Soil-Transmitted Helminths and Schistosomiasis Prevalence Probabilities Using Geostatistical-Based Models in 27 Counties of Kenya

Year 9 (2021-22) Survey Analysis

Technical Report Based on Data Collected Between September 2021 and June 2022

28th February, 2023

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Glossary

AOR: Adjusted odds ratio
CI: Confidence interval
DASH: Division of Adolescent and School Health
ECD: Early childhood development
EPHP: Elimination as a public health problem
GLMM: Generalized linear mixed models
GoK: Government of Kenya
IUs: Implementation units
KEMRI: Kenya Medical Research Institute
MBG: Model-based geostatistics
MDA: Mass drug administration
NTDs: Neglected tropical diseases
NSBDP: National School-Based Deworming Program
ODK: Open data kit
OR: Odds ratio
PC: Preventive chemotherapy
PSAC: Preschool age children
SAC: School age children
SCH: Schistosomiasis
SHNM: School Health, Nutrition and Meals
STH: Soil-transmitted helminths
WASH: Water, sanitation and hygiene
WHO: World Health Organization

Executive Summary

Infections caused by soil-transmitted helminths (STH) and schistosomes comprise the two most wide-spread neglected tropical diseases (NTDs) globally. Kenya is endemic with both STH and schistosomiasis (SCH) across 27 at-risk counties, with over 6 million children at risk of parasitic worm infection. In 2012, Kenya re-launched and expanded the National School-Based Deworming Programme (NSBDP) with a goal to eliminate parasitic worms as a public health problem for children in Kenya, providing preventive chemotherapy (PC) to school-age children (SAC) and preschool-age children (PSAC) for both diseases in selected counties across the country. After ten years of the NSBDP's operations it is important to establish the impact of treatment, assess prevalence and intensity changes, and have a more granular understanding of helminth prevalence across Kenya. The survey results may inform treatment strategy changes including; if and where treatment may be suspended and surveillance systems implemented as recommended by the World Health Organization (WHO), as well as where to target reservoirs of continued disease transmission using scarce resources to expedite program impact. To this end, Y9 impact assessment was conducted to determine the probability that the overall NSBDP geographic area, counties, and sub-counties (and in the case of SCH, wards) lie within programmatically relevant disease prevalence thresholds for both STH and SCH. Differing from previous surveys, the Y9 survey design made use of large amounts of pre-existing survey, environmental, coverage and spatial data to optimize survey design and analysis. Results from the survey suggest that across all at-risk counties, the overall prevalence for any STH infection sits between 2% to <10% with a >0.999 probability. Species specific thresholds sit at 2% to <10% for *A. lumbricoides,* 0% to <2% for hookworm, and 0% to <2% for T. *trichiuria* all with a >0.999 probability. County-specific thresholds for any STH showed more variation. Of the 27 NSBDP counties, 10 are assumed to sit within 0% to <2% prevalence (>0.999 probability with the exception of Wajir which had probability of 0.971), 10 within 2% to <10% (>0.999 probability), and 7 assumed to sit between 10% to <20% (>0.999 probability). Significant variation at the sub-county level was seen.

Prevalence of any SCH was estimated to sit between 1% to <10% with a 0.999 probability. This compromised a 0.999 probability that both *S. mansoni* and *S. haematobium* sat within 1% to <10%. Of the 27 NSBDP counties, four counties were assumed to be between 0% to <1% (>0.999 probability with the exception of Kitui at 0.998 and Taita Taveta at 0.711), 20 counties between 1% to <10% (>0.999 probability with the exception of Kericho at 0.878), two counties at 10% to <20% (>0.999 probability), and Migori County at 20% to <50% (0.953 probability). Again, significant variation in SCH prevalence was seen at sub-county, and also ward level.

Based on the survey findings, the following recommendations are made:

1. Due to the varying levels of STH and SCH infections in each county and the over ten years of national annual treatment delivery strategy, the programme should adopt county-level treatment frequencies based on the WHO prevalence categorization. Where appropriate, treatment frequency decisions should be further decentralized to sub-county level. In the case of SCH, ward level data may also be used.
2. Based on the county level STH prevalence estimates using the model-based geostatistics (MBG) approach, ten counties[1] may warrant suspending treatment, another ten counties[2] will require PC

[1] Kilifi, Kwale, Mombasa, Taita Taveta, Lamu, Machakos, Makueni, Kitui, Kirinyaga and Wajir

[2] Bomet, Kericho, Nandi, Migori, Homabay, Kisumu, Busia, Trans Nzoia, Tana River and Garissa

once every two years, and the remaining seven counties[3] may require PC once every year. These recommendations can be refined further by taking a sub-county approach to treatment frequency.

3. Based on the county level schistosome prevalence estimates using the MBG approach, two counties[4] may consider treatment suspension, twenty-two counties[5] will require PC once every two years, and three counties[6] will require PC once every year. These recommendations can be refined further by taking a sub-county approach to treatment frequency.
4. Given the demonstrable feasibility, improved precision, and improved cost–effectiveness of MBG approach, it is recommended that going forward, infection prevalence categorization be determined using this modeling approach which accounts for both the explanatory variables and the unobserved stochastic processes around survey location.
5. To avoid potential resurgence of disease, a cost-effective surveillance system should be put into place capable of detecting rising levels of prevalence in counties which have suspended treatment.
6. To sustain the chemotherapeutic gains especially in counties that have been shown not to require regular treatment, innovative, integrated, and cost-effective water, sanitation and hygiene (WASH) and health education approaches should be explored.
7. Based on the prevalence of the moderate-to-heavy intensity of STH, various counties have achieved elimination of STH infections as a public health problem[7] (EPHP). However, some counties have not achieved this goal.

Introduction

Global worm burden and interventions

Soil-transmitted helminth (STH) and schistosome infections comprise the two most wide-spread neglected tropical diseases (NTDs) globally. STH infections affect more than 1.5 billion people of the world's poorest population (800 million of whom are children in the ages 1 to 14 years) [1]. Over 200 million people living in Africa, Asia, South America and the Caribbean are infected with schistosomiasis (SCH) causative parasites [2,3]. While the global distribution of infection has changed, the majority of the disease burden is now concentrated in sub-Saharan Africa, this is likely due to the effective control and economic development in other regions, the absolute number of people infected or at risk may not be decreasing due to population growth [4].

School-age children are particularly vulnerable to chronic infection that can impair mental and physical development and reduce school attendance and educational achievement. Both STH and schistosomiasis have been recognized as having significant developmental and educational effects on children which can

[3] Bungoma, Kakamega, Vihiga, Narok, Kisii, Nyamira and Siaya

[4] Bungoma and Nyamira

[5] Narok, Bomet, Kericho, Nandi, Kisii, Kisumu, Siaya, Mombasa, Kilifi, Kwale, Lamu, Taita Taveta, Busia, Kakamega, Vihiga, Trans Nzoia, Machakos, Makueni, Kitui, Garissa, Wajir and Kirinyaga

[6] Migori, Homabay and Tana River

[7] EPHP is classified as a geographic area having reached less than 2% of moderate to heavy intensity for STH infection

hinder their ability to lead a full healthy life while also affecting productivity into adulthood [5]. Infection with both STHs and schistosomes can lead to local and systemic pathological effects including anemia, growth stunting, impaired cognition, decreased physical fitness, and organ-specific effects, while severe cases can lead to intestinal obstructions and gangrene [6-8].

Repeated preventative chemotherapy (PC) with albendazole or mebendazole for STH, and with praziquantel for schistosomiasis, is used to control helminth morbidity within at-risk populations. All three drugs are well suited to PC given their known safety profile, tolerability and low cost, and are often administered through school-based deworming campaigns [7]. Using schools as a platform for PC allows a captive population for treatment, maintaining high coverage levels while minimizing cost and targeting those at most risk. Regular school-based deworming is a proven, cost-effective strategy that can avert the health and educational consequences of STH infections [8-11].

Kenya worm burden and the national school-based deworming programme

Kenya is endemic with both STH and schistosomiasis, with over 6 million children at risk of parasitic worm infection. In 2012, Kenya re-launched and expanded the National School-Based Deworming Programme (NSBDP) with a goal to eliminate parasitic worms as a public health problem[8] (EPHP) in Kenya, by providing PC to all school-age children (SAC) and preschool-age children (PSAC) for both diseases in selected counties across the country. The NSBDP is a Kenya Vision 2030 flagship program and is aligned with the disease-specific targets within the World Health Organization (WHO's) road map for NTDs 2021 - 2030. The programme has annually targeted to deworm over 6 million children across 27 STH endemic counties in parts of Nyanza, Western, Rift Valley, Central, Eastern, North Eastern and Coast regions. The NSBDP aims to treat over 80% of all preschool and school-age children aged between 2 to 14 years for STH, whether enrolled or unenrolled in school, within all endemic areas necessitating treatment based on WHO guidelines as determined at the beginning of the program. Additionally, NSBDP treats a subset of counties that are co-endemic for schistosomiasis, targeting school-age children only, aged 5 to 14 years. The NSBDP is currently implemented by the Division of Adolescent and School Health (DASH) within the Ministry of Health and the School Health, Nutrition and Meals (SHNM) Unit within the Ministry of Education. The program has received independent impact monitoring via the Kenya Medical Research Institute (KEMRI) since its initiation. Prevalence surveys have been performed in Kenya from 2012 to 2020, with evaluation points being Y1 (2012), Y3 (2016), Y5 (2017) and Y6 (2018).

After ten years of the NSBDP's operations it is important to establish the impact of treatment, assess prevalence and intensity changes and have a more granular understanding of helminth prevalence across Kenya. The survey results may inform treatment strategy changes including; if and where treatment may be suspended and surveillance systems implemented as recommended by the World Health Organization (WHO), as well as where to target reservoirs of continued disease transmission using scarce resources to expedite program impact. To this end, Y9 (2021/2022) impact assessment was conducted. Differing from previous surveys, the Y9 survey design made use of the large amounts of survey, environmental, coverage and spatial data to geo-statistically optimize survey design and analysis for both STH and SCH infections. The overall goal of the survey was to determine the probability that the overall NSBDP geographic area, counties, and sub-counties (and in the case of SCH, wards) lie within programmatically relevant disease prevalence thresholds for both STH and SCH. In this way, the future treatment strategy of school-based

[8] EPHP is classified as a geographic area having reached less than 2% of moderate and/or heavy intensity for STH infection

deworming in Kenya will be optimized to ensure that resources are most efficiently targeted across the country.

Need for new sampling methods and cost effectiveness

Preventive chemotherapy is a cost-effective approach to controlling morbidity of both diseases, but relies on large scale surveys to determine and revise treatment frequency. Given the need for a SAC population estimates, surveys represent a substantial proportion of helminth control program budgets. As mass treatments of STH and schistosome infections have been sustained for a number of years, there is a global push to measure impact of investment and prevalence reductions across numerous geographies and therefore a need to cost-optimize components of these surveys to make best use of available resources. Recent innovations in survey design using geospatial statistical methods, such as model-based geostatistics (MBG), to select survey sites have been shown to deliver more precise results, given the same resources, than traditional design approaches.

Critically for the cost-effectiveness of helminth control programs, MBG differs from traditional survey design in the selection of sites for surveying and the information which is derived from those sites post-survey. Traditional design suggests randomization of sites for surveying across representative areas, such as ecological zones. MBG uses predictive models to identify sites which provide the most predictive power for post-survey modeling of prevalence. In this way, purposive sampling can be used to target the most informative sites and maximize survey precision under given resource constraints. In addition, traditional methods for post-survey estimation of prevalence do not consider prior prevalence, most risk factors, or geospatial variation. MBG, however, uses this information post-survey to create predictive models of prevalence which are as accurate as possible, under some stated assumptions. Such targeting also maximizes the potential of integration of STH and schistosomiasis, given their similarities in risk-factors. Finally, MBG allows the estimation of probabilities that post-analysis prevalence's lie within pre-defined programmatically relevant thresholds [14, 15, 17, 18].

Survey Method

Study objectives

As stated above the primary objective of the survey was to determine the probability of various levels of implementation units (IUs) (overall NSBDP geographic area, county, sub-county, and ward) lying within pre-defined prevalence ranges. The prevalence ranges were 0% to <2%, 2% to <10%, 10% to <20%, 20% to <50%, and 50% and above for STH, and 0% to <1%, 1% to <10%, 10% to <20%, 20% to <50%, and 50% and above for SCH. Secondary objectives were as follows:

- Estimate IU level mean prevalence, intensity and confidence intervals using MBG approach
- Estimate IU level mean prevalence, intensity and confidence intervals using traditional statistical approaches for comparison purposes
- Determine correlations of STH and SCH infection with water, sanitation and hygiene (WASH) (including questions around WASH changes due to COVID-19), and sociodemographic variables

Study design, and sampling using the geostatistical-based modeling approach

The traditional approach to large-scale representative surveying of STH and often schistosomiasis has been to use two-stage random sampling or modifications thereof, often stratified by ecological zones [16], [13]. However, established literature suggests that the prevalence of helminth infection is highly predictable based on environmental variables, treatment frequency, and other geo-spatial correlates. This suggests that traditional survey design estimates may be inefficient, because they only partially account for geographical variation. This presents the opportunity for a more efficient survey design incorporating geospatial and other risk covariates, generally referred to as a model-based geostatistical approach [14, 15, 17, 18].

The year 9 survey utilized a cross-sectional design where 200 schools drawn from parts of seven regions of Kenya (i.e., Western, Nyanza, Rift Valley, Coast, Eastern, North Eastern and Central) were sampled using a spatially regulated design [17]. This design is more efficient than the widely used random sampling designs or WHO recommendations for mapping surveys [16, 20], since it uses a constrained randomization that imposes a minimum distance between any two sampled locations. This sampling approach usually leads to better predictive performance [17, 21]. All the 27 counties that are currently receiving treatment for STH and schistosomiasis were included in the survey and were used as IU or stratum. Therefore, the spatially regulated sampling was conducted within each stratum. An implementation unit is a geographical area over which a particular treatment strategy is applied (e.g., a ward, sub county, county, province or a whole country). It is expected that after 5 to 6 years of consistent mass drug administration (MDA) the infection prevalence would substantially reduce within these strata and the infection endemicity classes need to be reviewed with the aim of changing the treatment delivery frequency according to the WHO decision tree [16,22]. In each school, a minimum random sample of 70 children (i.e., 10 children of equal gender per class for seven classes: one early childhood development (ECD) class and classes 1 – 6) was generated using random number tables. The sample of children per school was based on the MBG approach that compared the proportion of the correctly classified IUs based on a different set of number of children per school [17].

Survey procedures

The selected schools were visited three days prior to the survey date to have the purpose of the survey explained to the school head teacher and the school committee. On the day of the survey, each selected child was given a container (poly pot) labeled with a unique identifier and instructed to place a portion of his or her own stool sample in it. The stool samples were then processed in the laboratory within 24 hours and examined in duplicate for the presence of STH and *Schistosoma mansoni* eggs by two technicians using the Kato-Katz technique. Urine samples were obtained from all the sampled children and were then processed using the urine filtration technique in the laboratory within 24 hours using the polycarbonate membrane filters and examined in duplicate for the presence of *S. haematobium* eggs by two technicians.

Ethical considerations

Ethical approval for the study protocol was obtained from the KEMRI’s Scientific and Ethics Review Unit (SSC Number 2206). Permission to access the schools for the survey was obtained from the national-level Ministry of Education. At county-level, approval was provided by the respective county health and education authorities. At school-level, parental consent from parents/guardians of the children was based on passive, opt-out consent rather than written opt-in consents due to the low-risk nature of the survey procedure. Additionally, individual assent was obtained from each child before participation in the study. All data used was anonymized.

Data collection

The survey data was collected in two phases all prior to the year 10 MDA, phase one survey was conducted between 6th to 24th September 2021 and phase two between 9th May to 22nd June 2022. Data on the infection prevalence and intensity was collected by examining a single stool or urine sample using kato-katz (for the case of STH and *S. mansoni*) and urine filtration methods (for the case of *S. haematobium*) respectively among all the surveyed children. All the participating children (minimum 70 children per school) and schools (200 schools) were administered with a pre-tested questionnaire to collect information on demographic, individual, household and school levels WASH related behaviors, practices and characteristics. In addition, given the current COVID-19 pandemic, we collected information on the children's and schools' level of preparedness, awareness and mitigation measures towards the pandemic, and assessed how these measures related to the observed STH and schistosomiasis prevalence and intensity. Both the survey questionnaires and laboratory reporting forms were programmed onto android-based smartphones which were used to capture data electronically using the Open Data Kit (ODK) system that incorporated in-built data quality checks to reduce data entry errors [23].

Statistical analysis

Estimation of the infection prevalence

Using standard statistical methods and available guidelines for STH and schistosomiasis mapping [24], infection prevalence is usually calculated using the formula below;

$$Prevalence = \left[\frac{Number\ of\ children\ positive}{Number\ of\ children\ examined}\right] x\ 100 \qquad 1$$

However, this prevalence estimate (1) is most often biased and associated with a high degree of uncertainty especially when survey locations (schools) and participants (children) are randomly chosen from the general population of interest. Since STH and schistosomiasis infections have been driven to very low levels, owing to the consistent and high coverage MDAs for the last nine years [25, 26], there is a need to shift to better methods of estimating the infection prevalence. Therefore, in this analysis, we complemented our prevalence estimation with a more precise method, the model-based geostatistical approach. The approach proposed by Diggle and colleagues [17] is described below.

Briefly, in the MBG approach, the outcome of interest is the infection prevalence, $P(x)$, observed in a sampled location (x). The data collected at the sampled location include the total number of individuals sampled, $n(x)$, whose disease status were ascertained using a suitable test (i.e., kato-katz for STH and *S. mansoni*, and urine filtration for *S. haematobium*), out of whom, $y(x)$ individuals returned a positive test result. Therefore, the estimate of $P(x)$ implied by equation (1) is the observed proportion of test-positive results given as,

$$q(x) = \left[\frac{y(x)}{n(x)}\right] \qquad 2$$

However, equation (*2*) has two main limitations in its use; first, it only gives the prevalence information specific to location (x) and not any other place, and secondly, it is usually not even the best estimate of $P(x)$. To overcome these limitations and obtain a better estimate, we collected data on measurements of one or more predictor variables, $d(x)$, that can be attributed to (x) and may be associated with $P(x)$, this therefore allowed us to fit a logistic regression model to the complete dataset as described below.

$$E\left(\frac{y}{x}\right) = Z + d(x)'\beta$$

$$\rightarrow P(x) = \frac{e^{(Z+d(x)'\beta)}}{1+e^{(Z+d(x)'\beta)}}$$

With a logit transformation given as;

$$g(x) = log\left[\frac{P(x)}{1-P(x)}\right] \quad 3$$

$$\therefore g(x) = Z + d(x)'\beta$$

Further, in order to completely account for the spatial variation in prevalence (i.e., taking measures at different locations of x), we extended the logistic regression model (*3*), by including unobserved stochastic process, $S(x)$, to represent the spatial variation in $P(x)$ that is not explained by $d(x)$. Therefore, the resulting geostatistical-based model was given as;

$$g(x) = Z + d(x)'\beta + S(x) \quad 4$$

Where; $g(x)$ denoted the estimated prevalence, $y(x)$ denoted the number of individuals who returned a positive test result (this quantity is independent and binomially distributed), $d(x)'$ denoted set of predictor variables (i.e. context-specific covariate effects) at different sampled locations, say x and x', $S(x)$ denoted the unexplained residual spatial variation which are represented here as a spatial stochastic process, and Z is an unexplained residual non-spatial variation (these are a set of independent and normally distributed unstructured random effects).

In the geostatistical model (4), the main feature of $S(x)$ is that its values at different locations, say x and x', are correlated to an extent that depends on the distance between x and x' which then can allow us to estimate from the data the regression parameters β. For statistical efficiency, we used the maximum likelihood method to estimate the model parameters.

Analysis of risk factors

Data from the questionnaires reported individual, household and school-levels socio-demographic and COVID-19 WASH related factors of interest that are known to affect the transmission of STH and schistosomiasis. *Individual level factors* collected included age, gender, handwashing, defecation and urination, soil-eating and shoe-wearing behaviors at school and home. *Household level factors* included availability of toilet, anal cleansing material, handwashing facility equipped with water and soap, type of water source, as well as number of people living in an individual's household. *School level factors* included interviewer-verified availability and type of school toilet facility, availability and type of handwashing facility equipped with water and soap, and availability of anal cleansing material at school. *COVID-19 related factors* for both individual and school/household levels included knowledge about COVID-19, its transmission and symptoms, and ways of self-protection, availability of handwashing facilities equipped with water and soap at specific points within the school and household, and individual's handwashing practices.

