (1928)**	**4.9 (4.0-5.9)**	**1.5 (1.0-2.1)**	**69.8**	**26.5 (24.6-28.6)**	**21.4 (19.6-23.4)**	**19.4**	**0.11 (77.1%)**
Bomet	1 (108)	1 (103)	0	0	0	61.9 (53.3-71.9)	54.9 (46.0-65.5)	11.3	0.00 (42.1%)
Bungoma	1 (108)	1 (105)	0	2.0 (0.5-7.7)	+	8.6 (4.6-16.0)	14.6 (9.1-23.2)	+	0.06 (88.8%)
Busia	2 (214)	2 (210)	28.7 (23.2-35.5)	2.9 (1.3-6.4)	89.9*	46.6 (40.3-53.9)	23.3 (18.2-29.9)	50.0*	0.28 (71.4%)
Homa Bay	1 (108)	1 (102)	0	3.0 (1.0-9.1)	+	8.3 (4.5-15.6)	13.9 (8.5-22.5)	+	0.13 (89.3%)
Kakamega	2 (212)	2 (213)	1.9 (0.7-5.0)	5.8 (3.3-10.0)	+	20.2 (15.4-26.5)	36.8 (30.8-44.0)	+	0.12 (73.4%)
Kisii	1 (105)	1 (103)	0	0	0	12.1 (7.1-20.6)	15.0 (9.4-23.9)	+	0.00 (86.1%)
Kisumu	3 (312)	3 (313)	7.1 (4.7-10.6)	1.3 (0.5-3.5)	81.4*	34.3 (29.4-40.1)	14.1 (10.7-18.6)	58.9*	0.15 (77.4%)
Kwale	3 (317)	3 (316)	0	0	0	6.6 (4.3-10.2)	8.5 (5.9-12.3)	+	0.00 (92.5%)
Mombasa	1 (98)	1 (108)	1.9 (0.3-13.4)	0	100	9.7 (5.2-18.0)	5.6 (2.6-12.2)	42.1	-0.01 (90.3%)
Narok	2 (215)	2 (214)	0.9 (0.2-3.7)	0	100	47.4 (41.1-54.6)	42.9 (36.7-50.1)	9.5	0.01 (55.2%)
Taita Taveta	1 (102)	1 (91)	0	0	0	19.2 (12.8-28.8)	2.4 (0.6-9.3)	87.7	0.00 (88.5%)

Table 10: Showing *S. mansoni* prevalence based on both CCA and Kato-Katz technique; and performance measures of Kato-Katz by each survey round with CCA as the gold standard

Treatment Round	Schools (Children)	Prevalence* %(95%CI)	Prevalence$ %(95%CI)	Sensitivity %(95%CI)	Specificity %(95%CI)	LR^+ %(95%CI)	LR^- %(95%CI)	PPV %(95%CI)	NPV %(95%CI)	Kappa index (Agreement %)
Pre-treatment	18 (1921)	4.9 (4.0-5.9)	26.5 (24.6-28.6)	12.5 (9.7-15.8)	97.9 (97.0-98.6)	6.0 (3.8-9.3)	0.9 (0.9-0.9)	69.0 (58.1-78.5)	75.0 (72.8-77.0)	0.14 (74.7%)
Post-treatment	18 (1928)	1.5 (1.0-2.1)	21.4 (19.6-23.4)	5.2 (3.2-7.9)	99.5 (99.0-99.8)	10.6 (4.5-24.8)	1.0 (0.9-1.0)	74.1 (53.7-88.9)	79.5 (77.6-81.4)	0.07 (79.4%)
Overall P-value**	-	-	-	9.3 (7.4-11.4) X^2_m =782.0, p<0.001	98.7 (98.2-99.1) X^2_m =34.0, p<0.001	7.4 (5.0-10.92) -	0.9 (0.9-0.9) -	70.2 (60.9-78.4) -	77.3 (75.9-78.7) -	0.11 (77.1%) Z = 11.6, p<0.001

