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Communicating probabilistic climate-sensitive disease risk forecasts

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The transmission of many infectious diseases can be affected by weather and climate variability, particularly for diseases spread by arthropod vectors such as malaria and dengue. Previous epidemiological studies have demonstrated statistically significant associations between the incidence of certain infectious diseases and climate variability, and have highlighted the potential for developing climate-based early warning systems for disease epidemics. To establish how much variation in disease risk can be attributed to climatic conditions, non-climatic confounding factors should also be considered in the model parameterization to avoid reporting misleading climate-disease associations. This issue is sometimes overlooked in climate related disease studies. Due to the lack of spatial resolution and/or the capability to predict future disease risk (e.g. several months ahead), some previous models are of limited value for public health decision making. This paper proposes a framework to model spatio-temporal variation in disease risk using both climate and non-climate information. The framework is developed in the context of dengue fever in South East Brazil. Dengue is currently one of the most important emerging tropical diseases and dengue epidemics impact heavily on Brazilian public health services. A negative binomial generalised linear mixed model (GLMM) is adopted which makes allowances for unobserved confounding factors by including structured and unstructured spatial and temporal random effects. The model successfully accounts for the large amount of overdispersion found in disease counts. 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 (month/season). Given decision and epidemic thresholds, probabilistic forecasts can be issued, which are useful for developing epidemic early warning systems. A novel visualisation technique is presented and used to communicate ternary probabilistic forecasts for dengue risk using the proposed forecasting system. A comparison is made to a simple model representative of current practice for dengue surveillance in Brazil. For a probability decision threshold of 30% and the pre-defined epidemic threshold of 300 cases per 100,000 inhabitants, successful epidemic alerts would have been issued for 92% of the 54 microregions that experienced high dengue incidence rates in South East Brazil, during February - April 2008. The use of seasonal climate forecasts and previous dengue risk could allow predictions to be made several months ahead of an impending epidemic.