Overall, the factors associated with STH or schistosomiasis prevalence (i.e., calculated using standard frequentist approach) were analyzed, first using univariable analysis and described as odds ratio (OR) using mixed effects logistic regression model at three levels; pupils nested within schools selected within sub-counties, which are selected within counties. Further, minimum adequate variables for multivariable analysis were selected by pre-specifying an inclusion criterion of p-value < 0.1 in a sequential (block-wise) variable selection method. Adjusted OR (aOR), of the most parsimonious model, were obtained by mutually adjusting all the minimum generated variables using mixed effects logistic regression model (equation 5) at 95% confidence interval (CI) taking into account the hierarchical nature of the data. The risk factors analysis was performed by fitting a multilevel mixed effects logistic regression model. Let $y_{i,j,k}$ be the binary response variable of the i^{th} child in the j^{th} school in the k^{th} county. Further, let $\ _{i,j,k} = P(y_{i,j,k} = 1)$ denote the probability that an i^{th} a child's infection outcome is positive. Suppose, $X_{i,j,k}$ denotes design matrix of fixed effects (i.e., coefficients related to the fixed effects) which corresponds to the i^{th} child in the j^{th} school in the k^{th} county, β is the fixed effects vector, Z is the design matrix of random effects (i.e., counties and sub-counties included as random intercepts), and γ is the random effects vector. Then following the generalized linear mixed models (GLMM) framework, we formulate the mixed effects logistic regression model as follows,

$$
\begin{aligned}
P(X,Z) &= \pi \\
logit(\pi) &= log\left[\frac{\pi}{1-\pi}\right] \\
g(\theta) &= X\beta + Z\gamma
\end{aligned}
\qquad 5
$$

All data management and cleaning were carried out in STATA version 15.1 (STATA Corporation, College Station, TX, USA). Analyses of the infection prevalence using the MBG approach and analyses of risk factors were performed using the R software [10]. All graphs were developed using the *ggplot* package implemented in R software [11]. Geospatial maps of the school locations were developed using ArcGIS Desktop version 10.2.2 software (Environmental Systems Research Institute Inc., Redlands, CA, USA).

Results

During the year 9 survey, 200 schools (13,416 children) with median age of 9 years (range: 1 to 19 years) were surveyed across all the 27 counties covered by the NSBDP in parts of Western, Nyanza, Rift Valley, Coast, Eastern, North Eastern and Central regions. Approximately half 6,790 (50.6%) of the surveyed children were males. Distribution of the children per class was as follows: ECD 1,863 (13.9%), class one 842 (6.2%), class two 2,635 (19.6%), class three 2,636 (19.7%), class four 2,646 (19.7%), class five 2,625 (19.6%), class six 169 (1.3%). The number of schools and children surveyed varied per county as indicated in Table 1.

Predictive probability estimates of STH prevalence thresholds

The predictive probabilities of any STH prevalence lying within 0% to <2%, 2% to <10%, 10% to <20%, 20% to <50%, and 50% and above were determined. Probabilities were estimated at the level of the NSBDP geographic area, counties, and sub-counties. A given geographic unit was assumed to sit within the set threshold if its probability was greater than 0.500. All thresholds specific for county predictive probabilities can be seen in Table 2 and Figure 1, while an overview of the thresholds assigned to sub-counties can be seen in Figure 2.

The overall NSBDP geographic area prevalence for any STH infection was estimated to sit between 2% to <10% with a >0.999 probability. Species specific thresholds were 2% to <10% for *A. lumbricoides,* 0% to <2% for hookworm, and 0% to <2% for T. *trichiuria* all with a >0.999 probability. County specific thresholds showed variation. Of the 27 NSBDP counties, 10 counties[9] were assumed to sit within 0% to <2% prevalence (>0.999 predictive probability with the exception of Wajir at 0.971), another 10 counties[10] within 2% to <10% (>0.999 probability), and 7 counties[11] assumed to sit between 10% to <20% (>0.999 probability).

As described above the analysis was extended to determine sub-county variation in prevalence thresholds. It should be noted that with more geographic focality, less confidence can be placed on assumptions made to derive prevalence thresholds and predictive probabilities. Regardless, analysis suggested that 17 of the 27 NSBDP counties showed differential prevalence thresholds across sub-counties. As an example, of the 9 sub-counties which comprise Bungoma, three were assumed to sit between 2% to <10%, two between 10% to <20%, and four 20% to <50%. Table 3 and Figure 2 show the number of sub-counties classified according to their county endemicity lying within a set of STH thresholds.

Predictive probability estimates of SCH prevalence thresholds

SCH prevalence thresholds were set *a priori* at 0% to <1%, 1% to <10%, 10% to <20%, 20% to <50%, and 50% and above. Prevalence of any SCH was estimated to sit between 1% to <10% with a 0.999 predictive probability. This compromised a 0.999 probability that both *S. mansoni* and *S. haematobium* sat within 1% to <10%. All thresholds specific for county predictive probabilities can be seen in Table 4 and Figure 3, while an overview of the thresholds assigned to sub-counties can be seen in Figure 4. Of the 27 NSBDP counties, four counties[12] were assumed to between 0% to <1% (>0.999 probability with the exception of Kitui at 0.998 and Taita Taveta at 0.711), 20 counties[13] between 1% to <10% (>0.999 probability with the exception of Kericho at 0.878), two counties[14] at 10% to <20% (>0.999 probability), and Migori County at 20% to <50% (0.953 probability). Table 5 and Figure 4 show the number of sub-counties classified according to their county endemicity lying within a set of SCH thresholds.

As with STH, the analysis was extended to determine lower-level geographic variation in prevalence thresholds. As with more geographic focality, less confidence can be placed on assumptions made to derive prevalence thresholds and probabilities. Regardless, sub-county analysis suggested that 15 of the 27 NSBDP counties showed differential prevalence thresholds across their respective sub-counties. As an example, of all the 8 sub-counties in Homabay County, 2 were assumed to lie between 1% to <10%, 4 between 10% to <20%, and 2 between 20% to <50%. SCH analysis was further extended to wards, showing 25 of the 27 counties having differential prevalence thresholds at the ward level. As an example, of the 32 wards which comprise Busia County, four were assumed to sit between 0% to <1%, 25 between 1% to

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[9] Kilifi, Kirinyaga, Kitui, Kwale, Lamu, Machakos, Makueni, Mombasa, Taita Taveta, and Wajir

[10] Bomet, Busia, Garissa, Homa Bay, Kericho, Kisumu, Migori, Nandi, Tana River, and Trans Nzoia

[11] Bungoma, Kakamega, Kisii, Narok, Nyamira, Siaya, and Vihiga

[12] Bungoma, Kitui, Nyamira, and Taita Taveta

[13] Bomet, Busia, Garissa, Kakamega, Kericho, Kilifi, Kirinyaga, Kisii, Kisumu, Kwale, Lamu, Machakos, Makueni, Mombasa, Nandi, Narok, Siaya, Trans Nzoia, Vihiga, and Wajir

[14] Homa Bay, and Tana River

<10%, and three between 10% to <20%. Table 6 and Figure 5 show the number of wards classified according to their county endemicity lying within a set of SCH thresholds.

Estimation of STH and schistosome infections mean prevalence and confidence intervals using geostatistical based modelling approach

Using a model-based geostatistical approach, the overall STH prevalence was 5.8% (95%CI: 5.7-6.0) with species-specific prevalence of 4.3% (95%CI: 4.2-4.4) for *A. lumbricoides*, 0.3% (95%CI: 0.2-0.4) for hookworm, and 1.4% (95%CI: 1.3-1.5) for *T. trichiura* (Table 7). County level prevalence ranged from 0.7% to 16.9% for any STH, 0.2% to 14.2% for *A. lumbricoides*, 0.1% to 5.6% for *T. trichiura*, and 0.2% to 0.5% for hookworm. The school level (pixel) geographical distribution of STH prevalence across the NSBDP geographic area is shown in Figure 6.

Similarly, using the MBG approach, the overall prevalence of any schistosome infections was 5.0% (95%CI: 4.9-5.2) with species-specific prevalence of 3.0% (95%CI: 2.9-3.1) for *S. mansoni* and 2.2% (95%CI: 2.1-2.3) for *S. haematobium* (Table 8). Using this approach, county level prevalence ranged from 0.7% to 20.2% for any SCH, and specifically 0.1% to 17.5% for *S. mansoni*, and from 0.1% to 15.4% for *S. haematobium*. The school level (pixel) geographical distribution of schistosomiasis prevalence across the NSBDP geographic area is shown in Figure 7.

When compared to a traditional statistical analysis approach (binomial regression model), slightly higher prevalence estimates were seen for both STH (Table 7 and Figure 8) and SCH (Table 8 and Figure 9). The differences in the estimates for the two models were non-significant. However, the overall hookworm prevalence remained the same in both approaches.

Estimation of the prevalence of light, moderate and heavy intensity of STH and schistosome infections using the traditional statistical approach

Differing from the original analysis plan, prevalence of different STH and SCH intensity classes were conducted only using the traditional statistical approach (binomial regression model). This is due to a very low frequency of moderate and heavy intensity of infections making geostatistical modelling not viable. Calculation of the prevalence of intensity of the infections was conducted using two different options (denominators): (1) using the total number of children examined during the survey as denominator, and (2) using only the total number of children positive for any particular infection as denominator. It should be noted that the programmatically relevant option is option 1 (Figure 10, panel A), as this is used to determine EPHP (i.e., <2% prevalence of moderate to heavy intensity of STH infection, and <1% prevalence of heavy intensity of SCH).

Overall, during the Y9 survey, any STH prevalence of light infections was 3.8% (95%CI: 3.5-4.1) and 74.9% (95%CI: 70.6-79.4) using option 1 and 2 respectively. The prevalence of moderate intensity was 1.2% (95%CI: 1.1-1.4) and 24.3% (95%CI: 20.1-29.3) using option 1 and 2 respectively. The prevalence of heavy intensity was 0% (95%CI: 0-0.1) and 0.9% (95%CI: 0.4-2.0) using option 1 and 2 respectively. While the prevalence of moderate to heavy intensity was 1.3% (95%CI: 1.1-1.5) and 25.1% (95%CI: 21.1-30.0) using option 1 and 2 respectively (Table 9). The county level prevalence of moderate to heavy intensity of STH infections is shown in Table 10, and it varied from 0% to 8.1% using option 1 and 0% to 57.9% using option 2. Figure 10 gives the comparison of the prevalence of moderate to heavy intensity of STH infections between baseline and year 9 evaluation.

The Y9 survey prevalence of light infections for *S. mansoni* was 2.1% (95%CI: 1.9-2.4) and 57.2% (95%CI: 49.7-65.7), prevalence of moderate was 1.3% (95%CI: 1.1-1.5) and 33.9% (95%CI: 27.1-42.3), prevalence of heavy was 0.3% (95%CI: 0.2-0.4) and 9.0% (95%CI: 6.3-12.7), and the prevalence of moderate to heavy was 1.6% (95%CI: 1.4-1.8) and 42.8% (95%CI: 35.6-51.6), all respectively using option 1 and 2. Additionally, the prevalence of light infections for *S. haematobium* was 1.3% (95%CI: 1.2-1.6) and 91.8% (95%CI: 87.4-96.5), and the prevalence of heavy was 0.1% (95%CI: 0.1-0.2) and 8.2% (95%CI: 4.7-14.2), all respectively using option 1 and 2 (Table 9). The county level prevalence of moderate to heavy intensity of schistosome infections is shown in Table 10, and it varied from 0% to 10.5% using option 1 and 0% to 88.9% using option 2. Figure 10 gives the comparison of the prevalence of moderate to heavy intensity of schistosome infections between baseline and year 9 evaluation.

Comparisons of prior surveys to Y9 results

Compared to previous evaluation surveys, the Y9 evaluation survey showed low STH prevalence that significantly reduced after the nine years of chemotherapy (Figure 11). The overall prevalence for any STH reduced by 82.0% (p<0.001) from an initial prevalence of 32.3% to 5.8%, with more than half reduction from the last immediate evaluation survey (i.e., Y6 evaluation). Specifically, *A. lumbricoides* prevalence reduced by 76.2% (p<0.001) from an initial prevalence of 18.1% to 4.3%, hookworm prevalence reduced by 98.2% (p<0.001) from an initial prevalence of 15.4% to 0.3%, and *T. trichiura* prevalence reduced by 79.1% (p<0.001) from an initial prevalence of 6.7% to 1.4% (Table 11). Similarly, relative reductions in mean intensities for STH infections are given in Table 11, and closely mirrored the reductions observed for prevalence.

Compared to baseline survey, the Y9 evaluation survey showed low *S. haematobium* prevalence that significantly reduced after the nine years of chemotherapy (Figure 12 panel B). The overall prevalence for *S. haematobium* reduced by 87.8% (p<0.001) from an initial prevalence of 18.0% to 2.2%. However, *S. mansoni* prevalence instead has increased non-significantly after the nine years of treatment from initial prevalence of 2.4% to 3.0% (relative increase of 25.0%, p=0.180) (Table 11 and Figure 12 panel A). Additionally, when compared to the most immediate evaluation survey (i.e., Y6 survey), both schistosomes prevalence increased half-fold (relative increase of 36.4%, p=0.178) and 6-folds (relative increase of 633.3%, p=0.017) for *S. mansoni* and *S. haematobium*, respectively. Similarly, relative reductions (or increase) in mean intensities for schistosome infections is given in Table 11.

Individual, household and school WASH characteristics and improvements of WASH conditions due to COVID-19

All the 13,416 children surveyed from 200 schools were administered with a questionnaire, where they reported on their WASH practices and behaviors both at school and at home. The questionnaire also measured the WASH enhancement at school and home as a response towards COVID-19 pandemic. Table 12 gives the individual, household and school WASH characteristics, overall and stratified by region.

The overall reported average number of household occupants was 6.5 people (SD = 2.3 people). At the time of the interview, the majority (94.4%) of the pupils were wearing shoes. Geophagy was not uncommon at 8.9% of the pupils. Nearly three-quarters (63.0%) of the pupils reported use of an improved water source for drinking at their household. Reported latrine coverage at household level was high (87.2%). However, fewer pupils reported always having a handwashing facility equipped with water and soap near their latrine (23.8%), or tissues/water for anal cleansing (56.0%).

School WASH conditions varied considerably by region as well as by county (Table 12). The average number of children per school was 487.5 (SD = 372.6). Improved water sources were interviewer-observed in 81.5% of the schools. All the 200 schools had at least one latrine block. However, only 39.7% of the latrines were improved. Few schools had a handwashing facility equipped with water and soap near the latrines (15.0%), or tissue/water always available for anal cleansing (43.2%). The average number of pupils per latrine was high at 116.4 with only 27.0% of the schools meeting the Government of Kenya (GoK) standard of 30 male pupils per latrine, and 25 female pupils per latrine. Additionally, on the day of the visit a number of latrines had excessive smell (10.5%), visible feces outside or around (11.1%), or excessive flies (7.9%). Good cleanliness (92.8%), and good structural integrity (97.1%) were reported for the majority of the latrines.

Children's knowledge about COVID19 and their improvement of individual, household and school level WASH practices as a mitigation measure towards COVID-19 was measured and results shown in Table 12. The study found that over three-quarters of the surveyed children had heard about COVID-19 (74.5%), nearly two-thirds know how it is transmitted (61.8%), while only half of the children know the key symptoms associated with the novel disease (55.1%). A large majority of the children knew how to protect themselves from contracting COVID-19 (84.1%). Whilst, only below a quarter of the children (21.0%) reported that they had a specific handwashing station(s) with soap and water installed in their home compound, the overwhelming majority (93.5%) reported that they always practiced handwashing with soap and water while at home. However, only a few proportions of children (7.9%) reported that they had a specific handwashing station(s) with soap and water installed in their school compound, but nearly three-quarters of the children (72.4%) reported that they always practiced handwashing with soap and water while at school.

Univariable analysis of factors associated with the STH infections

Univariable analysis of individual, household and school levels WASH conditions revealed mixed significant associations between STH infections and many of the variables of interest as shown in Table 13. For any of the STH infections, individual-level factors like male children (OR = 1.23, p = 0.008), and children below 5 years old (OR = 14.11, p = 0.017) were significantly associated with higher odds of any STH infections. Household-level factors like high number of household members i.e., > 5 members (OR = 1.44, p < 0.001), households with floors made of earth/sand (OR = 1.64, p < 0.001), households with walls made of clay/mud (OR = 2.46, p < 0.001) or iron sheets (OR = 2.34, p < 0.001), and household possessions like radio (OR = 1.43, p < 0.001) or sofa set (OR = 1.45, p < 0.001) posed significant risk for any STH infections. While at school-level, school absenteeism of either one-day absenteeism (OR = 1.55, p < 0.001), two-days absenteeism (OR = 2.10, p < 0.001) or more than two-days absenteeism (OR = 1.83, p < 0.001) was significantly associated with higher odds of STH infections.

Assessment of risk factors associated with specific STH species showed that both individual, household and school-level factors like male children (OR = 1.23, p = 0.027), high number of household members i.e., > 5 members (OR = 1.25, p = 0.026), households with floors made of earth/sand (OR = 1.49, p < 0.001), household walls made of clay/mud (OR = 2.29, p < 0.001), and school absenteeism (OR = 1.79, p = 0.001) were all associated with higher odds of *A. lumbricoides* infection. Similar association trend was observed with *T. trichiura.* However, not many risk factors were found to be associated with hookworms, possibly due to the low number of individuals infected with this infection (Table 13).

Shared latrine availability at home (OR = 0.74, p = 0.002), availability of improved water source at home (OR = 0.60, p < 0.001), availability of tissue/water for anal cleansing at school (OR = 0.54, p < 0.001), and participant prior knowledge of COVID-19 infection (OR = 0.82, p = 0.025) were significantly associated with lower odds of any STH infections.

Multivariable analysis of factors associated with the STH infections

Table 14 gives the multivariable associations between individual, household or school WASH conditions and the STH infections. For any STH infections; male children (aOR = 1.31, p = 0.018) compared to females, children from houses whose walls were made of clay/mud (aOR = 2.87, p < 0.001) or iron sheets (aOR = 3.01, p < 0.001) compared to houses made of stones/bricks/cement, and children who reported school absenteeism (aOR = 1.85, p = 0.001) were at statistically significant increased odds with any STH infections. Availability of shared household latrine (aOR = 0.62, p < 0.001) and tissue/newspaper/water for anal cleansing at school (aOR = 0.67, p = 0.002) were statistically significantly associated with lower odds of any STH infections (Figure 8).

For *A. lumbricoides*, children whose household heads attained primary level of education (aOR = 1.42, p = 0.027) compared to secondary and above, children from houses whose walls were made of clay/mud (aOR = 2.36, p < 0.001) or iron sheets (aOR = 2.21, p = 0.042) compared to houses made of stones/bricks/cement, and children who reported school absenteeism (aOR = 1.88, p = 0.020) were at significant increased odds with the infection. However, availability of shared household latrine (aOR = 0.67, p = 0.034) and tissue/newspaper/water for anal cleansing both at home (aOR = 0.60, p = 0.005) and school (aOR = 0.57, p = 0.002) were significantly associated with lower odds of *A. lumbricoides* (Table 14 and Figure 8).

For *T. trichiura*, children from houses whose walls were made of clay/mud (aOR = 3.87, p < 0.001) or iron sheets (aOR = 5.27, p = 0.001) compared to houses made of stones/bricks/cement and school absenteeism (aOR = 2.86, p = 0.004) showed significantly increased odds with the infection. However, availability of shared household latrine (aOR = 0.38, p = 0.001) was significantly associated with lower odds (Table 14 and Figure 13).

For hookworm, there were no observed significantly increased odds with the infection, possibly due to the insufficient number of observations (individuals positive for this particular infection). However, children from households possessing television sets (aOR = 0.20, p = 0.010) and children from households with improved water sources (aOR = 0.28, p = 0.005) showed lower odds with the infection (Table 14 and Figure 13).

Univariable analysis of factors associated with the schistosome infections

Univariable analysis of individual, household and school levels WASH factors showed mixed impacts on the associations between schistosome infections and any of the variables of interest as shown in Table 13. For *S. mansoni*, male children (OR = 1.23, p = 0.024) compared to females showed significantly increased odds with the infection. Whereas, children from houses whose walls were made of wood (OR = 0.08, p < 0.001) compared to houses made of stones/bricks/cement, children from households possessing radio (OR = 0.55, p < 0.001) or bicycle (OR = 0.81, p = 0.036), availability of shared household latrine (OR = 0.80, p = 0.036), availability of handwashing facility equipped with water and soap both at home (OR = 0.51, p < 0.001) and school (OR = 0.27, p < 0.001) including availability of specific handwashing stations designated to respond to COVID19 pandemic (OR = 0.28, p < 0.001), and availability of tissue/newspaper/water for anal cleansing at school (OR = 0.45, p < 0.001) were all significantly associated with lower odds of *S. mansoni* (Table 13).

For *S. haematobium*, children not wearing shoes (OR = 1.71, p = 0.032), children from households with high number of household members i.e. > 5 members (OR = 2.27, p < 0.001), children whose household heads attained no formal education (OR = 2.14, p = 0.035) or only primary level of education (OR = 2.60, p < 0.001) compared to secondary and above, children from houses whose floors were made of earth/sand (OR = 2.28, p < 0.001) or walls made of clay/mud (OR = 1.87, p < 0.001), and sharing of household latrine (OR = 1.99, p < 0.001) were all significantly associated with increased odds of *S. haematobium*. However, children aged 5-14 years (OR = 0.36, p = 0.026) compared to older children over the age of 14 years, children from households possessing television sets (OR = 0.47, p < 0.001), sofa set chairs (OR = 0.41, p < 0.001), motorcycle (OR = 0.54, p = 0.002) or electricity (OR = 0.56, p < 0.001) had significantly lower odds of *S. haematobium* infection. Additionally, availability of household latrine (OR = 0.43, p < 0.001), availability of tissue/newspaper/water for anal cleansing at home (OR = 0.36, p < 0.001), availability of handwashing facility equipped with water and soap both at home (OR = 0.22, p < 0.001) and school (OR = 0.11, p = 0.002), and availability of drinking water at school (OR = 0.13, p < 0.001) were all associated with significantly lower odds of *S. haematobium* (Table 13).