PPV: positive predictive value; **NPV**: negative predictive value

LR^+: positive likelihood ratio; **LR^-**: negative likelihood ratio

**Obtained from McNemar's chi-square (X^2_m) test (sensitivity & specificity) / Weighted generalized score chi-square test (PPV & NPV)

+Prevalence was based on Kato-Katz

$Prevalence was based on POC-CCA

Table A1: Key performance indicators (KPI) from year 1 to 5 based on 59 schools

Indicator	Year 1	Year 2	Year 3	Year 4	Year 5
Combined STH (infection with any STH)					
Prevalence moderate-heavy (%) [pre - post]	8.4 – 0.9	6.8 – 0.6	5.6 – 0.7	6.8 – 0.7	7.4 – 1.9
Relative moderate-heavy prevalence reduction since last pre-MDA survey (%)	*NA*	*19.0 (p=0.006)*	*18.3 (p=0.093)*	increase	increase
Relative moderate-heavy prevalence reduction since baseline (%)	*NA*	*19.0 (p=0.006)*	*33.8 (p<0.001)*	19.3 (p=0.046)	12.3 (p=0.338)
Pre-MDA Prevalence (%)	33.2	19.1	16.4	15.9	14.1
Relative prevalence reduction since last pre-MDA survey (%)	*NA*	*42.3 (p<0.001)*	*14.3 (p=0.035)*	3.0 (p=0.712)	11.6 (p=0.156)
Relative prevalence reduction since baseline (%)	*NA*	*42.3 (p<0.001)*	*50.6 (p<0.001)*	52.1 (p<0.001)	57.6 (p<0.001)
Post-MDA prevalence (%)	8.8	6.0	6.4	5.9	3.0
Relative prevalence reduction since pre-MDA survey (%)	*73.5 (p<0.001)*	*68.5 (p<0.001)*	60.8 (p<0.001)	62.8 (p<0.001)	78.4 (p<0.001)
Schistosomiasis (infection with any type)					
Prevalence moderate-heavy (%) [pre - post]	1.7 – 1.4	2.5 – 0.7	2.0 – 0.3	2.1 – 1.0	3.1 – 1.9
Relative moderate-heavy prevalence reduction since last pre-MDA survey (%)	*NA*	increase	20.0 (p=0.374)	increase	increase
Relative moderate-heavy prevalence reduction since baseline (%)	*NA*	increase	increase	increase	increase
Pre-MDA prevalence (%)	26.6	15.4	14.9	9.4	10.8
Relative prevalence reduction since last pre-MDA survey (%)	*NA*	*42.3 (p=0.012)*	*3.0 (p=0.885)*	37.2 (p=0.137)	increase
Relative prevalence reduction since baseline (%)	*NA*	*42.3 (p=0.012)*	*44.1 (p=0.052)*	64.9 (p=0.005)	59.3 (p=0.002)
Post MDA prevalence (%)	**	6.8	8.5	8.8	4.8
Relative prevalence reduction since pre-MDA survey (%)	**	*56.0 (p=0.001)*	*42.9 (p=0.044)*	5.6 (p=0.868)	56.1 (p=0.005)

