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Incorporating Environmental factors in Modelling Malaria Transmission in under five children in Rural Burkina Faso

Malaria although preventable remains a deadly disease and a serious public health problem worldwide and especially in developing countries. In Burkina Faso it accounts for about 20 % of the under five mortality. The fifth Millennium Development Goal which is reducing infant mortality by two thirds by the year 2015 can only be achieved if mortality due to malaria is significantly reduced. Among other strategies for reducing the malaria burden, the WHO advocates for early detection and treatment particularly among high risk groups. To be effective this approach would require an early warning system which allows the health care system to be well prepared and to allocate scarce resources effectively. Unfortunately such a system is not available at the appropriate scale. This study therefore attempted to fill this gap by developing a malaria transmission model at a local (district) scale using environmental factors. We set out to address the following research questions: i) to what extent do weather conditions at the micro scale level affect malaria transmission among under five children (U5s) in a holo-endemic area? and ii) can malaria be predicted at local scale using weather parameters as a driving force?

The specific objectives were: i) to assess the incidence of *Plasmodium falciparum* infection and clinical malaria among U5s in four different ecological settings in a holo-endemic area, North–West, Burkina Faso; ii) to determine the effect of temperature, rainfall and relative humidity on *Plasmodium falciparum* infection risk among U5s in a holo-endemic area ; iii) to determine the impact of temperature, rainfall on mosquitoes population dynamics in a holo-endemic area; iv) to assess the *Plasmodium falciparum* seasonal transmission pressure among U5s in a holo-endemic area; and v) to develop and validate a dynamic a weather-based model of predicting malaria transmission risk. To address these objectives a population-based prospective cohort study was conducted. A cohort of 867 children aged between 6 and 59 months were recruited through a random selection of their household from three villages (Goni, Cissé and Kodougou) and Nouna town. These children were followed for 12 months (01.12.2003-30.11.2004) over one dry and one rainy season for active parasite detection. The longitudinal study started and ended with a cross-sectional survey. In addition, we assessed prospectively exposure variables such as land cover, meteorological factors (temperature, rainfall, and relative humidity) and mosquitoes bite by means of land-based data collection.

We demonstrated that *Plasmodium falciparum* infection incidence in all the four sites is perennial with high seasonal variation. The transmission peak is in the rainy season. Children in Goni and Kodougou have the highest incidence of *Plasmodium*

falciparum infection. Nouna a semi-urban site has the lowest. In the multivariate model using conventional logistic regression, only children in Kodougou have shown significant increase of odds of *Plasmodium falciparum* infection compared to whose in Nouna. This difference was cancelled out when in a random effects model we took into consideration individual and household levels variation. This suggests that given same conditions (individual and household) the odds of *Plasmodium falciparum* infection are similar in all the sites.

Plasmodium falciparum infection among children is regulated by weather conditions which impact on the malaria vector dynamics. Although all the individual weather parameters (with a lag of one month) have an impact on *Plasmodium falciparum* infection, mean temperature is the best predictor and seems to be the main driver.
Mosquito populations are predominantly *Culex* species caught mainly in the urban site (Nouna). Among the malaria vectors, *An. gambiae* is the most prominent specie. Its population dynamics are highly regulated by temperature and rainfall. Goni due to its ecological setting has the largest vector population.

The transmission pressure (EIR) is as well highly seasonal and varies significantly among sites. It was very high in Goni, due to vector abundance. This situation has led to a high crude incidence of *Plasmodium falciparum* infection. Surprisingly, the transmission pressure was very low in Kodougou despite its proximity to a perennial river.

We were able to develop and test a dynamic model of malaria transmission using the knowledge generated by this comprehensive time series data and the results provided by the different analyses. The dynamic model driven by temperature and rainfall successfully simulated seasonal vector abundance for each site. It also predicted successfully the monthly malaria incidence. However, the model needs to be tested for longer periods since the year in which the data was collected was not an average year in terms of weather parameters.