Multivariable analysis of factors associated with the schistosome infections

Table 15 gives the multivariable associations between individual, household or school WASH conditions and the schistosome infections. For *S. mansoni*, no notable factors with significant increased odds with the infection were observed. However, children from households possessing radio (OR = 0.59, p = 0.006), children from households with shared latrine (OR = 0.56, p = 0.019), children from households with handwashing facility equipped with water and soap (OR = 0.37, p = 0.033), and availability of tissue/newspaper/water for anal cleansing at school (OR = 0.40, p < 0.001) were all significantly associated with lower odds of *S. mansoni* infections. Similarly, for *S. haematobium*, no notable factors with significant increased odds with the infection were observed. However, children who reportedly last used home latrine to defecate (OR = 0.35, p = 0.014), children in schools where drinking water is always available (OR = 0.22, p = 0.003), and children who had sufficient knowledge on how to protect themselves from COVID19 (OR = 0.35, p = 0.008) were all significantly associated with lower odds of *S. haematobium* infections (Figure 13).

Conclusions and Recommendations

The findings from this report show a continued reduction in prevalence of STH since baseline. This is a resounding success for Kenya and the NSBDP. Based on the current results, morbidity due to STH is no longer an issue at population level among SAC. This, however, may not be the case when monitoring infection at specific county level. SCH paints a slightly different picture in that the prevalence has remained low, regardless of the slight increase for both species since the Y6 survey. These increases were however non-significant, suggesting that they may be related only to the; statistical precision of the current diagnostic tools, disruptions in treatment due to the COVID-19 pandemic and frequent praziquantel supply chain issues. In addition, given the focal nature of SCH, country or county levels of infections may be hiding hot spots of disease at lower geographic levels.

Using the MBG approach, treatment requirements for the two diseases can now be confidently refined. For STH, the prior approach has been to target all NSBDP geographic areas for yearly treatment. Currently, after nearly ten rounds of annual MDA, a number of counties have a very high probability of sitting below 2% prevalence, or between 2% to 10%. WHO guidelines suggest that at these stages' treatment can be suspended with continued monitoring for resurgence or treatment be reduced to only once every two years, respectively. These represent significant changes to the way the program has previously been administered and a potentially drastic reduction in resources required. Looking at a more granular level, an even larger proportion of the NSBDP geographic area may be able to shift treatment frequency, with the majority of infection isolated to select areas of Western Kenya. The decision to begin determining treatment frequency at a sub-county level however, should be balanced with political will and the potential logistic burden of a highly variable county wide approach.

SCH has a known focality around water bodies given the schistosome life cycle. This can be seen in the focalization of SCH from the current results particularly at the ward level. Through the use of MBG approach, SCH infection across counties can now be differentiated at lower geographic level like sub-county, and use ward level data to optimize treatment frequency, allowing higher prevalence wards which may have previously been hidden by county averages to be identified and targeted.

In settings where helminth prevalence has been reduced to very low levels, high frequency PC is decreasingly cost-effective due to the ratio of children needing treatment and those receiving it. At 2% prevalence, only two out of every 100 children will be infected, yet the entire cohort will be targeted to receive deworming medication. While it is critical that all children with helminths be attended to, subsequent deworming of an entire population becomes less cost-effective relative to other interventions and programs within national health budgets. WHO recommendations suggest reducing treatment frequencies in line with prevalence reductions, including suspension of PC, but with continued monitoring where STH or schistosomiasis prevalence is less than 2%. This is to ensure that resurgence is avoided when treatment suspension is warranted [22]. To maintain the cost-effectiveness of deworming, novel surveying strategies and avenues for maximizing cost-precision as a critical component of long-term deworming strategy should be explored. This is to ensure that deworming remains within health budgets and years of steady progress in elimination of both STH and schistosomiasis as a public health problem not be lost [22]. The MBG method used during this survey has been shown to be feasible and precise, capable of being performed with similar or lower levels of resources compared to traditional site selection and analysis methods. Future impact assessment surveys of the NSBDP will employ the MBG approach.

Based on the survey findings, the following are recommended:

1. Due to the varying levels of STH and SCH infections in each county and the over ten years of national annual treatment delivery strategy, the programme should adopt county-level treatment frequencies based on the WHO prevalence categorization. Where appropriate, treatment frequency decisions should be further decentralized to sub-county level. In the case of SCH, ward level data may also be used.
2. Based on the county level STH prevalence estimates using the model-based geostatistics (MBG) approach, ten counties[15] may warrant suspending treatment, another ten counties[16] will require PC once every two years, and the remaining seven counties[17] may require PC once every year.

[15] Kilifi, Kwale, Mombasa, Taita Taveta, Lamu, Machakos, Makueni, Kitui, Kirinyaga and Wajir

[16] Bomet, Kericho, Nandi, Migori, Homabay, Kisumu, Busia, Trans Nzoia, Tana River and Garissa

[17] Bungoma, Kakamega, Vihiga, Narok, Kisii, Nyamira and Siaya

These recommendations can be refined further by taking a sub-county approach to treatment frequency.

3. Based on the county level schistosome prevalence estimates using the MBG approach, two counties[18] may consider treatment suspension, twenty-two counties[19] will require PC once every two years, and three counties[20] will require PC once every year. These recommendations can be refined further by taking a sub-county approach to treatment frequency.
4. Given the demonstrable feasibility, improved precision, and improved cost–effectiveness of MBG approach, it is recommended that going forward, infection prevalence categorization be determined using this modeling approach which accounts for both the explanatory variables and the unobserved stochastic processes around survey location.
5. To avoid potential resurgence of disease, a cost-effective surveillance system should be put into place capable of detecting rising levels of prevalence in counties which have suspended treatment.
6. To sustain the chemotherapeutic gains especially in counties that have been shown not to require regular treatment, innovative, integrated, and cost-effective water, sanitation and hygiene (WASH) and health education approaches should be explored.
7. Based on the prevalence of the moderate-to-heavy intensity of STH, various counties have achieved elimination of STH infections as a public health problem[21] (EPHP). However, some counties have not achieved this goal.

[18] Bungoma and Nyamira

[19] Narok, Bomet, Kericho, Nandi, Kisii, Kisumu, Siaya, Mombasa, Kilifi, Kwale, Lamu, Taita Taveta, Busia, Kakamega, Vihiga, Trans Nzoia, Machakos, Makueni, Kitui, Garissa, Wajir and Kirinyaga

[20] Migori, Homabay and Tana River

[21] EPHP is classified as a geographic area having reached less than 2% of moderate to heavy intensity for STH infection

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Appendices

List of tables

Table 1: Number of schools and children examined by county as well as school level prevalence range (min-max) among school children in Kenya after ten rounds of MDA

County	No. schools (No. children)	Median age (min-max)	School level STH prevalence† range (min-max)				School level SCH prevalence† range (min-max)	
			STH combined	Hookworm	*A. lumbricoides*	*T. trichiura*	*S. mansoni*	*S. haematobium*
Bomet	7 (489)	9 (6-15)	0.0-18.8	0.0-2.9	0.0-15.9	0.0-1.4	0.0-7.1	0.0-1.4
Bungoma	9 (629)	10 (4-15)	1.4-50.7	0.0-1.5	1.4-34.8	0.0-15.9	0.0-1.4	0.0-0.0
Busia	7 (446)	9 (3-15)	0.0-10.1	0.0-1.4	0.0-4.3	0.0-7.2	0.0-10.1	0.0-1.5
Garissa	4 (237)	11 (5-16)	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.8
Homabay	9 (618)	10 (4-16)	0.0-8.3	0.0-1.4	0.0-2.9	0.0-6.7	0.0-64.3	0.0-15.9
Kakamega	8 (523)	10 (5-14)	1.5-19.7	0.0-2.8	1.5-18.3	0.0-4.2	0.0-7.0	0.0-0.0
Kericho	5 (350)	9 (6-14)	0.0-10.0	0.0-0.0	0.0-10.0	0.0-1.4	0.0-1.4	0.0-0.0
Kilifi	8 (554)	10 (5-17)	0.0-2.9	0.0-1.4	0.0-1.4	0.0-0.0	0.0-0.0	0.0-10.0
Kirinyaga	2 (138)	8 (5-14)	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0
Kisii	4 (244)	9 (5-16)	1.4-12.9	0.0-2.9	1.4-11.4	0.0-2.9	0.0-0.0	0.0-0.0
Kisumu	8 (552)	9 (1-14)	0.0-21.7	0.0-0.0	0.0-14.5	0.0-13.0	0.0-7.3	0.0-0.0
Kitui	22 (1473)	9 (3-15)	0.0-2.0	0.0-0.0	0.0-1.9	0.0-2.0	0.0-0.0	0.0-1.5
Kwale	6 (372)	10 (4-19)	0.0-1.5	0.0-1.5	0.0-0.0	0.0-0.0	0.0-0.0	0.0-7.5
Lamu	3 (203)	9 (5-14)	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-10.6
Machakos	15 (958)	8 (2-17)	0.0-11.4	0.0-2.9	0.0-8.6	0.0-2.9	0.0-26.5	0.0-4.5
Makueni	14 (936)	8 (4-`15)	0.0-5.7	0.0-1.5	0.0-5.7	0.0-2.9	0.0-11.8	0.0-14.3
Migori	8 (560)	9 (4-14)	0.0-10	0.0-1.4	0.0-10.0	0.0-0.0	0.0-61.4	0.0-18.6
Mombasa	2 (133)	10 (5-15)	0.0-1.4	0.0-0.0	0.0-1.4	0.0-0.0	0.0-0.0	0.0-1.4
Nandi	6 (411)	9 (2-16)	0.0-14.7	0.0-5.8	0.0-14.7	0.0-1.4	0.0-5.9	0.0-0.0
Narok	17 (1175)	10 (4-18)	0.0-71.4	0.0-3.0	0.0-24.3	0.0-67.1	0.0-25.7	0.0-3.0
Nyamira	3 (210)	9 (5-14)	8.6-21.4	0.0-0.0	8.6-18.6	0.0-2.9	0.0-0.0	0.0-0.0
Siaya	7 (483)	9 (4-15)	0.0-17.1	0.0-2.9	0.0-10.0	0.0-11.8	0.0-64.3	0.0-1.4
Taita Taveta	5 (344)	9 (5-15)	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-0.0	0.0-1.4
Tana River	4 (250)	11 (3-18)	0.0-8.7	0.0-0.0	0.0-4.3	0.0-5.1	0.0-0.0	13.0-61.1
Trans Nzoia	8 (552)	10 (1-15)	2.9-12.9	0.0-1.4	2.9-11.4	0.0-2.9	0.0-5.7	0.0-1.4
Vihiga	1 (70)	10 (4-15)	7.1-7.1	0.0-0.0	5.7-5.7	1.4-1.4	5.7-5.7	0.0-0.0
Wajir	8 (506)	11 (4-27)	0.0-1.7	0.0-1.7	0.0-1.5	0.0-0.0	0.0-0.0	0.0-0.0
Total	**200 (13,416)**	**9 (1-27)**	**0.0-71.4**	**0.0-5.8**	**0.0-34.8**	**0.0-67.1**	**0.0-64.3**	**0.0-61.1**

†Prevalence was calculated using binomial regression model accounting for the hierarchical nature of data

Table 2: STH county endemicity classification using predictive probabilities calculated from the fitted MBG model

County	Mean prevalence estimate (%)	Predictive probability of classifying a county to a given STH endemicity class				
		<2%	**2-10%**	**10-20%**	**20-50%**	**>50%**
Bomet	8.317	<0.001	**>0.999**	<0.001	<0.001	<0.001
Bungoma	16.856	<0.001	<0.001	**>0.999**	<0.001	<0.001
Busia	6.318	<0.001	**>0.999**	<0.001	<0.001	<0.001
Garissa	2.322	<0.001	**>0.999**	<0.001	<0.001	<0.001
Homa Bay	2.136	<0.001	**>0.999**	<0.001	<0.001	<0.001
Kakamega	14.192	<0.001	<0.001	**>0.999**	<0.001	<0.001
Kericho	4.983	<0.001	**>0.999**	<0.001	<0.001	<0.001
Kilifi	0.898	**>0.999**	<0.001	<0.001	<0.001	<0.001
Kirinyaga	0.736	**>0.999**	<0.001	<0.001	<0.001	<0.001
Kisii	12.311	<0.001	<0.001	**>0.999**	<0.001	<0.001
Kisumu	4.929	<0.001	**>0.999**	<0.001	<0.001	<0.001
Kitui	0.902	**>0.999**	<0.001	<0.001	<0.001	<0.001
Kwale	0.839	**>0.999**	<0.001	<0.001	<0.001	<0.001
Lamu	1.322	**>0.999**	<0.001	<0.001	<0.001	<0.001
Machakos	0.958	**>0.999**	<0.001	<0.001	<0.001	<0.001
Makueni	1.601	**>0.999**	<0.001	<0.001	<0.001	<0.001
Migori	4.891	<0.001	**>0.999**	<0.001	<0.001	<0.001
Mombasa	0.747	**>0.999**	<0.001	<0.001	<0.001	<0.001
Nandi	8.616	<0.001	**>0.999**	<0.001	<0.001	<0.001
Narok	10.815	<0.001	<0.001	**>0.999**	<0.001	<0.001
Nyamira	15.810	<0.001	<0.001	**>0.999**	<0.001	<0.001
Siaya	10.679	<0.001	<0.001	**>0.999**	<0.001	<0.001
Taita Taveta	0.683	**>0.999**	<0.001	<0.001	<0.001	<0.001
Tana River	3.915	<0.001	**>0.999**	<0.001	<0.001	<0.001
Trans Nzoia	9.101	<0.001	**>0.999**	<0.001	<0.001	<0.001
Vihiga	10.825	<0.001	<0.001	**>0.999**	<0.001	<0.001
Wajir	1.925	**0.971**	0.029	<0.001	<0.001	<0.001

Table 3: Number of sub-counties classified according to their respective county STH endemicity

County	Total sub-counties estimated	Total number of sub-counties in each county classified according to STH endemicity class				
		<2%	**2-10%**	**10-20%**	**20-50%**	**>50%**
Bomet	5	0	4	1	0	0
Bungoma	8	0	2	2	4	0
Busia	7	0	7	0	0	0

Garissa	6	3	3	0	0	0
Homa Bay	8	5	3	0	0	0
Kakamega	12	0	2	9	1	0
Kericho	6	0	6	0	0	0
Kilifi	7	7	0	0	0	0
Kirinyaga	4	4	0	0	0	0
Kisii	9	0	5	3	1	0
Kisumu	8	0	8	0	0	0
Kitui	8	8	0	0	0	0
Kwale	4	4	0	0	0	0
Lamu	2	1	1	0	0	0
Machakos	8	8	0	0	0	0
Makueni	6	5	1	0	0	0
Migori	8	1	7	0	0	0
Mombasa	6	6	0	0	0	0
Nandi	6	0	5	1	0	0
Narok	6	1	3	1	1	0
Nyamira	4	0	0	4	0	0
Siaya	6	0	2	4	0	0
Taita Taveta	4	4	0	0	0	0
Tana River	3	1	2	0	0	0
Trans Nzoia	5	0	3	2	0	0
Vihiga	5	0	2	3	0	0
Wajir	6	4	2	0	0	0

Table 4: Schistosomiasis county endemicity classification using predictive probabilities calculated from the fitted MBG model

County	Mean prevalence estimate (%)	Predictive probability of classifying a county to a given SCH endemicity class				
		<1%	1-10%	10-20%	20-50%	>50%
Bomet	2.583	<0.001	**>0.999**	<0.001	<0.001	<0.001
Bungoma	0.780	**>0.999**	<0.001	<0.001	<0.001	<0.001
Busia	3.393	<0.001	**>0.999**	<0.001	<0.001	<0.001
Garissa	5.851	<0.001	**>0.999**	<0.001	<0.001	<0.001
Homa Bay	14.682	<0.001	<0.001	**>0.999**	<0.001	<0.001
Kakamega	3.090	<0.001	**>0.999**	<0.001	<0.001	<0.001
Kericho	1.034	0.122	**0.878**	<0.001	<0.001	<0.001
Kilifi	6.146	<0.001	**>0.999**	<0.001	<0.001	<0.001
Kirinyaga	1.437	<0.001	**>0.999**	<0.001	<0.001	<0.001
Kisii	1.499	<0.001	**>0.999**	<0.001	<0.001	<0.001

Kisumu	4.361	<0.001	**>0.999**	<0.001	<0.001	<0.001
Kitui	0.952	**0.998**	0.002	<0.001	<0.001	<0.001
Kwale	7.162	<0.001	**>0.999**	<0.001	<0.001	<0.001
Lamu	7.244	<0.001	**>0.999**	<0.001	<0.001	<0.001
Machakos	6.409	<0.001	**>0.999**	<0.001	<0.001	<0.001
Makueni	6.429	<0.001	**>0.999**	<0.001	<0.001	<0.001
Migori	20.234	<0.001	<0.001	0.047	**0.953**	<0.001
Mombasa	1.550	<0.001	**>0.999**	<0.001	<0.001	<0.001
Nandi	3.961	<0.001	**>0.999**	<0.001	<0.001	<0.001
Narok	2.921	<0.001	**>0.999**	<0.001	<0.001	<0.001
Nyamira	0.698	**>0.999**	<0.001	<0.001	<0.001	<0.001
Siaya	6.883	<0.001	**>0.999**	<0.001	<0.001	<0.001
Taita Taveta	0.981	**0.711**	0.289	<0.001	<0.001	<0.001
Tana River	15.754	<0.001	<0.001	**>0.999**	<0.001	<0.001
Trans Nzoia	2.689	<0.001	**>0.999**	<0.001	<0.001	<0.001
Vihiga	5.112	<0.001	**>0.999**	<0.001	<0.001	<0.001
Wajir	3.168	<0.001	**>0.999**	<0.001	<0.001	<0.001

Table 5: Number of sub-counties classified according to their respective county SCH endemicity

County	**Total sub-counties estimated**	**Total number of sub-counties in each county classified according to SCH endemicity class**				
		<1%	**1-10%**	**10-20%**	**20-50%**	**>50%**
Bomet	5	0	5	0	0	0
Bungoma	8	7	1	0	0	0
Busia	7	0	6	1	0	0
Garissa	6	0	5	1	0	0
Homa Bay	8	0	2	4	2	0
Kakamega	12	0	12	0	0	0
Kericho	6	3	3	0	0	0
Kilifi	7	0	5	2	0	0
Kirinyaga	4	1	3	0	0	0
Kisii	9	2	7	0	0	0
Kisumu	8	1	7	0	0	0
Kitui	8	6	2	0	0	0
Kwale	4	0	4	0	0	0
Lamu	2	0	2	0	0	0
Machakos	8	0	6	2	0	0
Makueni	6	0	5	1	0	0

Migori	8	0	3	1	4	0
Mombasa	6	0	6	0	0	0
Nandi	6	0	6	0	0	0
Narok	6	0	6	0	0	0
Nyamira	4	4	0	0	0	0
Siaya	6	0	5	1	0	0
Taita Taveta	4	3	1	0	0	0
Tana River	3	0	0	3	0	0
Trans Nzoia	5	0	5	0	0	0
Vihiga	5	0	5	0	0	0
Wajir	6	0	6	0	0	0

Table 6: Number of wards classified according to their respective county SCH endemicity

County	Total wards estimated	Total number of wards in each county classified according to SCH endemicity class				
		<1%	**1-10%**	**10-20%**	**20-50%**	**>50%**
Bomet	25	2	23	0	0	0
Bungoma	42	33	9	0	0	0
Busia	31	4	25	1	1	0
Garissa	27	0	23	4	0	0
Homa Bay	41	0	16	13	11	0
Kakamega	57	3	54	0	0	0
Kericho	27	18	9	0	0	0
Kilifi	34	3	22	9	0	0
Kirinyaga	19	4	15	0	0	0
Kisii	33	11	22	0	0	0
Kisumu	29	1	28	0	0	0
Kitui	37	26	11	0	0	0
Kwale	19	0	15	4	0	0
Lamu	10	0	8	2	0	0
Machakos	39	0	32	7	0	0
Makueni	30	0	25	5	0	0
Migori	38	0	16	6	15	0
Mombasa	10	0	10	0	0	0
Nandi	30	1	29	0	0	0
Narok	30	5	25	0	0	0
Nyamira	18	17	1	0	0	0
Siaya	24	0	20	2	2	0

Taita Taveta	20	9	11	0	0	0
Tana River	15	0	3	9	3	0
Trans Nzoia	23	7	16	0	0	0
Vihiga	18	0	18	0	0	0
Wajir	28	5	23	0	0	0

Table 7: Comparisons of the county level STH prevalence estimates using the traditional statistical approach and the model-based geostatistics approach

