MENTORSHIP, SCHOLARSHIP, AND SERVICE: A SPECIAL ISSUE HONOURING PROFESSOR ADAMU N. BABA-KUTIGI, FNIP ON HIS RETIREMENT

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Modelling the Dynamics of Sara-Suka Crime with Rehabilitation Strategy in Bauchi State

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ABSTRACT

As in other states in Nigeria, there is a reasonable number of young men and women without jobs in Bauchi State. These individuals have few opportunities to improve their socioeconomic status. Some of them have joined the Sara-Suka Boys, loosely organized criminal gangs. In this work, we formulate and analyze a mathematical model for the transmission dynamics of Sara-Suka crime and assess the effectiveness of rehabilitation and empowerment interventions in reducing criminal activities among youths in Bauchi State. we developed a model based on mathematical techniques, resulting in a system of ordinary differential equations, to analyze the dynamics of the Sara-Suka crime while accounting for the State's rehabilitation programme. We used the Lipschitz condition to test for the existence and uniqueness of the model, determined the solution's positivity and the invariant region respectively. The basic reproduction number (Ro) was calculated using a next-generation matrix technique. According to the study, the Sara-Suka Crime-Free Equilibrium (SSCFE) is unstable whenever Ro exceeds one and locally asymptotically stable (LAS) whenever it is less than 1. The SSCFE's global stability was also established. Numerical investigations illustrated that an increase in the arrest rate of Sara-Suka boys, a reduction in the Sara-Suka conversion rate, and a boost in the rehabilitation programme will significantly help reduce and, with time, completely eradicate the Sara-Suka thuggery.

Keywords: Modelling, Dynamics, Sara-Suka Crime, Thuggery, Rehabilitation Strategies

INTRODUCTION

The term Sara-Suka is a compound of the words 'Sara' and 'Suka', which literally mean cutting and stabbing, respectively. The name was given to a group of unemployed youth who engaged in thuggery in Bauchi State. Their ages range from 14 to 35; some are in secondary school, some are school dropouts, and others never attended school. Similarly, they are all drug addicts and perpetrators of violence (Lawanti, 2009). Their activities were characterized by drug addiction, as they occasionally came in to the streets to cut and stab everyone they met in the name of 'Shara' (sweeping) and destroy people's properties, such as parked vehicles. They also fight among different groups of Sara-Suka boys. The Sara-Suka boys of Yakubu wanka fought the Sara-Suka boys of Bakwaro; those of Kwanar kwaila fought those of Kofar Dumi, and so on. To buttress further, between January and June 2014, the National Drugs Law Enforcement Agency (NDLEA) seized about 346.5 kg of illicit drugs in the state. Additionally, 117 suspects, all youth, were arrested, while 73 convictions were recorded within the period, and most of those detained were youth (City Voiced, 2014). This clearly indicates that youth have access to illicit drugs, and they can take them for their personal motives at any time. At this point, drugs can be said to be another major factor contributing to youth involvement in the Sara-Suka menace.

The transition from military rule to democratic government has raised people's expectations of good governance, an improved standard of living, and a better life. In reality, the majority of people in most societies of Nigeria, especially in Bauchi and other areas like Zamfara, Jigawa, and Katsina, are suffering from abject poverty and severe hardship, which has led to frustration and a high rate of insecurity among the people of the country, especially in Bauchi State Wunti, 2012). As the 2003 general elections approached, politicians invited these groups to serve as their guards whenever they embarked on campaigns. Consequently, more jobless youth engaged in one form of political violence or another (Umar, 2013). Their activities became worrisome during the 2003 and 2007 general elections in the state, and politicians used the groups to win or maintain their political positions (Ilelah, 2015). Garba (2009) also believed that the rate of Sara Suka activities and other crimes in Bauchi has been on the increase since the advent of democracy in 1999. Shehu (2012) opined that these unemployed youths could easily be lured into negative tendencies and are therefore ready to be recruited in to antisocial acts.

Nigerian Watch (2014) reported that Nigeria has one of the highest numbers of children out of school in the world; that is, about 10.5 million of the 61 million children not attending school are from Nigeria. It means that illiteracy has become one of the most significant challenges to both the federal and state governments, and this has contributed immensely to the high rate of youth involvement in Sara Suka. Haruna and Jumba (2011) observed that the denial of any part of the democratic process in society typically leads to acts of thuggery.

