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Batik Motif of a Mathematical Model for The Spread of HIV/Aids with Education and Art Treatment

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Abstract: Mathematical modeling plays a crucial role in understanding the dynamics of infectious disease transmission, including HIV/AIDS. This study examines a mathematical model of HIV/AIDS spread that incorporates public awareness education and Antiretroviral Therapy (ART) treatment. The proposed model is a modification of the SITA model by adding a compartment of susceptible individuals who are aware of HIV/AIDS transmission risks, along with parameters representing education rate and treatment effectiveness. The analysis focuses on the existence and stability of equilibrium points as well as the basic reproduction number (R_0). The results reveal two equilibrium points: the disease-free and endemic equilibria. The disease-free equilibrium is locally asymptotically stable when $R_0 < 1$, indicating the eventual eradication of the disease, whereas $R_0 > 1$ leads to an endemic state. Numerical simulations confirm that increased education and effective ART treatment significantly reduce the number of infected individuals. These findings highlight the critical role of educational interventions and ART programs in controlling the spread of HIV/AIDS.

Keywords: Mathematical model, HIV/AIDS, ART treatment.

Introduction

Batik is one of Indonesia's cultural heritages that carries profound aesthetic and philosophical values. Each batik motif not only displays visual beauty but also contains symbolic meanings that represent life perspectives, social values, and local wisdom. In its development, batik is not merely understood as an artistic creation but can also be examined through scientific approaches, including mathematical visualization. One innovative approach is to relate batik patterns and motifs to mathematical models, particularly those associated with biological phenomena such as the spread of diseases.

In the field of mathematical biology, mathematical models are used to explain and simulate the dynamics of infectious disease transmission. One widely applied example is the epidemiological model of HIV/AIDS. This model describes the interactions among susceptible, infected, and treated populations, while taking into account educational factors and antiretroviral therapy (ART Treatment). The model developed by Syafi'i, Sabran, and Rianjaya (2023) utilizes systems of differential equations to analyze the stability and dynamics of HIV/AIDS transmission, considering educational and treatment parameters that influence infection rates.

This research is based on the idea that the visual form of such mathematical models can be translated into patterns or batik motifs. The graphical visualization of differential equations describing the interactions among population variables such as susceptible, educated, infected, and treated individuals can produce complex, rhythmic, and aesthetically pleasing patterns. Thus, mathematical modeling not only yields scientific analyses but can also generate new forms of artistic expression based on data and mathematical functions.

The purpose of this study is to construct batik motifs based on graphical visualization and mathematical equations of HIV/AIDS transmission

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with education and ART Treatment. This study seeks to explore the rarely discussed relationship between science and art particularly between mathematics and batik demonstrating that mathematical patterns can be transformed into visual artworks that carry both scientific and aesthetic meaning.

Through this approach, it is expected that a new awareness will emerge: mathematics is not merely a tool for quantitative analysis, but also a creative medium for understanding and communicating complex phenomena in more humanistic and cultural forms. By integrating the mathematical model of HIV/AIDS transmission with the philosophy of batik art, this research opens up a space for interdisciplinary innovation between mathematics, biology, and visual arts, each enriching the other.

Mathematical Model

Before formulating the mathematical model, several assumptions are established to describe the interactions among the population compartments involved in the transmission of HIV/AIDS. The model divides the total population into several groups based on their health status and awareness level regarding HIV/AIDS. Each compartment represents a specific stage of the infection or treatment process, and the transitions between compartments are governed by defined parameters such as recruitment rate, contact rate, treatment rate, and natural death rate. These assumptions are used to construct a system of differential equations that captures the dynamics of HIV/AIDS transmission with both ART treatment and educational interventions. The mathematical model of HIV/AIDS transmission with ART treatment and education in this study is as follows:

$$\frac{dS}{dt} = \Lambda - \beta SI - \alpha S - \mu S$$

$$\frac{dS_e}{dt} = \alpha S - \varepsilon\beta S_e I - \mu S_e \qquad (1)$$

$$\frac{dI}{dt} = \beta I(S + \varepsilon S_e) - \Gamma I - \gamma I - \mu I$$

$$\frac{dT}{dt} = \Gamma I - \sigma T - \mu T$$

$$\frac{dA}{dt} = \gamma I + \sigma T - \delta A - \mu A.$$

The total population in this study is divided into five compartments, namely:

$$N(t) = S(t) + S_e(t) + I(t) + T(t) + A(t).$$

Based on the definition of the equilibrium point, the equilibrium point of the HIV/AIDS transmission model with ART treatment and education in system (2) is obtained when