County	Prevalence estimated using traditional statistical approach†				Prevalence estimated using geostatistical-based modeling approach††			
	STH combined	**Hookworm**	***A. lumbricoides***	***T. trichiura***	**STH combined**	**Hookworm**	***A. lumbricoides***	***T. trichiura***
Bomet	7.8 (4.3-14.0)	1.0 (0.5-2.2)	7.0 (3.9-12.3)	0.2 (0.0-1.5)	8.3 (8.2-8.5)	0.5 (0.5-0.5)	7.3 (7.1-7.4)	0.7 (0.6-0.7)
Bungoma	19.9 (12.2-32.4)	0.3 (0.1-1.2)	17.3 (11.5-26.2)	3.5 (1.4-8.9)	16.9 (16.7-17.0)	0.3 (0.3-0.3)	14.2 (14.0-14.3)	2.9 (2.8-3.0)
Busia	3.6 (1.7-7.5)	0.7 (0.3-1.6)	2.0 (1.0-4.3)	1.3 (0.3-6.6)	6.3 (6.2-6.4)	0.5 (0.5-0.5)	4.3 (4.2-4.3)	1.6 (1.6-1.7)
Garissa	0	0	0	0	2.3 (2.2-2.4)	0.2 (0.2-0.2)	0.9 (0.9-1.0)	1.2 (1.1-1.2)
Homabay	1.5 (0.5-4.4)	0.2 (0.0-1.1)	0.6 (0.2-1.9)	0.6 (0.1-4.7)	2.1 (2.1-2.2)	0.2 (0.2-0.2)	1.3 (1.2-1.3)	0.7 (0.6-0.7)
Kakamega	10.9 (7.5-15.9)	0.4 (0.1-1.5)	9.4 (6.3-13.9)	1.3 (0.5-3.8)	14.2 (14.0-14.4)	0.4 (0.4-0.4)	11.8 (11.6-11.9)	2.3 (2.3-2.4)
Kericho	3.7 (1.3-11.0)	0	3.7 (1.3-11.0)	0.6 (0.2-1.9)	5.0 (4.9-5.1)	0.2 (0.2-0.3)	4.0 (3.9-4.1)	0.8 (0.7-0.8)
Kilifi	0.4 (0.1-2.6)	0.2 (0.0-1.3)	0.2 (0.0-1.3)	0	0.9 (0.9-0.9)	0.2 (0.2-0.2)	0.4 (0.4-0.4)	0.3 (0.3-0.3)
Kirinyaga	0	0	0	0	0.7 (0.7-0.8)	0.2 (0.2-0.2)	0.3 (0.3-0.3)	0.2 (0.2-0.3)
Kisii	7.8 (3.9-15.5)	0.4 (0.0-3.8)	7.0 (3.6-13.5)	0.8 (0.1-5.4)	12.3 (12.1-12.6)	0.2 (0.2-0.2)	10.1 (9.9-10.4)	2.3 (2.2-2.4)
Kisumu	4.0 (1.1-14.9)	0	2.7 (0.7-10.1)	2.2 (0.5-9.2)	4.9 (4.8-5.0)	0.2 (0.2-0.2)	3.1 (3.0-3.2)	1.7 (1.6-1.8)
Kitui	0.2 (0.1-0.6)	0	0.1 (0.0-0.5)	0.1 (0.0-0.5)	0.9 (0.9-0.9)	0.2 (0.2-0.2)	0.4 (0.3-0.4)	0.4 (0.4-0.4)
Kwale	0.5 (0.2-1.8)	0.5 (0.2-1.8)	0	0	0.8 (0.8-0.9)	0.3 (0.3-0.3)	0.3 (0.3-0.3)	0.2 (0.2-0.3)
Lamu	0	0	0	0	1.3 (1.3-1.4)	0.2 (0.2-0.2)	0.5 (0.5-0.6)	0.6 (0.5-0.7)
Machakos	1.3 (0.6-2.7)	0.2 (0.0-1.5)	0.9 (0.4-2.1)	0.1 (0.0-0.8)	1.0 (0.9-1.0)	0.2 (0.2-0.2)	0.6 (0.6-0.6)	0.2 (0.2-0.2)
Makueni	1.1 (0.4-2.6)	0.1 (0.0-0.8)	0.7 (0.2-2.4)	0.2 (0.0-1.5)	1.6 (1.6-1.6)	0.2 (0.2-0.2)	1.1 (1.1-1.1)	0.3 (0.3-0.4)
Migori	2.9 (1.1-7.6)	0.2 (0.0-1.3)	2.7 (0.9-7.8)	0	4.9 (4.8-5.0)	0.2 (0.2-0.2)	4.3 (4.2-4.4)	0.5 (0.4-0.5)
Mombasa	0.8 (0.1-5.0)	0	0.8 (0.1-5.0)	0	0.7 (0.7-0.8)	0.2 (0.2-0.2)	0.4 (0.4-0.4)	0.1 (0.1-0.2)
Nandi	9.0 (5.4-14.9)	1.9 (0.8-4.8)	6.8 (3.4-13.5)	0.5 (0.1-1.7)	8.6 (8.5-8.8)	0.9 (0.8-0.9)	6.9 (6.8-7.1)	0.9 (0.9-1.0)
Narok	14.7 (8.0-27.2)	0.3 (0.1-1.1)	5.7 (2.8-11.8)	11.1 (5.1-24.3)	10.8 (10.7-10.9)	0.2 (0.2-0.3)	6.2 (6.1-6.3)	5.0 (4.9-5.1)
Nyamira	13.3 (7.3-24.2)	0	12.4 (7.6-20.3)	1.0 (0.1-6.8)	15.8 (15.5-16.1)	0.2 (0.2-0.2)	14.1 (13.7-14.4)	1.9 (1.7-2.0)
Siaya	7.9 (4.4-14.0)	0.8 (0.3-2.3)	3.9 (1.9-8.0)	4.3 (2.1-8.9)	10.7 (10.5-10.8)	0.5 (0.5-0.5)	5.0 (4.9-5.0)	5.6 (5.5-5.8)
Taita Taveta	0	0	0	0	0.7 (0.6-0.7)	0.2 (0.2-0.2)	0.2 (0.2-0.2)	0.3 (0.2-0.3)
Tana River	5.2 (2.4-11.2)	0	2.4 (1.0-5.6)	2.8 (1.2-6.5)	3.9 (3.8-4.0)	0.2 (0.2-0.2)	1.6 (1.5-1.6)	2.2 (2.1-2.3)
Trans Nzoia	7.1 (4.8-10.3)	0.2 (0.0-1.3)	6.0 (4.1-8.8)	0.9 (0.3-2.5)	9.1 (9.0-9.2)	0.2 (0.2-0.2)	7.6 (7.5-7.7)	1.4 (1.4-1.5)
Vihiga	7.1 (3.1-16.6)	0	5.7 (2.2-14.8)	1.4 (0.2-10.0)	10.8 (10.5-11.1)	0.3 (0.3-0.3)	7.4 (7.1-7.6)	3.5 (3.3-3.7)
Wajir	0.4 (0.1-1.4)	0.2 (0.0-1.4)	0.2 (0.0-1.4)	0	1.9 (1.8-2.0)	0.3 (0.3-0.3)	0.8 (0.8-0.9)	0.8 (0.8-0.9)
Total	**5.1 (3.9-6.5)**	**0.3 (0.2-0.4)**	**3.5 (2.7-4.5)**	**1.7 (1.0-2.9)**	**5.8 (5.7-6.0)**	**0.3 (0.2-0.4)**	**4.3 (4.2-4.4)**	**1.4 (1.3-1.5)**

†Prevalence was calculated using binomial regression model accounting for the hierarchical nature of data
††Prevalence was calculated using geostatistical-based modelling approach that accounted for both the observed explanatory variables and the unobserved stochastic processes around a specific location

Table 8: Comparisons of the county schistosomes prevalence estimates using the traditional statistical approach and the geostatistical-based modeling approach

County	Prevalence estimated using traditional statistical approach†			Prevalence estimated using model-based geostatistical approach††		
	Any SCH	***S. mansoni***	***S. haematobium***	**Any SCH**	***S. mansoni***	***S. haematobium***
Bomet	3.1 (1.6-5.8)	3.1 (1.6-5.8)	0.2 (0.0-1.4)	2.6 (2.5-2.7)	2.4 (2.3-2.4)	0.2 (0.2-0.3)
Bungoma	0.2 (0.0-1.1)	0.2 (0.0-1.1)	0	0.8 (0.7-0.8)	0.7 (0.6-0.7)	0.1 (0.1-0.1)
Busia	2.7 (0.8-9.0)	2.0 (0.5-8.8)	0.7 (0.3-1.6)	3.4 (3.3-3.5)	2.7 (2.7-2.8)	0.7 (0.6-0.7)
Garissa	0.8 (0.3-2.5)	0	0.8 (0.3-2.5)	5.9 (5.6-6.1)	1.0 (0.9-1.1)	4.9 (4.7-5.2)
Homabay	17.3 (8.3-36.3)	15.2 (6.4-36.1)	2.4 (0.6-9.8)	14.7 (14.5-14.9)	12.7 (12.5-13.0)	2.2 (2.2-2.3)
Kakamega	2.9 (1.5-5.3)	2.9 (1.5-5.3)	0	3.1 (3.0-3.2)	3.0 (2.9-3.1)	0.1 (0.1-0.1)
Kericho	0.3 (0.0-2.0)	0.3 (0.0-2.0)	0	1.0 (0.9-1.1)	0.9 (0.9-1.0)	0.1 (0.1-0.1)
Kilifi	2.7 (1.0-7.5)	0	2.7 (1.0-7.5)	6.1 (5.9-6.4)	0.2 (0.2-0.2)	6.0 (5.7-6.2)
Kirinyaga	0	0	0	1.4 (1.3-1.6)	0.9 (0.8-1.0)	0.5 (0.5-0.6)
Kisii	0	0	0	1.5 (1.4-1.6)	1.2 (1.1-1.3)	0.3 (0.3-0.3)
Kisumu	3.6 (2.1-6.1)	3.6 (2.1-6.1)	0	4.4 (4.2-4.5)	4.3 (4.1-4.4)	0.1 (0.1-0.1)
Kitui	0.1 (0.0-0.5)	0	0.1 (0.0-0.5)	1.0 (0.9-1.0)	0.4 (0.4-0.4)	0.5 (0.5-0.6)
Kwale	3.8 (1.8-8.0)	0	3.8 (1.8-8.0)	7.2 (6.9-7.4)	0.2 (0.2-0.2)	7.0 (6.7-7.2)
Lamu	5.4 (1.8-16.1)	0	5.4 (1.8-16.1)	7.2 (7.0-7.5)	0.3 (0.3-0.4)	7.0 (6.7-7.2)
Machakos	8.6 (4.5-16.3)	7.6 (3.7-15.9)	1.0 (0.6-1.9)	6.4 (6.3-6.5)	4.6 (4.5-4.7)	1.9 (1.8-2.0)
Makueni	5.6 (3.0-10.1)	3.5 (1.9-6.6)	2.0 (0.9-4.6)	6.4 (6.3-6.5)	4.4 (4.4-4.6)	2.1 (2.0-2.2)
Migori	28.9 (16.6-50.5)	25.5 (13.5-48.1)	4.6 (1.5-14.1)	20.2 (20.0-20.5)	17.5 (17.2-17.8)	3.7 (3.6-3.8)
Mombasa	0.8 (0.1-5.0)	0	0.8 (0.1-5.0)	1.6 (1.4-1.7)	0.1 (0.1-0.1)	1.5 (1.3-1.6)
Nandi	1.9 (0.7-5.2)	1.9 (0.7-5.2)	0	4.0 (3.8-4.1)	3.9 (3.8-4.0)	0.1 (0.1-0.1)
Narok	2.3 (0.6-9.0)	2.0 (0.4-9.0)	0.3 (0.1-1.1)	2.9 (2.8-3.0)	2.4 (2.3-2.5)	0.6 (0.5-0.6)
Nyamira	0	0	0	0.7 (0.6-0.7)	0.5 (0.5-0.6)	0.2 (0.1-0.2)
Siaya	11.2 (2.3-54.6)	11.0 (2.2-55.6)	0.2 (0.0-1.5)	6.9 (6.7-7.0)	6.5 (6.4-6.7)	0.4 (0.4-0.4)
Taita Taveta	0.3 (0.0-2.1)	0	0.3 (0.0-2.1)	1.0 (0.9-1.0)	0.3 (0.3-0.3)	0.7 (0.6-0.7)
Tana River	28.4 (14.1-57.3)	0	28.4 (14.1-57.3)	15.8 (15.4-16.1)	0.4 (0.4-0.4)	15.4 (15.1-15.8)
Trans Nzoia	2.0 (0.8-5.0)	1.8 (0.8-4.3)	0.2 (0.0-1.3)	2.7 (2.6-2.8)	2.5 (2.4-2.6)	0.2 (0.2-0.3)
Vihiga	5.7 (2.2-14.8)	5.7 (2.2-14.8)	0	5.1 (4.9-5.4)	5.0 (4.8-5.3)	0.1 (0.1-0.1)
Wajir	0	0	0	3.2 (3.0-3.3)	1.3 (1.2-1.4)	1.9 (1.8-2.0)
Total	**5.1 (3.8-7.0)**	**3.7 (2.5-5.5)**	**1.5 (0.9-2.3)**	**5.0 (4.9-5.2)**	**3.0 (2.9-3.1)**	**2.2 (2.1-2.3)**

†Prevalence was calculated using binomial regression model accounting for the hierarchical nature of data

[††]Prevalence was calculated using geostatistical-based modelling approach that accounted for both the observed explanatory variables and the unobserved stochastic processes around a specific location

Table 9: Prevalence % (95%CI) and year 1 (Y1) to year 9 (Y9) relative reductions (RR) % (p-value) of light, moderate and heavy intensity of infections among school children in Kenya after ten rounds of MDA

Infections	Total children examined (Total positive)	Prevalence[†] of light infections			Prevalence[†] of moderate infections			Prevalence[†] of heavy infections			Prevalence[†] of moderate-heavy infections		
		n	Calculated using total children examined as denominator	Calculated using total positives as denominator	n	Calculated using total children examined as denominator	Calculated using total positives as denominator	n	Calculated using total children examined as denominator	Calculated using total positives as denominator	n	Calculated using total children examined as denominator	Calculated using total positives as denominator
STH infections													
STH combined													
Y1 baseline	18626 (6274)	4435	23.8 (23.2-24.4)	70.7 (67.3-74.2)	1808	9.7 (9.3-10.1)	28.8 (25.6-32.5)	31	0.2 (0.1-0.2)	0.5 (0.2-1.5)	1839	9.9 (9.4-10.3)	29.3 (26.1-33.0)
Y9 evaluation	13416 (680)	509	3.8 (3.5-4.1)	74.9 (70.6-79.4)	165	1.2 (1.1-1.4)	24.3 (20.1-29.3)	6	0.0 (0.0-0.1)	0.9 (0.4-2.0)	171	1.3 (1.1-1.5)	25.1 (21.1-30.0)
RR %(p-value)	-	-	84.0% (p<0.001) *	[Increased: 5.9%, p=0.144]	-	87.6% (p<0.001) *	15.8% (p=0.131)	-	100.0% (p=0.124)	[Increased: 78.6%, p=0.413]	-	86.9% (p<0.001) *	14.2% (p=0.156)
Hookworm													
Y1 baseline	18626 (2856)	2809	15.1 (14.6-15.6)	98.4 (97.8-98.8)	33	0.2 (0.1-0.2)	1.2 (0.7-1.8)	14	0.1 (0-0.1)	0.5 (0.3-0.9)	47	0.3 (0.2-0.3)	1.6 (1.1-2.4)
Y9 evaluation	13416 (38)	37	0.3 (0.2-0.4)	97.4 (86.2-99.9)	0	0	0	1	0	2.6 (0.4-19.1)	1	0	2.6 (0.4-19.1)
RR %(p-value)	-	-	98.0% (p<0.001) *	1.3% (p=0.636)	-	100.0% (p=0.634)	15.8% (p=0.131)	-	100.0% (p=0.723)	[Increased: 436.8%, p=0.108]	-	100.0% (p=0.326)	[Increased: 59.9%, p=0.645]
A. lumbricoides													
Y1 baseline	18626 (3843)	2086	11.2 (10.7-11.7)	54.3 (51.1-57.7)	1757	9.4 (9.0-9.9)	45.7 (42.5-49.2)	0	0	0	1757	9.4 (9.0-9.9)	45.7 (42.5-49.2)
Y9 evaluation	13416 (469)	315	2.3 (2.1-2.6)	67.2 (62.1-72.7)	151	1.1 (1.0-1.3)	32.2 (27.4-37.8)	3	0.0 (0.0-0.1)	0.6 (0.2-2.0)	154	1.1 (1.0-1.3)	32.8 (27.9-38.6)
RR %(p-value)	-	-	79.5% (p<0.001) *	[Increased: 23.7%, p<0.001] [$]	-	88.3% (p<0.001) *	29.6% (p<0.001) *	-	0	[Increased: 100.0%, p=0.109]	-	88.3% (p<0.001) *	28.2% (p<0.001) *
T. trichiura													
Y1 baseline	18626 (1169)	1112	6.0 (5.6-6.3)	95.1 (92.0-98.4)	40	0.2 (0.2-0.3)	3.4 (2.4-4.8)	17	0.1 (0-0.1)	1.5 (0.2-10.1)	57	0.3 (0.2-0.4)	4.9 (2.5-9.4)
Y9 evaluation	13416 (230)	208	1.6 (1.3-1.8)	90.4 (87.4-93.6)	20	0.1 (0.1-0.2)	8.7 (6.0-12.8)	2	0.0 (0.0-0.1)	0.9 (0.2-4.4)	22	0.2 (0.1-0.2)	9.6 (6.9-13.2)
RR %(p-value)	-	-	73.3% (p=0.001) *	4.9% (p=0.038) *	-	50.0% (p=0.046) *	[Increased: 154.1%, p<0.001] [$]	-	98.0% (p=0.078)	40.2% (p=0.689)	-	33.3% (p=0.086)	[Increased: 96.2%, p=0.070]
SCH infections													
S. mansoni													
Y1 baseline	18626 (450)	183	1.0 (0.8-1.1)	40.7 (27.2-60.9)	130	0.7 (0.6-0.8)	28.9 (21.1-39.6)	137	0.7 (0.6-0.9)	30.4 (17.3-53.5)	267	1.4 (1.3-1.6)	59.3 (45.0-78.2)
Y9 evaluation	13416 (502)	287	2.1 (1.9-2.4)	57.2 (49.7-65.7)	170	1.3 (1.1-1.5)	33.9 (27.1-42.3)	45	0.3 (0.2-0.4)	9.0 (6.3-12.7)	215	1.6 (1.4-1.8)	42.8 (35.6-51.6)
RR %(p-value)	-	-	[Increased: 110%, p=0.126]	[Increased: 40.6%, p=0.116]	-	[Increased: 85.7%, p=0.235]	[Increased: 17.2%, p=0.416]	-	57.1% (p=0.034) *	70.6% (p<0.001) *	-	[Increased: 14.3%, p=0.098]	27.8% (p=0.054)
S. haematobium													
Y1 baseline	1399 (252)	169	12.1 (10.4-13.9)	67.1 (56.8-79.2)	-	-	-	83	5.9 (4.8-7.3)	32.9 (23.5-46.3)	83	5.9 (4.8-7.3)	32.9 (23.5-46.3)

Y9 evaluation	13416 (196)	180	1.3 (1.2-1.6)	91.8 (87.4-96.5)	-	-	-	16	0.1 (0.1-0.2)	8.2 (4.7-14.2)	16	0.1 (0.1-0.2)	8.2 (4.7-14.2)
RR %(p-value)	-	-	89.3% (p<0.001)	[Increased: 36.9%, p<0.001] $	-	-	-	-	98.3 (p<0.001) *	75.2% (p<0.001) *		98.3 (p<0.001) *	75.2% (p<0.001) *
†Prevalence was calculated using binomial regression model accounting for the hierarchical nature of data													

Table 10: County level prevalence of moderate to heavy intensity of infections % (95%CI) for STH and SCH among school children in Kenya after ten rounds of MDA

