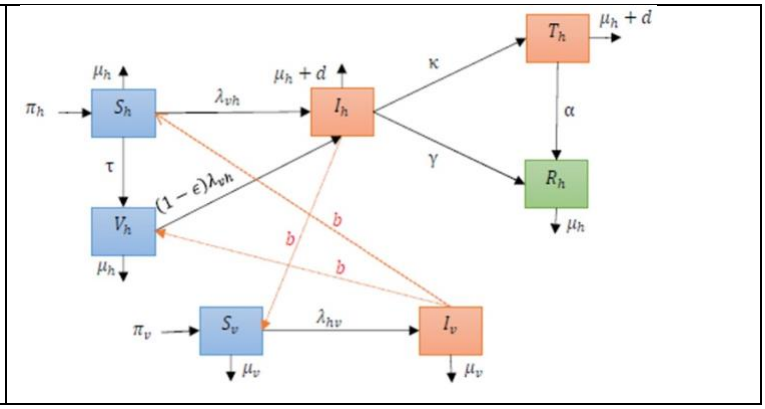
Synergistic Effects of Vaccination and Treatment in Dengue Epidemic Control

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This study focuses on developing an epidemic model to assess the combined effects of vaccination and treatment on dengue transmission dynamics [1].

The proposed compartmental model shown in Figure 1 uses ordinary differential equations to describe the interactions between individuals and mosquito populations [2]. The state variables include susceptible humans (S_h), vaccinated humans (V_h), infected humans (I_h), treated humans (T_h), recovered humans (R_h), susceptible mosquitoes (S_v), and infected mosquitoes (I_v).

- π_h: Recruitment rate of humans
- π_v: Recruitment rate of mosquitoes
- τ: Vaccination rate
- μ_h: Natural mortality rate of humans
- μ_v: Natural mortality rate of mosquitoes
- ϵ: Vaccine efficacy
- γ: Recovery rate for humans
- κ: Treatment rate for infected humans
- α: Recovery rate of treated humans
- δ: Disease-induced mortality rate of humans
- β_{vh}: Probability of mosquito to human transmission per bite
- β_{hv}: Probability of human to mosquito transmission per bite
- N_h: Total human population ($N_h = S_h + V_h + I_h + T_h + R_h$)



The study examines both disease-free and endemic equilibria. The disease-free equilibrium is globally stable when the basic reproduction number is less than one, ensuring dengue eradication under this condition.

When vaccine effectiveness is low, treatment proves more effective in reducing cases. Conversely, a highly effective vaccine significantly decreases dengue incidence on its own. An optimal control problem is formulated to determine the best strategies for using vaccination and treatment. The objective is to minimize the number of infected individuals and the associated costs. The control variables are the rates of vaccination and treatment. The optimal control problem is solved using Pontryagin's Maximum Principle, which provides optimal conditions. Results show that a balanced approach, which adjusts the rates of vaccination and treatment according to the disease dynamics, is the most effective strategy. This approach minimizes the total number of infected individuals and reduces the overall cost of the intervention. The model demonstrates that a comprehensive approach, combining vaccination and treatment, is necessary for effective dengue control. It has implications for resource allocation and prioritization in public health planning. Investments in vaccine development and distribution are crucial. Ensuring high coverage can significantly reduce the burden of dengue. Simultaneously, improving access to treatment can mitigate the severity of outbreaks and prevent complications. It also emphasizes the need for early intervention. Rapid response to outbreaks, with timely vaccination and treatment, can prevent the spread of dengue and protect vulnerable populations. Future work will focus on refining the model to enhance public health outcomes [3-4].

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