$$\frac{dS}{dt} = \frac{dS_e}{dt} = \frac{dI}{dt} = \frac{dT}{dt} = \frac{dA}{dt} = 0$$

thus,

$$\Lambda - \beta SI - \alpha S - \mu S = 0 \qquad (2)$$

$$\alpha S - \varepsilon\beta S_e I - \mu S_e = 0 \qquad (3)$$

$$\beta I(S + \varepsilon S_e) - \Gamma I - \gamma I - \mu I = 0 \quad (5) \qquad (4)$$

$$\Gamma I - \sigma T - \mu T = 0 \quad (6) \qquad (5)$$

$$\gamma I + \sigma T - \delta A - \mu A = 0 \quad (7). \qquad (6)$$

Basic Reproduction Number (R_0)

In determining the basic reproduction number (R_0) of system (1), the maximum eigenvalue is obtained using the Next Generation Matrix method. The equations representing the infected cases in system (1) are selected. In this system, the infected subsystems are I, T, A.

$$J(I,T,A) = \begin{bmatrix} \beta\frac{\Lambda}{\alpha+\mu} + \beta\varepsilon\frac{\alpha\Lambda}{\mu(\alpha+\mu)} - (\Gamma+\gamma+\mu) & 0 & 0 \\ \Gamma & -\sigma & 0 \\ \gamma & \sigma & -(\delta+\mu) \end{bmatrix}.$$

The Jacobian matrix (J) is decomposed into $J = F - V$, where F is the transmission matrix and V is the transition matrix, resulting in:

$$F = \begin{bmatrix} \beta\frac{\Lambda}{\alpha+\mu} + \beta\varepsilon\frac{\alpha\Lambda}{\mu(\alpha+\mu)} & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$V = \begin{bmatrix} (\Gamma+\gamma+\mu) & 0 & 0 \\ \Gamma & -\sigma & 0 \\ \gamma & \sigma & -(\delta+\mu) \end{bmatrix}.$$

By determining R_0 using $R_0 = \rho(FV^{-1})$, it is obtained that:

$$\begin{vmatrix} -\dfrac{\beta\frac{\Lambda}{\alpha+\mu} + \beta\varepsilon\frac{\alpha\Lambda}{\mu(\alpha+\mu)}}{(\Gamma+\gamma+\mu)} + \lambda & 0 & 0 \\ 0 & \lambda & 0 \\ 0 & 0 & \lambda \end{vmatrix}$$

thus,

$$\lambda^2\left(-\frac{\beta\frac{\Lambda}{\alpha+\mu} + \beta\varepsilon\frac{\alpha\Lambda}{\mu(\alpha+\mu)}}{(\Gamma+\gamma+\mu)} + \lambda\right) = 0.$$

The eigenvalues obtained are $\lambda_{1,2} = 0$, or

$$\lambda_3 = \frac{\beta\frac{\Lambda}{\alpha+\mu} + \beta\varepsilon\frac{\alpha\Lambda}{\mu(\alpha+\mu)}}{\Gamma+\gamma+\mu}$$

$$= \frac{\beta\Lambda}{(\alpha+\mu)(\Gamma+\gamma+\mu)} + \frac{\beta\varepsilon\alpha\Lambda}{\mu(\alpha+\mu)(\Gamma+\gamma+\mu)}$$

$$= \frac{\beta\Lambda\mu + \beta\varepsilon\alpha\Lambda}{\mu(\alpha+\mu)(\Gamma+\gamma+\mu)}$$

$$= \frac{\beta\Lambda(\mu+\varepsilon\alpha)}{\mu(\alpha+\mu)(\Gamma+\gamma+\mu)}.$$

Since the basic reproduction number is obtained from the spectral radius or the largest eigenvalue, then

$$R_0 = \frac{\beta\Lambda(\mu+\varepsilon\alpha)}{\mu(\alpha+\mu)(\Gamma+\gamma+\mu)}.$$

Based on the value of the basic reproduction number, if $R_0 > 1$ or $\beta\Lambda(\mu+\varepsilon\alpha) > \mu(\alpha+\mu)(\Gamma+\gamma+\mu)$, then an endemic occurs in the population, meaning that the number of infected individuals increases and the disease spreads.