County	Total children examined	STH prevalence† of moderate to heavy intensity % (95%CI)								SCH prevalence† of moderate to heavy intensity % (95%CI)			
		STH combined		Hookworm		*A. lumbricoides*		*T. trichiura*		*S. mansoni*		*S. haematobium*	
		Calculated using total children examined as denominator	Calculated using total positives as denominator	Calculated using total children examined as denominator	Calculated using total positives as denominator	Calculated using total children examined as denominator	Calculated using total positives as denominator	Calculated using total children examined as denominator	Calculated using total positives as denominator	Calculated using total children examined as denominator	Calculated using total positives as denominator	Calculated using total children examined as denominator	Calculated using total positives as denominator
Bomet	489	1.8 (0.8-3.5)	23.7 (16.7-33.6)	0	0	1.8 (0.8-3.5)	26.5 (18.8-37.4)	0	-	0.2 (0.0-1.1)	6.7 (0.9-49.4)	0	-
Bungoma	629	8.1 (6.1-10.5)	40.8 (31.9-52.1)	0	0	8.1 (6.1-10.5)	46.8 (39.2-55.9)	0.2 (0.0-0.9)	4.5 (0.6-36.7)	0.2 (0.0-0.9)	-	0.2 (0.0-0.9)	-
Busia	446	0.7 (0.1-2.0)	18.8 (4.2-83.1)	0	0	0.7 (0.1-2.0)	33.3 (9.2-120.2)	0	0	1.8 (0.8-3.5)	88.9 (81.9-96.5)	0.2 (0.0-1.2)	0
Garissa	237	0	-	0	-	0	-	0	-	0	-	0	0
Homabay	618	0.2 (0.0-0.9)	11.1 (1.2-99.5)	0	-	0.2 (0.0-0.9)	25.0 (5.7-108.7)	0	0	5.5 (3.8-7.6)	36.2 (21.4-61.0)	0	6.7 (3.3-13.5)
Kakamega	523	2.5 (1.3-4.2)	22.8 (13.9-37.4)	0	0	2.5 (1.3-4.2)	26.5 (15.5-45.5)	0	0	1.0 (0.3-2.2)	33.3 (19.0-58.6)	0	-
Kericho	350	2.0 (0.8-4.1)	53.8 (32.1-90.4)	0	-	2.0 (0.8-4.1)	53.8 (32.1-90.4)	0	0	0	-	0	-
Kilifi	554	0	0	0	-	0	-	0	-	0	-	0	6.7 (1.4-32.0)
Kirinyaga	138	0	-	0	-	0	-	0	-	0	-	0	-
Kisii	244	4.5 (2.3-7.9)	57.9 (44.3-75.7)	0	-	4.5 (2.3-7.9)	64.7 (47.3-88.6)	0.4 (0.0-2.3)	50.0 (12.5-199.9)	0	-	0	-
Kisumu	552	1.1 (0.4-2.4)	27.3 (19.7-37.8)	0	-	0.9 (0.3-2.1)	33.3 (22.5-49.3)	0.4 (0.0-1.3)	16.7 (6.0-46.2)	2.0 (1.0-3.5)	55.0 (35.4-85.4)	0.2 (0.0-1.0)	-
Kitui	1,473	0	0	0	-	0	0	0	0	0	-	0	-
Kwale	372	0	0	0	0	0	-	0	-	0	-	0	28.6 (10.8-75.5)
Lamu	203	0	-	0	-	0	-	0	-	0	-	0	9.1 (2.2-37.8)
Machakos	958	0.1 (0.0-0.6)	8.3 (1.0-71.3)	0	0	0.1 (0.0-0.6)	11.1 (1.3-93.8)	0	-	3.1 (2.1-4.4)	41.1 (29.8-56.6)	0	0
Makueni	936	0.1 (0.0-0.6)	10.0 (2.3-44.2)	0	-	0.1 (0.0-0.6)	14.3 (4.7-43.8)	0	0	1.0 (0.4-1.8)	27.3 (15.7-47.3)	0	0
Migori	560	0.4 (0.0-1.3)	12.5 (8.5-18.4)	0	-	0.4 (0.0-1.3)	13.3 (9.7-18.4)	0	-	10.5 (8.1-13.4)	41.3 (28.6-59.5)	0	3.8 (0.9-16.2)
Mombasa	133	0	-	0	-	0	-	0	-	0	-	0	-
Nandi	411	2.4 (1.2-4.4)	27.0 (14.7-49.5)	0.2 (0.0-1.3)	12.5 (1.2-133.3)	2.2 (1.0-4.1)	32.1 (16.9-61.2)	0	0	1.0 (0.3-2.5)	50.0 (21.4-116.8)	0	-
Narok	1,175	2.5 (1.7-3.5)	16.8 (11.2-25.0)	0	0	1.6 (1.0-2.5)	28.4 (17.2-46.7)	1.1 (0.6-1.9)	9.9 (6.9-14.2)	0.9 (0.4-1.6)	43.5 (32.4-58.3)	0.2 (0.0-0.6)	0
Nyamira	210	4.8 (2.3-8.6)	35.7 (12.8-99.6)	0	-	4.3 (2.0-8.0)	34.6 (10.6-113.2)	0.5 (0.0-2.6)	50.0 (12.5-199.9)	0	-	0	-
Siaya	483	2.3 (1.1-4.0)	28.9 (19.9-42.2)	0	0	1.7 (0.7-3.2)	42.1 (27.3-64.9)	0.6 (0.1-1.8)	14.3 (5.8-35.2)	8.1 (5.8-10.9)	73.6 (69.5-77.9)	0.2 (0.0-1.1)	-
Taita Taveta	344	0	-	0	-	0	-	0	-	0	-	0	-
Tana River	250	0	0	0	-	0	0	0	0	0	-	0	11.3 (4.5-27.9)
Trans Nzoia	552	1.1 (0.4-2.4)	15.4 (7.9-29.8)	0	-	0.9 (0.3-2.1)	15.2 (6.1-37.6)	0.2 (0.0-1.0)	20.0 (1.9-210.1)	0.7 (0.2-1.8)	40.0 (28.0-57.2)	0.2 (0.0-1.0)	-
Vihiga	70	0	0	0	-	0	0	0	-	0	0	0	-

Wajir	506	0	0	0	-	0	-	0	-	0	-	0	-
Total	**13,416**												
†Prevalence was calculated using binomial regression model accounting for the hierarchical nature of data													

Table 11: Overall prevalence % (95%CI), mean intensity epg (95%CI) and relative reductions (RR) % (p-value) among school children in Kenya after ten rounds of MDA

Survey	**No. schools (children) surveyed**	**STH combined**	**Hookworm**	***A. lumbricoides***	***T. trichiura***	***S. mansoni***	***S. haematobium***
Prevalence† % (95%CI)							
Y1 baseline	173 (18,626)	32.3 (30.0-34.8)	15.4 (13.6-17.6)	18.1 (15.8-20.7)	6.7 (5.4-8.2)	2.4 (1.5-4.1)	18.0 (13.0-24.9)
Y3 evaluation	173 (18,199)	16.4 (14.4-18.6)	2.3 (1.8-3.0)	11.9 (10.2-13.9)	4.5 (3.4-6.0)	1.7 (0.8-3.6)	7.9 (3.8-16.2)
Y5 evaluation	172 (18,207)	13.5 (11.6-15.7)	1.3 (1.0-1.6)	9.6 (8.0-11.5)	4.1 (3.1-5.5)	2.0 (1.2-3.2)	3.9 (1.7-9.0)
Y6 evaluation	100 (9,801)	12.9 (10.4-16.1)	1.0 (0.6-1.5)	9.7 (7.5-12.6)	3.6 (2.2-5.8)	2.2 (1.2-4.3)	0.3 (0.1-1.0)
Y9 evaluation	200 (13,416)	5.8 (5.7-6.0)	0.3 (0.2-0.4)	4.3 (4.2-4.4)	1.4 (1.3-1.5)	3.0 (2.9-3.1)	2.2 (2.1-2.3)
RR (Y1– Y9), %(p-value)	-	84.9 (p<0.001)	98.2 (p<0.001)	83.1 (p<0.001)	72.7 (p<0.001)	Incur: 54.9 (p=0.180) £	91.9 (p<0.001)
Mean intensity‡ epg (95%CI)							
Y1 baseline	173 (18,626)	-	63 (50-81)	1659 (1378-1998)	33 (11-105)	14 (5-41)	20 (11-39)
Y3 evaluation	173 (18,199)	-	8 (5-14)	960 (801-1151)	17 (11-26)	6 (2-16)	7 (3-16)
Y5 evaluation	172 (18,207)	-	10 (5-19)	917 (750-1121)	16 (10-26)	5 (3-10)	4 (1-12)
Y6 evaluation	100 (9,801)	-	6 (2-16)	741 (535-1027)	15 (8-27)	12 (5-31)	0 (0-1)
Y9 evaluation	200 (13,416)	-	1 (0-2)	203 (150-275)	8 (3-18)	7 (4-11)	0
RR (Y1– Y9), %(p-value)	-	-	99.1 (p<0.001)	89.3 (p<0.001)	77.8 (p=0.046)	51.0 (p=0.238)	98.9 (p<0.001)
†Prevalence was calculated using binomial regression model accounting for the hierarchical nature of data, except the Y9 evaluation estimate which was calculated using MBG approach ‡Mean intensity was calculated using negative binomial regression model accounting for the hierarchical nature of data							

Table 12: Individual, household and school WASH characteristics overall and stratified by regions in Kenya after tens rounds of MDA

Characteristics	**Overall (N = 13,416)**	**Coast (n = 1,856)**	**Nyanza (n = 2,667)**	**Western (n = 2,220)**	**Rift Valley (n = 2,425)**	**Eastern (n = 3,367)**	**N. Eastern (n = 743)**	**Central (n = 138)**
STH Infections (n=13,416)								
Any STH infections prevalence†	5.8 (5.7-6.0)	1.0 (0.4-2.2)	4.9 (3.3-7.3)	10.9 (7.8-15.2)	10.8 (7.0-16.6)	0.7 (0.4-1.3)	0.3 (0.1-1.0)	0
Hookworm prevalence†	0.3 (0.2-0.4)	0.2 (0.1-0.5)	0.3 (0.1-0.6)	0.4 (0.2-0.7)	0.7 (0.3-1.3)	0.1 (0-0.4)	0.1 (0-1.0)	0
Hookworm mean intensity‡	1 (0-2)	0	0 (0-1)	0 (0-1)	2 (0-11)	0	0	0
A. lumbricoides prevalence†	4.3 (4.2-4.4)	0.4 (0.2-1.1)	3.6 (2.4-5.5)	9.2 (6.7-12.7)	5.9 (3.9-8.7)	0.5 (0.3-1.0)	0.1 (0-0.9)	0

A. lumbricoides mean intensity‡	203 (150-275)	0 (0-1)	299 (163-550)	522 (348-784)	296 (188-465)	15 (5-39)	0 (0-1)	0
T. trichiura prevalence†	1.4 (1.3-1.5)	0.4 (0.1-1.2)	1.5 (0.8-2.9)	1.8 (1.0-3.4)	5.6 (2.5-12.6)	0.1 (0.1-0.4)	0	0
T. trichiura mean intensity‡	8 (3-18)	0 (0-1)	8 (3-19)	6 (2-14)	30 (9-98)	0	0	0
SCH Infections (n=13,416)								
S. mansoni prevalence†	3.0 (2.9-3.1)	0	11.6 (6.9-19.5)	1.8 (1.1-2.9)	1.9 (0.9-4.3)	3.1 (1.7-5.8)	0	0
S. mansoni mean intensity‡	7 (4-11)	0	23 (12-44)	3 (1-5)	3 (1-8)	5 (2-14)	0	0
S. haematobium prevalence†	2.2 (2.1-2.3)	6.1 (3.1-11.9)	1.6 (0.6-3.8)	0.2 (0.1-0.5)	0.2 (0.1-0.6)	0.9 (0.5-1.6)	0.3 (0.1-1.0)	0
S. haematobium mean intensity‡	0	1 (1-3)	0 (0-1)	0	0	0	0	0
Individual characteristics (n=13,416)								
Boys; n (%)	6790 (50.6%)	945 (50.9%)	1354 (50.8%)	1114 (50.2%)	1232 (50.8%)	1687 (50.1%)	386 (52.0%)	72 (52.2%)
Age; mean (SD)	9.3 (2.3)	9.6 (2.4)	9.1 (2.2)	9.4 (2.1)	9.5 (2.1)	8.8 (2.3)	10.6 (2.8)	8.5 (2.3)
Wearing shoes; n (%)	12659 (94.4%)	1625 (87.6%)	2653 (99.5%)	2057 (92.7%)	2413 (99.5%)	3052 (90.6%)	721 (97.0%)	138 (100%)
Soil-eating behavior; n (%)	1194 (8.9%)	302 (16.3%)	177 (6.6%)	241 (10.9%)	207 (8.5%)	180 (5.4%)	65 (8.8%)	22 (15.9%)
Household characteristics (n=13,416)								
Number of household occupants; mean (SD)	6.5 (2.3)	6.9 (2.4)	6.3 (2.0)	6.6 (2.3)	6.7 (2.3)	6.0 (2.2)	7.4 (2.3)	4.9 (1.4)
Household has improved water source; n (%)	8449 (63.0%)	1381 (74.4%)	1660 (62.2%)	1614 (72.7%)	966 (39.8%)	1996 (59.3%)	716 (96.4%)	116 (84.1%)
Household has toilet/latrine; n (%)	11693 (87.2%)	1378 (74.3%)	2555 (95.8%)	2160 (97.3%)	2117 (87.3%)	3149 (93.5%)	197 (26.5%)	137 (99.3%)
Household has handwashing facility with water and soap always; n (%)	3186 (23.8%)	149 (8.0%)	389 (14.6%)	1312 (59.1%)	978 (40.3%)	272 (8.1%)	17 (2.3%)	69 (50.0%)
Household has tissue/water for anal cleansing always; n (%)	7513 (56.0%)	508 (27.4%	1578 (59.2%)	1662 (74.9%)	1652 (68.1%)	1920 (57.0)	58 (7.8%)	135 (97.8%)
School characteristics (n=200)								
Number of children in school; mean (SD)	487.5 (372.6)	545.5 (426.2)	485.8 (292.8)	775.6 (367.8)	523.1 (340.8)	234.7 (126.2)	547.2 (618.5)	423.5 (50.2)
School has toilet/latrine; n (%)	200 (100%)	28 (100%)	39 (100%)	33 (100%)	35 (100%)	51 (100%)	12 (100%)	2 (100%)
Number of latrines in school; mean (SD)	4.2 (4.0)	3.6 (4.2)	3.5 (1.9)	7.2 (6.8)	5.2 (3.9)	2.9 (1.3)	2.4 (0.8)	5.0 (2.8)

Number of children per latrine; median (IQR)	116.4 (145.2)	140.0 (158.2)	145.2 (138.7)	134.0 (158.2)	117.7 (137.3)	73.0 (61.5)	180.5 (164.3)	104.2 (97.6)
School has improved water source; n (%)	163 (81.5%)	22 (78.6%)	29 (74.4%)	27 (81.8%)	34 (97.1%)	37 (72.6%)	12 (100%)	2 (100%)
School has handwashing facility with soap and water always near toilet/latrine; n (%)	30 (15.0%)	2 (7.1%)	6 (15.4%)	11 (33.3%)	10 (28.6%)	1 (2.0%)	0	0
School has specific handwashing station(s) with soap and water for COVID19 mitigation; n (%)	55 (27.5%)	8 (28.6%)	14 (35.9%)	13 (39.4%)	14 (40.0%)	4 (7.8%)	1 (8.3%)	1 (50.0%)
School has drinking water always; n (%)	146 (73.0%)	20 (71.4%)	33 (84.6%)	31 (93.9%)	30 (85.7%)	28 (54.9%)	2 (16.7%)	2 (100%)
Number of months without water in the school; mean (SD)	2.7 (3.0)	2.5 (2.9)	2.2 (3.0)	1.4 (1.9)	1.7 (1.7)	5.2 (3.2)	2.1 (1.2)	0
School has tissue/water for anal cleansing always*; n (%)	5793 (43.2%)	1474 (79.4%)	761 (28.5%)	735 (33.1%)	809 (33.4%)	1155 (34.3%)	724 (97.4%)	135 (97.8%)
COVID19 Information (n=13,416)								
Participant has heard about COVID19; n (%)	10000 (74.5%)	1363 (73.4%)	2086 (78.2%)	1851 (83.4%)	1741 (71.8%)	2373 (70.5%)	477 (64.2%)	109 (79.0%)
Participant know how COVID19 is transmitted; n (%)	6179 (61.8%)	791 (58.0%)	1455 (69.8%)	1434 (77.5%)	1195 (68.6%)	1000 (42.1%)	250 (52.4%)	54 (49.5%)
Participant know symptoms associated with COVID19; n (%)	5509 (55.1%)	675 (49.5%)	1410 (67.6%)	1229 (66.4%)	1071 (61.5%)	848 (35.7%)	188 (39.4%)	88 (80.7%)
Participant know how to protect self against COVID19; n (%)	8410 (84.1%)	982 (72.1%)	1792 (85.9%)	1687 (91.1%)	1595 (91.6%)	1898 (80.0%)	354 (74.2%)	102 (93.6%)
Specific handwashing station(s) with water and soap is always available at participant's home; n (%)	2812 (21.0%)	91 (4.9%)	362 (13.6%)	1181 (53.2%)	829 (34.2%)	270 (8.0%)	13 (1.8%)	66 (47.8%)
Participant wash hands with soap and water always at the home handwashing station(s); n (%)	4195 (93.5%)	358 (89.3%)	656 (87.0%)	1520 (94.6%)	1137 (98.4%)	406 (90.0%)	34 (97.1%)	84 (97.7%)

Specific handwashing station(s) with water and soap is always available at participant's school; n (%)	1053 (7.9%)	21 (1.1%)	42 (1.6%)	550 (24.8%)	435 (17.9%)	3 (0.1%)	2 (0.3%)	0 (0.0%)
Participant wash hands with soap and water always at the school handwashing station(s); n (%)	5536 (72.4%)	581 (66.6%)	1274 (72.0%)	1595 (76.7%)	1276 (83.6%)	565 (49.1%)	111 (93.3%)	134 (100%)

[†]Prevalence was calculated using binomial regression model accounting for the hierarchical nature of data; the overall prevalence was estimated using the MBG approach
[‡]Mean intensity was calculated using negative binomial regression model accounting for the hierarchical nature of data
*Availability of tissue/water for anal cleansing was measured using children questionnaire rather than school observation tool.

Table 13: Univariable associations between WASH conditions and STH/SCH infections among school children in Kenya after ten rounds of MDA

Factors	**STH infections [OR (95%CI), p-value]** [$]				**SCH infections [OR (95%CI), p-value]** [$]	
	STH combined (n=680)	**Hookworm (n=38)**	***A. lumbricoides*** **(n=469)**	***T. trichiura*** **(n=230)**	***S. mansoni*** **(n=502)**	***S. haematobium*** **(n=196)**
Individual factors						
Male children	**1.23 (1.06-1.44), 0.008***	0.79 (0.42-1.50), 0.469	**1.23 (1.02-1.48), 0.027***	1.21 (0.93-1.57), 0.159	**1.23 (1.03-1.47), 0.024***	1.04 (0.78-1.38), 0.795
ECD children	0.89 (0.71-1.13), 0.338	1.16 (0.49-2.79), 0.734	0.78 (0.58-1.05), 0.100	1.15 (0.81-1.65), 0.435	0.80 (0.61-1.06), 0.124	0.66 (0.41-1.07), 0.090
Soil-eating behavior	1.09 (0.84-1.41), 0.536	1.92 (0.80-4.61), 0.142	1.12 (0.82-1.52), 0.482	0.87 (0.53-1.41), 0.564	0.86 (0.62-1.20), 0.365	1.37 (0.88-2.12), 0.162
Not wearing shoes	1.05 (0.75-1.45), 0.781	0.45 (0.06-3.29), 0.433	1.28 90.89-1.83), 0.184	0.52 (0.24-1.11), 0.090	**0.51 (0.30-0.85), 0.010***	**1.71 (1.05-2.79), 0.032***
Age group:						
<5 years vs >14 years	**14.11 (1.61-124.05), 0.017***	-	0.56 (0.08-4.04), 0.563	**11.04 (1.20-101.38), 0.034***	-	0.50 (0.06-4.41), 0.534
5-14 years vs >14 years	6.8 (0.95-48.81), 0.056	-	-	2.20 (0.31-15.78), 0.434	5.00 (0.70-35.81), 0.109	**0.36 (0.14-0.89), 0.026***
Did not reportedly receive treatment during last MDA	**0.41 (0.33-0.51), <0.001***	0.92 (0.45-1.91) 0.832	**0.39 (0.30-0.51), <0.001***	**0.33 (0.22-0.49), <0.001***	**0.73 (0.59-0.90), 0.004***	1.06 (0.78-1.45), 0.700
Household factors						
Household members:						
>5 members vs 1-5 members	**1.44 (1.22-1.71), <0.001***	1.33 (0.67-2.63), 0.418	**1.25 (1.03-1.52), 0.026***	**2.55 (1.84-3.54), <0.001**	**0.79 (0.66-0.95), 0.010***	**2.27 (1.61-3.20), <0.001***
Household head level of education:						
No formal education vs secondary and above	0.83 (0.53-1.30), 0.419	2.55 (0.69-9.44), 0.162	**0.47 (0.24-0.92), 0.028***	1.37 (0.74-2.56), 0.317	**0.25 (0.10-0.62), 0.003***	**2.14 (1.05-4.34), 0.035***
Primary education vs secondary and above	0.94 (0.75-1.17), 0.573	1.04 (0.39-2.79), 0.940	1.01 (0.78-1.30), 0.932	0.73 (0.49-1.10), 0.134	1.11 (0.87-1.42), 0.400	**2.60 (1.73-3.90), <0.001***
Roof materials:						
Iron sheets vs tiles	1.36 (0.33-5.62), 0.667	-	0.94 (0.23-3.88), 0.933	-	2.13 (0.29-15.45), 0.455	-
Grass/thatch/makuti vs tiles	0.76 (0.18-3.26), 0.716	1.14 (0.35-3.72), 0.825	0.35 (0.08-1.58), 0.174	1.31 (0.79-2.19), 0.294	0.17 (0.02-1.54), 0.114	**0.27 (0.19-0.37), <0.001***
Floor materials:						

