Modelling the Impact of Effective Malaria Vaccination on Child Mortality in Ugandan Children Under 5 Years Old.

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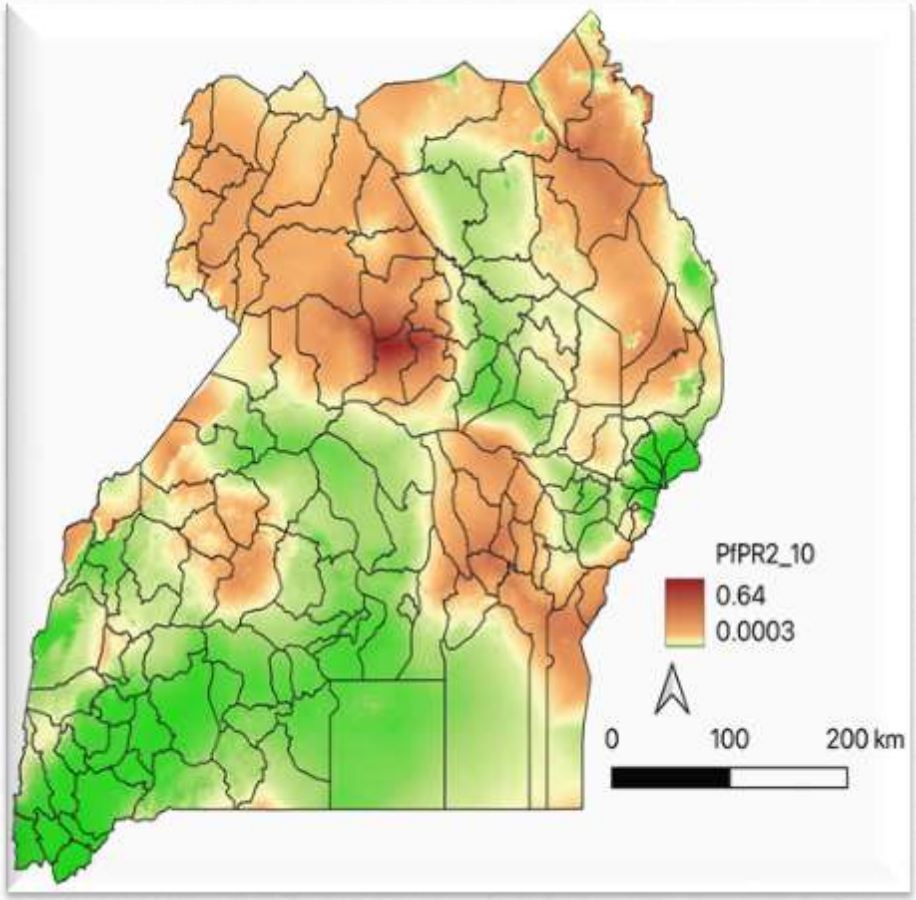
Agent-Based Modeling

Introduction

- In 2022, there were an estimated 249 million malaria cases globally, an increase of 5 million cases compared with 2021 [1].
- Uganda, HBHI country, contributed ~5% of the global malaria burden.
- Vaccines which are said to be the most effective way to avert many deaths and disease severity may reduce this burden.
- To guide the deployment of interventions including vaccines, the country has been stratified into three strata namely
    1) Very-low burden area (<2% malaria prevalence) about 2.4% of the population;
    2) Urban cities (6.2m; 14.4% of the total population)
    3) High burden (rest of the country) areas.



Malaria prevalence map in 2020

Research aim, and model assumptions

Research question

What vaccination coverage target for malaria is needed to achieve a 90% reduction in child mortality in Uganda, in line with the 2030, WHO mortality reduction strategy

Aim

To investigate the implementation of a vaccination intervention aligned with the World Health Organization's target of reducing mortality rates by 90%.

