The Plan:

Part 1: Take a simplified case:

* Strains 1–100: targeted by the vaccine → transmission rate reduced (β\_i ← β\_i × (1 - ε), where ε = vaccine efficacy for strain *i*).
* Strains 101–300: unaffected → β\_i unchanged.

Part 2: Then simulate the superinfection model (11.10) again, but break it into two compartments:

* Group A: vaccine-targeted strains.
* Group B: non-targeted strains.

Part 3: Track dynamics over time:

* Does Group B fill the “ecological gap”?
* Is total prevalence reduced?
* What happens to virulence if Group B is more/less virulent?

# Simplified 2-strain-group model (group A: vaccine-targeted, group B: not targeted)

Lets start with modelling for one strain:

**ChatGPT said:**

Two vaccines against malaria are:

1. **RTS,S/AS01 (Mosquirix)**
   * **Target:** *Plasmodium falciparum*
   * **Approved by:** WHO in 2021 for widespread use in children in sub-Saharan Africa.
   * **Type:** Protein-based vaccine targeting the circumsporozoite protein of the parasite.
2. **R21/Matrix-M**
   * **Target:** *Plasmodium falciparum*
   * **Approved by:** WHO in 2023.
   * **Type:** Similar to RTS,S but designed for higher efficacy and longer-lasting immunity.

Let me know if you want a comparison or more technical details.

**Result**:

* Reduced risk of infection.
* Lower severity of disease if infection does occur.

**🧭 Here’s the journey of the malaria parasite:**

1. **Mosquito bites you** → injects **sporozoites** into your skin.
2. **Sporozoites travel in your blood** for a short time.
3. They go straight to your **liver**.
4. Inside liver cells, they **multiply** a lot.
5. Then they **burst out** of the liver and infect your **red blood cells**.
6. That’s when you start feeling **sick** (fever, chills, etc.).

✅ So the **sporozoite stage** is **before** the parasite reaches your red blood cells or even your liver cells — it’s the **"sneaking in"** stage.

It means that **in clinical trials**, RTS,S reduced **clinical malaria cases** (actual illness with symptoms) by about **30%** over a certain period (usually 1–3 years) **compared to people who didn’t get the vaccine**.

<https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(25)00022-1/fulltext>

**Published Clinical Trials**

* Example: **Phase 3 RTS,S Trial (2015, *The Lancet*)**
* Title: *Efficacy and safety of RTS,S/AS01 malaria vaccine*
* Link (or search): The Lancet or PubMed

<https://pubmed.ncbi.nlm.nih.gov/25913272/>

<https://clinicaltrials.gov/study/NCT00197054?term=RTS,S%20malaria%20vaccine&rank=1&tab=results>

But R21 was built to be:

* **Stronger**
* **Cheaper**
* **Easier to produce in large amounts**
* Possibly more **effective** (70–80% in trials, for a short period)