During his time as the former Executive Governor of Bauchi State, Dr. Malam Isah Yuguda mandated that Operation Safe Haven and the state government meet at a roundtable to discuss possible ways out of the problem. After a series of meetings and brainstorming sessions, it was decided that the matter would not be approached with force but by appealing to the reason and conscience of the individuals in the gang. Those who were ready to renounce the group were encouraged to do so and were promised empowerment to become self-reliant (Nigerian Tribune, 2019). Furthermore, Timi Owolabi (2024) reported that the Bauchi government orders security agencies to go after notorious cult groups terrorizing residents.

As a result, an empowerment scheme (ES) has been implemented by the administration of His Excellency, Alhaji Muhammad Abdulkadir Bala Kaura, who has served from

2019 to date. It was designed to address the needs of the teeming youth and reduce the network of violence expected from them. By hiring the youngsters who were left behind from the Anti-Sara-Suka squad, the ES was designed to supplement the squad in reducing crime. Additionally, it was anticipated to facilitate the squad's work by reducing crime committed by young people due to unemployment (Bashir, 2021). Over 500 suspected thugs, popularly known as Sara-Suka, renounced all forms of criminality in Bauchi State (Crime Watch, 2024).

Mathematical models of crime have played a significant role in providing grounds for studying and suggesting possible control strategies for social vices. Sanda *et al.* (2019) developed a model to study the dynamics of Kalare crime within the Gombe Metropolis. They determined that the crime-free equilibrium is unstable if the threshold exceeds one and locally asymptotically stable if it is less than 1. They ran a numerical simulation in three alternative situations to demonstrate how crime in Kalare may decrease significantly. In this study, the same techniques were employed in Bauchi State under the name Sara-Suka Crime to assess the state's dynamic situation.

MATERIALS AND METHODS

Model Formulation

The population is divided into seven (7) compartments and the total population is equal to the sum of all individuals in all the compartments. These are: the Susceptible literate, S_l, the Susceptible illiterate S_i, the Exposed class E, the Sara-Suka Crime class, S_c , the Jailed class J, the Rehabilitated class, R_h and the Removed class, R_m.

Assumptions

The following presumptions form the basis of the model:

i. All susceptible individuals have equal chances of joining the Sara-Suka crime group when they come into contact with infected individuals
ii. Individuals in the susceptible illiterate class are more vulnerable to being affected.
iii. Rehabilitated individuals are moved into the removed class for a particular period.
iv. We assume that removed individuals may rejoin either the susceptible literate class or the susceptible illiterate class after being removed.
v. Removal from the crime is not permanent.

Variables

S_l →Number of Susceptible literate individuals at time t
S_i → Number of Susceptible illiterate individuals at time t
E →Number of Exposed individuals at time t
S_c → Number of Sara-Suka crime individuals at time t
J →Number of Jailed individuals at time t
R_h →Number of Rehabilitated individuals at time t
R_m → Number of Removed individuals at time t

Parameters

ρ - Rate of recruitment to susceptible population
η - Proportion of youth that have been enrolled in school
α - Rate of moving from susceptible literate class to the exposed class
β - Rate of moving from susceptible illiterate class to the exposed class
δ- Rate of moving from exposed class to the Sara-Suka crime class
ϑ- Rate of moving from exposed class to the jailed class
Ψ- Rate of moving from exposed class to the rehabilitated class
a - Rate of moving from Sara-Suka crime class to the rehabilitated class
γ - Rate of moving from Sara-Suka crime class to the removed class
σ - Rate of moving from Sara-Suka crime class to the jailed class
φ - Rate of moving from rehabilitated class to the removed class
τ - Rate of moving from jailed class to the rehabilitated class
π - Rate of moving from jailed class back to the Sara-Suka crime class
θ - Rate of moving from jailed class to the removed class
b- Rate of moving from removed class to the susceptible literate class
d- Rate of moving from remove class to the susceptible illiterate class
μ - Natural death rate that can happen in all the classes
ε - Death rate as a result of Sara-Suka crime
ω - Death rate by being exposed to Sara-Suka crime

Governing Equations

From the above schematic diagram, the transition between compartments can be expressed by the following system of differential equations:

