Malaria Anticipation Project: A predictive malaria early warning system to aid operational planning in Jonglei State, South Sudan

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INTRODUCTION

- Malaria is endemic throughout South Sudan. There are high transmission rates throughout the year, and a seasonal peak usually around September to January. It is one of the leading causes of child mortality in the country.
- Médecins Sans Frontières (MSF) has been working in Lankien for decades. In recent years, there has been years with an unusually high seasonal burden of malaria, leaving health facilities overwhelmed.
- The Malaria Anticipation Project (MAP) was launched in 2021 to see if MSF could predict the timing and intensity of these malaria peaks using machine-leading based predictive models.
- The aim of the project is to **develop an early warning system (EWS) to support the implementation of early/anticipatory action, with the goal of reducing malaria morbidity and mortality.**

WHAT IS EARLY/ANTICIPATORY ACTION?

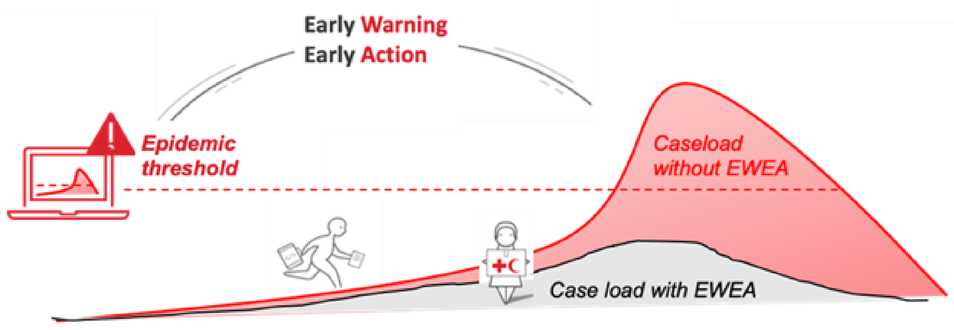

Figure 1: Illustration of the impact of early warning, early action. Source: Red Cross Climate Centre

Anticipatory or early action involves acting before a threat or shock is experienced to reduce the impact on the population.

In the case of malaria these actions could be:

- Implementing prevention activities such as **vector control** or **chemoprevention**
- **Increasing clinical capacity** for diagnosis and treatment
- e.g. increasing health facility bed numbers, implementing community-based malaria points
- **Working with other actors** and advocating for them to scale up their malaria response
- **Disseminating predictions to the community** so they can implement a community-led response.

METHODS

- MSF worked with external company, Arup, to build the predictive models. They were built using routine malaria surveillance data from the MSF Lankien project and different meteorological and environmental variables as inputs.
- Monthly antenatal care (ANC) malaria positivity rate was selected as an input and output as this serves as a proxy for community prevalence. Data was extracted and cleaned from MSF databases and uploaded to the MAP platform manually.
- Meteorological and environmental data was collected from climate and space agencies (Google Earth Engine, Copernicus, NOAA) and was automatically extracted from the internet using APIs.
- Environmental variables were selected as there is a wealth of evidence that shows connection between temperature, rainfall etc with malaria transmission, and because data is available open-access and can be accessed retrospectively.
- 10 years of data (2011-2021) was used - 8 years to train and validate the models and two years as a test dataset in which to compare the predictions with observed ANC prevalence.
- A combination of regression and tree-based models were deployed. A central model prediction and 95% confidence intervals were generated for each lead time (i.e. one month, two months etc before the start of malaria season)
- The predictive models was then integrated into a PowerBI dashboard.

RESULTS

- The predictive models were tested on malaria data (ANC) from the period between January 2019 and July 2022, as if the models had been deployed in January 2019
- During this period 79% of observed malaria prevalence values fall within the estimated 95% confidence interval at a lead time of one month, This increases to 83% at a lead time of 2 months: 70% for lead time 3, but decreases to 54% - 58% at a 4 and 5 month lead times, This indicates a reduction in performance in the models that are predicting at lead times greater than 3 months.
- The models consistently overpredicted the malaria peak in the 2019/2020 season for all lead times. In 2020/2021, the models with lead times of 1-3 months provide good predictions: and for 2021/2022 all models provide good predictions for the magnitude of the expected malaria peak, however there was an atypical smaller peak earlier on in October that the models did not capture.