Agents:

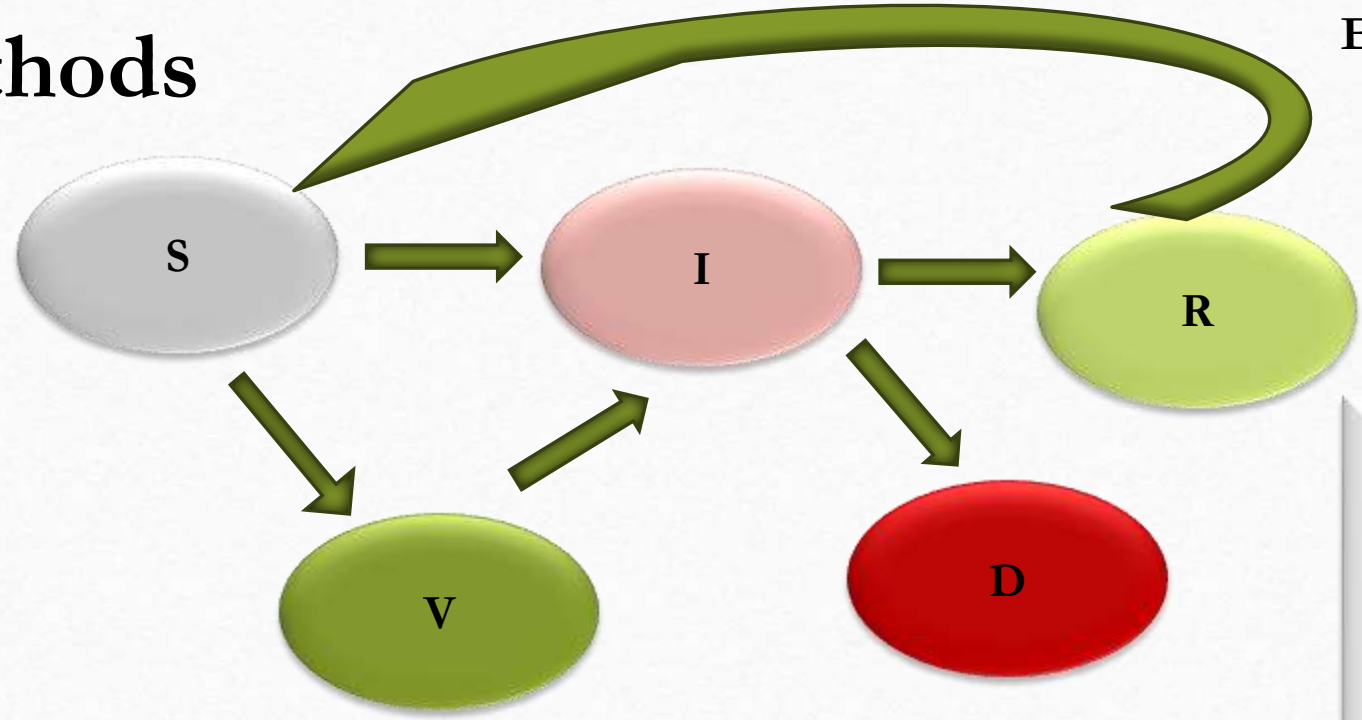
Population: Children under 5 years

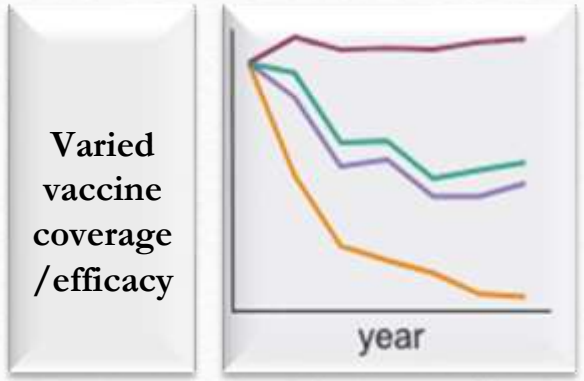
Assumptions made

1. Death rate is constant
2. No recruitment into the population
3. Once a child recovers they become susceptible
4. A proportion of the children is vaccinated
5. The vaccine wanes with time
6. We vaccinate immediately
7. The vaccine efficacy is not at 100%
8. The vaccine and efficacy are varied
9. All deaths are malaria-related