Wooden vs cement/tiles	0.46 (0.06-3.32), 0.439	-	0.63 (0.09-4.59), 0.648	-	0.47 (0.06-3.40), 0.453	-
Earth/sand vs cement/tiles	**1.64 (1.37-1.95), <0.001***	1.11 (0.57-2.17), 0.758	**1.49 (1.21-1.83), <0.001***	**2.15 (1.56-2.95), <0.001***	1.07 (0.89-1.29), 0.482	**2.28 (1.61-3.23), <0.001***
Iron sheets vs cement/tiles	0.58 (0.08-4.23), 0.590	-	-	2.19 (0.30-16.19), 0.443	-	-
Wall materials:						
Clay/mud vs stones/bricks/cement	**2.46 (2.02-3.00), <0.001***	1.57 (0.75-3.27), 0.228	**2.29 (1.82-2.88), <0.001***	**2.84 (2.00-4.03), <0.001***	0.92 (0.76-1.10), 0.352	**1.87 (1.33-2.64), <0.001***
Wood vs stones/bricks/cement	1.22 (0.80-1.84), 0.356	1.13 (0.25-5.17), 0.874	1.07 (0.64-1.79), 0.787	1.16 (0.54-2.49), 0.701	**0.08 (0.03-0.26), <0.001***	**2.48 (1.44-4.26), 0.001***
Iron sheets vs stones/bricks/cement	**2.34 (1.51-3.60), <0.001***	1.14 (0.14-8.89), 0.904	**2.08 (1.23-3.51), 0.007***	**2.65 (1.28-5.52), 0.009***	1.24 (0.78-1.97), 0.360	0.77 (0.24-2.50), 0.666
Household possessions:						
Radio	**1.43 (1.20-1.70), <0.001***	1.36 (0.66-2.81), 0.400	1.20 (0.98-1.47), 0.079	**2.34 (1.66-3.30), <0.001***	**0.55 (0.46-0.66), <0.001***	0.77 (0.57-1.02), 0.070
Television	0.87 (0.74-1.03), 0.102	0.51 (0.24-1.08), 0.080	0.92 (0.76-1.12), 0.400	0.88 (0.67-1.16), 0.362	1.09 (0.91-1.31), 0.353	**0.47 (0.34-0.66), <0.001***
Mobile phone	0.98 (0.71-1.34), 0.886	0.56 (0.20-1.58), 0.274	0.97 (0.66-1.41), 0.853	1.32 (0.72-2.43), 0.372	1.22 (0.81-1.82), 0.337	0.93 (0.53-1.64), 0.798
Sofa set	**1.45 (1.24-1.69), <0.001***	1.41 (0.75-2.68), 0.286	**1.59 (1.33-192), <0.001***	**1.32 (1.02-1.72), 0.035***	0.92 (0.77-1.10), 0.362	**0.41 (0.29-0.57), <0.001***
Bicycle	0.88 (0.74-1.04), 0.136	0.74 (0.36-1.52), 0.409	0.99 (0.81-1.21), 0.925	**0.71 (0.53-0.96), 0.024***	**0.81 (0.66-0.99), 0.036***	1.10 (0.82-1.48), 0.531
Motorcycle	0.89 (0.74-1.07), 0.228	0.47 (0.18-1.21), 0.118	0.94 (0.76-1.17), 0.592	0.91 (0.67-1.24), 0.550	0.86 (0.69-1.07), 0.171	**0.54 (0.36-0.80), 0.002***
Electricity	0.94 (0.81-1.10), 0.468	0.72 (0.38-1.37), 0.312	**0.70 (0.58-0.84), <0.001***	**2.19 (1.66-2.90), <0.001***	0.85 (0.71-1.02), 0.074	**0.56 (0.41-0.75), <0.001***
Car	0.97 (0.68-1.38), 0.869	1.03 (0.25-4.27), 0.972	0.91 (0.59-1.40), 0.657	1.30 (0.76-2.20), 0.338	0.84 (0.55-1.30), 0.436	0.48 (0.20-1.17), 0.106
Toilet/latrine available	0.85 (0.68-1.05), 0.137	0.97 (0.38-2.49), 0.954	**2.12 (1.47-3.07), <0.001***	**0.28 (0.21-0.37), <0.001***	**3.86 (2.44-6.13), <0.001***	**0.43 (0.31-0.60), <0.001***
Toilet/latrine shared with other households	**0.74 (0.61-0.90), 0.002***	0.97 (0.46-2.03), 0.928	**0.73 (0.58-0.91), 0.005***	**0.68 (0.47-0.99), 0.045***	**0.80 (0.65-0.99), 0.036***	**1.99 (1.43-2.75), <0.001***
Used toilet/latrine to defecate last time at home	0.85 (0.69-1.05), 0.137	1.12 (0.44-2.87), 0.812	**1.71 (1.24-2.35), 0.001***	**0.32 (0.24-0.42), <0.001***	**5.34 (3.24-8.81), <0.001***	**0.30 (0.22-0.40), <0.001***
Tissue/water always available for anal cleansing at home	**1.64 (1.39-1.93), <0.001***	1.35 (0.70-2.61), 0.375	**1.41 (1.17-1.71), <0.001***	**2.54 (1.87-3.44), <0.001***	**1.71 (1.41-2.07), <0.001***	**0.36 (0.26-0.49), <0.001***
Handwashing facility with soap and water always available at home	**2.49 (2.13-2.92), <0.001***	**2.61 (1.37-4.95), 0.003***	**2.50 (2.08-3.02), <0.001***	**2.66 (2.04-3.46), <0.001***	**0.51 (0.39-0.66), <0.001***	**0.22 (0.13-0.40), <0.001***
Improved water source	**0.60 (0.52-0.70), <0.001***	**0.21 (0.10-0.43), <0.001***	**0.76 (0.63-0.92), 0.004***	**0.42 (0.32-0.55), <0.001***	0.94 (0.76-1.12), 0.443	0.95 (0.71-1.27), 0.717
School factors						
Handwashing facility with soap and water always available at school	**2.09 (1.68-2.61), <0.001***	**3.48 (1.64-7.37), <0.001***	**2.24 (1.74-2.89), <0.001***	1.31 (0.85-2.00), 0.221	**0.27 (0.15-0.47), <0.001***	**0.11 (0.03-0.46), 0.002***
Tissue/water always available for anal cleansing at school	**0.54 (0.46-0.64), <0.001***	0.86 (0.45-1.65), 0.644	**0.55 (0.45-0.68), <0.001***	**0.54 (0.40-0.71), <0.001***	**0.45 (0.37-0.55), <0.001***	**2.35 (1.75-3.15), <0.001***
Drinking water always available at school	**2.82 (2.40-3.31), <0.001***	1.78 (0.94-3.37), 0.076	**2.85 (2.35-3.45), <0.001***	**3.12 (2.37 4.11), <0.001***	**1.39 (1.17-1.67), <0.001***	**0.13 (0.08-0.22), <0.001***
Always use school latrine/toilet	**2.16 (1.31-3.57), 0.003***	1.87 (0.26-13.68), 0.536	**2.64 (1.36-5.14), 0.004***	1.90 (0.84-4.30), 0.121	**1.94 (1.11-3.38), 0.020***	1.37 (0.64-2.93), 0.415
Days absent from school in the last one week:						
One day vs never absent	**1.55 (1.23-1.96), <0.001***	0.27 (0.04-1.95), 0.192	**1.44 (1.09-1.91), 0.011***	**2.47 (1.74-3.50), <0.001***	0.94 (0.69-1.29), 0.711	**0.41 (0.21-0.81), 0.010***
Two days vs never absent	**2.10 (1.61-2.74), <0.001***	2.31 (0.90-6.00), 0.083	**1.79 (1.29-2.49), 0.001***	**2.97 (1.98-4.46), <0.001***	1.26 (0.88-1.79), 0.207	**0.40 (0.16-1.00), 0.043***
More than two days vs never absent	**1.83 (1.30-2.59), <0.001***	0.73 (0.10-5.34), 0.755	**1.68 (1.11-2.55), 0.015***	**2.58 (1.53-4.36), <0.001***	1.07 (0.67-1.71), 0.778	0.50 (0.19-1.36), 0.176

COVID19-related factors						
Participant has heard about COVID19	**0.82 (0.69-0.98), 0.025***	0.58 (0.30-1.13), 0.111	0.93 (0.75-1.14), 0.478	**0.64 (0.48-0.84), 0.001***	1.08 (0.88-1.33), 0.476	1.05 (0.76-1.46), 0.753
Participant know how COVID19 is transmitted	1.10 (0.91-1.33), 0.329	1.50 (0.62-3.63), 0.365	1.23 (0.98-1.55),0.070	0.78 (0.57-1.09), 0.142	**1.43 (1.15-1.79), 0.002***	1.22 (0.86-1.71), 0.265
Participant know symptoms associated with COVID19	1.11 (0.92-1.33), 0.282	1.36 (0.59-3.11), 0.467	1.19 (0.96-1.48), 0.121	0.93 (0.67-1.29), 0.663	**1.53 (1.23-1.89), <0.001***	**1.43 (1.02-2.00), 0.039***
Participant know how to protect self against COVID19	**1.84 (1.35-2.50), <0.001***	**4.36 (0.59-32.29), 0.002***	**1.94 (1.33-2.81), 0.001***	**1.71 (1.00-2.93), 0.049***	**2.04 (1.42-2.92), <0.001***	**0.44 (0.31-0.63), <0.001***
Specific handwashing station(s) with water and soap is always available at participant's home	2.52 (2.15-2.96), 0.190	-	**2.58 (2.14-3.12), <0.001***	**2.66 (2.04-3,47), <0.001***	**0.44 (0.33-0.59), <0.001***	**0.22 (0.12-0.41), <0.001***
Participant wash hands with soap and water always at the home handwashing station(s)	1.39 (0.85-2.26), 0.190	-	1.07 (0.63-1.80), 0.803	2.91 (0.92-9.19), 0.069	1.23 (0.57-2.66), 0.602	1.76 (0.24-13.01), 0.581
Specific handwashing station(s) with water and soap is always available at participant's school	**2.02 (1.61-2.54), <0.001***	**3.15 (1.44-6.88), 0.004***	**2.17 (1.67-2.82), <0.001***	1.38 (0.90-2.11), 0.143	**0.28 (0.16-0.50), <0.001***	**0.18 (0.06-0.56), 0.003***
Participant wash hands with soap and water always at the school handwashing station(s)	**1.59 (1.27-1.98), <0.001***	1.20 (0.51-2.82), 0.673	1.15 (0.91-1.47), 0.240	**6.38 (3.25-12.54), <0.001***	**1.59 (1.21-2.09), 0.001***	1.61 (0.92-2.84), 0.098

$The odds ratios were calculated using univariable analysis which was performed in a multilevel linear mixed effects model accounting for the hierarchical nature of data
*Indicates a significant factor (p<0.005)

Table 14: Multivariable associations between WASH conditions and STH infections among school children in Kenya after ten rounds of MDA

Factors	STH infections [aOR (95%CI), p-value] $			
	STH combined (n=680)	**Hookworm (n=38)**	***A. lumbricoides* (n=469)**	***T. trichiura* (n=230)**
Individual factors				
Male children	**1.31 (1.05-1.64), p=0.018***		1.27 (0.94-1.72), p=0.113	
Did not reportedly receive treatment during last MDA	**0.62 (0.43-0.90), p=0.012***		0.71 (0.44-1.17), p=0.177	0.55 (0.24-1.29), p=0.169
Household factors				
Household members:				
>5 members vs 1-5 members	1.21 (0.95-1.53), p=0.119		1.28 (0.92-1.77), p=0.143	1.55 (0.94-2.55), p=0.086
Household head level of education:				
No formal education vs secondary and above			0.56 (0.17-1.82), p=0.333	
Primary education vs secondary and above			**1.42 (1.04-1.95), p=0.027***	
Floor materials:				
Wooden vs cement/tiles	0.51 (0.07-3.94), p=0.518			-

Earth/sand vs cement/tiles	0.78 (0.56-1.09), p=0.147			0.70 (0.38-1.31), p=0.268
Iron sheets vs cement/tiles	0.38 (0.05-2.95), p=0.358			1.37 (0.16-11.49), p=0.771
Wall materials:				
Clay/mud vs stones/bricks/cement	**2.87 (1.96-4.21), p<0.001***		**2.36 (1.55-3.59), p<0.001***	**3.87 (1.82-8.27), p<0.001***
Wood vs stones/bricks/cement	1.43 (0.73-2.79), p=0.299		1.24 (0.37-4.17), p=0.724	1.11 (0.25-5.03), p=0.891
Iron sheets vs stones/bricks/cement	**3.01 (1.74-5.20), p<0.001***		**2.21 (1.03-4.76), p=0.042***	**5.27 (2.02-13.78), p=0.001***
Household possessions:				
Radio	1.13 (0.86-1.48), p=0.387		1.06 (0.74-1.54), p=0.737	**2.60 (1.34-5.05), p=0.005***
Television		**0.20 (0.06-0.68), p=0.010***		
Sofa set	1.22 (0.95-1.58), p=0.124		1.29 (0.89-1.88), p=0.178	0.98 (0.59-1.63), p=0.947
Bicycle				0.92 (0.57-1.46), p=0.710
Electricity			0.73 (0.51-1.03), p=0.072	1.33 (0.83-2.14), p=0.239
Toilet/latrine shared with other households	**0.62 (0.48-0.80), p<0.001***		**0.67 (0.47-0.97), p=0.034***	**0.38 (0.21-0.67), p=0.001***
Used toilet/latrine to defecate last time at home			1.65 (0.64-4.22), p=0.297	0.41 (0.14-1.24), p=0.115
Tissue/water always available for anal cleansing at home	0.84 (0.63-1.10), p=0.206		**0.60 (0.42-0.85), p=0.005***	1.65 (0.88-3.11), p=0.120
Handwashing facility with soap and water always available at home	**1.72 (1.32-2.25), p<0.001***	1.93 (0.43-8.79), p=0.394	1.63 (0.85-3.15), p=0.145	1.08 (0.50-2.33), p=0.849
Improved water source	0.90 (0.72–1.13), p=0.369	**0.28 (0.11-0.68), p=0.005***	0.98 (0.72-1.34), p=0.908	0.85 (0.54-1.34), p=0.492
School factors				
Handwashing facility with soap and water always available at school	1.62 (0.97-2.72), p=0.067	2.39 (0.85-6.70), p=0.099	**2.32 (1.09-4.96), p=0.030***	
Tissue/water always available for anal cleansing at school	**0.67 (0.52-0.87), p=0.002***		**0.57 (0.39-0.82), p=0.002***	0.68 (0.41-1.13), p=0.138
Drinking water always available at school	1.16 (0.90-1.50), p=0.252	1.44 (0.56-3.74), p=0.449	1.36 (0.96-1.92), p=0.088	1.17 (0.70-1.96), p=0.549
Always use school latrine/toilet	1.55 (0.37-6.52), p=0.550		1.69 (0.51-5.60), p=0.390	
Days absent from school in the last one week:				
One day vs never absent	1.32 (0.94-1.85), p=0.103		1.31 (0.82-2.10), p=0.266	**2.19 (1.21-3.96), p=0.010***
Two days vs never absent	**1.85 (1.27-2.70), p=0.001***		**1.88 (1.11-3.21), p=0.020***	**2.38 (1.20-4.72), p=0.013***
More than two days vs never absent	1.40 (0.87-2.23), p=0.164		0.87 (0.39-1.93), p=0.725	**2.86 (1.39-5.89), p=0.004***
COVID19-related factors				
Participant know how COVID19 is transmitted			0.87 (0.61-1.25), p=0.462	
Participant know how to protect self against COVID19	1.23 (0.81-1.85), p=0.337	3.19 (0.42-23.93), p=0.259	1.41 (0.80-2.50), p=0.237	0.80 (0.38-1.71), p=0.568
Specific handwashing station(s) with water and soap is always available at participant's home		1.41 (0.31-6.41), p=0.660	1.81 (0.94-3.50), p=0.077	0.96 (0.44-2.09), p=0.915
Specific handwashing station(s) with water and soap is always available at participant's school	0.68 (0.40-1.16), p=0.158		0.49 (0.22-1.09), p=0.082	
Participant wash hands with soap and water always at the school handwashing station(s)	1.11 (0.83-1.49), p=0.472			**3.54 (1.54-8.11), p=0.003***

[$]The adjusted odds ratios were calculated using multivariable analysis which was performed in a multilevel linear mixed effects model accounting for the hierarchical nature of data
*Indicates a significant factor (p<0.005)

Table 15: Multivariable associations between WASH conditions and SCH infections among school children in Kenya after ten rounds of MDA

Factors	**SCH infections [aOR (95%CI), p-value]** [$]	
	***S. mansoni* (n=502)**	***S. haematobium* (n=196)**
Individual factors		
Male children	1.08 (0.77-1.51), p=0.666	
ECD children		0.35 (0.05-2.57), p=0.300
Not wearing shoes	0.48 (0.11-2.01), p=0.313	0.52 (0.12-2.25), p=0.383
Age group:		
<5 years vs >14 years		-
5-14 years vs >14 years		0.96 (0.11-8.02), p=0.967
Did not reportedly receive treatment during last MDA	0.70 (0.36-1.33), p=0.276	
Household factors		
Household members:		
>5 members vs 1-5 members	0.89 (0.63-1.25), p=0.485	1.21 (0.68-2.14), p=0.524
Household head level of education:		
No formal education vs secondary and above	1.45 (0.54-3.91), p=0.463	0.52 (0.07-4.11), p=0.538
Primary education vs secondary and above	1.39 (0.96-2.01), p=0.079	1.64 (0.95-2.83), p=0.079
Roof materials:		
Iron sheets vs tiles		-
Grass/thatch/makuti vs tiles		0.80 (0.31-2.10), p=0.658
Floor materials:		
Wooden vs cement/tiles		-
Earth/sand vs cement/tiles		1.41 (0.59-3.37), p=0.434
Iron sheets vs cement/tiles		-
Wall materials:		
Clay/mud vs stones/bricks/cement	0.72 (0.49-1.08), p=0.114	1.07 (0.44-2.57), p=0.885
Wood vs stones/bricks/cement	-	1.04 (0.21-5.27), p=0.959
Iron sheets vs stones/bricks/cement	1.22 (0.53-2.81), p=0.636	1.53 (0.32-7.27), p=0.593
Household possessions:		
Radio	**0.59 (0.40-0.86), p=0.006***	1.12 (0.59-2.11), p=0.736
Television		1.12 (0.54-2.32), p=0.763
Sofa set		1.01 (0.49-2.08), p=0.977
Bicycle	1.15 (0.78-1.69), p=0.478	
Motorcycle		0.53 (0.25-1.12), p=0.095
Electricity		0.59 (0.30-1.17), p=0.132

Toilet/latrine shared with other households	**0.56 (0.34-0.91), p=0.019***	1.42 (0.74-2.71), p=0.290
Used toilet/latrine to defecate last time at home	2.55 (0.34-19.08), p=0.362	**0.35 (0.15-0.81), p=0.014***
Tissue/water always available for anal cleansing at home	**3.17 (1.96-5.11), p<0.001***	1.01 (0.54-1.89), p=0.974
Handwashing facility with soap and water always available at home	**0.37 (0.15-0.92), p=0.033***	1.53 (0.38-6.23), p=0.552
School factors		
Handwashing facility with soap and water always available at school	0.24 (0.03-1.86), p=0.173	-
Tissue/water always available for anal cleansing at school	**0.40 (0.25-0.64), p<0.001***	1.85 (0.94-3.66), p=0.076
Drinking water always available at school	0.88 (0.61-1.26), p=0.481	**0.22 (0.08-0.59), p=0.003***
Always use school latrine/toilet	1.03 (0.13-7.99), p=0.981	
Days absent from school in the last one week:		
One day vs never absent		1.84 (0.75-4.52), p=0.181
Two days vs never absent		-
More than two days vs never absent		0.92 (0.12-7.12), p=0.933
COVID19-related factors		
Participant know how COVID19 is transmitted	0.84 (0.48-1.47), p=0.534	
Participant know symptoms associated with COVID19	1.04 (0.60-1.79), p=0.898	**2.49 (1.22-5.10), p=0.012***
Participant know how to protect self against COVID19	1.55 (0.68-3.53), p=0.297	**0.35 (0.16-0.76), p=0.008***
Specific handwashing station(s) with water and soap is always available at participant's home	0.69 (0.28-1.72), p=0.427	0.50 (0.10-2.44), p=0.393
Specific handwashing station(s) with water and soap is always available at participant's school	0.38 (0.05-2.91), p=0.354	3.09 (0.38-25.39), p=0.293
Participant wash hands with soap and water always at the school handwashing station(s)	**1.82 (1.12-2.97), p=0.016***	

$The adjusted odds ratios were calculated using multivariable analysis which was performed in a multilevel linear mixed effects model accounting for the hierarchical nature of data
*Indicates a significant factor (p<0.005)

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Figure 1: STH county endemicity classification using predictive probabilities calculated from the fitted MBG model

