A Mathematical Model on the Effects of Cultural Practices on HIV Transmission Dynamics in Luo-Nyanza region

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Outline

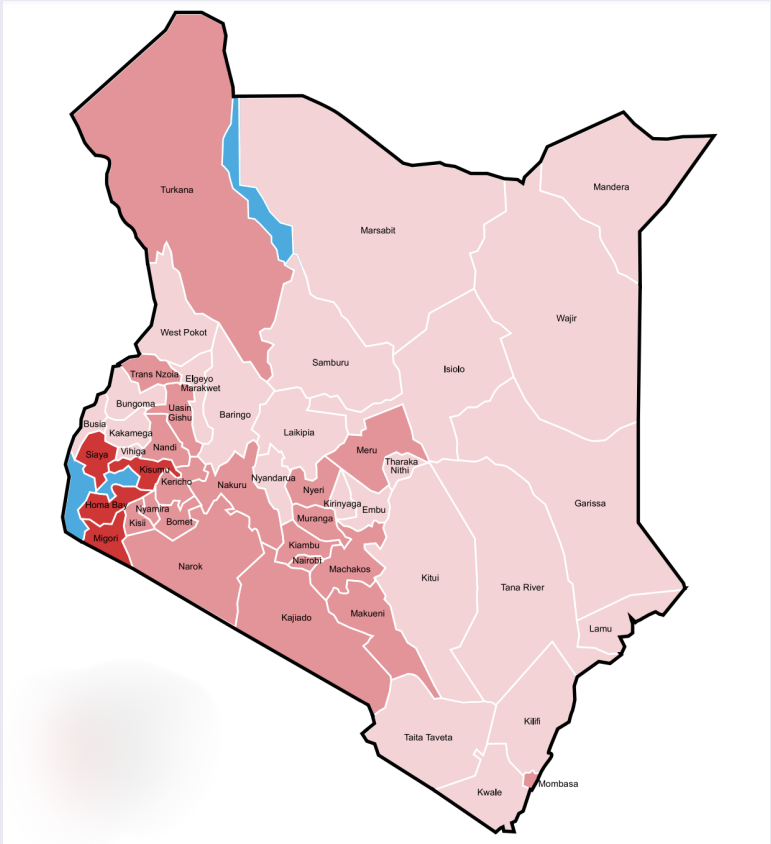
Background

Why HIV?

- The HIV/AIDS epidemic- one of the most pressing global health challenges of our time (Kharsany and Karim, 2016) .
- 38.4 million people worldwide living with HIV at the end of 2021 (Garcia and Guzman, 2021).
- Sub-Saharan Africa bears the heaviest burden of the disease
- Kenya, like many countries in sub-Saharan Africa, grapples with significant HIV infection rates and AIDS-related mortality (van Schalkwyk et al., 2024).
- The Luo-Nyanza region bears a disproportionate burden. Historically, the region has been a hotspot for HIV infection (Gelmon, 2009).

Problem Statement

Kenya Map



Problem Statement

- The Luo-Nyanza region is a culturally rich region. There are cultural practicessuch as widow cleansing, wife inheritance and polygamy .
- It is hypothesized that the unique traditions predispose the region to a higher risk of HIV prevalence (Magadi et al., 2021).
- There are significant medical strides that have been made in HIV prevention and treatment in Luo-Nyanza through various strategies
- However, stigma, poverty, and risky cultural behaviors impede this efforts
- Little mathematical research has been done to assess the extent to which cultural practices affect the transmission dynamics in the Luo-Nyanza region