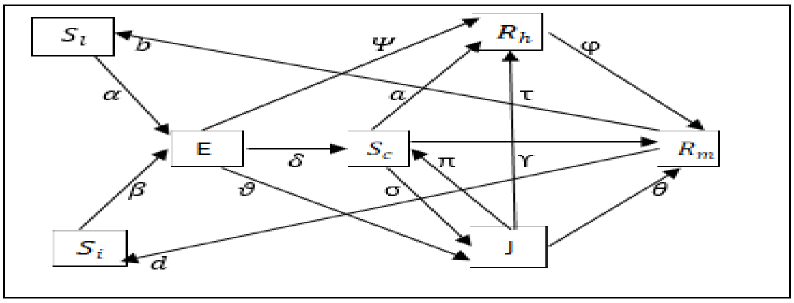

Figure 1: Schematic Diagram of the Model

$$\left.\begin{aligned}
\frac{dS_l}{dt} &= \eta\rho + bR_m - \alpha S_l S_c - \mu S_l \\
\frac{dS_i}{dt} &= \rho(1-\eta) + dR_m - \beta S_i S_c - \mu S_i \\
\frac{dE}{dt} &= \alpha S_l S_c + \beta S_i S_c - \delta E - \vartheta E - \Psi E - \omega E - \mu E \\
\frac{dS_c}{dt} &= \delta E + \pi J - aS_c - \sigma S_c - \gamma S_c - \varepsilon S_c - \mu S_c \\
\frac{dJ}{dt} &= \vartheta E + \sigma S_c - \pi J - \tau J - \theta J - \mu J \\
\frac{dR_h}{dt} &= \Psi E + \tau J + aS_c - \varphi R_h - \mu R_h \\
\frac{dR_m}{dt} &= \varphi R_h + \gamma S_c + \theta J - bR_m - dR_m - \mu R_m
\end{aligned}\right\} \qquad (1)$$

The fundamental components of the system of equations above are examined in this section. It is possible to achieve the existence of the equilibrium and their stability. The basic reproduction number could also be obtained.

Model Description

The population of both susceptible literates, S_l and susceptible illiterate S_i changes due to the coming in of new recruited young individuals at the rate ρ. The later reduces to exposed class due to the rate α, and the former due to the rate β. Individuals exposed class E also move to Sara-Suka crime class, S_c. Rehabilitated class, R_h or Jailed class, J, at the rates δ, Ψ, or ϑ respectively. Individuals in the Sara-Suka crime class move to rehabilitated class, Jailed class or removed compartment, R_m at the rates a, σ, or γ respectively. Some of Jailed individuals move back to Sara-Suka crime class at the rate π while others move to rehabilitated class at the rate τ. Rehabilitated and Jailed individuals move to removed compartment at the rates ϕ and θ respectively. Due to the fact that removed individuals may rejoin either the susceptible literate class or the susceptible illiterate class after being removed. That is to say, removal from the crime is not permanent. Therefore, removed individuals also move to susceptible literate and susceptible illiterate group at the rates b and d respectively.

Basic Properties of the Model

We now discuss the properties of the proposed model.

Positivity of the solution

We demonstrated the positivity of the solutions to the model by expressing and demonstrating the following theorem:

Theorem 1:

Let the initial solution set be:

$\{S_l(0) > 0, S_i(0) > 0, E(0) > 0, S_c(0) > 0, J(0) > 0, R_h(0), > 0, R_m(0) > 0\} \in \Re^7_+$

If $t > 0$, then the solution set is positive forever.

Proof:

From,

$$\frac{dS_l}{dt} = \eta\rho + bR_m - \alpha S_l S_c - \mu S_l$$

We have:

$$\frac{dS_l}{dt} = \eta\rho + bR_m - (\alpha S_c + \mu)S_l$$

$$\frac{dS_l}{dt} \geq -\alpha(S_c + \mu)S_l \qquad (2)$$

By separating the variables in equation (2), we have

$$\frac{dS_l}{S_l} \geq -\alpha(S_c + \mu)dt \qquad (3)$$

Integrating (3) we have

$$\int \frac{1}{S_l} dS_l \geq \int -(\alpha S_c + \mu)dt$$

$$lnS_l \geq \int -(\alpha S_c + \mu)dt \qquad (4)$$

Taking exponential of both side of (4) gives:

$$S_l(t) \geq e^{\int -(\alpha S_c + \mu)dt}$$

At $t > 0$, $S_l(t) \geq 0$

Similarly, for $\frac{dS_l}{dt}, \frac{dS_i}{dt}, \frac{dE}{dt}, \frac{dS_c}{dt}, \frac{dJ}{dt}, \frac{dR_h}{dt}$ and $\frac{dR_m}{dt}$, according to theorem 1, the solution to equation (1) is therefore positive for all times $t > 0$.