Figure 1: Outline of the 5-year M&E programme

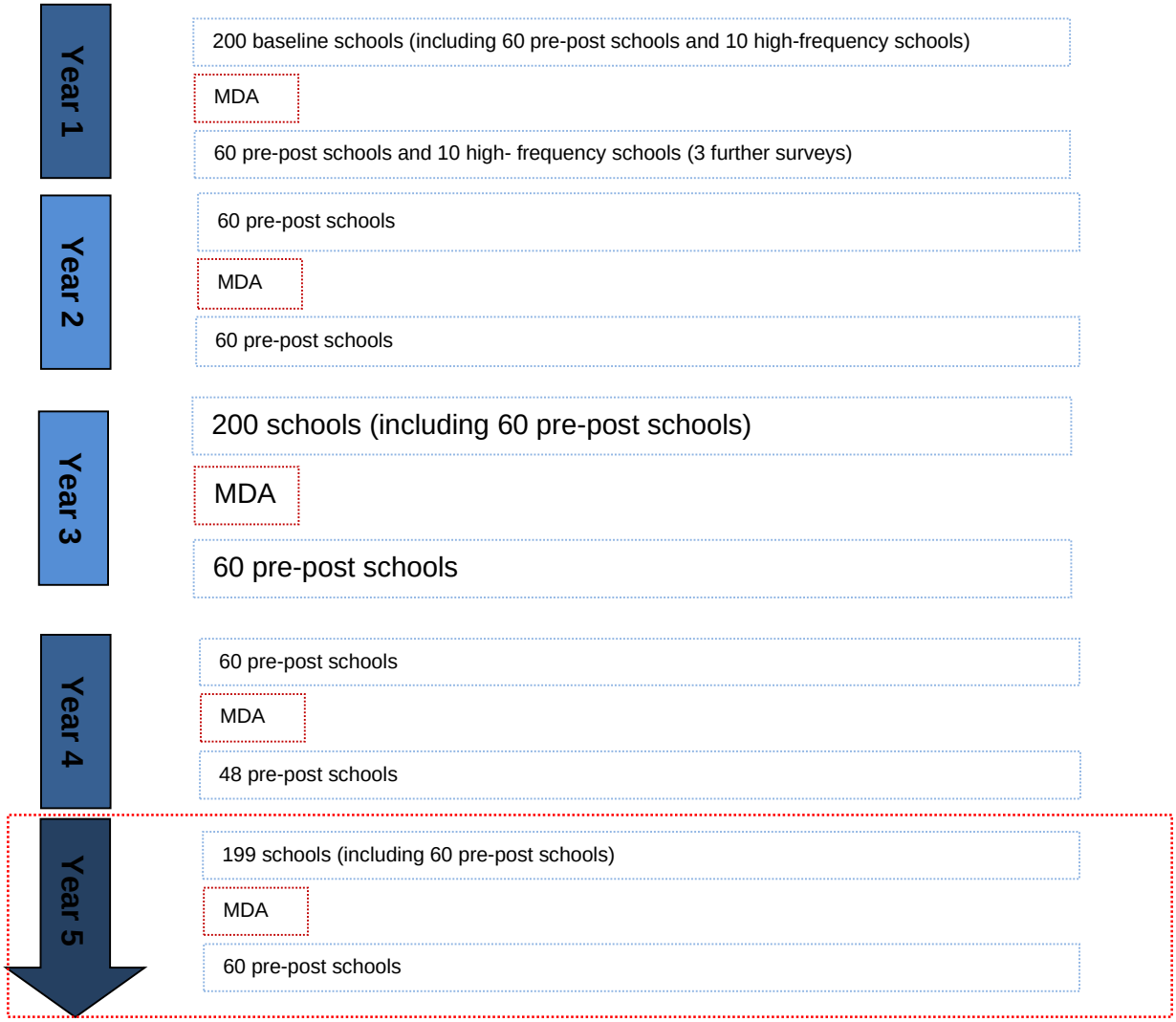

Figure 2: Baseline, midterm and endline STH infections prevalence (%) distribution