Research Objective

General Objectives

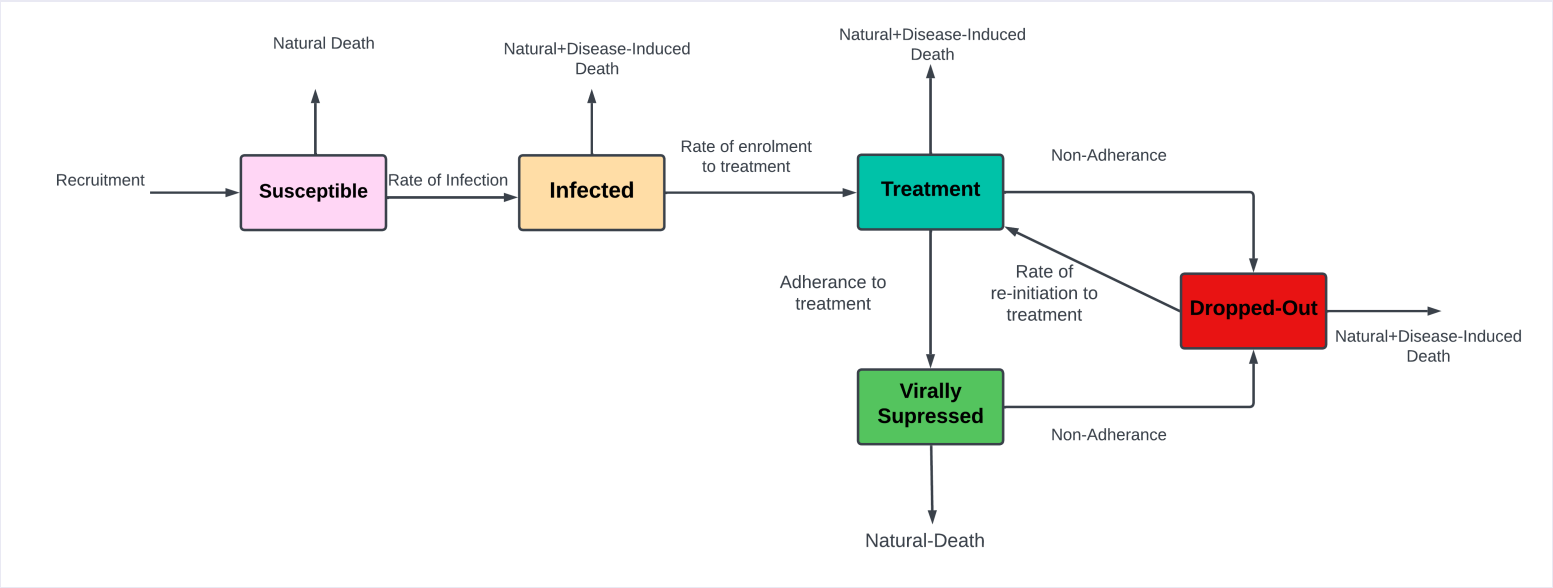
To develop and analyze a mathematical model for HIV transmission that incorporates the effects of cultural practices

Specific Objectives

1. To develop a model for HIV infection incorporating cultural practices in Luo-Nyanza region.
2. To perform mathematical analysis to assess the epidemiological suitability of the parameters.
3. To analyze the compartmental Model to assess how predisposing cultural practices impact HIV transmission dynamics in the Luo-Nyanza region.