Existence of invariant region

From the model equation, the population estimate is provided by

$$N = S_l + S_i + E + S_c + J + R_h + R_m \qquad (5)$$

That is,

$$\frac{dN}{dt} = \frac{dS_l}{dt} + \frac{dS_i}{dt} + \frac{dE}{dt} + \frac{dS_c}{dt} + \frac{dJ}{dt} + \frac{dR_h}{dt} + \frac{dR_m}{dt}. \qquad (6)$$

Consequently, when the differential equations are included, we have

$$\frac{dN}{dt} = \rho - \mu(S_l + S_i + E + S_c + J + R_h + R_m) - \omega E - \varepsilon S_c \qquad (7)$$

That is,

$$\frac{dN}{dt} = \rho - \mu N - \omega E - \varepsilon S_c \qquad (8)$$

Which implies,

$$\frac{dN}{dt} \leq \rho - \mu N \qquad (9)$$

By integrating this, we obtain:

$$N(t) \leq \frac{\rho}{\mu} \;\; as\, t \to \infty \qquad (10)$$

Consequently, the area where the model makes biological sense is indicated by

$$\Phi = \left\{S_l, S_i, E, S_c, J, R_h, R_m \in \; \Re^7_+ : S_l + S_i + E + S_c + J + R_h + R_m \leq \frac{\rho}{\mu}\right\} \qquad (11)$$

Accordingly, every solution with initial condition(s) in Φ continues to be in the region Φ. Hence our model is mathematically sound, positively invariant, and physiologically plausible in the region Φ.

Crime Free Equilibrium point (CFE)

In the absence of Sara-Suka crime, we obtain the following CFE, denoted by E_0

$$E_0 = \left(\frac{\eta\rho}{\mu}, \frac{\rho(1-\eta)}{\mu}, 0, 0, 0, 0, 0\right) \qquad (12)$$

Crime Equilibrium Point (CE)

Theorem 2: The Sara-Suka Crime model has a unique crime equilibrium if and only if $R_0 > 1.$

Proof:

When computing the crime equilibrium point, denoted by E_1, we let $S_c^* = C$ and put everything interms C which gives:

$$E_1 = \begin{pmatrix} \frac{A_4\eta\rho\delta^2 + \eta\rho\vartheta\pi\delta + CbG_1}{\delta(A_4\delta + \vartheta\pi)(\alpha C + \mu)}, \frac{A_1 A_4 A_6 \delta^2 + A_1 A_2 \vartheta\pi\delta + CdG_2}{\delta A_6(A_4\delta + \vartheta\pi)(\alpha C + \mu)}, \frac{CG_3}{A_6(A_4\delta + \vartheta\pi)} \\ S_c^* = C \;\;, \frac{C(\sigma\delta + A_3\vartheta)}{A_4\delta + \vartheta\pi}, \frac{CG_1}{\delta(A_4\delta + \vartheta\pi)}, \frac{CG_2}{A_6\delta(A_4\delta + \vartheta\pi)} \end{pmatrix} \qquad (13)$$

Where:

$G_1 = A_3A_4\Psi\delta + A_3\Psi\vartheta\pi + a\delta^2A_4 + a\delta\vartheta\pi + \tau\sigma\delta^2 + \tau\vartheta\delta A_3 - \pi\sigma\delta\Psi - A_3\pi\vartheta\Psi$

$G_2 = A_4\gamma\delta^2 + \gamma\delta\vartheta\pi + \varphi G_1 + \theta\delta^2\sigma + \theta\delta\vartheta A_3$

$G_3 = A_3A_4\delta + A_3\vartheta\pi - \pi(\sigma\delta + A_3\vartheta)$

Basic Reproduction Number, R_0

Given the crime-free equilibrium, if F_i represents the rate at which new crimes emerge in the compartment and V_i represents the rate at which people move from i, then R_0 is the spectral radius (largest eigen value) of the subsequent generation matrix represented by $G = \rho FV^{-1}$.

In order to determine F and V, which are their respective Jacobian matrices at a crime-free

Equilibrium, E_0, Therefore, the basic reproduction number is given below:

$$R_0 = \frac{\rho\big(\alpha\eta + \beta(1-\eta)\big)(\vartheta\pi + \delta(\pi + \tau + \theta + \mu))}{\mu(\delta + \vartheta + \Psi + \omega + \mu)((a + \sigma + \gamma + \varepsilon + \mu)(\pi + \tau + \theta + \mu) - \sigma\pi)} \qquad (14)$$

3.6 Local Stability Analysis of the Crime Free Equilibrium (CFE)

$$\begin{vmatrix} -\mu-\lambda & 0 & 0 & 0 & 0 & b & 0 \\ 0 & -\mu-\lambda & 0 & 0 & 0 & 0 & d \\ 0 & 0 & -a_1-\lambda & a_2 & 0 & 0 & 0 \\ 0 & 0 & \delta & -a_3-\lambda & \pi & 0 & 0 \\ 0 & 0 & \vartheta & \sigma & -a_4-\lambda & 0 & 0 \\ 0 & 0 & \Psi & a & \tau & -a_5-\lambda & 0 \\ 0 & 0 & 0 & \gamma & \theta & \varphi & -a_6-\lambda \end{vmatrix} = 0 \qquad (15)$$