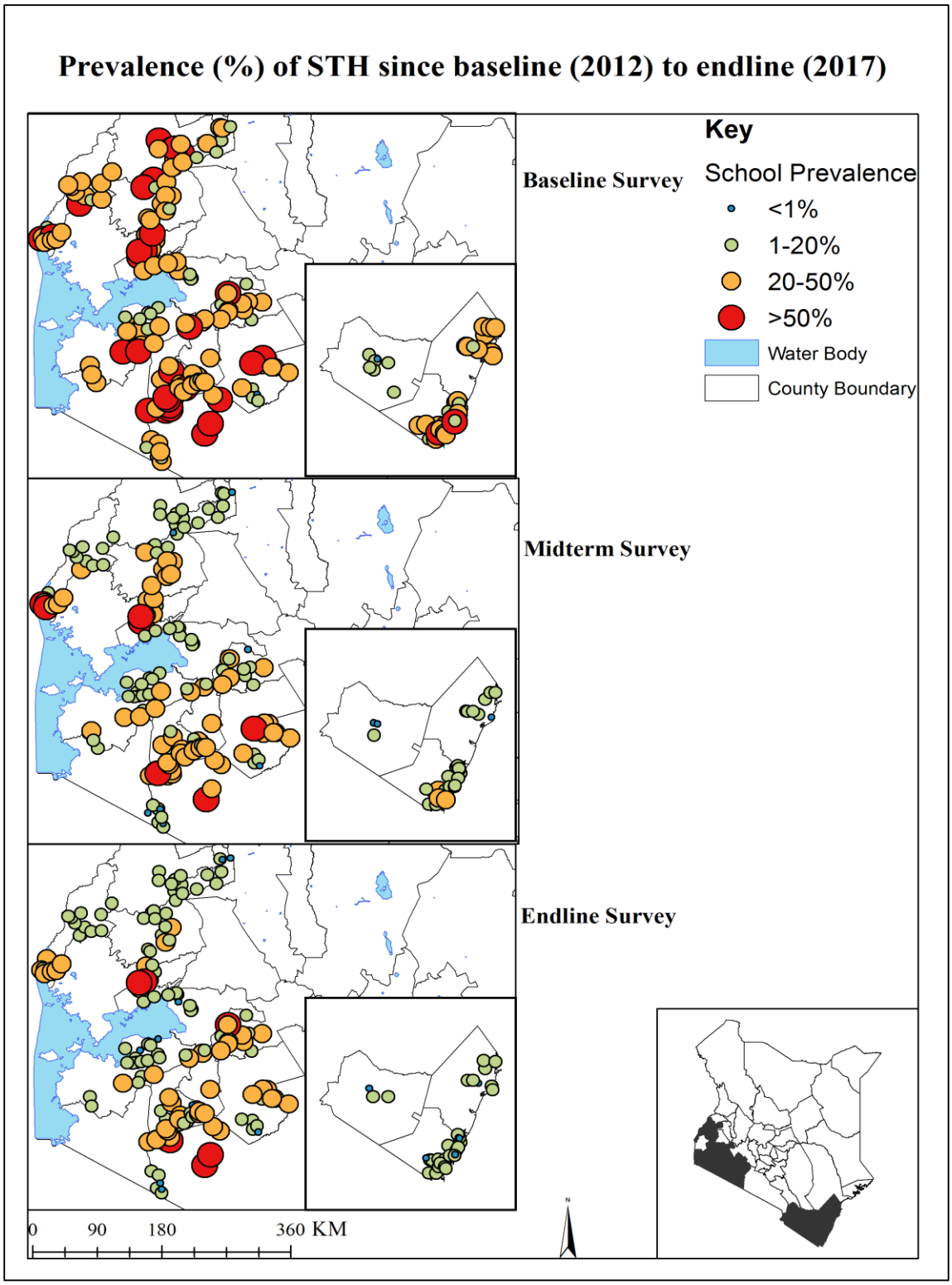

Figure 3: Infection prevalence (%) and prevalence of moderate to heavy intensity of STH infections from year 1 – 5 based on 59 schools

