Report

Simulation of Intervention in Tanga, Tanzania using OpenMalaria.

Emmanuel Kirui BARKACHA & Détagnon Bernic GBAGUIDI

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Introduction

Tanga Region, known as Mkoa wa Tanga in Swahili, stands as one of Tanzania's 31 administrative regions, encompassing an expanse of 26,667 km^2. Its vastness is akin to the entirety of Burundi's landmass. The regional hub lies within the confines of Tanga city municipality. Nestled in the northeastern reaches of Tanzania, it shares borders with Kenya and Kilimanjaro Region to the north, Manyara Region to the west, and Morogoro and Pwani Regions to the south. To the east, it meets the Indian Ocean coastline. As per the 2022 national census, the region was home to a populace of 2,615,597.

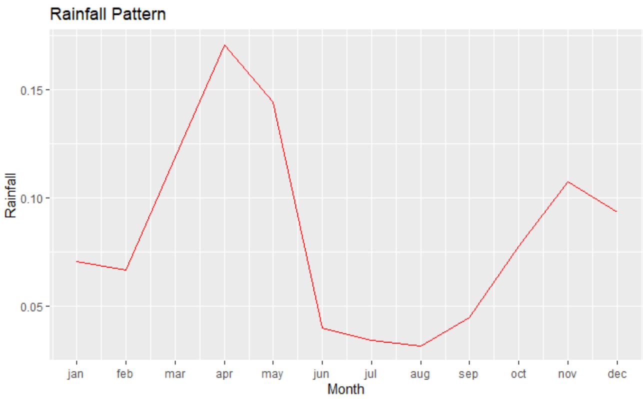
Tanzania grapples with malaria as an endemic challenge, particularly evident in regions like Tanga, where malaria dynamics are pronounced. In 2022, the region reported 7,959,890 malaria cases, with a 4% prevalence among children under five years old. Despite the Tanzanian government's implementation of various anti-malaria strategies, the disease persists as a significant obstacle. Today, modeling stands out as an emerging approach to combat malaria. In this study, utilizing OpenMalaria, we aim to analyze the situation in the Tanga region and propose recommendations for future strategies.

1. Methods

a. Parameters

From the literature , we obtained some useful paramters for our analysis. Mainly there are :

- Proportion of children with fever who were treated with an ACT (54.07%)
- Prevalence of malaria in children (4.0%)
- Rainfall Pattern:



- Proportion of children under 5 who slept under an ACT (63.4%)
- Coverage of IRS (94.9%)
- BCG vaccine coverage (88%)
- Population in Tanga region in 2022
- Number of total cases in 2022

Let now presents now the main tools we used for our analysis.

b. OpenMalaria and VecNet

- OpenMalaria
  OpenMalaria is an open-source initiative that involves researchers from various fields like epidemiology, biology, mathematics, and computer science. By using computational models, OpenMalaria aims to better understand the dynamics of malaria transmission and to evaluate the potential impact of different control strategies, such as vector control measures or vaccination campaigns.
- VecNet
  VecNet that stands for Vector-Born Diseases Network, offers a user-friendly web interface designed for the OpenMalaria model. Through this portal, users can generate simulations, set environmental parameters, and investigate the impact of various interventions such as drugs, spraying, and bednets on malaria transmission rates. The model can be seamlessly executed via our high-performance cluster directly from the web interface. Additionally, users can conveniently visualize the model output or download it for in-depth analysis and processing.

In our analysis we focused mainly on four intervention and all combinations we can make with them. The four mains intervention are: An improvement in access to treatment, Distribution of bed nets, Spraying of indoor residuals (IRS) and Vaccine. All of this leads to 16 scenarios we will simulate through VecNet.

In our work firstly, we calibrated a baseline model on VecNet, that is, from a standard model we found the entomological inoculation rate (EIR) that match the prevalence among children under five-year-old in Tanga region (8.0 average EIR) in 2022 by assuming that the entomological inoculation rate has the same pattern as the rainfall. Secondly using this baseline model, we simulated the 16 scenarios that show the impact for these interventions from 2025 to 2030.

The output of theses scenarios has been analysed using excel and R. Let now present how we investigate about the cost-effectiveness of these scenarios.

- Cost-effectiveness

For the cost-effectiveness analysis the following table has been given to us.