Endemic Equilibrium Point

The endemic equilibrium point is obtained when $I \neq 0$ and $I > 0$, which means that disease transmission occurs within the population. The endemic equilibrium point of system (1) is obtained as follows:

$$E_2(S, S_e, I, T, A) = (S^*, S_e^*, I^*, T^*, A^*)$$

with

$$S^* = \frac{\Lambda}{\beta I^* + \alpha + \mu}$$

$$S_e^* = \frac{\alpha\Lambda}{(\beta I^* + \alpha + \mu)(\varepsilon\beta I^* + \mu)}$$

$$I^* = \frac{-k_2 \pm \sqrt{k_2^2 - 4k_1k_3}}{2k_1}$$

$$T^* = \frac{\Gamma I^*}{\sigma + \mu}$$

$$A^* = \frac{\gamma I^*(\sigma+\mu) + \sigma\Gamma I^*}{(\delta+\mu)(\sigma+\mu)}$$

with

$k_1 = G\varepsilon\beta^2$

$k_2 = G\alpha\varepsilon\beta + G\mu\varepsilon\beta + G\mu\beta + \varepsilon\Lambda\beta^2$

$k_3 = G\alpha\mu + G\mu^2 - \mu\beta\Lambda - \beta\varepsilon\alpha$

$G = (\Gamma + \gamma + \mu)$.

Stability Analysis

The stability analysis of the equilibrium point can be determined by finding the eigenvalues of the Jacobian matrix obtained from the linearization of system (2). The following is the Jacobian matrix resulting from the linearization of the mathematical model of HIV/AIDS transmission with ART treatment and education around the disease-free equilibrium point:

$$J(E_1) = \begin{bmatrix} -\alpha-\mu & 0 & -\beta\left(\frac{\Lambda}{\alpha+\mu}\right) & 0 & 0 \\ \alpha & -\mu & -\varepsilon\beta\left(\frac{\alpha\Lambda}{\mu(\alpha+\mu)}\right) & 0 & 0 \\ 0 & 0 & \beta\left(\frac{\Lambda}{\alpha+\mu}\right) + \beta\varepsilon\left(\frac{\alpha\Lambda}{\mu(\alpha+\mu)}\right) - \Gamma - \gamma - \mu & 0 & 0 \\ 0 & 0 & \Gamma & -\sigma-\mu & 0 \\ 0 & 0 & \gamma & \sigma & -\delta-\mu \end{bmatrix}.$$

The characteristic equation of the Jacobian matrix around E_1 is

$$(-\alpha-\mu-\lambda)(-\mu-\lambda)\left(\beta\left(\frac{\Lambda}{\alpha+\mu}\right) + \varepsilon\beta\left(\frac{\alpha\Lambda}{\mu(\alpha+\mu)}\right) - \Gamma - \gamma - \mu - \lambda\right)(-\sigma-\mu-\lambda)(-\delta-\mu-\lambda) = 0.$$

Based on the characteristic equation, five eigenvalues are obtained, namely

$$\lambda_1 = -(\alpha+\mu), \quad \lambda_2 = -\mu, \quad \lambda_3 = -(\sigma+\mu), \quad \lambda_4 = -(\delta+\mu),$$

$$\lambda_5 = \beta\left(\frac{\Lambda}{\alpha+\mu}\right) + \varepsilon\beta\left(\frac{\alpha\Lambda}{\mu(\alpha+\mu)}\right) - \Gamma - \gamma - \mu.$$

The eigenvalue λ_5 will be negative if $\beta < \frac{(\Gamma+\gamma+\mu)(\alpha\mu+\mu^2)}{\Lambda\mu+\varepsilon\alpha\Lambda}$, thus the equilibrium point E_1 is locally asymptotically stable.

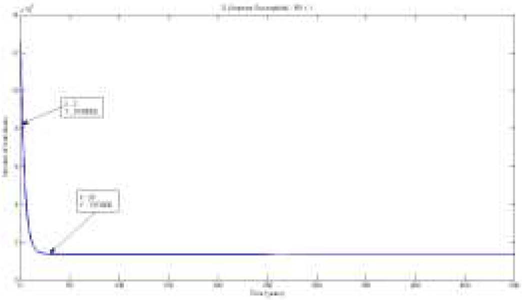

Figure 1. Dynamics of Unaware Susceptible Population (S) under $R_0 < 1$

The graph illustrates the dynamics of the number of **S (Unaware Susceptible)** individuals, or those who are still susceptible but unaware of the risk of infection, under the condition $R_0 < 1$ over a period of 500 years. At the beginning of the observation (when ttt approaches 0), the number of individuals in this group is very high, exceeding 12 million people. However, during the first two years, there is a sharp decline, leaving around 8.19 million individuals by the second year. This decrease continues until approximately the 29th year, when the number of unaware susceptible individuals reaches about 1.37 million. After that, the graph shows a tendency to stabilize or flatten, indicating that the population has reached a **steady-state condition** with a relatively constant number of individuals.