Methods

Extended the SIRS to SVIRD





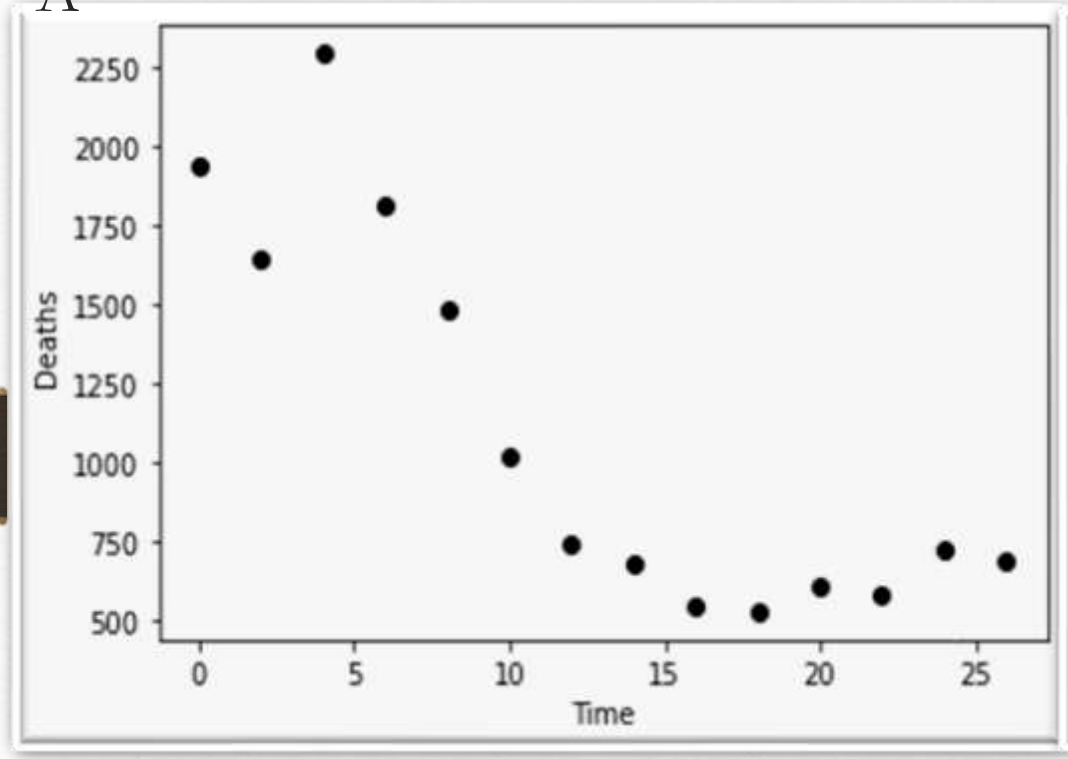
Vaccination rate =?

ABM-Model

Scenarios: Baseline coverage/efficacy
Baseline vs coverage
Coverage ((0.2, 0.4);(0.7,0.7); (0.9,0.9)

