

PREDICTING THE PUBLIC HEALTH IMPACT OF ANOPHELES STEPHENSII INVASION ON THE TRANSMISSION OF FALCIPARUM MALARIA IN ETHIOPIA

Arran Hamlet and Thomas Churcher
with support from Seth Irish, Dereje Dengela, Aklilu
Seyoum, Eric Tongren & Jennifer Armistead

PMI

U.S. PRESIDENT'S
MALARIA INITIATIVE

LED BY



U.S. PRESIDENT'S MALARIA INITIATIVE



*MRC Centre for Global Infectious Disease Analysis, Department of Infectious Disease
Epidemiology, Imperial College London, London, United Kingdom
*arran.hamlet14@imperial.ac.uk

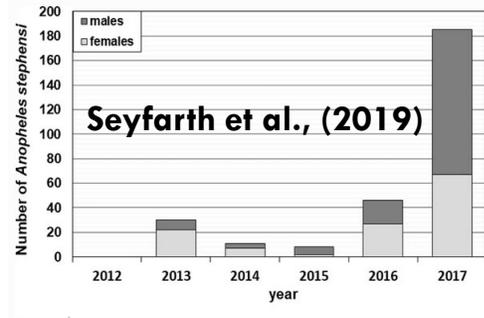
BACKGROUND

Sinka et al., (2020) modelling exercise found high suitability across large parts of Africa, particularly in large cities

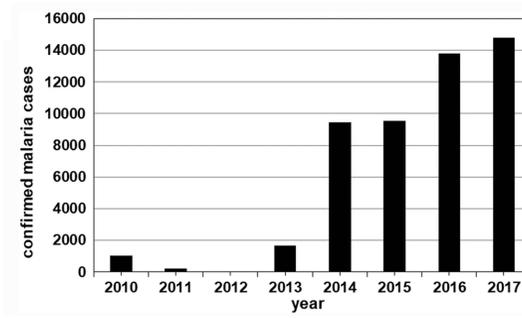
- Primary vector of urban malaria in India

Evidence that *An. stephensi* is playing a role in malaria transmission in Djibouti