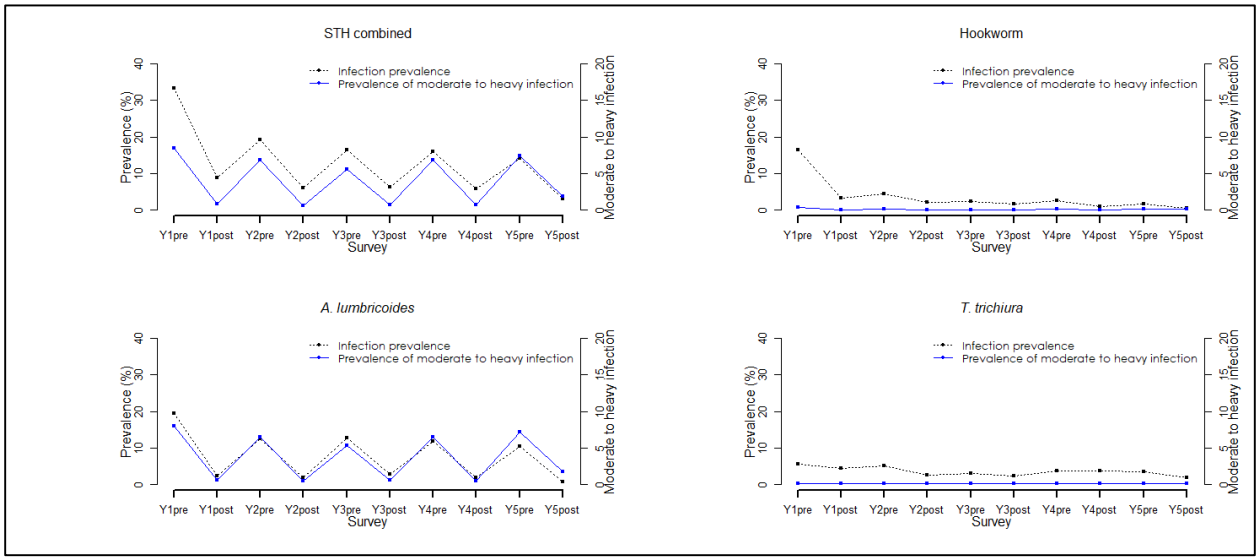

Figure 4: Baseline, midterm and endline *S. mansoni* infection prevalence (%) distribution