Results

A



B

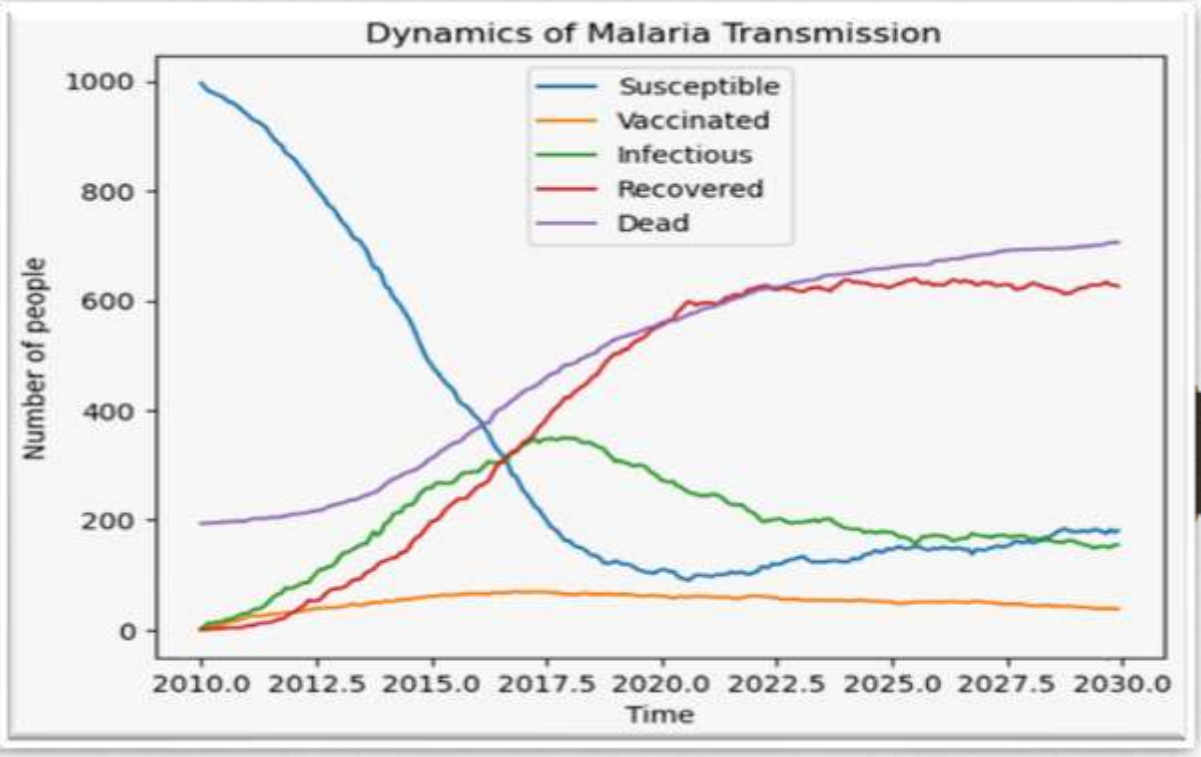
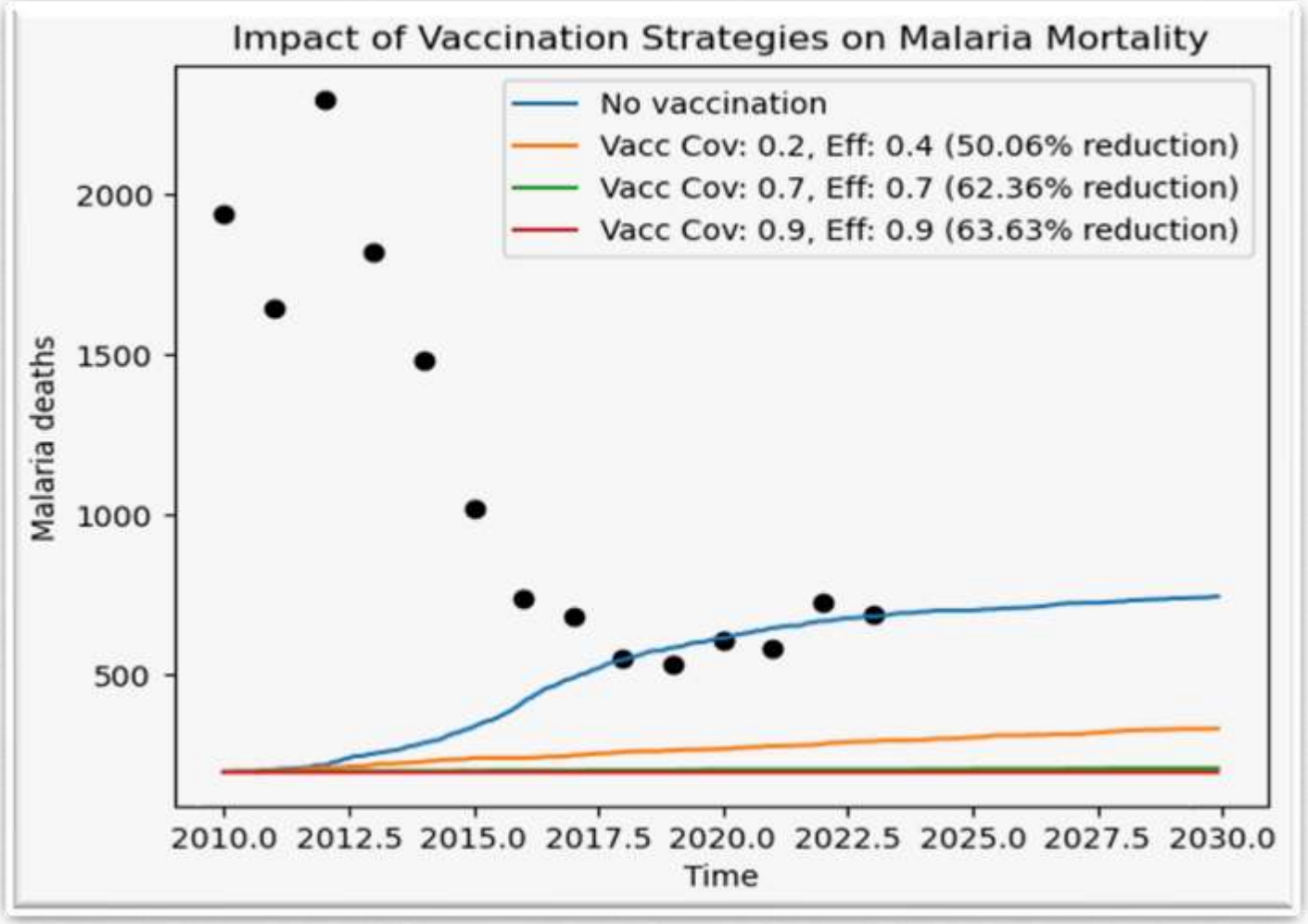