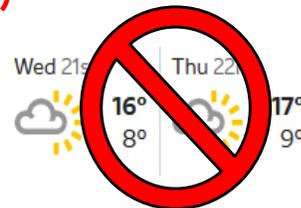
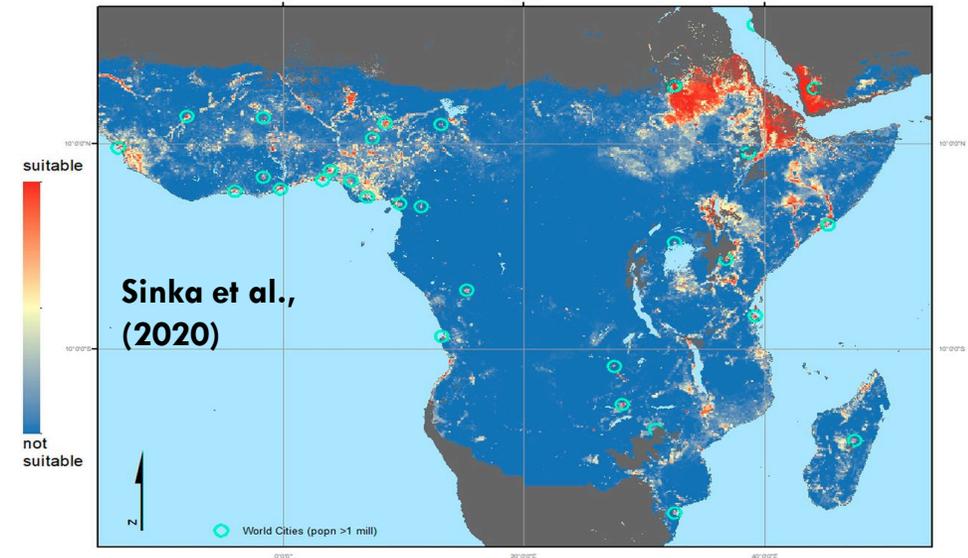
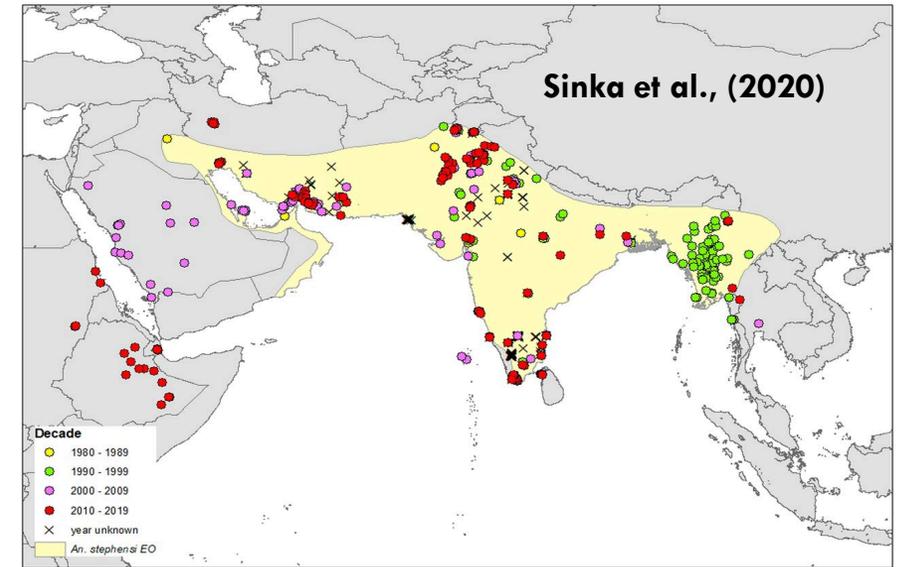
Occurrence of *Anopheles stephensi* in Djibouti City



Annual confirmed malaria cases in Djibouti, MoH



Can we attempt to quantify what has potentially happened in Djibouti in order to project what could happen in Ethiopia?
(not a forecast or prediction of what will happen)



METHOD

Fit deterministic malaria model to Djibouti malaria incidence to produce estimates of vector density

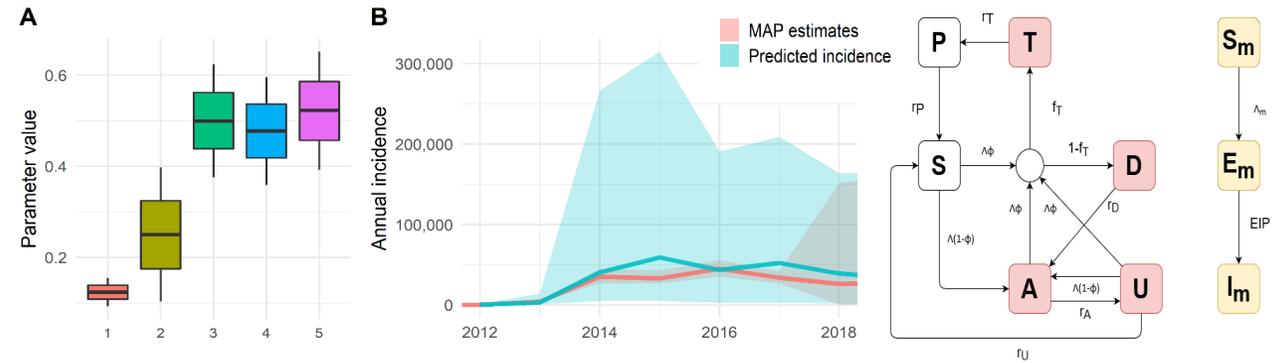
- <https://github.com/mrc-ide/deterministic-malaria-model>
 - (Griffin et al., 2014, Challenger et al., 2021, Griffin et al., 2010, White et al., 2011,
- Multiple runs to account for uncertainty in mosquito bionomics. Daily mortality (1), Anthropophagy (2), Endophily (3), Proportion of bites taken indoors (4) and in bed (potentially protected by a bednet) (5)