This condition aligns with epidemiological theory when $R_0 < 1$, meaning that the basic reproduction number of the disease is less than one each infected individual, on average, transmits the disease to fewer than one other person. Consequently, the disease cannot sustain ongoing transmission, leading to a significant decline in the number of susceptible individuals before eventually stabilizing. Epidemiologically, this suggests that interventions that reduce R_0 such as vaccination, increased public awareness, or social restrictions are effective in suppressing disease transmission. Therefore, the graph demonstrates that, in the long term, the system will reach a stable condition with a relatively small number of susceptible individuals and no persistent outbreak.

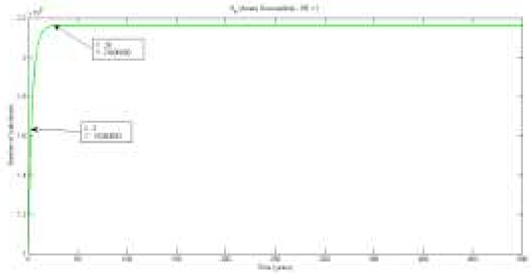

Figure 2. Dynamics of Aware Susceptible Population (S_e) under $R_0 < 1$

The graph shows the dynamics of the number of **S_e (Aware Susceptible)** individuals those who are susceptible but already aware of the disease under the condition $R_0 < 1$ over a period of 500 years. At the beginning of the observation (when t approaches 0), the number of individuals in this group is around $1{,}0 \times 10^8$ (100 million people). During the first three years, the number increases rapidly to approximately $1{,}626 \times 10^8$ (162.6 million people), indicating that more individuals are becoming aware of the infection risk and transitioning into the aware susceptible group. This increase continues until it reaches a peak of about $2{,}16 \times 10^8$ (216 million people) in the 26th year. After this point, the graph shows a flat or stable pattern (steady state), meaning that the number of aware susceptible individuals remains relatively constant until the end of the observation period (500 years).

From an epidemiological perspective, this pattern is consistent with the condition $R_0 < 1$, in which the disease cannot spread sustainably because the transmission rate is lower than the rate of recovery or prevention. The increase in the number of aware susceptible individuals reflects the effectiveness of raising public awareness in reducing the risk of infection. As more people become aware and cautious, disease transmission is successfully controlled, leading the system to reach a stable equilibrium. This demonstrates that when the basic reproduction number is below one, the population aware of the disease risk increases sharply until it stabilizes, indicating the long term success of awareness and disease control efforts.

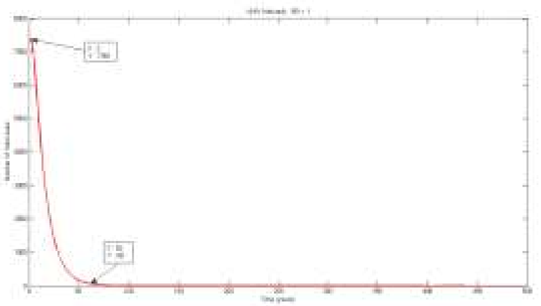

Figure 3. Dynamics of HIV-Infected Population (I) under $R_0 < 1$

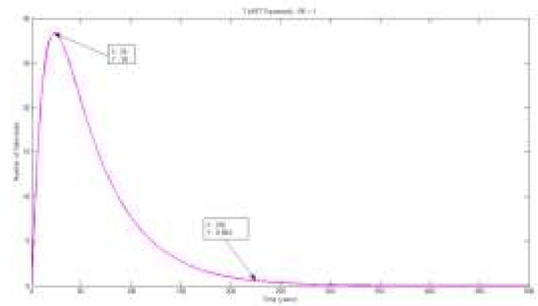

Figure 4. Dynamics of ART Treatment Population (T) under $R_0 < 1$

The graph illustrates the dynamics of the number of **I (HIV Infected)** individuals under the condition $R_0 < 1$ over a period of 500 years. At the beginning of the simulation (around year 0 to year 2), the number of infected individuals is relatively high, approximately 7,351 people. However, over time, the number of HIV-infected individuals decreases very rapidly and significantly, especially during the first 60 years. By year 62, the number of infected individuals drops drastically to only about 58 people. After this point, the curve becomes nearly flat, approaching zero and remaining stable until the end of the observation period (500 years). This pattern indicates that HIV gradually diminishes and eventually almost disappears from the population.