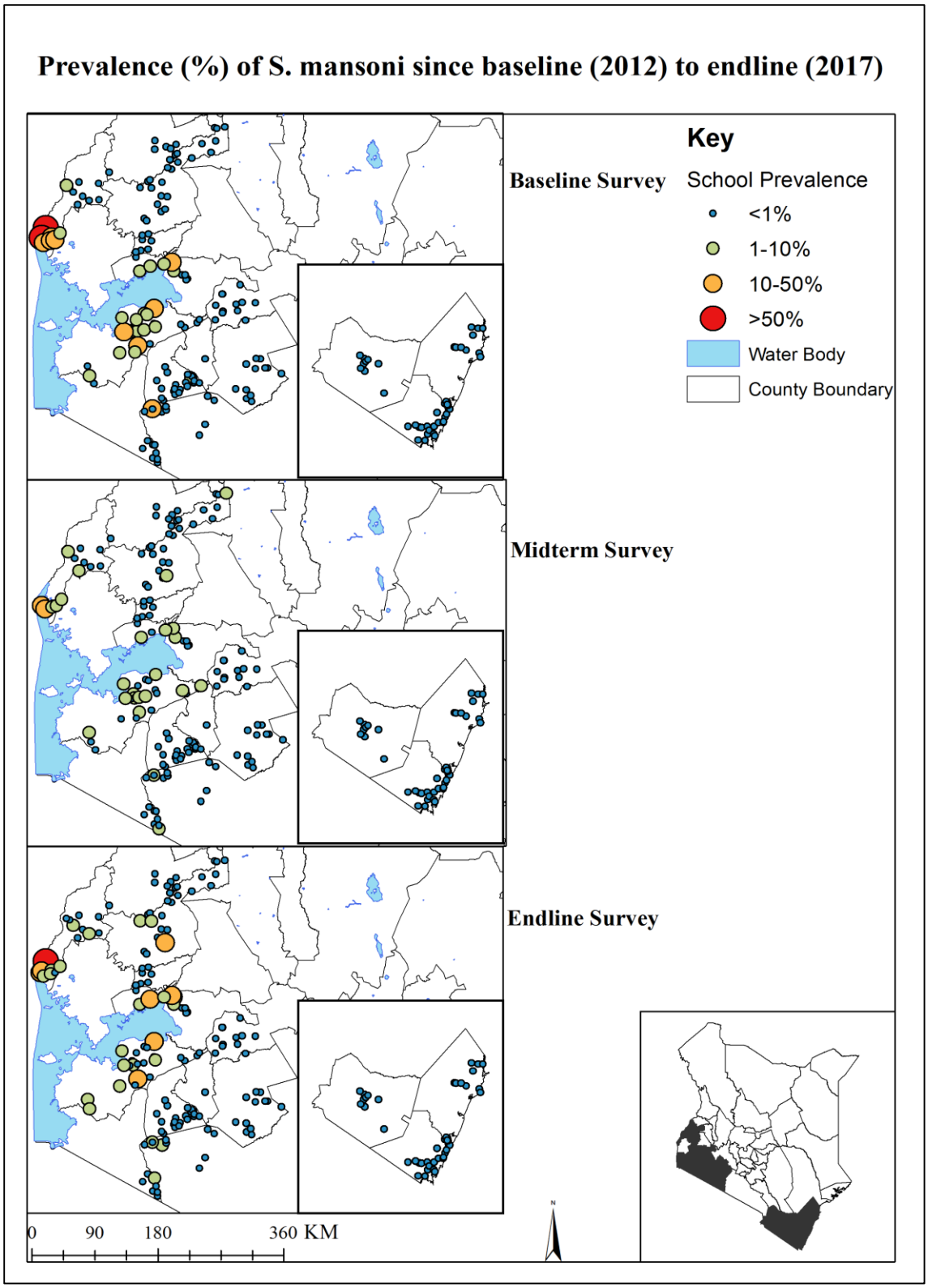

Figure 5: Baseline, midterm and endline *S. mansoni* infection prevalence (%) distribution