Extrapolate vector density from Djibouti fitting to Ethiopia to produce predictions of how malaria incidence may change

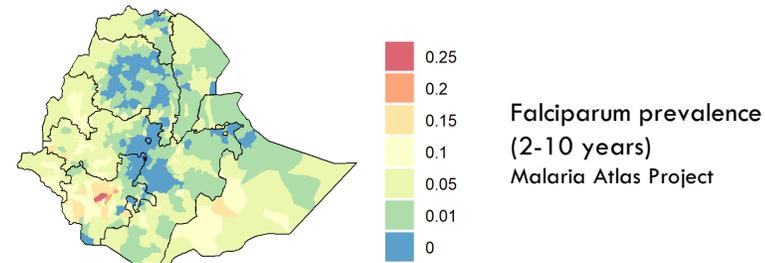
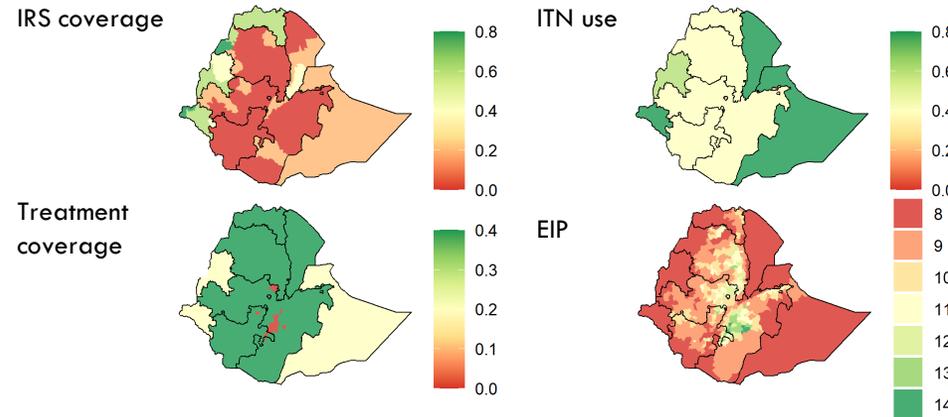
- Account for pre-existing IRS/ITN/treatment/prevalence and temperature dependent EIP

Scale up interventions and apply these to new predictions of malaria transmission

Vector bionomics sampled, fits to Djibouti data and model structure



Incorporated data



Currently being updated with Ethiopian National Control Programme data so estimates will likely change

RESULTS

Huge uncertainty around results

Substantial increases in prevalence across Ethiopia with large amounts of subnational heterogeneity