Where:

$a_1 = (\delta + \vartheta + \Psi + \omega + \mu)$, $a_2 = \frac{\rho(\alpha\eta + \beta(1-\eta))}{\mu}$, $a_3 = (a + \sigma + \gamma + \varepsilon + \mu)$,
$a_4 = (\pi + \tau + \theta + \mu)$, $a_5 = (\varphi + \mu)$, $a_6 = (b + d + \mu)$.
The first four eigenvalues of the above matrix are:
$\lambda_1 = -\mu$, $\lambda_2 = -\mu$, $\lambda_3 = -a_6$, and $\lambda_4 = -a_5$, while the remaining three eigenvalues are obtained from 3 by 3 matrix below:

$$G = \begin{vmatrix} -a_1 & a_2 & 0 \\ \delta & -a_3 & \pi \\ \vartheta & \sigma & -a_4 \end{vmatrix} \qquad (16)$$

Thus, the eigenvalues of G are real and negative if the Routh-Hurwitz condition is satisfied (Bashir U. S. & Sule B., 2020 and Bashir, Muhammad & Garba, 2023). Applying the Routh-Hurwitz condition: (i) $Tr(G) < 0$ (ii) $Det(G) > 0$.
Thus, $Tr(G) = -a_1 - a_3 - a_4 = -(a_1 + a_3 + a_4) < 0$ and $Det(G) = \sigma\pi a_1 + \pi\vartheta a_2 + \delta a_2 a_4 - a_1 a_3 a_4$
$= (\delta + \vartheta + \Psi + \omega + \mu)\big(\sigma\pi - (a + \sigma + \gamma + \varepsilon + \mu)(\pi + \tau + \theta + \mu)\big)(1 - R_0)$
Following theorem 2, we conclude that the CFE point is locally asymptotically stable.

Global stability Analysis of the Crime Free Equilibrium (CFE)
We employ the theorem by Castillo-Chavez *et al.* (2002) to prove the global stability of the Sara-Suka Crime free equilibrium of the model (1).
$H_1 : \frac{dX}{dt} = H(X, 0), X^0$ is globally assymptotically stable (GAS)
$H_2 : G(X, Z) = PZ - \overset{\frown}{G}(X, Z), \overset{\frown}{G}(X, Z) \geq 0$ For $(X, Z)\epsilon\Phi$ where $P = \Delta_2 G(X^0, 0)$ is an
M-*matrix* (the off-diagonal elements of P are non-negative) and is also Jacobian of $G(X, Z)$. We then write the model equation given by (1) as:

$$\frac{dX}{dt} = H(X, Z)$$

$$\frac{dZ}{dt} = G(X, Z), G(X, 0) = 0$$

$$E_0(X^0, 0) = \left(\frac{\eta\rho}{\mu}, \frac{\rho(1-\eta)}{\mu}, 0\right)$$

Where:
$X = (S_l, S_i, R_m)\epsilon\Re^3$ Denotes the number of un-affected individuals and
$Z = (E, S_c, J, R_h) \in \Re^4$ Denotes the number of infected individuals.
$E_0 = (X^0, 0)$Denotes the CFE of the system.

Take (E, S_c, J, R_h) and evaluated at $E_0(S_l, S_i, R_m) = \left(\frac{\eta\rho}{\mu}, \frac{\rho(1-\eta)}{\mu}, 0\right)$ if the system satisfies the conditions H_1 and H_2 above, then according to Castillo-Chavez, (2002), the following theorem holds.

Theorem 3: The fixed point $E_0 = (X^0, 0)$ is a globally asymptotic stable (GAS) provided that $R_0 < 1$ (L.A.S) and those assumptions $H_1$and H_2 are satisfied.

