ADAPTIVE GEOSTATISTICAL DESIGN AND ANALYSIS FOR PREVALENCE SURVEYS.

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Background

- Can we improve the efficiency of sampling to capture fine scale malaria heterogeneity by using adaptive sampling?
- Most malaria surveys provide average prevalence estimates at national and regional level. These do not take into account the widely varying level of transmission at local and sub-district level.
- Random sampling methods provide disease prevalence estimate with a level of precision around that estimate.
- Malaria shows small scale variation - Fig. 1, Chikwawa study site; describing such heterogeneity can guide targeted intervention strategies.

Non-adaptive Geostatistical Designs

Random sampling is efficient for parameter estimation, whilst Regular sampling is efficient for spatial prediction when model parameters are known[1]. A good compromise in semi-inhibitory design - Figures 2 and 3

Adaptive Geostatistical Designs (AGD)

- New locations are added to the sample if they meet defined criteria, e.g. locations $x^*$ at which predicted values of $S(x)$ have high prediction variance.
- We performed simulation studies to compare the efficiency of specific adaptive and non-adaptive designs in terms of predictive efficiency.
- Singleton adaptive sampling locations are chosen sequentially, allowing $x_{k+1}$ to depend on data obtained at locations $x_1, \ldots, x_k$; whereas Batch adaptive sampling locations are chosen in batches (clusters) of size $b > 1$, allowing a new cluster $\{x_{k+b+1}, \ldots, x_{k+b}\}$ to depend on data obtained at locations $x_1, \ldots, x_k$.
- Using Minimum Distance Batch Adaptive Sampling we allow locations in a new batch to be at least a prescribed distance $\delta$ from each other and from all existing $x_1, \ldots, x_k$ locations.
- This design ensures wide coverage of the study region’s spatial extent, which brings benefits in terms of high efficiency (low variance) of spatial predictions.

Materials and methods

- We use data from the initial wave of sampling from large-scale malaria transmission reduction study currently being implemented in Majete wildlife reserve in Malawi to demonstrate how we are applying AGDs.
- We fit a standard geostatistical model for prevalence data:

$$\log\left[p(x_i)/\left(1 - p(x_i)\right)\right] = d(x_i)/\beta + S(x_i)$$

(1)

Main results and application

We apply AGD sampling to a rolling Malaria Indicator Survey (rMIS) around Majete Wildlife Reserve perimeter

Discussion and Conclusion

- Adaptive sampling is more efficient than non-adaptive sampling.
- Increasing the batch size is associated with a small loss of efficiency in predictive performance.
- Adaptive sampling allows effective detection and subsequent evaluation of hotspots as it results in progressive concentration of sampling into areas of high disease prevalence.
- Minimum distance batch adaptive sampling results in more efficient mapping of malaria disease prevalence.

References