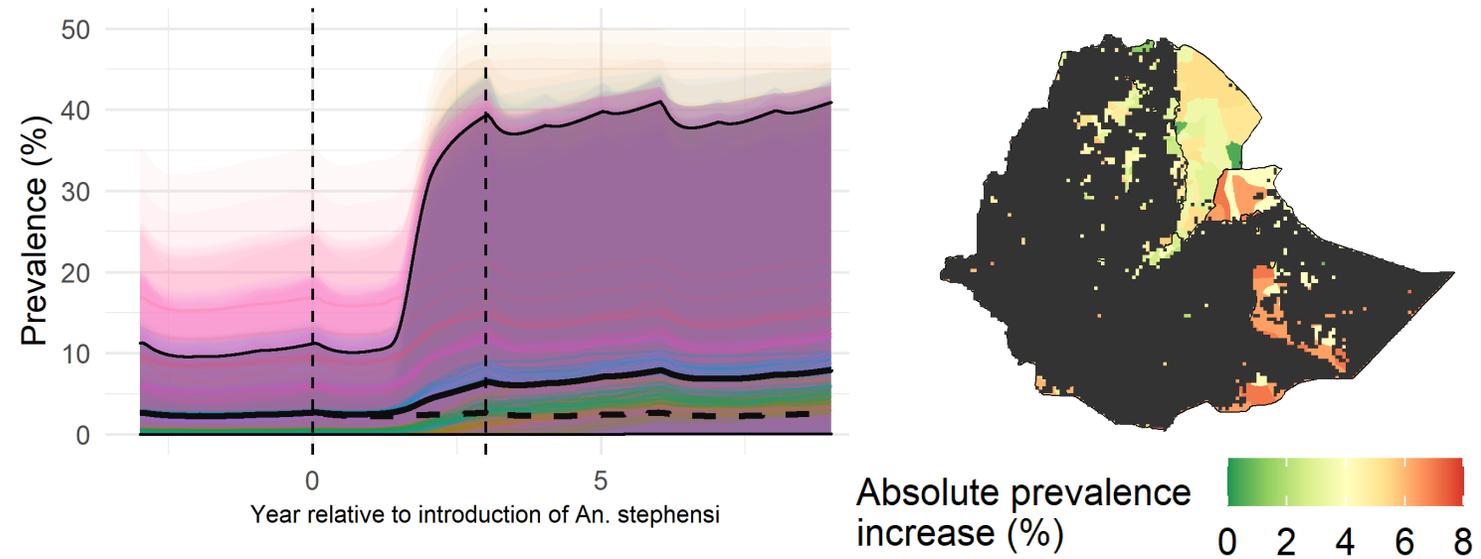
Large increases seen in areas with low existing transmission

- Except those at altitude where low temperatures lead to a high EIP, limiting potential impact

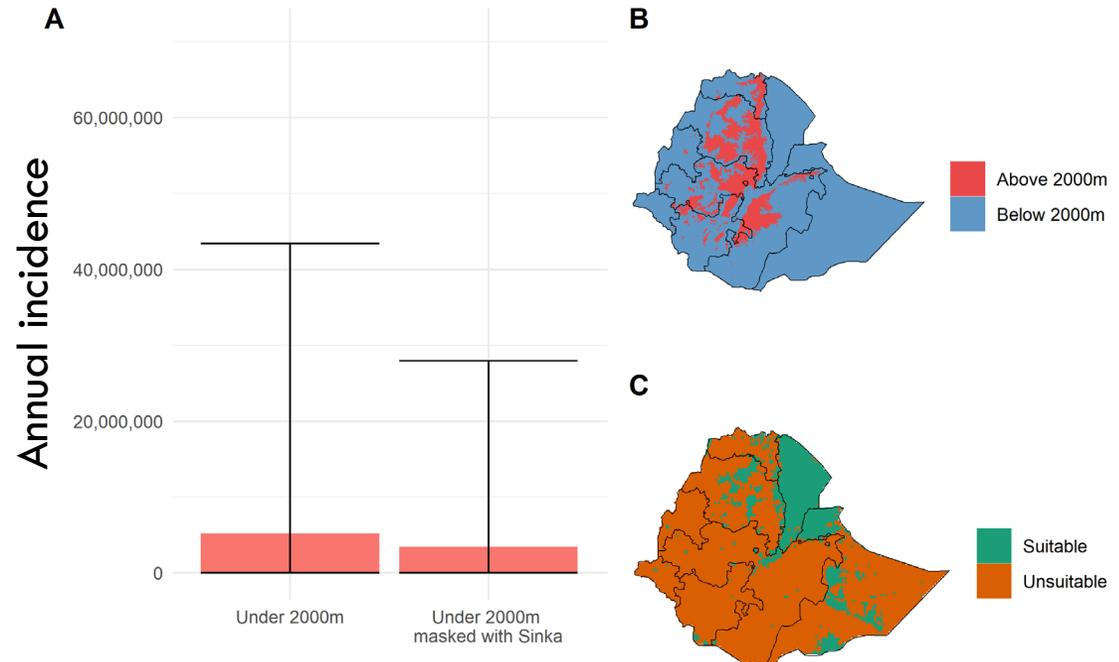
Increase in incidence depends on population expected to be at risk