Proof: The two functions $H(X, Z)$ and $G(X, Z)$ are given by

$$H(X, Z) = \begin{bmatrix} \eta\rho + bR_m - (\alpha S_c + \mu)S_l \\ \rho(1-\eta) + dR_m - (\beta S_c - \mu)S_i \\ \varphi R_h + \gamma S_c + \theta J - (b + d + \mu)R_m \end{bmatrix} \qquad (17)$$

And

$$G(X, Z) = \begin{bmatrix} \alpha S_l S_c + \beta S_i S_c - (\delta + \vartheta + \Psi + \omega + \mu)E \\ \delta E + \pi J - (a + \sigma + \gamma + \varepsilon + \mu)S_c \\ \vartheta E + \sigma S_c - (\pi + \tau + \theta + \mu)J \\ \Psi E + \tau J + aS_c - (\varphi + \mu)R_h \end{bmatrix} \qquad (18)$$

We then consider the reduced system $\frac{dX}{dt} = H(X, 0)$ from condition (1)

$$H(X, 0) = \begin{bmatrix} \eta\rho - \mu S_l \\ \rho(1-\eta) - \mu S_i \\ 0 \end{bmatrix} \qquad (19)$$

Convergence of X^0 is therefore global in Φ. This implies $X^0 = \left(\frac{\eta\rho}{\mu}, \frac{\rho(1-\eta)}{\mu}, 0\right)$ is g.a.s equilibrium of$\frac{dX}{dt} = H(X, 0)$.
Considering the second equation, we have

$$G(X, Z) = PZ - \hat{G}(X, Z), \hat{G}(X, Z) \geq 0 \qquad (20)$$

Therefore (*3) gives,

$$P = \begin{bmatrix} -(\delta + \vartheta + \Psi + \omega + \mu) & \alpha S_l + \beta S_i & 0 & 0 \\ \delta & -(a + \sigma + \gamma + \varepsilon + \mu) & \pi & 0 \\ \vartheta & \sigma & -(\pi + \tau + \theta + \mu) & 0 \\ \Psi & a & \tau & -(\varphi + \mu) \end{bmatrix}$$

And$= \begin{bmatrix} E \\ S_c \\ J \\ R_h \end{bmatrix}$. Therefore, $\overset{\frown}{G}(X, Z) = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$

But it is clear that $\overset{\frown}{G}(X, Z) = PZ - G(X, Z) \geq 0$. This implies that$G(X, Z) = 0$, hence the Sara-Suka crime free equilibrium of the system is globally asymptotically stable, implying that Sara-Suka crime will be eradicated if contact rate is low in the environment and rehabilitation programme is effectively employed.

RESULTS AND DISCUSSION

Estimated parameter values were freely chosen and used to generate the following simulations in MATLAB.