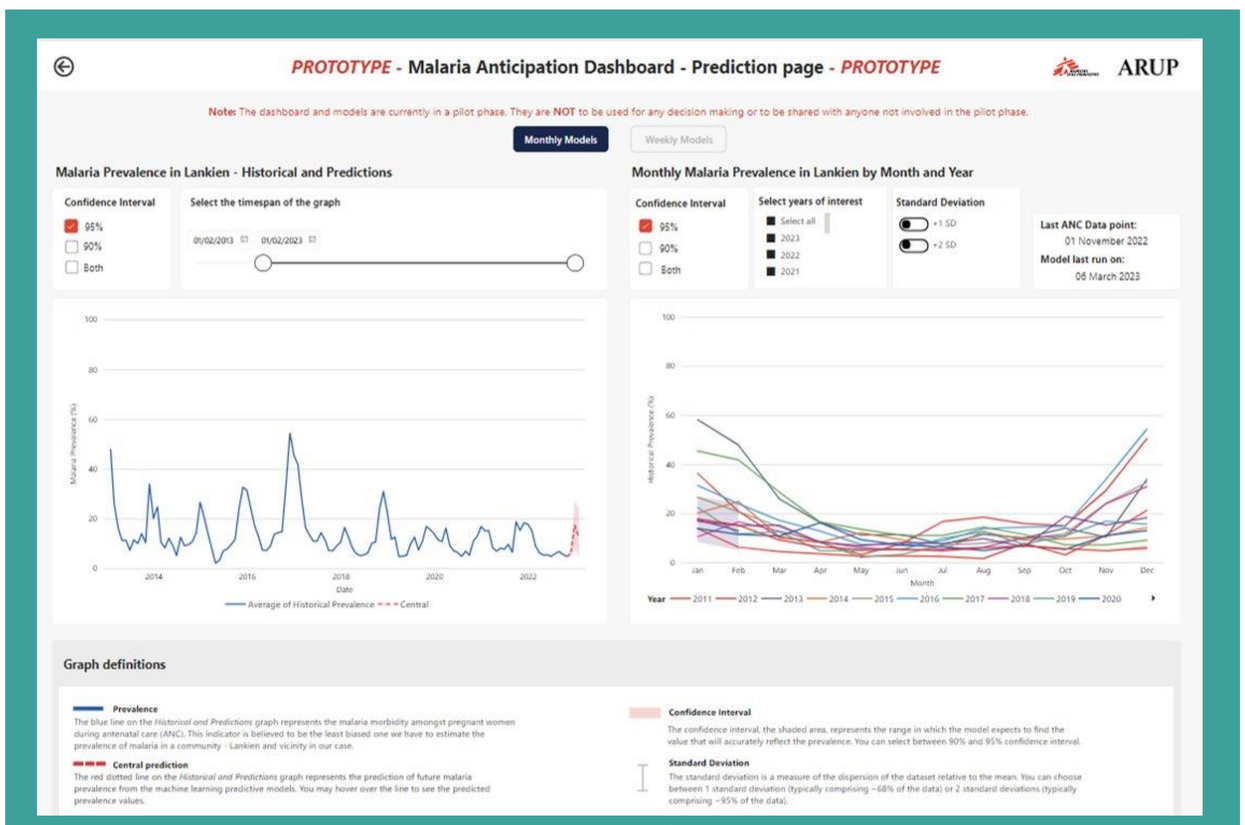

Figure 2: Screenshot of the MAP dashboard

LIMITATIONS

- The models do not incorporate other factors that influence malaria transmission e.g. population movement, moments of conflict, entomology, as there was no clear metric that could be incorporated across the time-series needed to train the models. It is very unlikely that environmental variables alone could explain all variance in malaria prevalence so a social science study is taking place this year to further contextualise the malaria transmission dynamic
- Feedback the MSF team is that models using outpatient (OPD) malaria case count as an input and output would be more useful than ANC positivity rate for operational planning. Models using OPD data have been developed and will be incorporated into the dashboard this year

CONCLUSION

- This state-of-the-art predictive modelling approach has been used for the first time with malaria MSF data. Model performance varies amongst the malaria seasons used to compare the predictions with observed data.
- The shorter the lead time, the better the predictive performance of the models. However, longer lead times give more time for operational planning. How to operationalise the EWS factoring in this uncertainty is being explored with the MSF South Sudan team this year.
- This is the first MSF project to explore early action and the only project we are aware of globally exploring early action for malaria.
- **Moving from real-time surveillance to predictions could bring a paradigm shift in malaria responses: less reactive, more anticipatory planning/responses.**

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