This condition is consistent with $R_0 < 1$, meaning that each infected individual, on average, transmits the disease to fewer than one other person. In epidemiological terms, this shows that disease transmission cannot be sustained in the population. The decline in cases can be interpreted as the result of successful health interventions, such as increased awareness, the use of antiretroviral therapy (ART), and effective prevention practices. Overall, this graph indicates that when the basic reproduction number is below one, HIV will decline exponentially to nearly zero, and the population will eventually reach a **disease-free equilibrium**.

The graph shows the dynamics of the number of **T (ART Treatment)** individuals, representing those undergoing antiretroviral therapy, under the condition $R_0 < 1$ over a period of 500 years. At the beginning, the number of individuals receiving treatment is relatively small around 5 to 6 people. Over time, this number increases rapidly, reaching a peak around year 24, with approximately 28 individuals undergoing ART. However, after reaching the peak, the curve shows a consistent and gradual decline, indicating that the number of individuals requiring ART decreases over time. Around year 226, only about 0.564 individuals remain in treatment, and the graph flattens near zero for the rest of the observation period.

This phenomenon aligns with the condition $R_0 < 1$, where HIV transmission is successfully controlled, leading to a significant reduction in the number of infected individuals and consequently, those needing ART over time. The initial rise represents the phase when the healthcare system actively begins treating infected individuals, while the subsequent decline reflects the success of therapy and the effectiveness of preventive measures in reducing new infections. This graph demonstrates that in the long term, when $R_0 < 1$, the need for ART therapy decreases significantly to nearly zero, indicating that the system has reached a stable condition where new infections are almost nonexistent and large-scale treatment is no longer required.

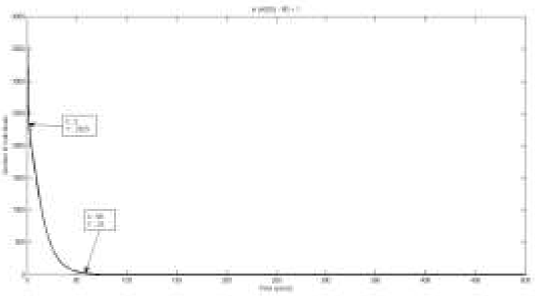

Figure 5. Dynamics of AIDS Population (A) under $R_0 < 1$

The graph depicts the dynamics of the number of **A (AIDS)** individuals—those in the final stage of HIV infection—under the condition $R_0 < 1$ over a 500-year period. At the beginning (when (t) approaches 0), the number of individuals in this group is relatively high, around 2,323 people by year 2. However, the graph shows a sharp decline during the first several decades. Around year 59, the number of AIDS cases drops dramatically to only about 23 people. After that, the graph flattens and approaches zero, showing that the number of AIDS patients continues to decrease until almost no new cases appear.

This steep decline reflects the epidemiological condition when $R_0 < 1$, meaning the basic reproduction number of the disease is less than one. Each infected individual transmits the disease, on average, to fewer than one other person. In this situation, disease transmission cannot be sustained in the long term, leading to a steady reduction in the number of individuals reaching the AIDS stage. This result demonstrates the success of interventions that lower R_0, such as increasing public awareness, widespread ART usage, and transmission prevention efforts. Thus, the graph illustrates that when R_0 is successfully reduced below one, the AIDS epidemic gradually disappears, and the system reaches a stable, disease-free equilibrium in the long term.

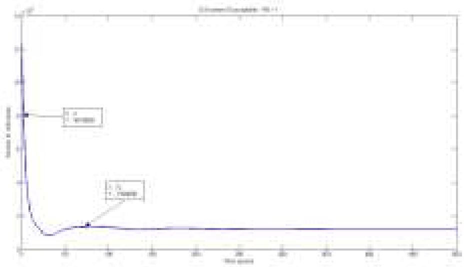

Figure 6. Dynamics of Unaware Susceptible Population (S) under $R_0 > 1$

The graph illustrates the dynamics of **S (Unaware Susceptible)** individuals those who are still susceptible but unaware of the risk of infection—under the condition $R_0 > 1$ over a 500-year period. At the beginning (when (t) approaches 0), the number of individuals in this group is very large, exceeding 12 million people. However, during the first two years, the number drops sharply to around 8.02 million by year 2. This decline continues until it reaches the lowest point, approximately 1.32 million individuals, around year 72. After that, the graph shows slight fluctuations and then flattens, indicating that the population reaches a *steady state* with a relatively constant number of individuals.