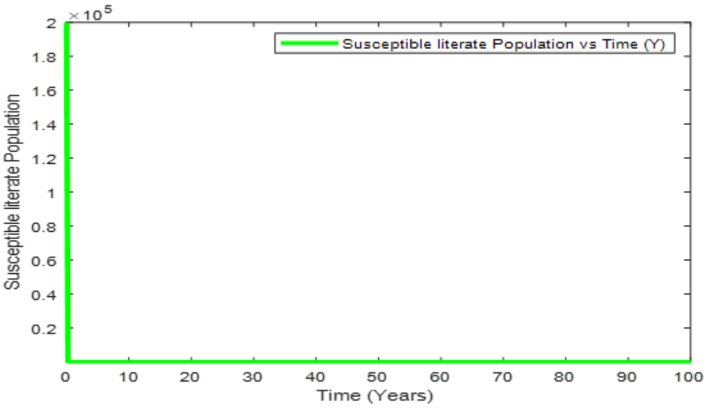

Figure 2: Dynamics of the Susceptible Literate Population with Time

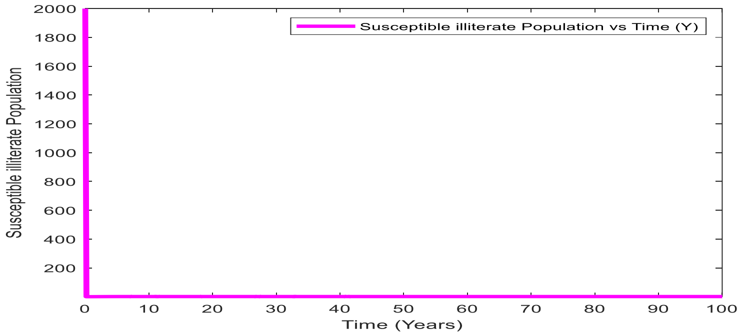

Figure 3: Dynamics of the Susceptible Illiterate Population with Time

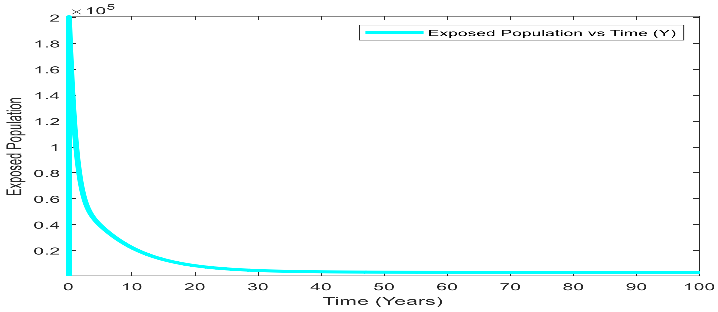

Figure 4: Dynamics of the Exposed Population with Time

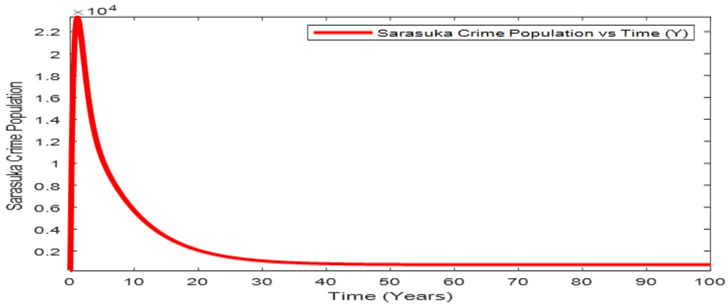

Figure 5: Dynamics of the Jail Population with Time

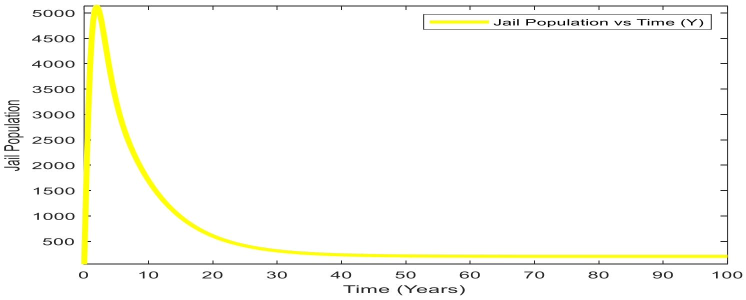

Figure 6: Dynamics of the Rehabilitated Population with Time

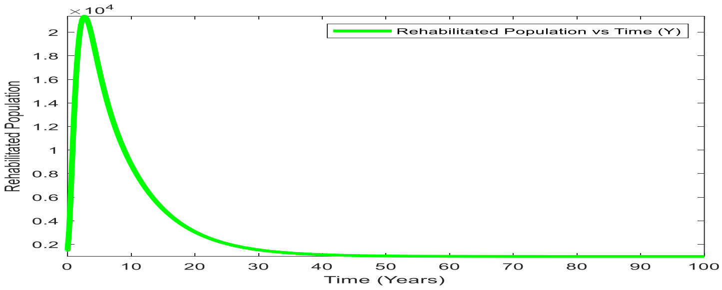

Figure 7: Dynamics of the Sara-Suka Crime Population with Time

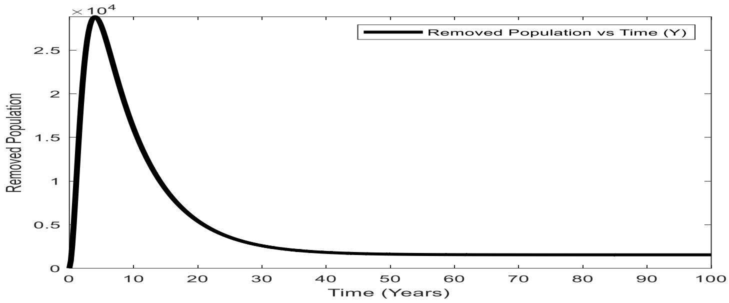

Figure 8: Dynamics of the Removed Population with Time

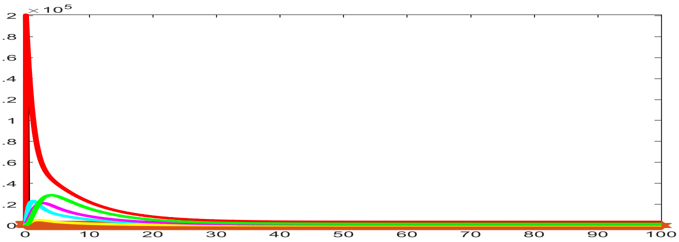

Figure 9: Overall Dynamics of the Sara-Suka Crime Model Populations with Time

Discussion

The mathematical analysis of the Sara-Suka crime model established that the solutions of the system remain positive and bounded for all time, indicating that the model is mathematically well posed and biologically meaningful. The existence of a positively invariant region guarantees that all state variables remain within realistic limits throughout the simulation period, making the model suitable for investigating the dynamics of Sara-Suka crime in Bauchi State. Similar properties have been reported in compartmental models of crime and social behaviour dynamics (Castillo-Chavez et al., 2002; Sanda et al., 2019).