- **1.0 – 6.1 million additional malaria cases per year (95% CI 0 – 40 million)**
- Currently ~2.1 million cases of falciparum malaria per year in Ethiopia (World Malaria report 2020)

Prevalence increase by administrative grouping



National increase in annual falciparum incidence by population



RESULTS

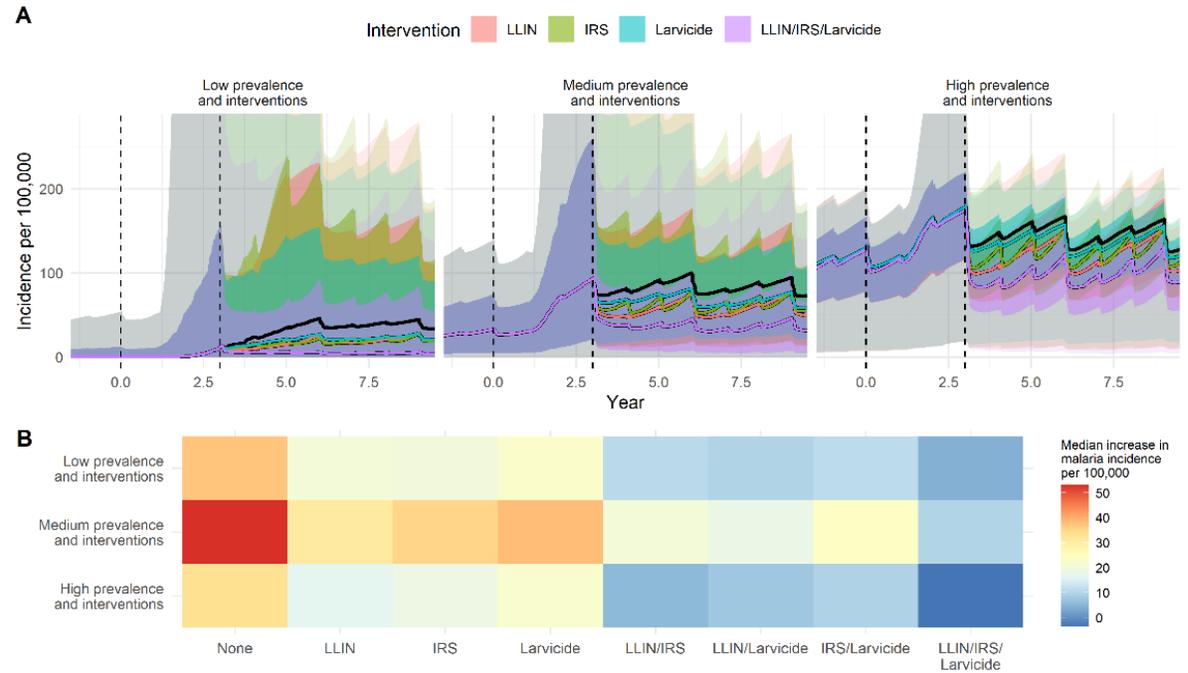
Considered different combinations of interventions at different coverages (0/40/80%)