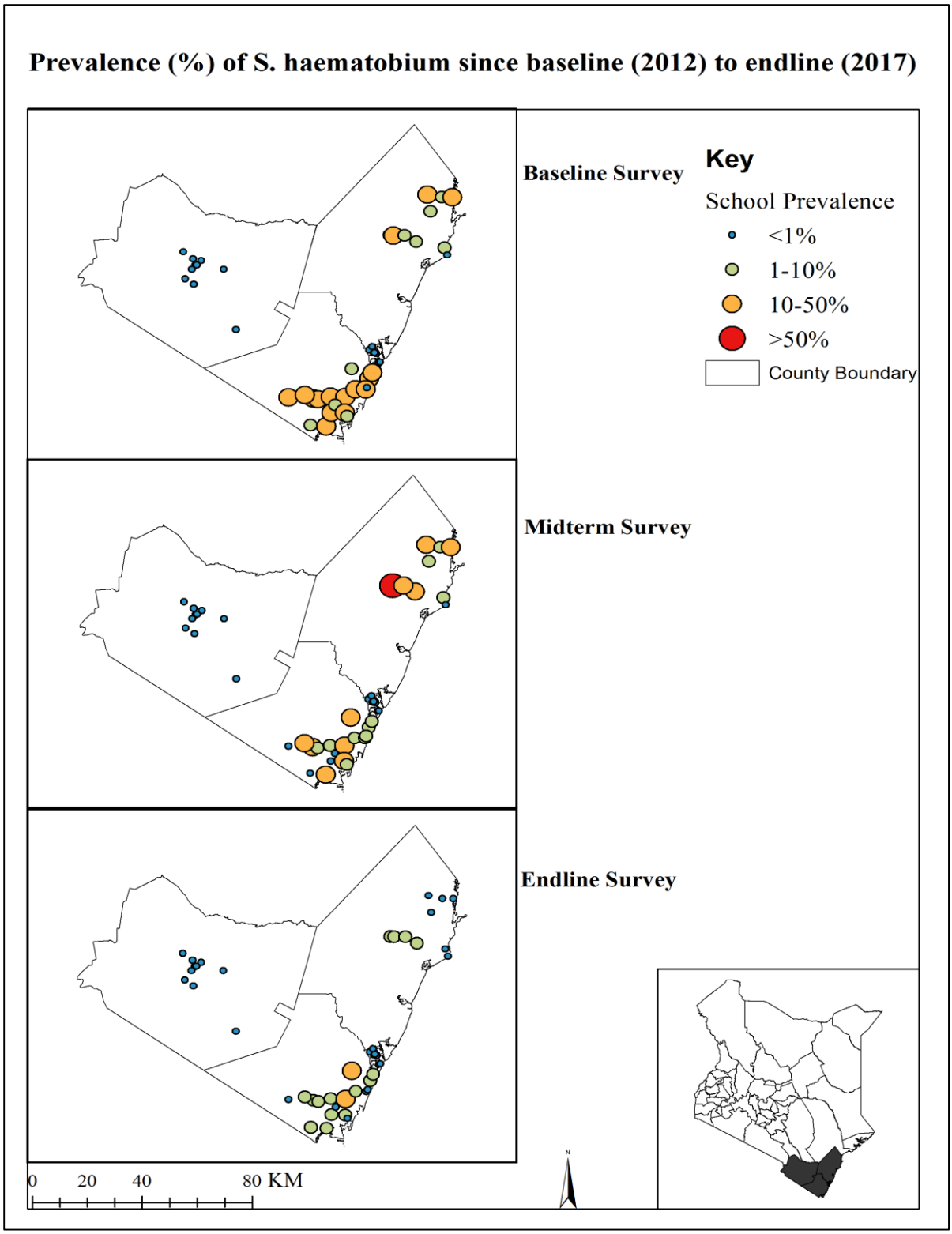

Figure 6: Infection prevalence (%) and prevalence of moderate to heavy intensity of schistosome infections from year 1 – 5 based on 59 schools