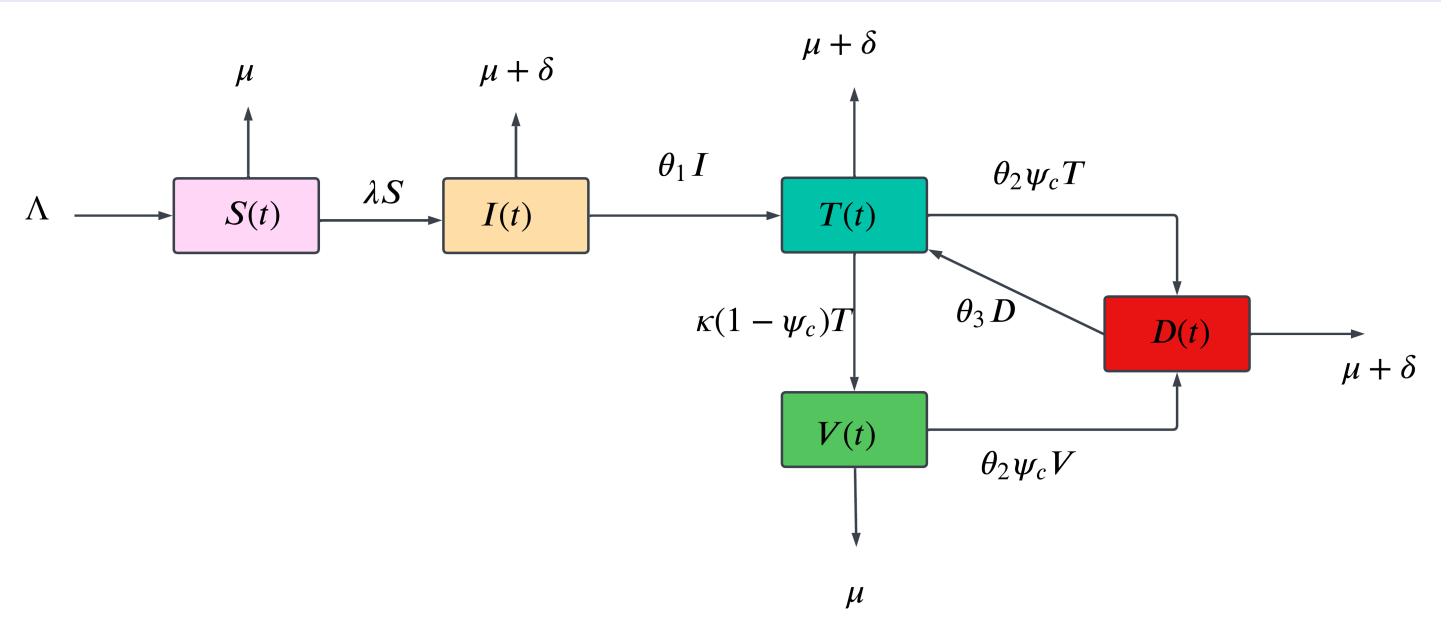
Model Formulation

Parameterized Model



Model Formulation

Non Parameterized Model



Model Formulation

Equations of the Model

$$\begin{aligned}
\frac{dS}{dt} &= \Lambda - (\lambda + \mu)S \\
\frac{dI}{dt} &= \lambda S - (\theta_1 + \mu + \delta)I \\
\frac{dT}{dt} &= \theta_1 I + \theta_3 D - (\theta_2\psi_c + \kappa(1-\psi_c) + \mu + \delta)T \\
\frac{dV}{dt} &= \kappa(1-\psi_c)T - (\theta_2\psi_c + \mu)V \\
\frac{dD}{dt} &= \theta_2\psi_c(T+V) - (\theta_3 + \mu + \delta)D
\end{aligned} \tag{1}$$

Model Formulation

The Infection rate

$$\lambda(t) = \beta(1-\psi_m)\frac{\pi_o I(t) + \pi_1 D(t)}{(1-\psi_c)N(t)} \tag{2}$$

Deterministic Threshold

The Jacobian matrices of $\mathcal{F}(X)$ and $\mathcal{V}(X)$ at the disease free equilibrium E_0

$$\mathcal{F} = \mathcal{F}(E_0) = \begin{bmatrix} \frac{\beta(1-\psi_m)\pi_0}{(1-\psi_c)} & \frac{\beta(1-\psi_m)\pi_1}{(1-\psi_c)} \\ 0 & 0 \end{bmatrix}$$

$$\mathcal{V} = \mathcal{V}(E_0) = \begin{bmatrix} \theta_1 + \mu + \delta & 0 \\ 0 & \theta_3 + \mu + \delta \end{bmatrix}$$

