**2023 Harvard/University of Global Health Equity**
**Mathematical Modeling for Infectious Disease Planning**

**Modeling COVID-19- Part A**

**Time: 1 hour**

At the end of the activity, you would:

i. understand how different assumptions of transmission affect a model structure

The natural history of COVID-19 can be described by a SLIAR (Susceptible (S)-Latent (L)-Infectious symptomatic (I) -Infectious asymptomatic (A)- Recovered (R)) model, with a mean latent period of 3 days (the duration of the latent period is $1/\alpha$ ) and a mean infectiousness period of 5 days (the duration of the infectiousness period is $1/\gamma$ ). The transmission rate is 0.5 (parameter $\beta$ ). People infected with COVID-19 may be either symptomatic or asymptomatic, with approximately 30% of infections estimated to be asymptomatic (parameter $p$). Asymptomatic and symptomatic individuals recover at the same rate. Asymptomatic individuals are approximately 50% as infectious as symptomatic individuals (parameter $a$).

1. **Without looking at the BM codes**, draw the compartments and write out the equations for this SLIAR model. Use the parameter variables from the prompt (written in parentheses).

2. List two assumptions this model is making other than the ones we provided in the question prompt.

3. How does the waning of COVID-19 infection-driven immunity affect transmission dynamics and burden?

4. Explain why a separate "Pre-symptomatic" compartment may or may not be included in your COVID-19 model structure.

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**Modeling COVID-19- Part B**

**Time: 1 hour 10 minutes**

1) Run the model described in question 1 in **Berkeley Madonna** using a total population of 1,000,000. Start with 1 initial infected individual in each of the latent (L), infectious symptomatic (I), and infectious asymptomatic (A) compartments. Run the simulation for 365 days and a daily time step.
    a. Provide the figure of your simulation curves.

    b. Record the proportion of the population in each compartment (S, L, I, A, R) at the end of the simulation.

    c. On what day (approximately) does the outbreak peak?

    d. Rerun the simulations with the same values. Do your results change? Explain your observation.

    e. Double the transmission coefficient, $\beta$, and rerun your simulation. What changes do you observe? [*Hint: you may compare both simulations based on: i) the proportions of individuals in each health state at the end of the outbreak and, ii) the timing and size of the outbreak peak*]