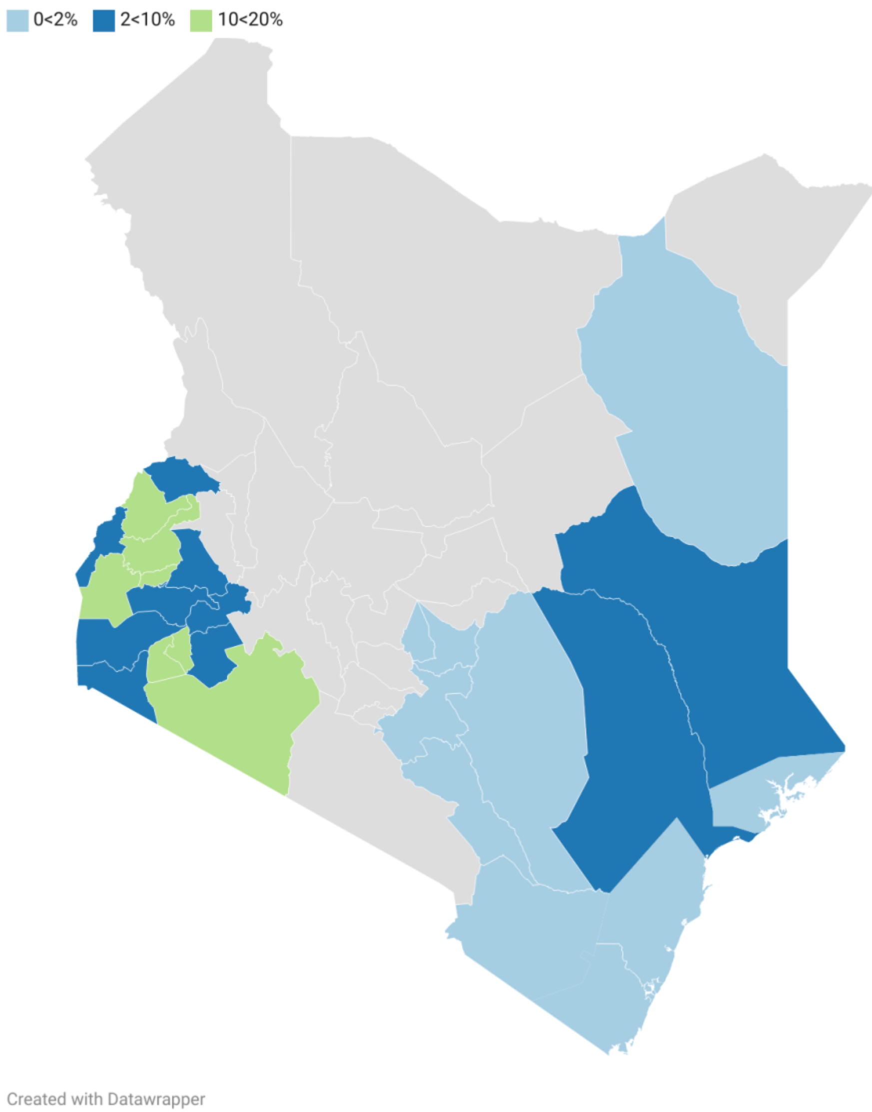


Figure 2: STH subcounty endemicity classification using predictive probabilities calculated from the fitted MBG model

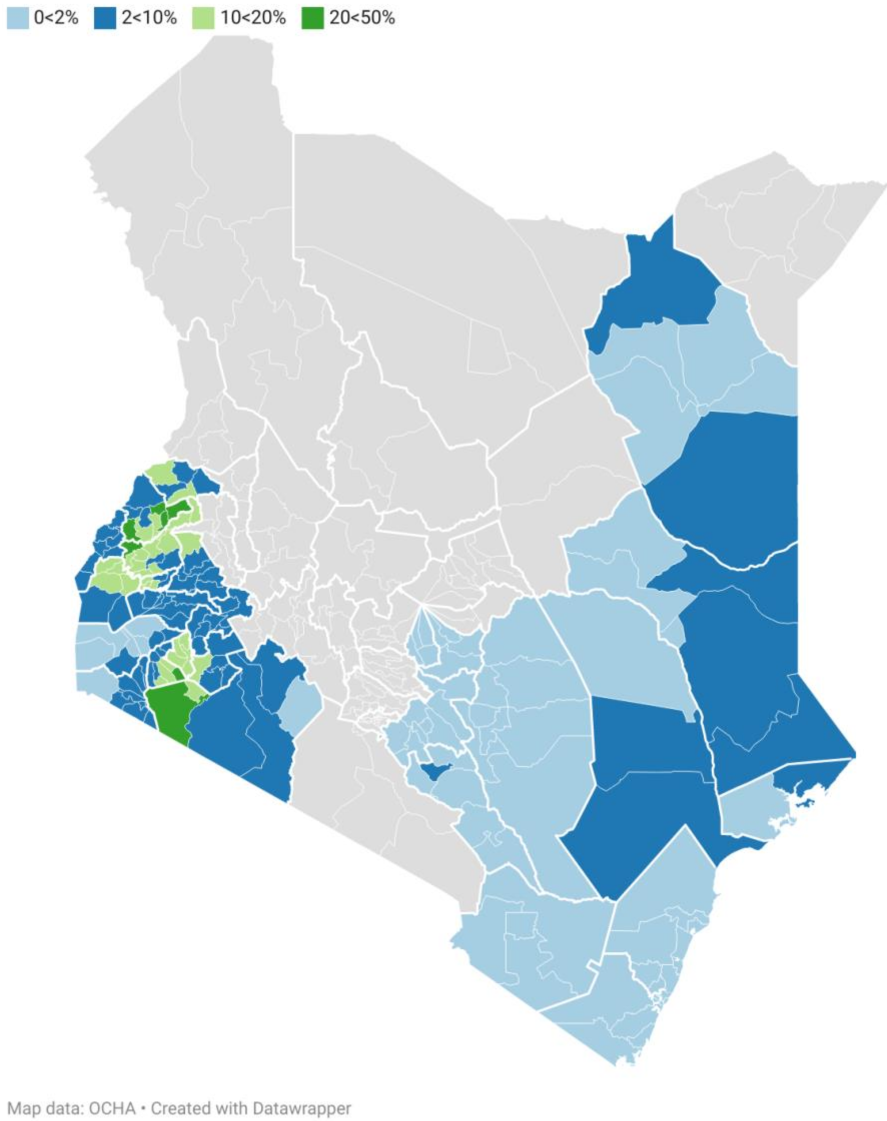


Figure 3: Schistosomiasis County endemicity classification using predictive probabilities calculated from the fitted MBG model

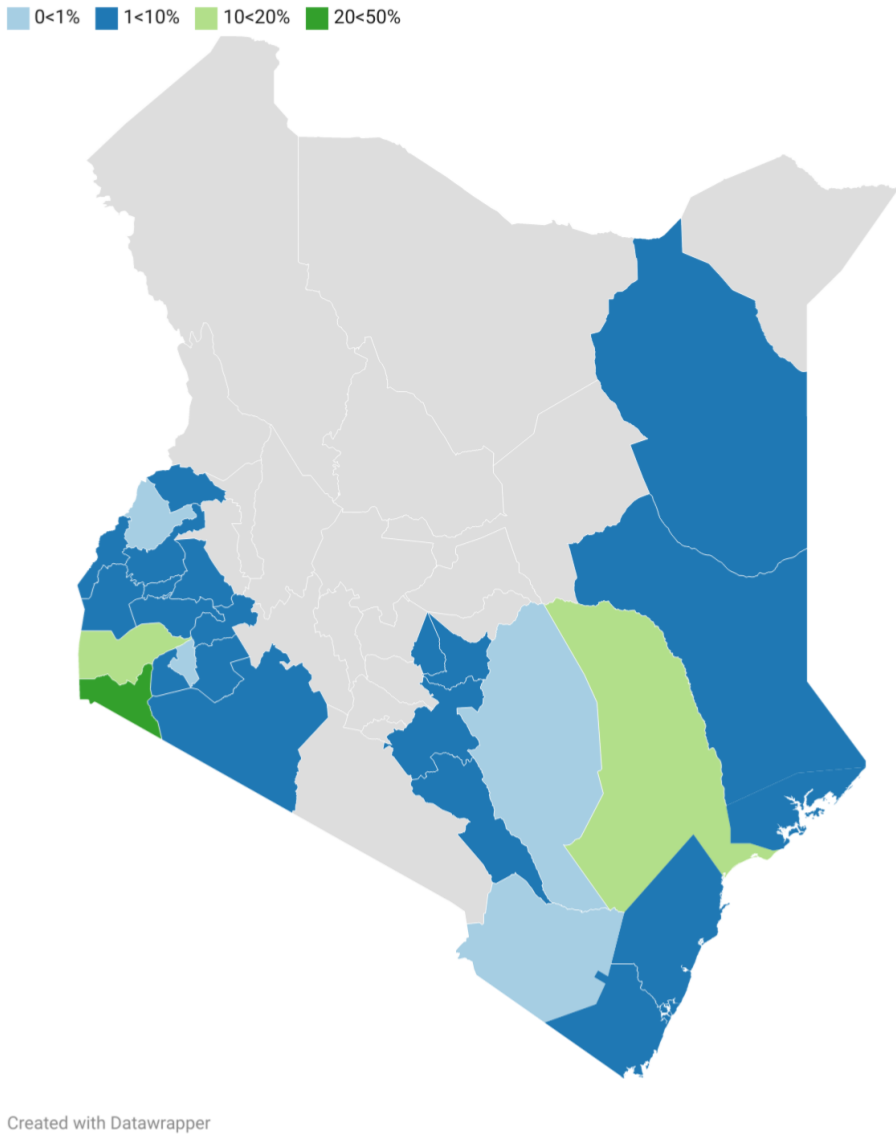


Figure 4: Schistosomiasis subcounty endemicity classification using predictive probabilities calculated from the fitted MBG model

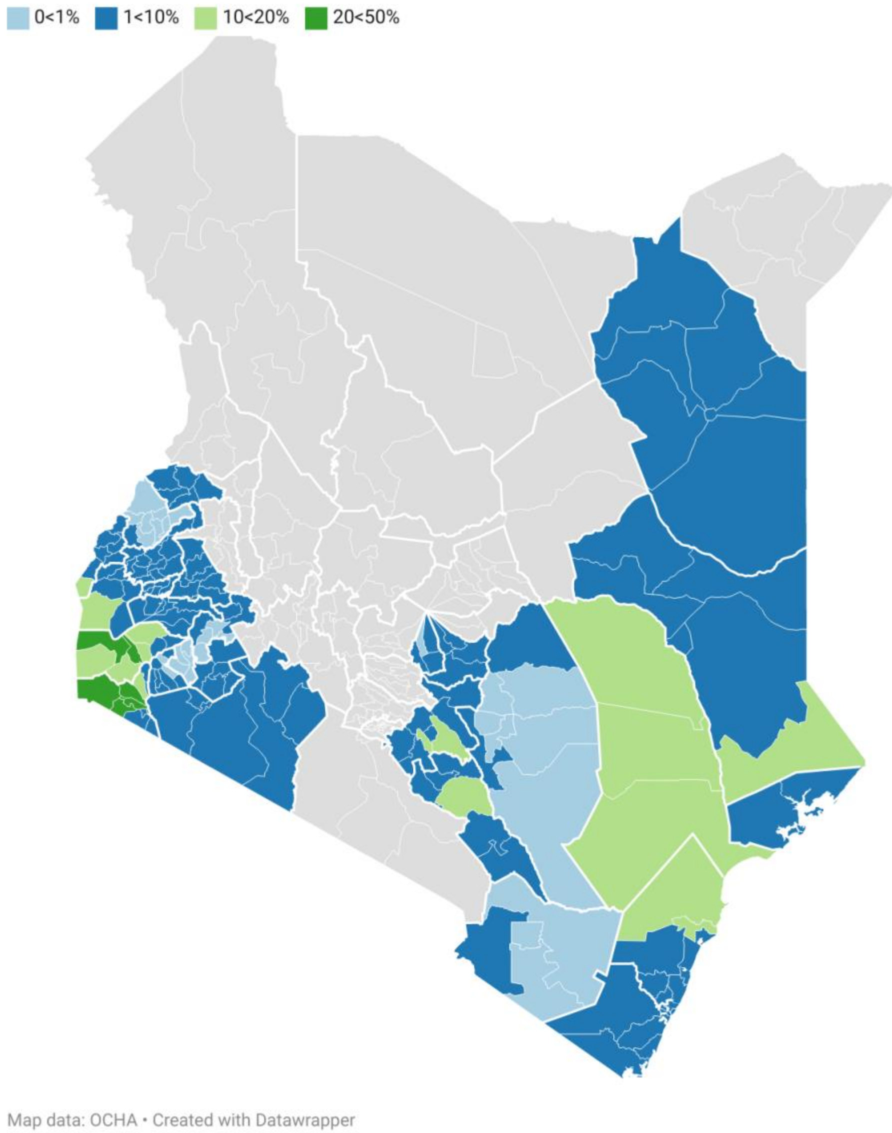


Figure 5: Schistosomiasis ward endemicity classification using predictive probabilities calculated from the fitted MBG model

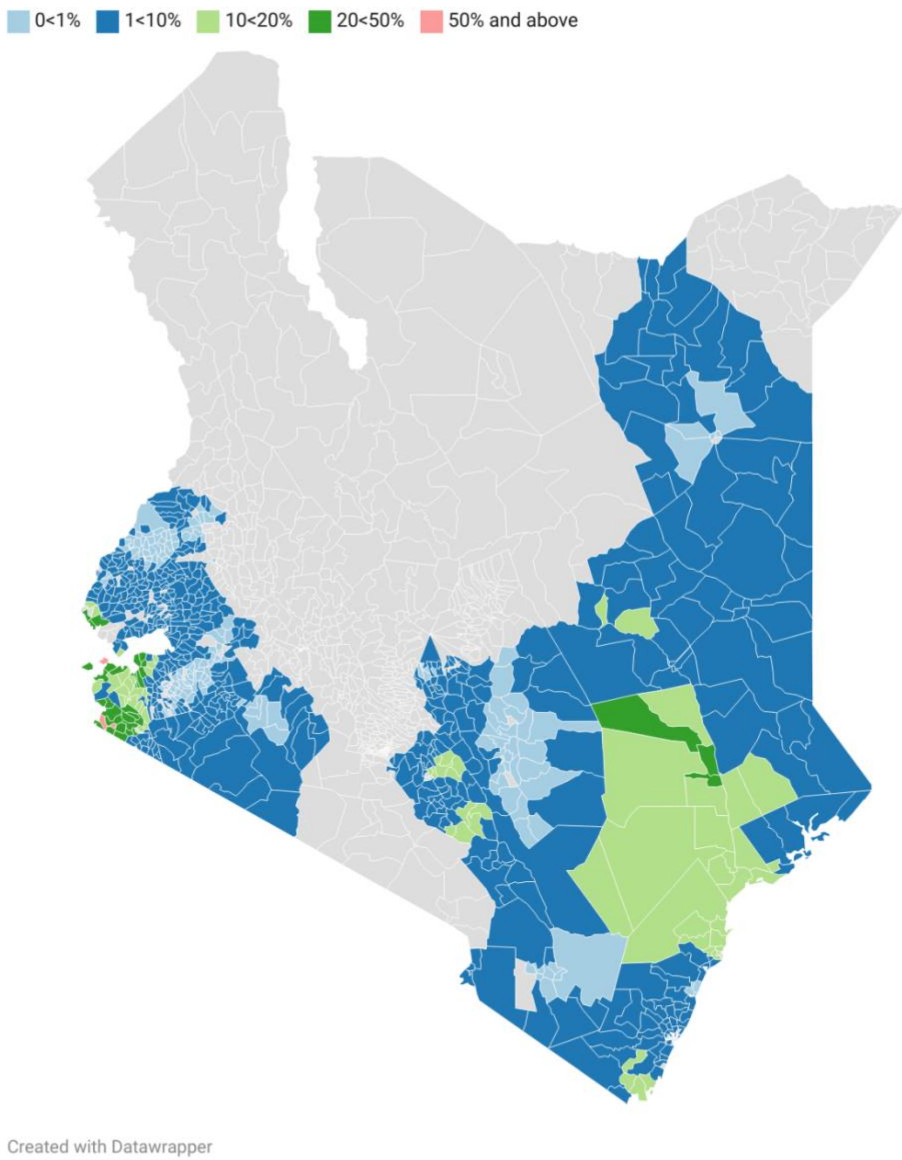


Figure 6: School level (pixel) geographical distribution of STH mean prevalence estimate using MBG approach

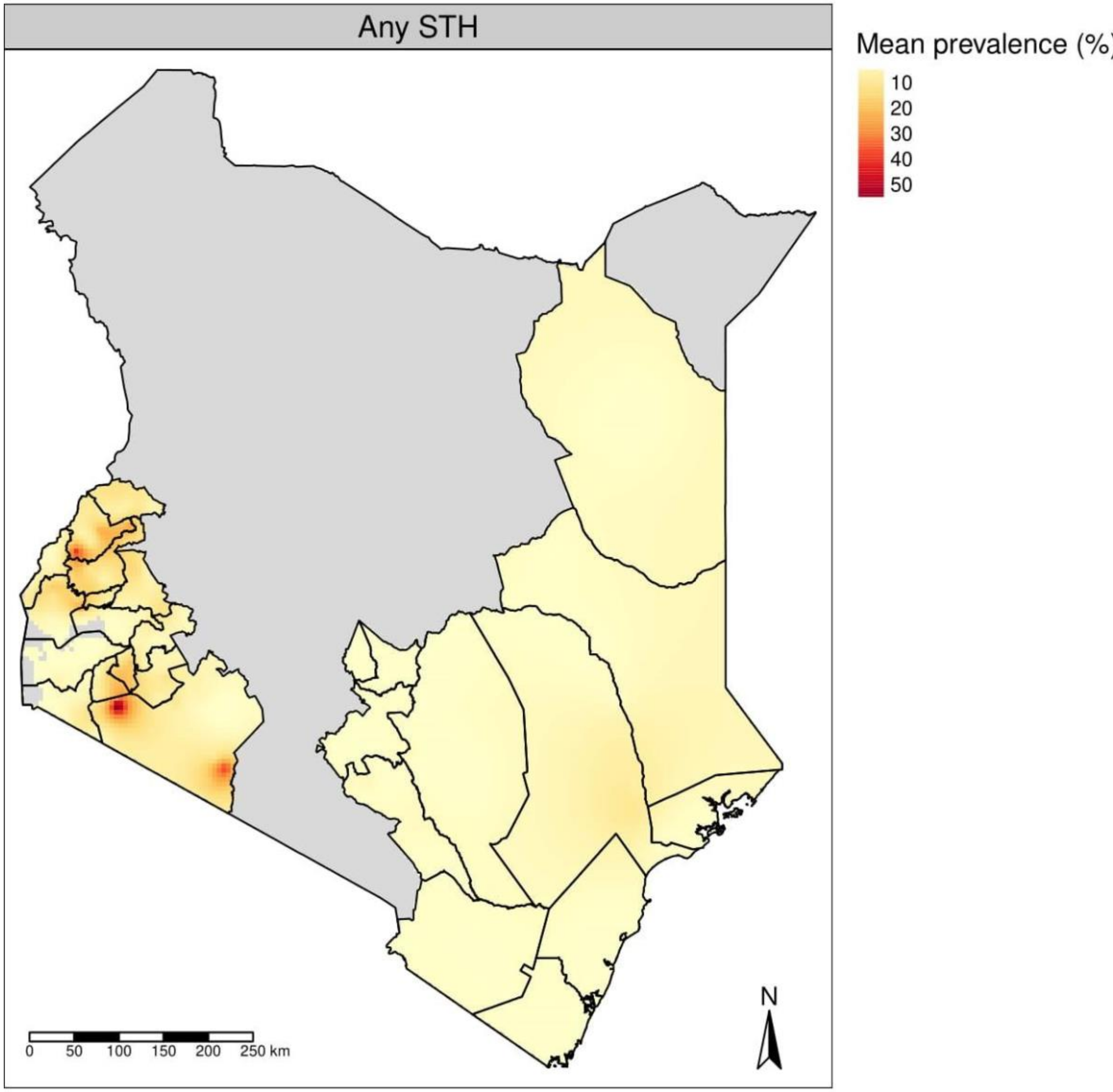


Figure 7: School level (pixel) geographical distribution of schistosomiasis mean prevalence estimate using MBG approach