Deterministic Threshold

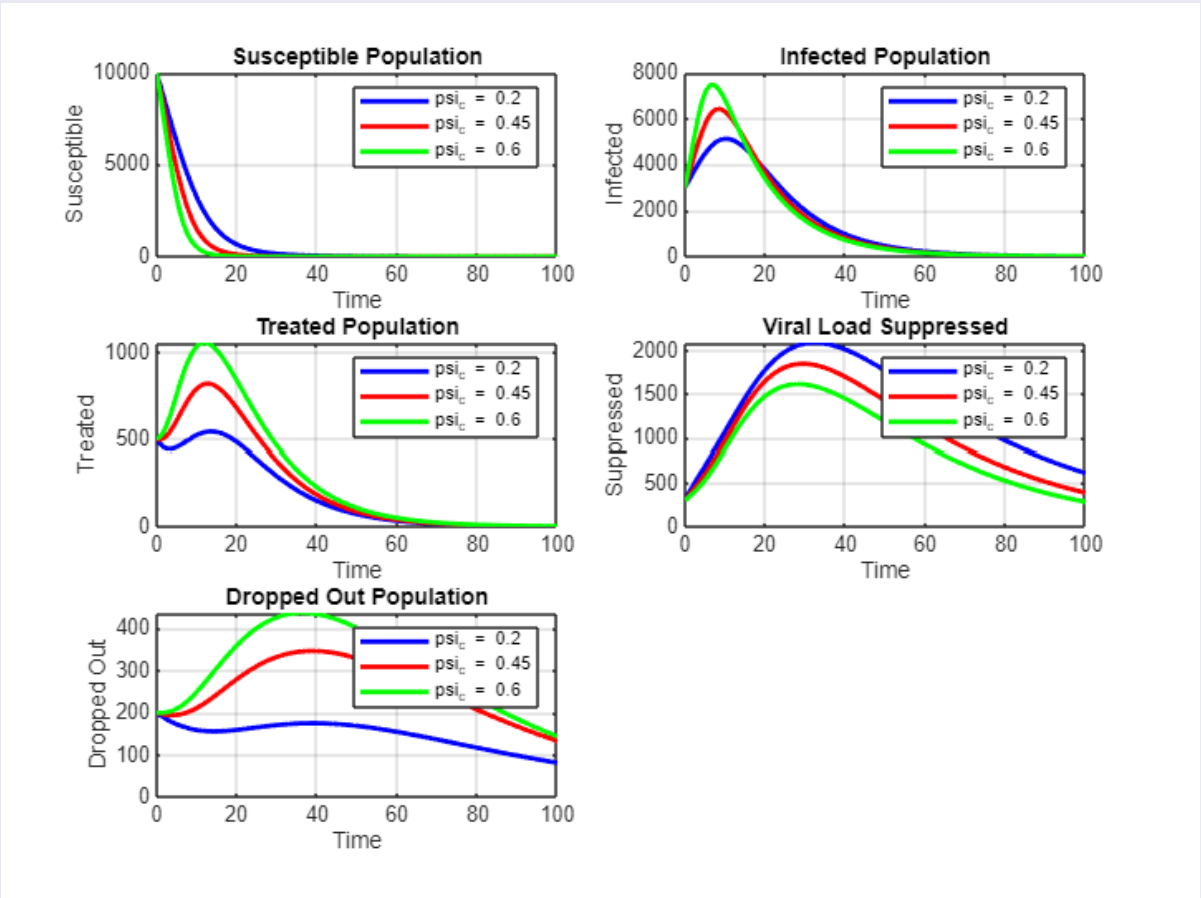
The next generation matrix and R_o

$$R_o = \frac{\beta\pi_0(1-\psi_m)}{(1-\psi_c)(\delta+\theta_1+\mu)} \tag{3}$$

- Viral suppression $\Rightarrow R_o < 1$.
- R_o can be reduced by reducing β , ψ_c , π_o.
- The parameters can be reduced by use of the Therapeutic interventions.
- The parameters can be reduced by use of the Therapeutic intervention and culturally sensitive intervenetion