Fig A: Displays the data on malaria child mortality across a period of 14 years

FigB: Illustrates the dynamics of malaria transmission in the study population (The recovered become susceptible, and the vaccine wanes with time)

Results



The figure shows how the child mortality rate varies with differences in vaccine coverage and efficacy.

Discussions

- Our findings align with other studies that have shown that increasing coverage – averts mortality in children under 5 as shown in the GAVI supported countries [2].
- Significant progresses (62% reduction) made towards achieving the WHO target of a 90% reduction in child mortality by 2030[1].
- The modeling results suggests that Uganda may not fully attain the target solely through vaccination efforts.

Limitations

1. The analysis could be limited by simplifications in the simulation model and data
2. We did not include in our model the role of the mosquito vector and other intervention strategies
3. Uncertainties exist regarding assumptions about intervention effectiveness and coverage.
4. Further research and data are needed to inform the implementation of integrated malaria control strategies effectively.

Conclusions and recommendation

Increasing malaria vaccine coverage, as well as vaccine efficacy, will decrease child mortality cases due to malaria.

As a recommendation, a holistic approach that includes other interventions such as sleeping under mosquito nets, chemoprophylaxis, education, indoor residual spraying(IRS) e.tc are crucial for comprehensive malaria control and the achievement of the WHO target of 90% reduction in child mortality in Uganda.

For future work: Refine our model to include environmental factors, vector and host dynamics.

References

1. The World Malaria 2023 Repott https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2023

1. Zhang H, Patenaude B, Zhang H, Jit M, Fang H. Global vaccine coverage and childhood survival estimates: 1990-2019. Bull World Health Organ. 2024 Apr 1;102(4):276-287. doi: 10.2471/BLT.23.290129. Epub 2024 Feb 29. PMID: 38562199; PMCID: PMC10976869.

ABM-01 cohort

Asanteni sana

African Population and Health Research Center

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