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# Challenges for modelling spatio-temporal variations of malaria risk in Malawi

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Malaria is the leading cause of morbidity and mortality in Malawi with more than 6 million episodes reported each year. Malaria poses a huge economic burden to Malawi in terms of the direct cost of treating malaria patients and also indirect costs resulting from workdays lost in agriculture and industry and absenteeism from school. Malawi implements malaria control activities within the Roll Back Malaria framework, with the objective to provide those most at risk (i.e. children under five years, pregnant woman and individuals with suppressed immune systems) access to personal and community protective measures. However, at present there is no mechanism by which to target the most 'at risk' populations ahead of an impending epidemic. Malaria transmission is influenced by variations in meteorological conditions, which impact the biology of the mosquito and the availability of breeding sites, but also socio-economic conditions such as levels of urbanisation, poverty and education, which influence human vulnerability and vector habitat. The many potential drivers of malaria, both extrinsic, such as climate, and intrinsic, such as population immunity are often difficult to disentangle. This presents a challenge for modelling of malaria risk in space and time.

Using an age-stratified spatio-temporal dataset of malaria cases at the district level from July 2004 – June 2011, we use a spatio-temporal modelling framework to model variations in malaria risk in Malawi. Climatic and topographic variations are accounted for using an interpolation method to relate gridded products to administrative districts. District level data is tested in the model to account for confounding factors, including the proportion of the population living in urban areas; residing in traditional housing; with no toilet facilities; who do not attend school, etc, the number of health facilities per population and yearly estimates of insecticide-treated mosquito net distribution. In order to account for the unobserved confounding factors that influence malaria, which are not accounted for using measured covariates, a negative binomial generalised linear mixed model (GLMM) is adopted, which includes structured and unstructured spatial and temporal random effects. The parameters in this spatio-temporal Bayesian hierarchical model are estimated using Markov Chain Monte Carlo (MCMC). This allows posterior predictive distributions for disease risk to be derived for each spatial location and time period. A novel visualisation technique is then used to display seasonal probabilistic forecasts of malaria risk, derived from the developed model using pre-defined risk category thresholds, on a map. This technique allows decision makers to identify areas where the model predicts with certainty a particular malaria risk category (high, medium or low); in order to effectively target limited resources to those districts most at risk for a given season.