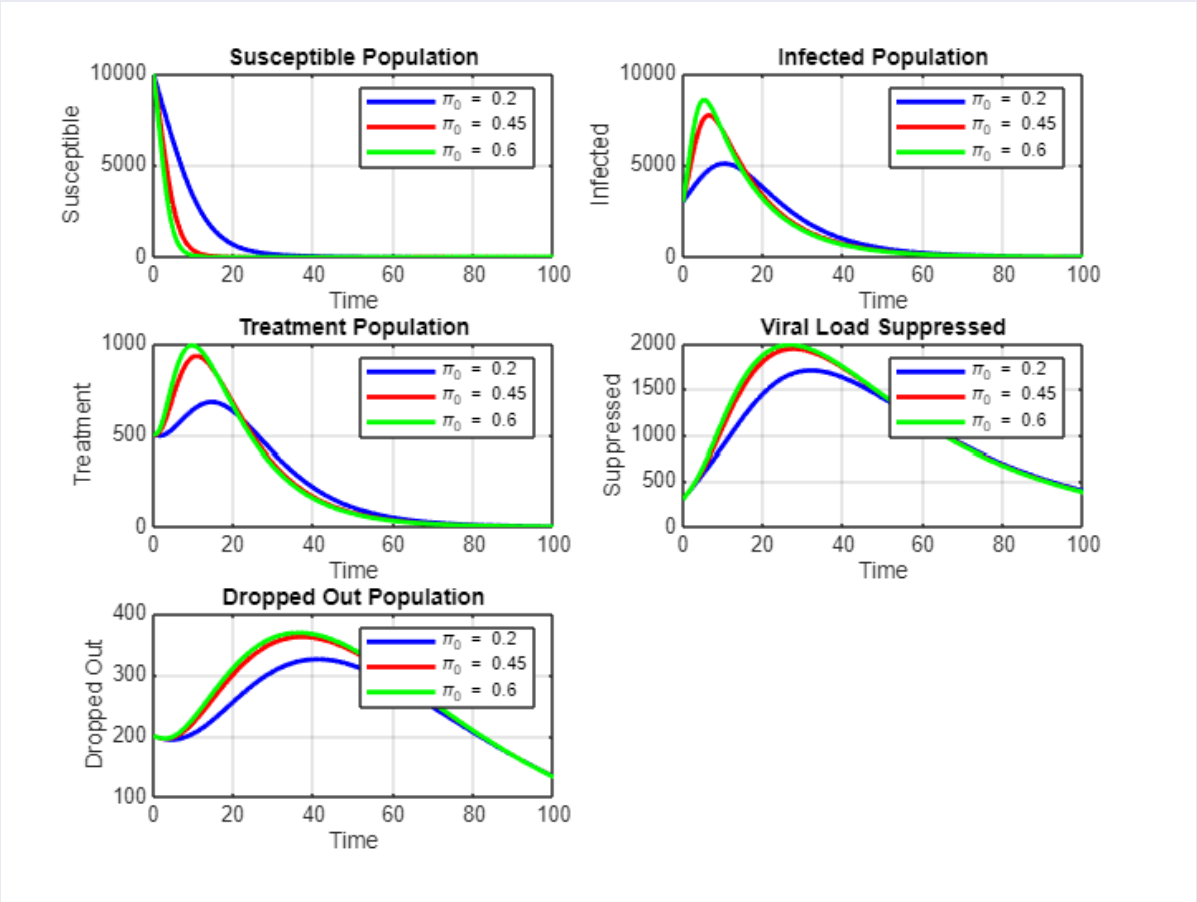
Model Analysis

Effects of cultural practices on the dynamics of system



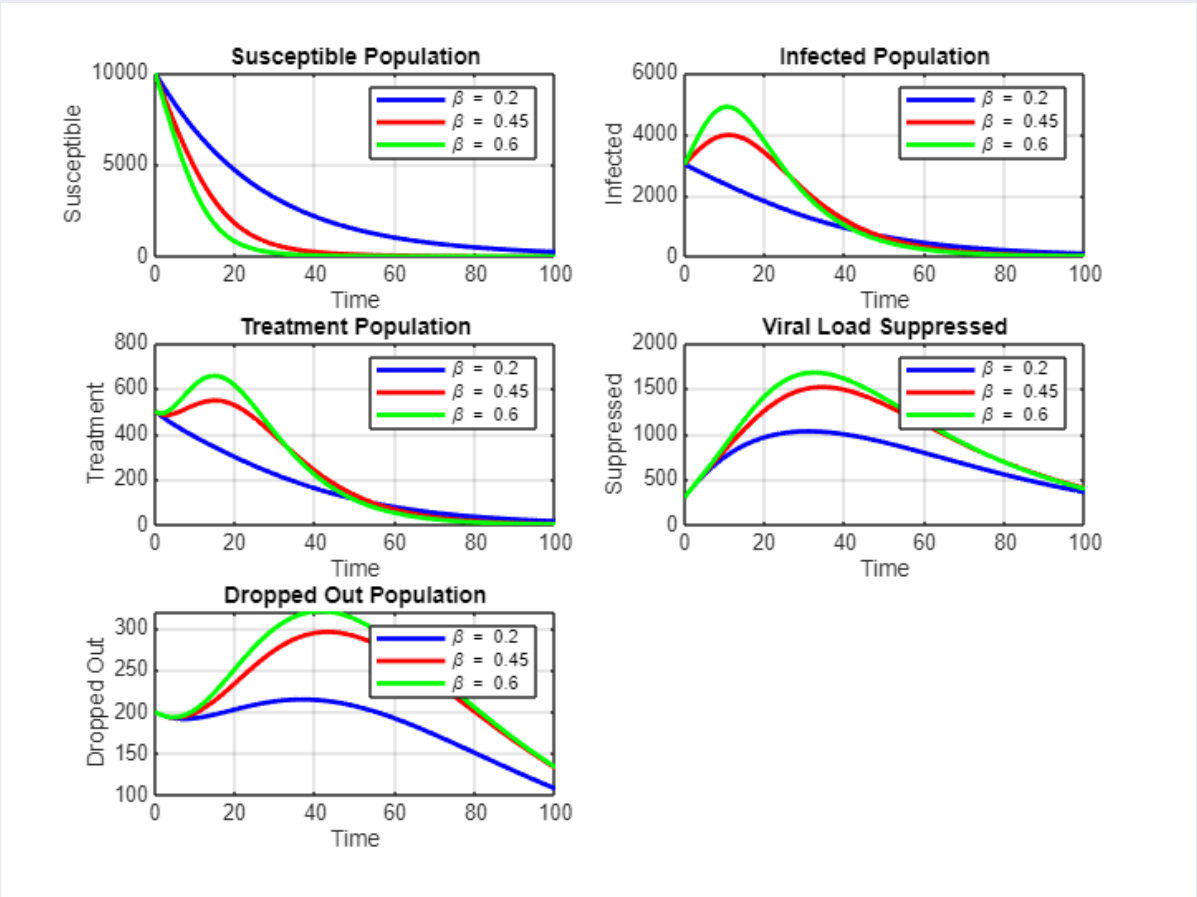
Model Analysis

Effects of infectiousness on the dynamics of system



Model Analysis

Effects of transmission rate on the dynamics of system



Discussion and Recommendation

Discussion

- When ψ_c is set to higher values (e.g., 0.8), the infection spreads much more rapidly through the population. In populations where cultural practices make infection more likely, interventions like treatment and circumcision become less effective.
- A higher π_o leads to a quicker depletion of susceptible individuals and a faster increase in infected individuals, driving the overall spread of the disease.

Discussion and Recommendation

Recommendation

- Public health efforts should focus on mitigating the effects of these parameters by promoting behavioral changes, ensuring wide access to and adherence to ART, and targeting cultural norms that increase transmission. These results highlight the complex interplay of social and biological factors in controlling the spread of infectious diseases like HIV.

End