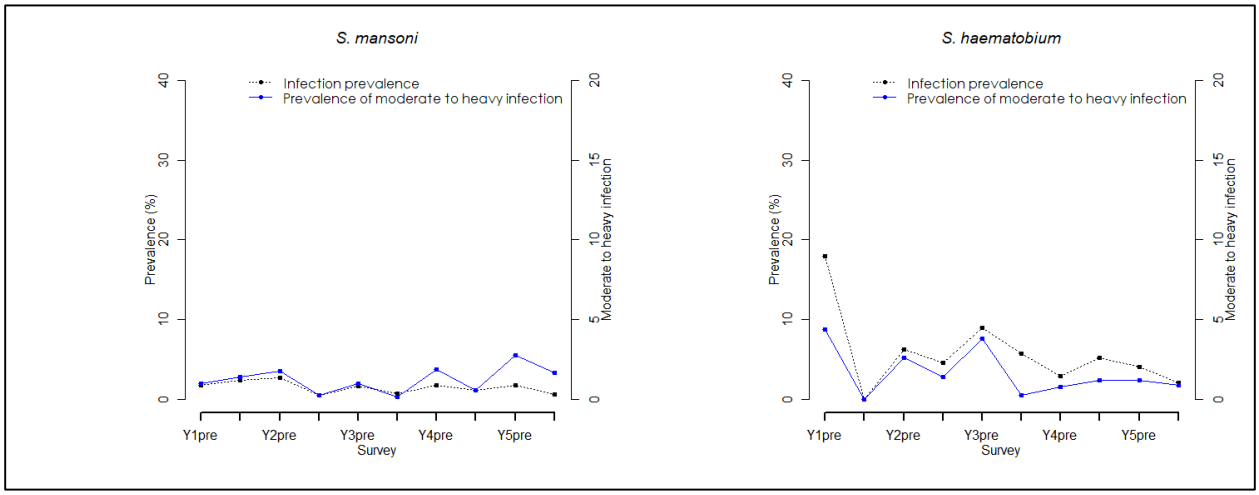

Figure 7: STH Treatment Coverage (Children): Year 1 – 5

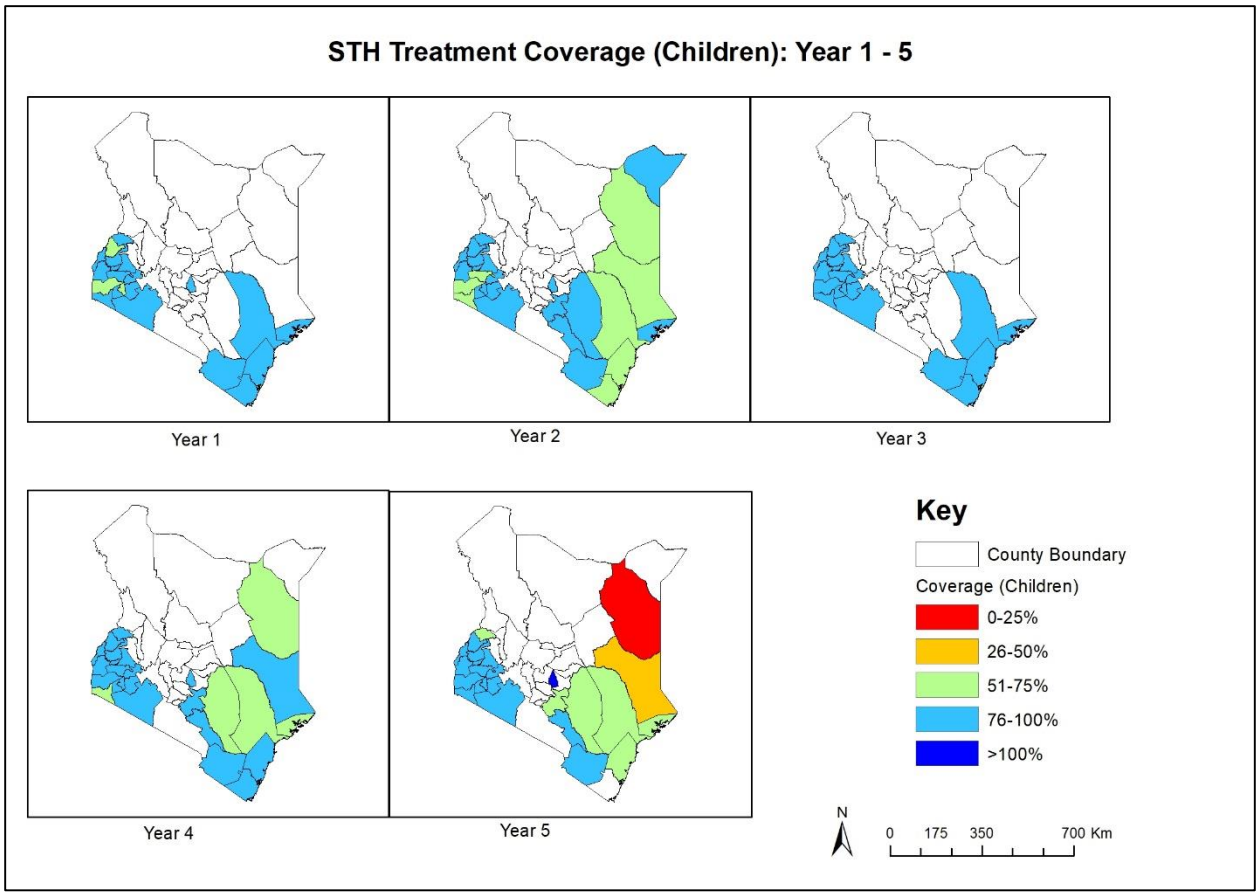

Figure 8: Schistosomiasis Treatment Coverage (Children): Year 1 – 5