At the onset of the rainy season in a village of fifteen thousand people in Sub Saharan Africa, about eight mosquitoes buzz around each person. Twenty five villagers are already infectious with a vector-borne disease, and about twelve percent of the mosquitoes carry the parasite. In humans, the average infectious period is about twenty-five days, after which individuals immediately return to the susceptible class

Mosquitoes live only around fourteen days, bite humans at a rate of 0.3 bites per day, seek hosts at a rate of 0.1, and each bite has a 0.45 probability of transmitting infection from mosquito to human. Records suggest that the transmission rate from infectious humans to mosquitoes is about 0.5.

Once infected, mosquitoes enter a latent period lasting approximately 7 days, during which the parasite develops inside the mosquito but mosquitoes cannot transmit yet. After this latent period, mosquitoes become infectious and remain so until death.

Both the human and mosquito populations are assumed to be closed during the period of analysis.

**Tasks for Participants**

1. **Write the flow diagram of the baseline model (i.e. without interventions**), its assumptions, model parameters and the simulation code.
2. **Simulate the dynamics** of this vector-borne disease over 365 days without interventions.
   1. Calculate the prevalence of the disease in the population at the end of the simulation period?
   2. What is your interpretation of the computed prevalence?
3. **Update the model structure**:

We now consider the following intervention scenarios in the model

1. **Scenario 1: Vector control** — Increases the mortality rate of mosquitoes by 60%. Assume the vector control program has an **annual budget of 80,000 USD** to implement the intervention.
2. **Scenario 2: Treatment** - Reduces the average human infectious period by 40%. About 75% of the infectious population are able to access the treatment and the treatment has an efficacy of 0.9. Assume the **cost of treatment is 15 USD per person treated**.
3. **Scenario 3: Combined intervention** — applying both vector control and treatment simultaneously, with the costs of both interventions considered.
   1. Write the flow diagram for each scenario to include the updated information on the model structure and the proposed intervention. That is, you will include the interventions one at a time, then combine the two interventions.
   2. State the model assumptions.
   3. Could you give an example of an intervention that you know has a similar mode of action to the interventions described here?
4. **Obtain the model parameters of your updated** model structure described in the narrative.
5. **Write the equations of the updated model structure**: Translate the flow diagram into a system of differential equations.
6. **Update the code**: Modify the R code to include the updated model structure.
7. **Quantify intervention impact:** Run simulations for each intervention and in combination and then calculate infections averted compared to the baseline at the end of the simulation period. What is your interpretation of the results.
8. **Cost-effectiveness**: Calculate the cost per case averted for each intervention and in combination compared to the baseline scenario after 365 days? Which scenario gives you better value of money? What is your interpretation of the results*? Hint: use incidence (new infections per unit time) as an epidemiological metric when doing cost effectiveness analysis.*
9. **Optional question:** Groups interested in model fitting or sensitivity analysis should inform us early so we can provide simulated data to fit the human-to-mosquito transmission parameter.
10. **Present your results** on the final day of the course in the following structure.

**Key information to include in your presentation (with visuals):**

* Brief description of the model including the interventions and the assumptions i.e. flow diagrams, equations, submit codes on Github.
* Model parameters.
* Epidemiological output(s) - make sure to include at least one figure showing the epidemic curves for each intervention compared to baseline.
* Costs and Cost effectiveness output(s).
* Discussion of results.
* Your recommendation on which interventions to implement.