Interventions	Unit costs	Coverage	Duration
Improvement in access to treatment.	• 1 USD for uncomplicated • 28 USD for severe	Increase in the percentage of fevers treated of 20% from the baseline.	2025-2030
Distribution of bed nets (LLIN)	• 2 USD per person protected	63.4%	2025 and 2028
Spraying of indoor residual insecticide (IRS)	• 3 USD per person protected	94.9%	2025-2030
Vaccine	• 50 USD per child vaccinated	88.0%	2025-2030

Table 1 Cost,Coverage,Duration per individual intervention

Our main measure for the cost-effectiveness is the Incremental Cost Effectiveness Ratio (ICER)

$$ICER = \frac{Cost\ new\ strategy - Cost\ Baseline}{Impact\ new\ strategy - Impact\ Baseline}$$

2. Results

From our simulations we obtained the incidence predicted by each scenario.

We can see that the incidence decreases significantly for most of the intervention except the intervention with an improvement in access to treatment with ACT.

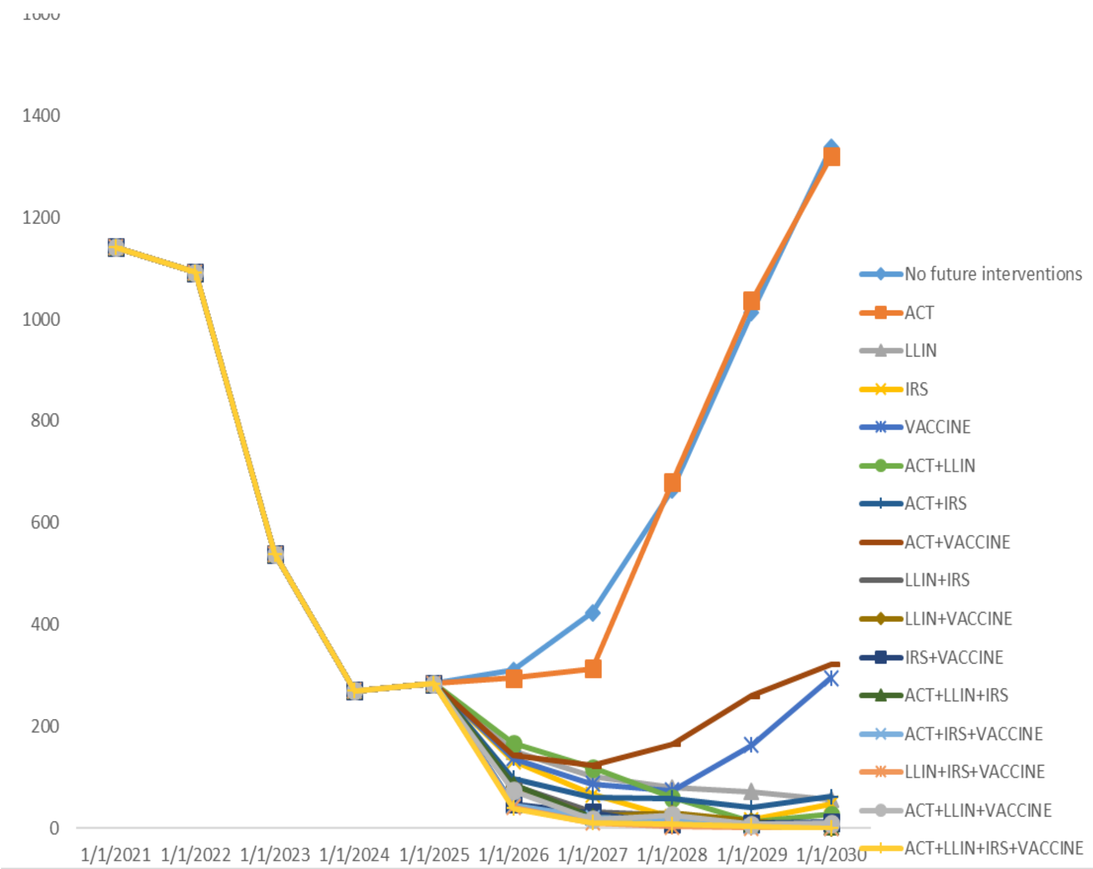


Figure 1: Incidence per scenario

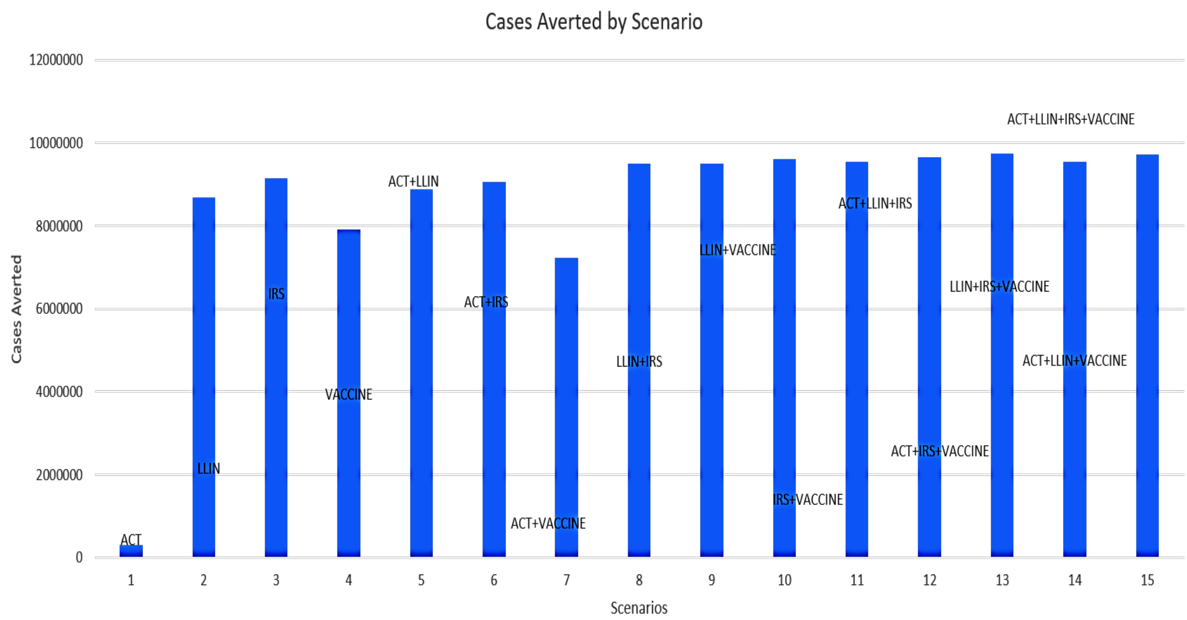


Figure 2: Cases averted per scenario

From this we see that the scenario averting the most cases is the scenario 13: LLIN+IRS+VACCINE and the scenario averting the least cases is the scenario 1: ACT.