Pre-existing intervention and transmission important to consider

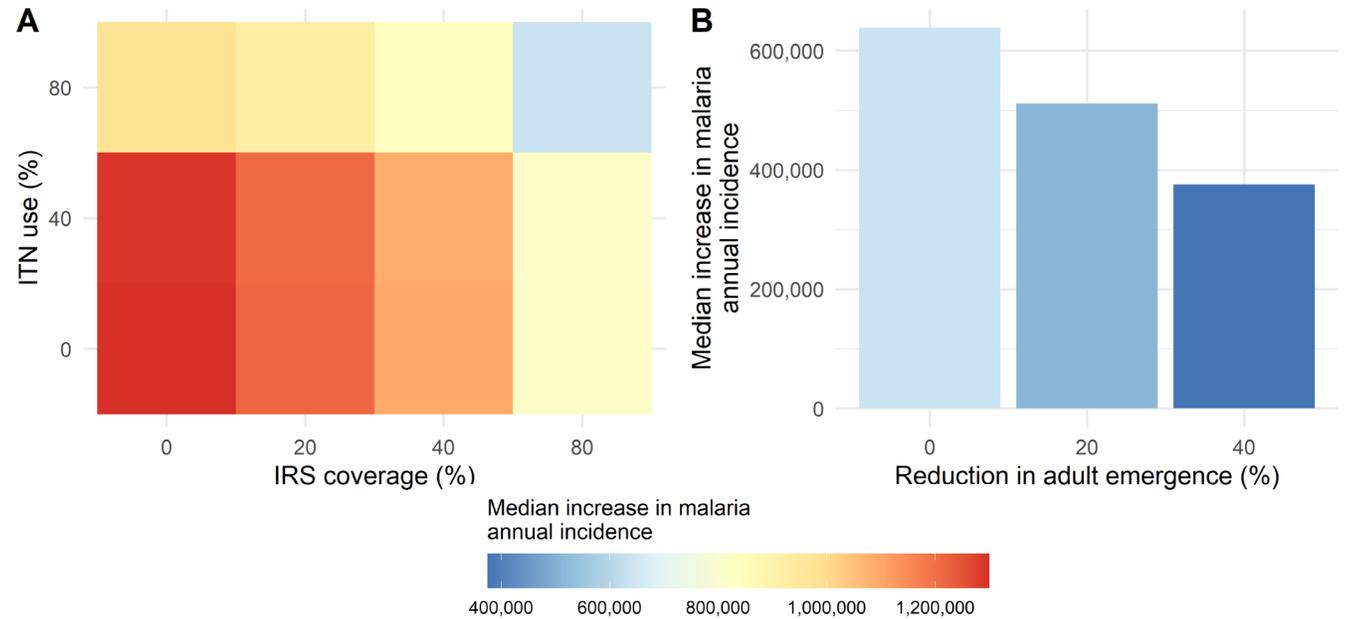
However, in all cases a combination of interventions is needed

Cost of implementing these interventions is substantial, measured in the \$10's – \$100's of millions

Subnational heterogeneity in the impact of interventions



National impact of interventions



CONCLUSION

Large parts of Ethiopia are vulnerable to substantial increases in malaria if *An. stephensi* establishes itself across the country

Huge uncertainty in estimated impact

Large scale up of interventions needed following estimated increases

Additional surveillance and data needed

- This study is a first step of a long process of estimating the impact of *An. stephensi*
- Work estimates large increases, but huge uncertainty around this, in order to improve estimates more data on vector bionomics and the actual impact of stephensi to transmission in Africa needed

Several limitations

- Many assumptions due to limited data
 - These, and the method utilized, lead to huge levels of uncertainty in predictions
- Single vector considered, no accounting for inter-species competition
 - Assuming increase in Djibouti is purely due to stephensi
 - Unknown if stephensi will contribute to malaria transmission in Ethiopia, and invasion dynamics will most likely be different to those in Djibouti
- Invasion dynamics are very simple
 - No accounting of geographic spread or differential suitability in administrative units, no seasonality
 - Invasion and establishment in Ethiopia is likely to be very different to Djibouti, but the absence of data has necessitated assuming it will be the same

Acknowledgements

Seth Irish, Dereje Dengela, Aklilu Seyoum, Eric Tongren & Jennifer Armistead

Imperial team – Tom Churcher

Funders/collaborators

- PMI/Vector-link/Ethiopian National Malaria Programme
- CEASE group
 - control the spread of *Anopheles stephensi* in Ethiopia and Sudan