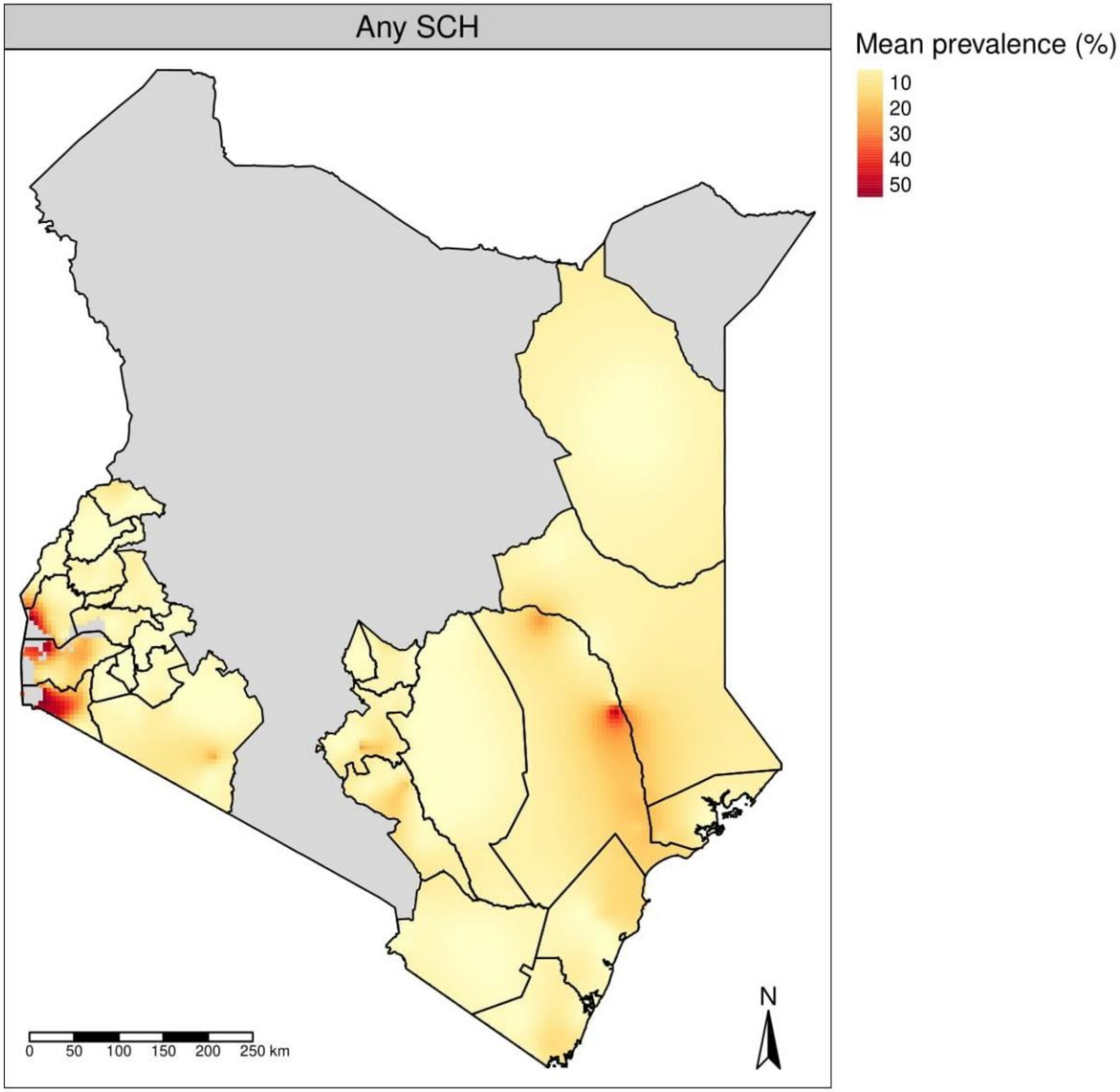


Figure 8: Comparison of the county level STH prevalence estimated using two models, binomial regression model and model-based geostatistics

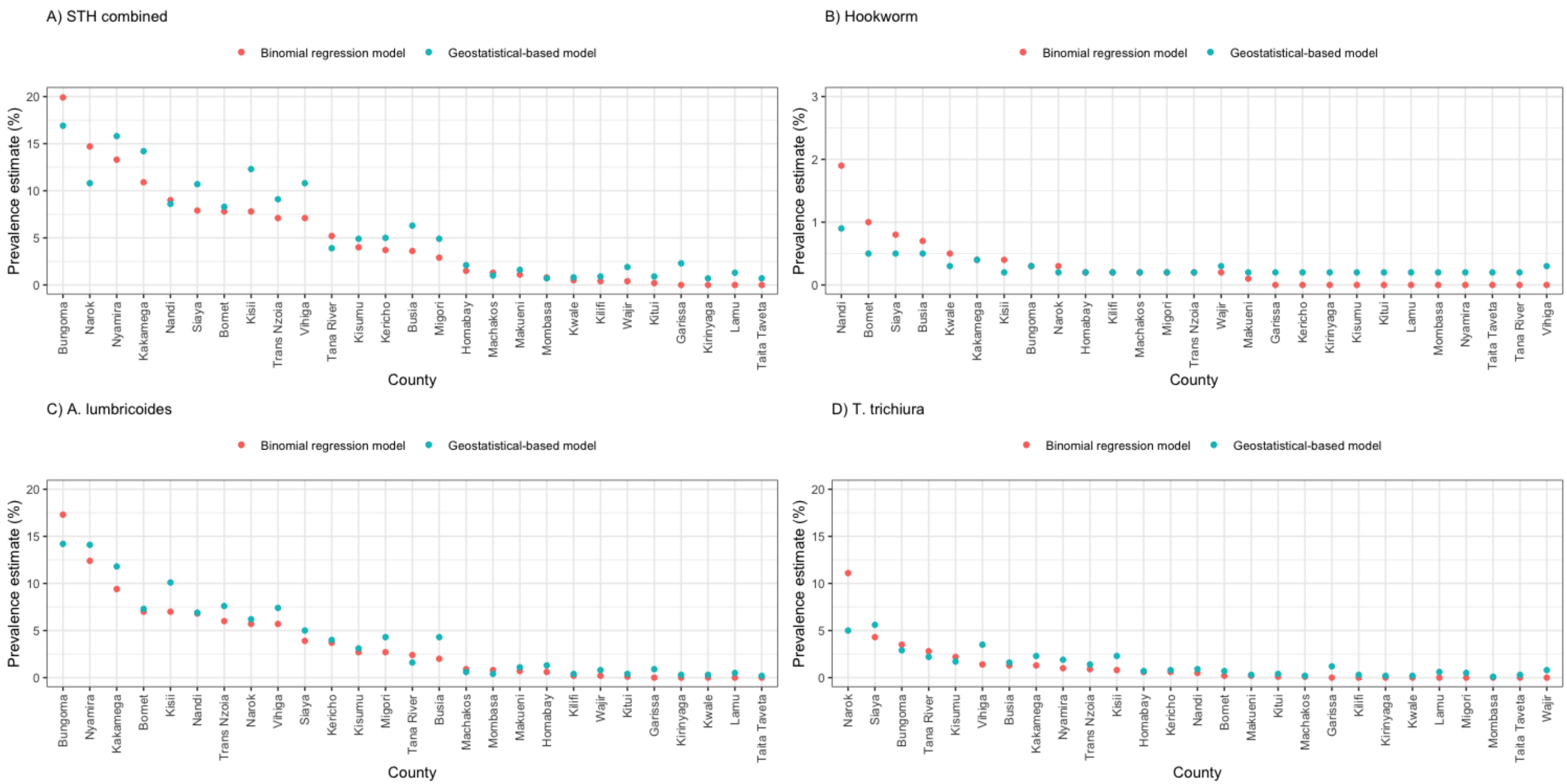


Figure 9: Comparison of the county level schistosome prevalence estimated using two models, binomial regression model and geostatistical-based model

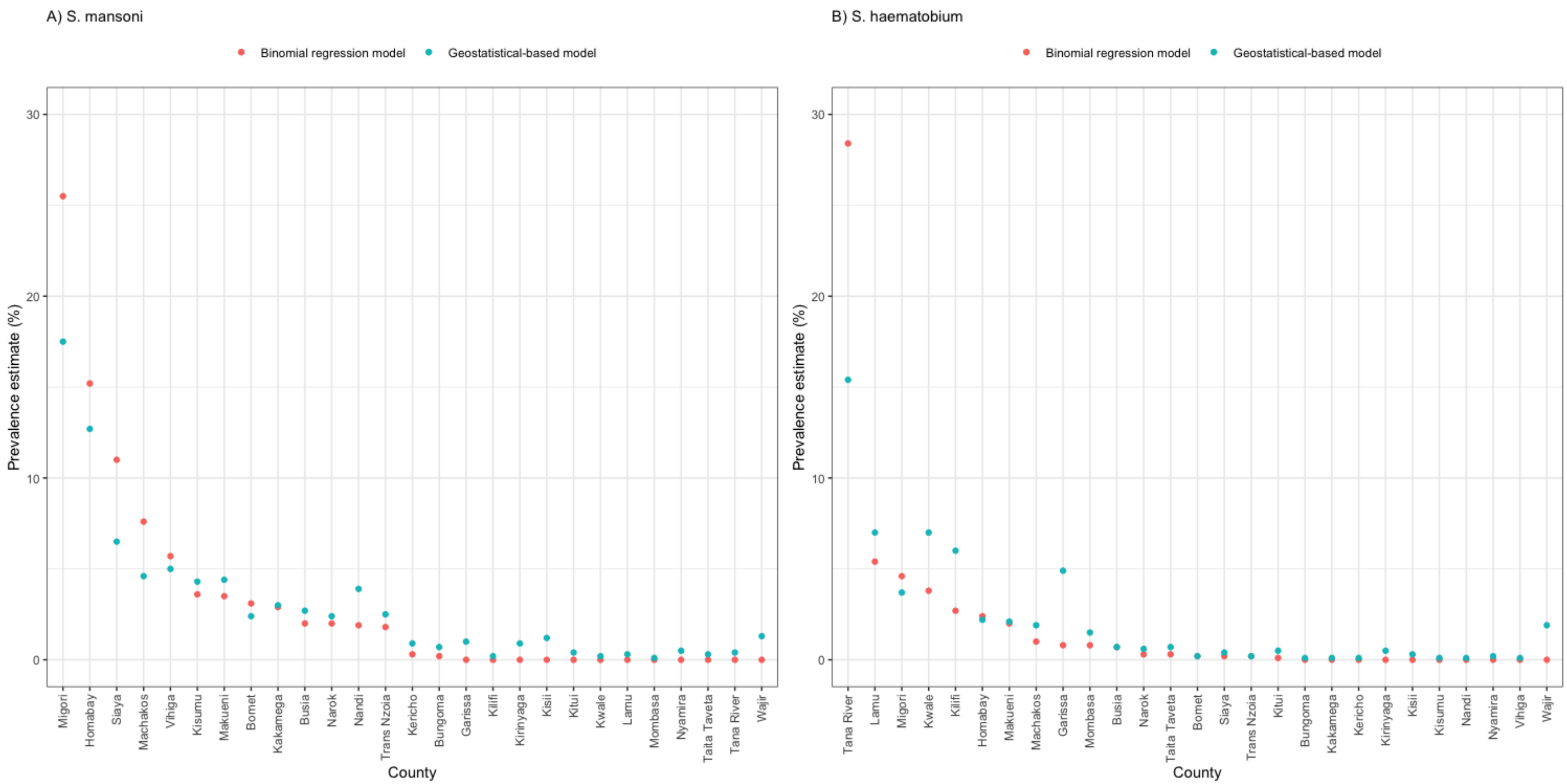


Figure 10: The overall prevalence of moderate to heavy intensity of STH and schistosome infections

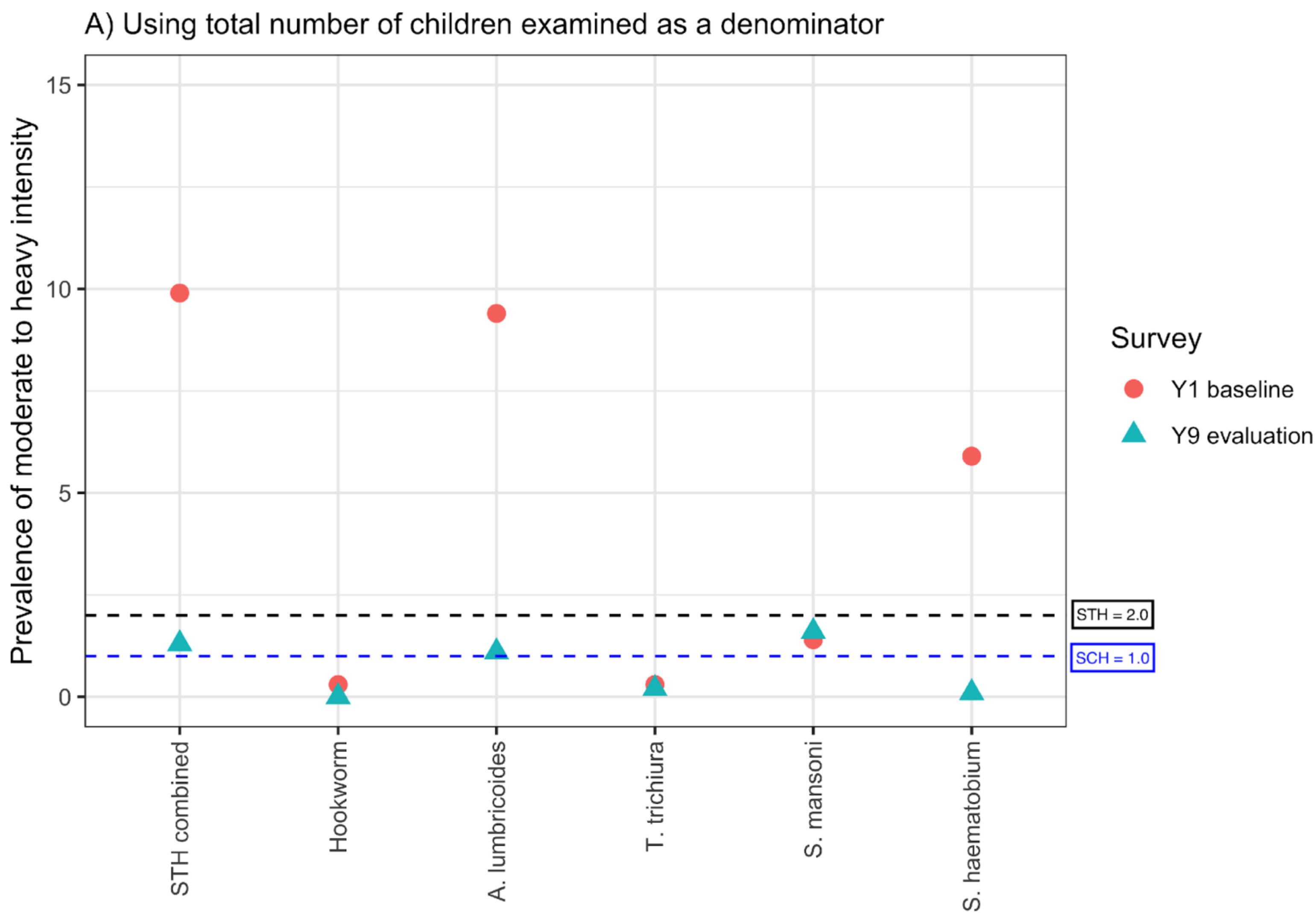


Figure 11: The overall STH prevalence comparison from Y1 baseline to Y9 evaluation

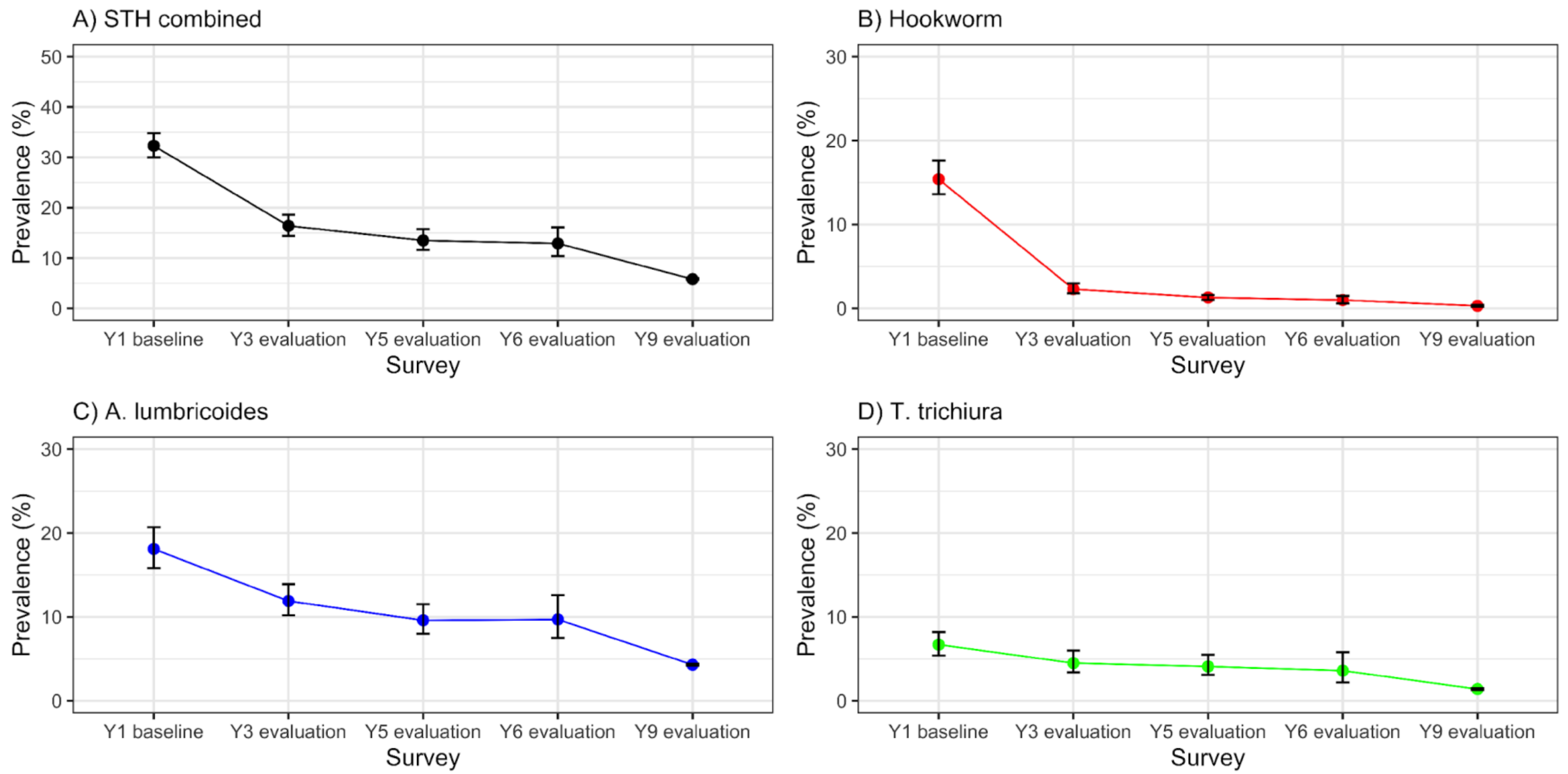
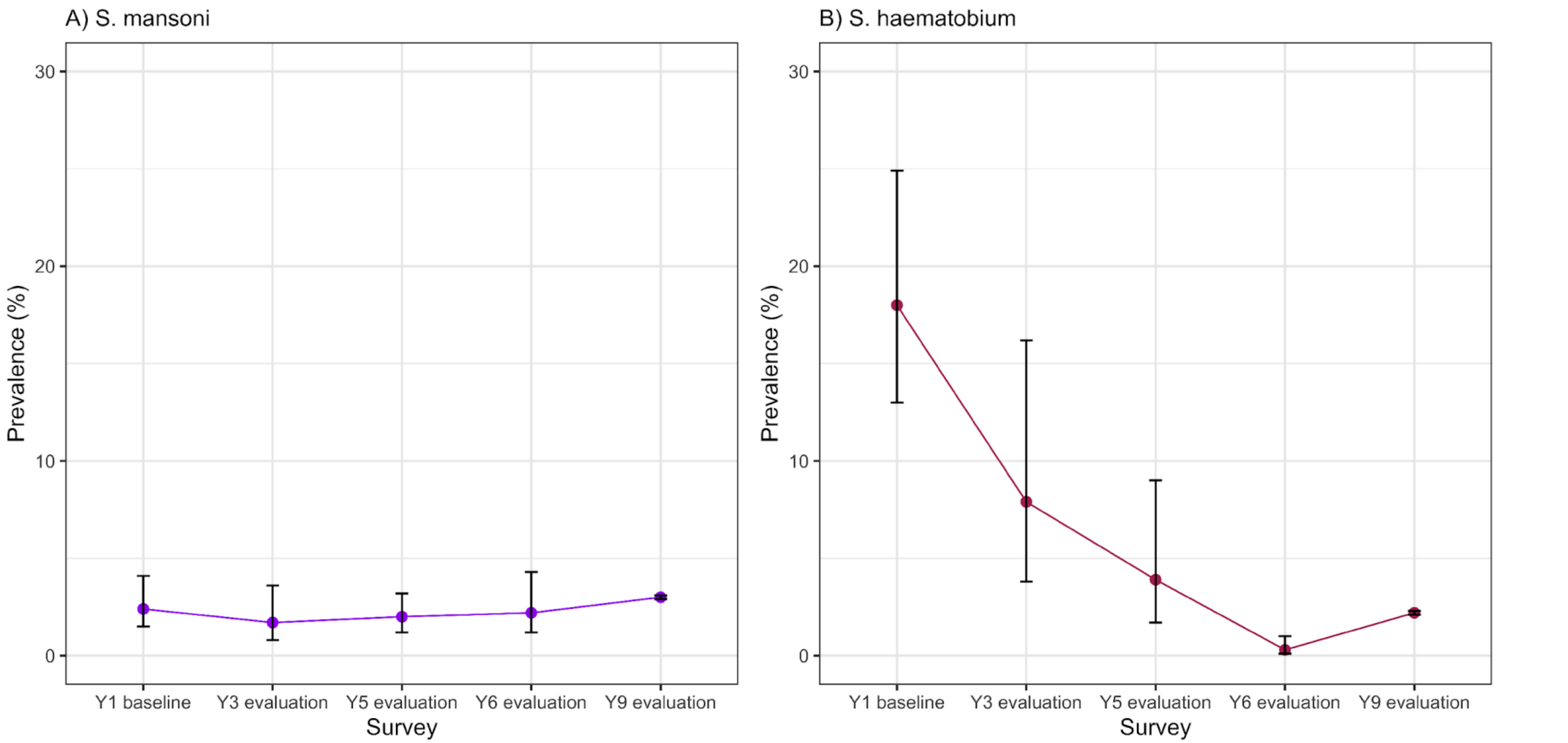


Figure 12: The overall schistosome prevalence comparison from Y1 baseline to Y9 evaluation



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