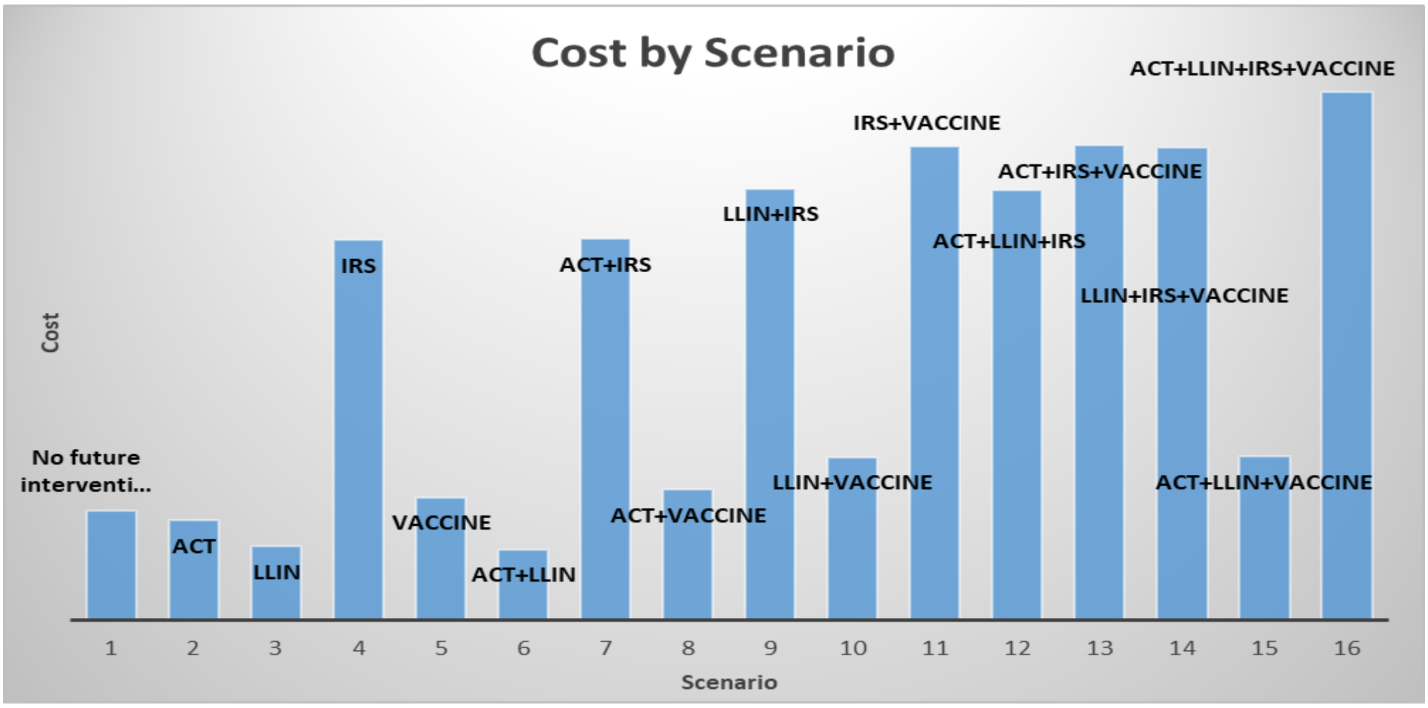


Figure 3 Cost per scenario

We can see that the most expensive single intervention is IRS while the cheapest is LLIN. This implies that all scenario containing IRS is very expensive. We can notice also that ACT+LLIN +VACCINE is relatively cheap but include more interventions.

Combining all above we can plot the cost-effectiveness plan.

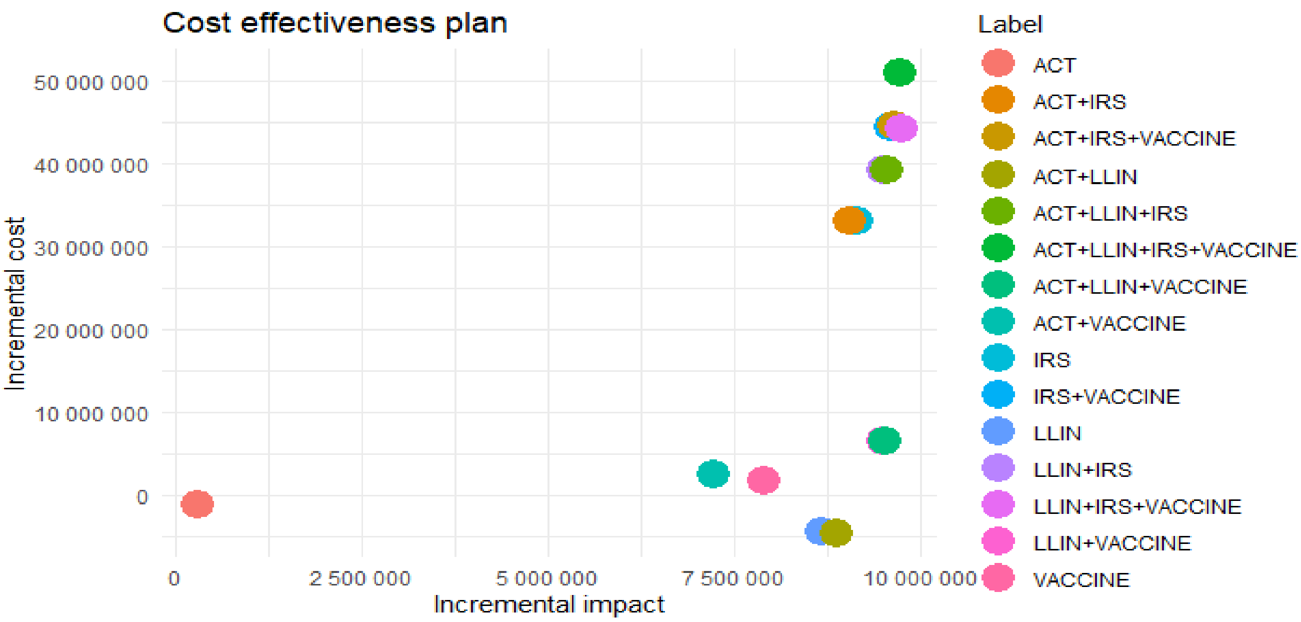


Figure 4: Cost-effectiveness

We can conclude from this figure that ACT is very cheap but less impactful while ACT+LLIN+IRS+VACCINE is very effective but at the same time very expensive. The main conclusion here is that ACT+LLIN is the most cost-effective as it is both cheap and impactful.

