

Using geostatistical methods to analyze spatio-temporal changes in childhood malaria following scale-up of control efforts in Chikwawa District, Malawi

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Background

Programmatic challenges

- Most malaria surveys are cross-sectional national surveys that provide average estimates of prevalence at national and provincial level. These do not take into account the widely varying level of transmission at local and sub-district level.
- In order to obtain timely and accurate sub-district estimates of parasite prevalence, continuous prevalence surveys can provide a more powerful approach for identifying local hotspots and guiding more targeted control efforts.

Statistical issues

- How should data from continuous Malaria Indicator Surveys (MIS) be analysed so as best to interpolate the spatio-temporal pattern of malaria?
- Disease maps are usually presented as point estimates of prevalence. This can lead to over-interpretation of imprecise estimated features. How should disease maps be presented in order to convey uncertainty in a way that is both statistically accurate and understandable by public health decision-makers?
- How do we quantify the potential impact of programmatic scale-up of control efforts?

Materials

We analysed **data** from a continuous “rolling” MIS conducted in 50 villages of Chikwawa District, Southern Malawi, between May 2010 and June 2013. Blood samples were collected from children aged 6-59 months and prepared for Rapid Diagnostic Test (RDT). Information was obtained on age, Socio-Economic-Status (SES), availability of **Insecticide Treated Nets** (ITN) and **Indoor Residual Spraying** (IRS). Two IRS campaigns were conducted from February 2011 to April 2011 and in November 2012, respectively. An ITN district-wide distribution campaign also took place between June 2012 and July 2012, aiming to move from 60% ITN coverage at household level to reach 1 ITN per 2 individuals. Figure 1 shows the observed coverages of ITN and IRS for the whole period.

Methods

We used a **geostatistical binomial logistic model** [1] with spatially and temporally correlated random effects in order to model RDT prevalence. Age, SES, availability of ITN and IRS were also included in the model as explanatory variables. To account for the **seasonality of malaria**, we used linear combinations of sine and cosine functions with frequencies of one year and six months. We then used the resulting estimates of RDT prevalence to determine the associated **exceedance probabilities**, i.e. the probability that the estimated RDT prevalence is above a given policy threshold. We also developed a multiple imputation algorithm so as to predict changes in prevalence and number of infected children that would result from different **control progress scenarios**.

Conclusions

- Maps of exceedance probabilities are useful for identifying disease hotspots.
- Conveying uncertainty in prevalence estimates is essential to avoid over-interpretation of point estimates.
- Scaling up current ITN and IRS interventions to 100% household level coverage, is predicted to achieve the highest reduction in number of infected children in hotspots.
- Guidance is needed on the definition of policy-relevant prevalence thresholds.
- More accurate disease maps can be obtained by combining data from household surveys with more economical convenience samples; see [2] for an example.

References

[1] P. J. Diggle, J. A. Tawn, and R. A. Moyeed. Model-based geostatistics (with discussion). *Applied Statistics*, 47:299–350, 1998.

[2] E. Giorgi, S. S. S. Sesay, D. J. Terlouw, and P. J. Diggle. Combining data from multiple spatially referenced surveys using generalized linear geostatistical models. *Journal of the Royal Statistical Society, Series A*, 2015. In press.

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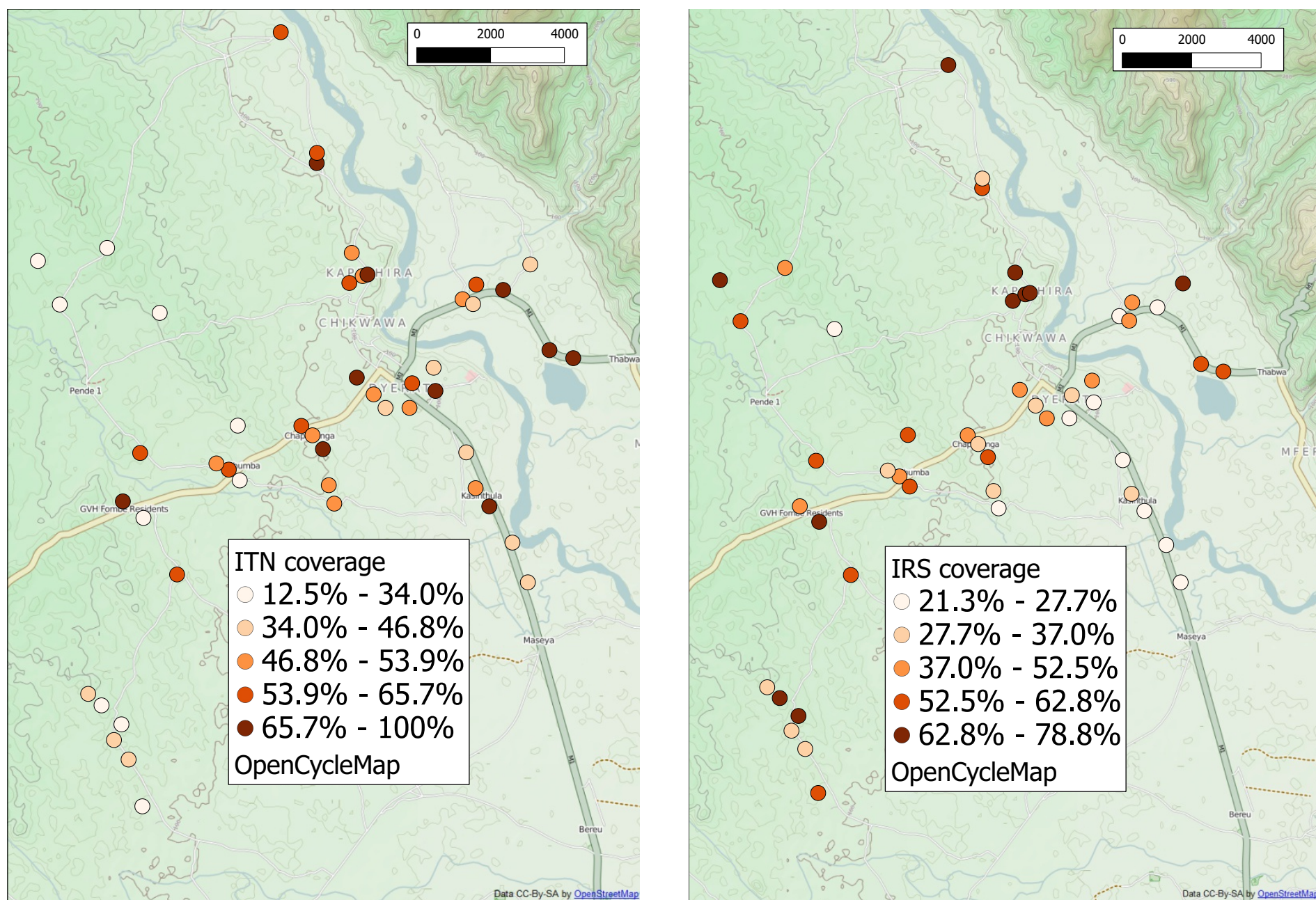