The condition $R_0 > 1$ indicates that each infected individual can, on average, transmit the disease to more than one other person, allowing sustained disease transmission within the population. The initial decline in susceptible individuals reflects a high transmission rate. However, over time, the system reaches a balance between transmission, awareness changes, and demographic factors (e.g., births), so the number of susceptible individuals stabilizes at a certain level instead of reaching zero. Epidemiologically, this indicates that the disease may become endemic persisting in the population over the long term unless interventions are implemented to reduce R_0.

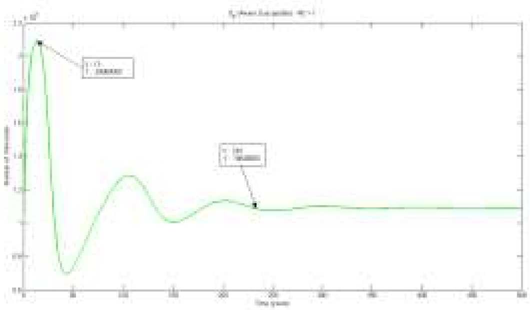

Figure 7. Dynamics of Aware Susceptible Population (S_e) under $R_0 > 1$

The graph shows the dynamics of $\mathbf{S_e}$ **(Aware Susceptible)** individuals those who are susceptible to infection but aware of the risks and may take preventive measures under the condition $R_0 > 1$ over a 500-year period. At the beginning, this group increases in number, peaking at around

206.8 million people by year 13. After reaching the peak, the number of aware susceptible individuals drops sharply, hitting its lowest point around year 50. The graph then exhibits an oscillating pattern rising and falling with gradually decreasing amplitude over time. Around year 234, the number of individuals stabilizes at approximately 108.4 million, and the system reaches a **steady state** with a relatively stable population size.

The condition $R_0 > 1$ means that disease transmission can continue over time, so the dynamics of aware susceptible individuals are influenced by the interaction between awareness increase, behavioral change, and infection processes. The initial increase may occur due to growing public awareness of infection risks, followed by a decline as part of the population becomes infected or transitions to another category. The oscillations reflect a dynamic balance between disease transmission and awareness within the population. Over time, the system moves toward stability, showing that although the disease remains endemic, awareness interventions help maintain the susceptible population at a relatively constant level in the long term.

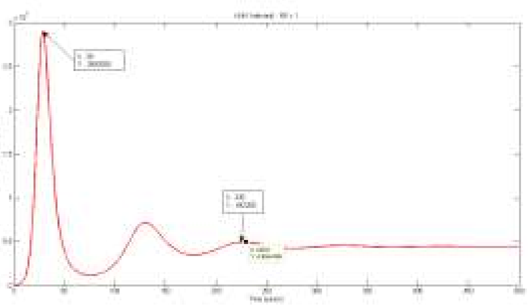

Figure 8. Dynamics of HIV-Infected Population (I) under $R_0 > 1$

The graph illustrates the dynamics of **I (HIV Infected)** individuals under the condition $R_0 > 1$ over a period of 500 years. In the early phase, the number of infected individuals rises rapidly, peaking around year 28 with approximately 28.92 million people. After reaching the first peak, the number drops drastically to a low point around year 80. However, the graph then shows an oscillating pattern, with another increase in the number of infected individuals around year 130, followed by another decline. Around year 226, the number of infected individuals is about 492,200, after which fluctuations become smaller until the system moves toward a steady state with a relatively stable number of infected individuals in the long term.

This oscillating pattern reflects the complex interaction between disease transmission, population awareness changes, and prevention or treatment factors. Since $R_0 > 1$, HIV transmission can persist within the population, leading to a large initial outbreak before natural adjustments or awareness reduce the number of cases. However, because transmission continues, the number of infected individuals never drops to zero and eventually stabilizes at an endemic level. Therefore, the graph shows that HIV persists within the population and can only be suppressed not eliminated without interventions that significantly reduce R_0.