3. Discussion and recommendations

We have found that our most cost-effective intervention is the combination of treatment with ACT and use of LLIN which will have an approximate cost of 8.7 million. Now if we had 20% more which will be 10.4 million (red line), we can see from the figure 5 that we will still be able implement the same interventions. Now if we suppose we had 20% less which will be 6.9 million (blue line), we can see from figure 5 that there is no intervention at the moment will be implemented with this budget. Though we can recommend that since LLIN is impactful we can implement it but with a less coverage compared to the initial coverage.

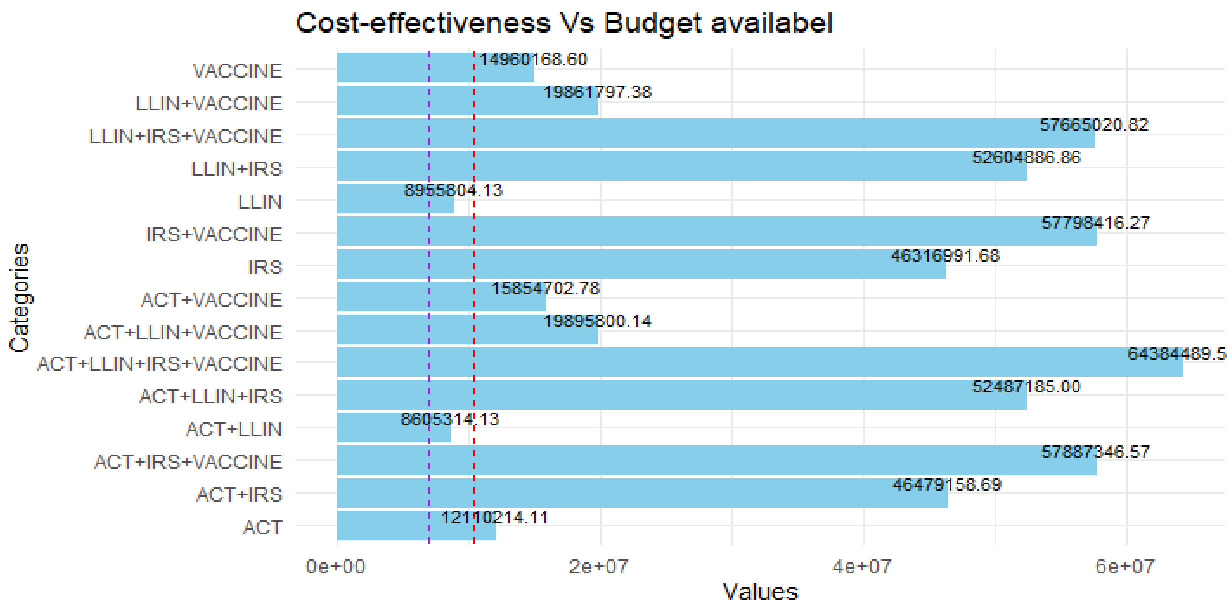


Figure 5 Cost-effectiveness vs Budget available

4. Limitations and Assumptions

The main challenge in modelling is that most of time we made a lot of assumptions. For example, in our work we were constrained to make assumptions like:

- Vaccine coverage for malaria is the same as that of BCG
- IRS coverage in Tanga is the same as national level.
- The entomological inoculation rate (EIR) pattern is the same as the one of rainfall with a lag of one month.

Also because of the stochasticity of the agent-based model of OpenMalaria to have an accurate result, we should run simulation many times and take the average. This obviously required time resources. Our work because of time we just run one simulation.

Another limitation is the lack of automation in running simulation. In our case we run the 16 simulations manually that was a bit challenging as we can easily make a mistake in setting parameters.

5. Acknowledgment

- Demographic and Health Survey and Malaria Indicator Survey (TDHS-MIS) 2022.
- Administrative Units Population Distribution Report 2022.
- End of Spray Report IRS Campaign Tanzania 2022.
- World Malaria Report 2023.
- World Climate- normalized_rainfall_tza_csv.