Figure 1: Quintiles of observed ITN (left panel) and IRS (right panel) coverage in each of the 50 villages.

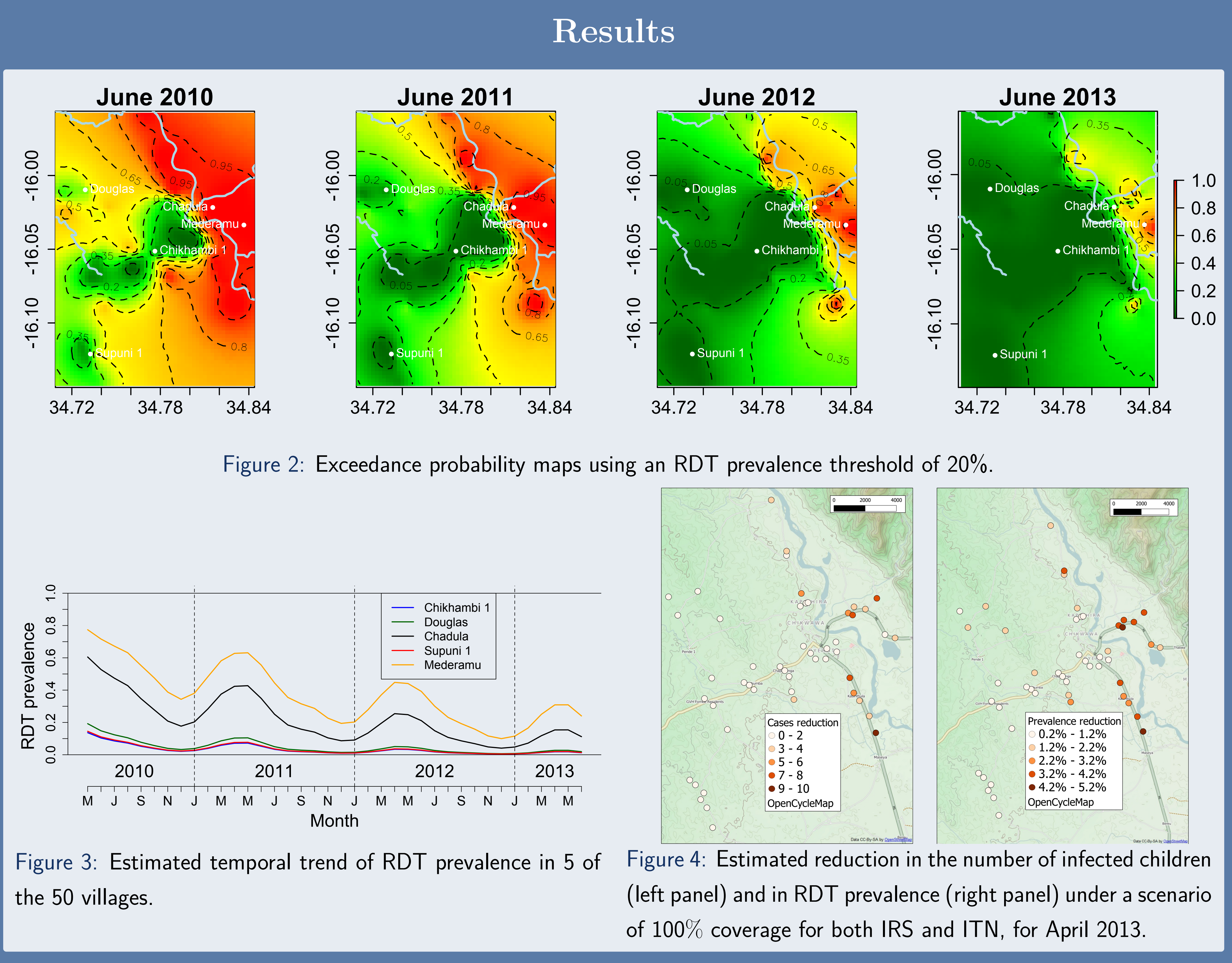


Figure 2: Exceedance probability maps using an RDT prevalence threshold of 20%.

Figure 3: Estimated temporal trend of RDT prevalence in 5 of the 50 villages.

Figure 4: Estimated reduction in the number of infected children (left panel) and in RDT prevalence (right panel) under a scenario of 100% coverage for both IRS and ITN, for April 2013.