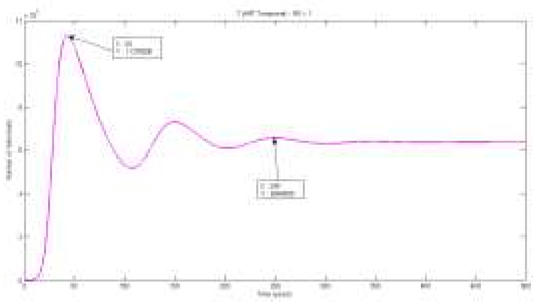

Figure 9. Dynamics of ART Treatment Population (T) under $R_0 > 1$

The graph shows the dynamics of **T (ART Treatment)** individuals those receiving antiretroviral therapy under the condition $R_0 > 1$ over a 500-year period. At the beginning (when (t) approaches 0), the number of individuals in this group is very low but increases sharply, reaching the first peak around year 44 with about 11.27 million people. This rise indicates that during the early stage, when $R_0 > 1$, disease transmission remains high, leading to more individuals requiring ART. After reaching this peak, the graph shows a significant decline in the number of treated individuals, indicating the positive impact of therapy in controlling the spread of the disease.

Subsequently, the graph shows several fluctuations with decreasing amplitude. The second peak occurs around year 249, with about

6.56 million individuals. This wave pattern suggests that although the number of individuals receiving therapy fluctuates, the system gradually approaches stability. After that period, the curve flattens, indicating that the number of individuals undergoing ART has reached a **steady state** with a relatively constant population over time.

Epidemiologically, this condition indicates that when $R_0 > 1$, the disease can still spread within the population, but ART therapy plays an important role in reducing infection rates and keeping the number of infected individuals under control. The fluctuations indicate an adjustment process toward a new equilibrium. Thus, the graph shows that while disease transmission does not disappear immediately, ART therapy can stabilize the infected population dynamics in the long term until a relatively steady condition is achieved.

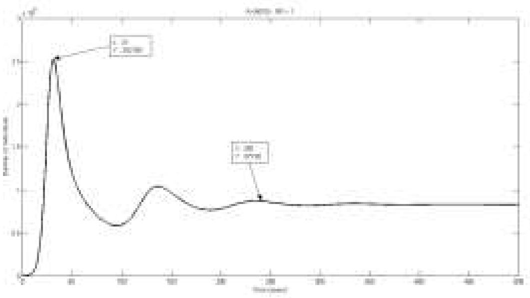

Figure 10. Dynamics of AIDS Population (A) under $R_0 > 1$

The graph illustrates the dynamics of **A (AIDS)** individuals those who have progressed to the final stage of HIV infection under the condition $R_0 > 1$ over a 500-year period. At the beginning (when (t) approaches 0), the number of individuals in this group is still very low. However, the graph shows a sharp increase, reaching the first peak around year 31 with approximately 2.52 million individuals. This surge indicates that during the early phase of transmission, when the basic reproduction number exceeds one, the infection spreads rapidly, leading to more individuals progressing to the AIDS stage.

After reaching the peak, the number of AIDS individuals declines significantly, reaching its lowest point around year 100. Then, the graph shows a second fluctuation with a peak around year 240, where the number of individuals is about 87,190. After this period, the curve gradually decreases and flattens, indicating that the system has reached a *steady state* with a relatively constant number of AIDS cases over time.

Epidemiologically, this pattern shows that when $R_0 > 1$, the disease can continue to spread, but through interventions such as ART therapy, increased awareness, and transmission control, the number of individuals reaching the AIDS stage can be significantly reduced. The fluctuations represent the population's adjustment process toward epidemic stability. Thus, the graph illustrates that although the disease does not disappear immediately, effective management can reduce the number of AIDS cases until the system reaches a stable state with low case numbers in the long term.

BATIK

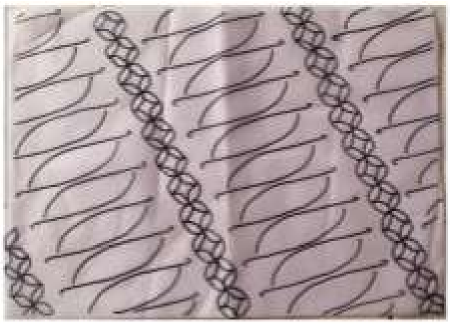

Figure 11. Batik Visualization of HIV Waves

Philosophical Meaning

This batik motif is a visual representation of the dynamic journey of human life, inspired by the mathematical model graph of HIV/AIDS transmission with ART Treatment under the condition $R_0 > 1$. The repeated curved lines symbolize the waves seen in the ART Treatment graph, reflecting struggle, adaptation, and the process of achieving life balance. The peaks and troughs in the pattern represent the ups and downs of human existence times of crisis, recovery, and eventual stability. Just as the graph initially experiences high fluctuations before reaching a stable state, the motif illustrates that every human struggle goes through cycles of fall and rise before attaining peace and equilibrium.