The basic reproduction number, (R_0), was derived using the next-generation matrix approach and was found to govern the persistence or elimination of Sara-Suka crime within the population. The local and global stability analyses showed that the Sara-Suka Crime-Free Equilibrium (SSCFE) is stable whenever ($R_0 < 1$), implying that the crime will gradually disappear from the population under effective intervention measures. Conversely, when ($R_0 > 1$), criminal activities persist and the crime-free state becomes unstable. This finding agrees with the threshold principle established by Castillo-Chavez et al. (2002), where the reproduction number serves as a critical indicator for the control of social and epidemiological phenomena.

Figures 2 and 3 illustrate the dynamics of the susceptible literate and susceptible illiterate populations, respectively. Both populations decrease with time as individuals become exposed to criminal influences. However, the decline is more pronounced among the susceptible illiterate class, suggesting that lack of education increases vulnerability to recruitment into Sara-Suka activities. This observation supports the findings of Haruna and Jumba (2011), who argued that social exclusion and limited educational opportunities contribute significantly to youth involvement in criminal and violent activities.

The exposed population shown in Figure 4 initially increases due to continuous contact between susceptible individuals and active criminals. As rehabilitation and law-enforcement measures become effective, the exposed population gradually declines and approaches a steady state. This result indicates that timely intervention can prevent exposed individuals from progressing into active criminality. Similar behaviour was observed in the Kalare crime model developed by Sanda et al. (2019), where intervention programmes reduced the number of individuals progressing into criminal groups.

Figure 5 depicts the dynamics of the jail population. The rapid increase in the number of jailed individuals demonstrates the effectiveness of arrest and incarceration strategies in removing offenders from active participation in crime. While imprisonment alone may not eliminate criminal activities, it contributes significantly to reducing the number of active offenders and provides an opportunity for rehabilitation before reintegration into society.

The rehabilitated population in Figure 6 increases substantially before stabilizing, reflecting the positive impact of rehabilitation programmes introduced by the Bauchi State Government. This result suggests that structured rehabilitation initiatives can successfully reform offenders and reduce recidivism. The finding is consistent with reports that empowerment and rehabilitation schemes have encouraged many former Sara-Suka members to renounce criminal activities and pursue productive livelihoods.

The Sara-Suka crime population presented in Figure 7 initially rises because of continued recruitment and exposure within the community. However, the population subsequently declines as rehabilitation, arrests, and empowerment programmes take effect. The downward trend demonstrates the potential of combined intervention strategies to suppress criminal activities and restore social stability. This finding agrees with Sanda et al. (2019), who reported that effective control measures substantially reduced the prevalence of Kalare crime in Gombe State.

Figure 8 shows a continuous increase in the removed population, representing individuals who have successfully completed rehabilitation and permanently withdrawn from criminal activities as observed by (Bashir, 2017). The growth of this compartment highlights the importance of reintegration programmes in sustaining long-term crime reduction. Increased movement into the removed class indicates that rehabilitation not only reduces current criminal activities but also prevents future participation in crime.

The overall dynamics illustrated in Figure 9 reveal the interactions among all population classes. The crime compartment increases initially but subsequently declines as rehabilitation, incarceration, and removal mechanisms become more effective. Simultaneously, the rehabilitated and removed populations increase, demonstrating that intervention programmes play a critical role in reducing criminal activities. These results suggest that a combination of law-enforcement measures, rehabilitation programmes, and youth empowerment schemes provides a sustainable approach for controlling Sara-Suka crime.

Overall, the study demonstrates that increasing arrest rates, reducing recruitment into criminal groups, expanding educational opportunities, and strengthening rehabilitation and empowerment programmes are essential for the effective control and eventual eradication of Sara-Suka crime in Bauchi State. The findings provide quantitative support for government policies aimed at youth empowerment, social inclusion, and crime prevention.

CONCLUSION

In this study, we created a deterministic $S_l, S_i, E, S_c, J, R_h, R_m$ to investigate how sara-suka spreads within the population. It was observed that the state government's rehabilitation programme and empowerment scheme reduced the level of crime and violence, thereby restoring peace in the state. This method should be applied to all other states to ensure peace nationwide. The government should also ensure adequate food, shelter, security, and safety for the people in order to restore peace and harmony in the state.

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