Meanwhile, the geometric pattern resembling interwoven knots at the center of the composition signifies the role of collaboration, awareness, and social bonds in maintaining the stability of life systems. In the context of the ART Treatment graph, this corresponds to the steady-state point, where the number of individuals undergoing treatment becomes constant symbolizing the harmony between effort, knowledge, and hope.

Biological Meaning

Biologically, this batik motif represents the biological dynamics of the human body in facing infection and the healing process. The rising, falling, and stabilizing wave patterns correspond to the biological response of the body to HIV infection starting from the initial infection phase (an increase in infected individuals), followed by the active treatment phase (a decline due to ART therapy), and finally the biological equilibrium phase (steady state) where the immune system and treatment reach a stable point.

The curved lines symbolize the adaptive journey of the human immune system, which continuously strives to maintain internal balance (homeostasis) despite external disturbances. Meanwhile, the repetitive geometric patterns represent cellular interactions and disease regulation mechanisms that occur rhythmically within the body such as viral replication, immune cell activation, and the suppressive effect of ART in controlling infection.

Thus, from a biological perspective, this batik motif symbolizes the connection between mathematical patterns and the biological reality of the human body, illustrating that every fluctuation in a biological system reflects the body's struggle to achieve stability through the balance between infection, immune response, and therapeutic intervention.

Mathematical Meaning

Mathematically, this batik motif is a visual representation of a dynamic function describing system stability in a disease transmission model specifically, the HIV/AIDS model with ART treatment under the condition $R_0 > 1$. The rising, falling, and stabilizing wave patterns illustrate the solution of a nonlinear differential equation system, showing that the model exhibits damped oscillations before reaching a steady-state equilibrium.

The repeated curved lines in the motif represent the change of variables over time (t), where each curve symbolizes the fluctuation of a specific compartment population, such as individuals receiving ART treatment. When the graph becomes stable, the motif reflects convergence toward equilibrium, which mathematically indicates that the system satisfies the local asymptotic stability condition, characterized by negative eigenvalues at the equilibrium point.

Meanwhile, the repetitive and symmetrical geometric patterns in the batik express mathematical order and structure, suggesting that behind the visual beauty lies a logical framework and functional interdependence among variables. Thus, this batik motif embodies the unity between aesthetic harmony and mathematical regularity, where art serves as a bridge to interpret the concepts of stability, continuity, and balance within dynamic systems.

Conclusions

This study integrates mathematical modeling and artistic visualization through the development of a batik motif inspired by the dynamics of HIV/AIDS transmission with education and ART treatment. Building upon the model proposed by Syafi'i et al. (2023), the research adopts a modified SITA framework that includes an additional compartment of susceptible but aware individuals, as well as parameters representing education rate and treatment effectiveness. Analytical results reveal two equilibrium points: a disease-free equilibrium (when $R_0 < 1$) and an endemic equilibrium (when $R_0 > 1$). The disease-free equilibrium is locally asymptotically stable, signifying that the disease will eventually disappear from the population if the basic reproduction number remains below one. Conversely, when $R_0 > 1$, the system exhibits oscillatory behavior before reaching a steady endemic state, where infection persists at a relatively constant level.

Numerical simulations demonstrate that enhanced education and effective ART programs significantly reduce the number of infected and AIDS-affected individuals. This confirms that awareness interventions play a vital role in decreasing the contact rate among susceptible individuals, while ART treatment contributes to prolonging life expectancy and reducing transmission risk.

Beyond mathematical analysis, this research translates the oscillatory patterns of the model into a **batik motif** that symbolizes the dynamic equilibrium of human life and biological systems. The peaks and troughs in the motif correspond to fluctuations in infection and recovery, representing resilience, adaptation, and eventual stability. Thus, this interdisciplinary approach not only deepens the scientific understanding of epidemiological models but also transforms mathematical data into visual art that embodies cultural and philosophical meaning.

In summary, the integration of mathematics, biology, and art demonstrates that mathematical models can transcend numerical interpretation serving as tools for both scientific exploration and aesthetic expression. This study emphasizes the essential role of education and ART treatment in controlling HIV/AIDS transmission while showcasing how mathematical modeling can inspire creative representations that bridge science and culture.

References

Syafi'i, M., Sabran, L. O., & Rianjaya, I. D. (2023). Analisis Dinamik Model Matematika Penyebaran Penyakit HIV/AIDS dengan Edukasi dan ART Treatment. *MES (Journal of Mathematics Education and Science)*, 31-44.