Applied and Computational Mathematics
2025, Vol. 14, No. 5, pp. 293-300
https://doi.org/10.11648/j.acm.20251405.15

Research Article

Mathematical Modelling of Gambling Addiction Dynamics in Society

Hillary Kiprop Kosgei[1, *], Phylis Jerotich Kibet[2]

[1]Department of Mathematics and Computer Science, University of Eldoret, Eldoret, Kenya
[2]Department of Public Health, Kabarak University, Nakuru, Kenya

Abstract

Gambling addiction is a silent monster that pose a serious public health threat globally. For instance, compulsive gambling has led to family breakdowns, legal troubles, financial ruins, significant health issues, strained relationships, or even loss of lives. In this study, we formulate and analyze a gambling addiction mathematical model to understand and manage a gambling problem in society. The basic properties of the model were established to show that the model is mathematically and biologically feasible. The basic reproduction number, $\Re_0$ was obtained using the next generation matrix method. The conditions for the existence of gambling free equilibrium and gambling endemic equilibrium were established, that is, both equilibria states were found to be locally and globally asymptotically stable whenever $\Re_0 < 1$ and unstable when $\Re_0 > 1$. Numerical simulation results shows that management of gambling problem depends on the control efforts invested, for instance, higher control efforts increase the chances of overcoming the challenge. The model results further reveal that the rate of contact between susceptible individuals and gamblers (casual and heavy) influences the development of gambling habits in the community. The study findings also show that serious early gambling interventions play a predominant role in mitigating this harmful behavior in society.

Keywords

Mathematical Model, Gambling Addiction, Gambling Control, Gambling Problem, Gambling Interventions

1. Introduction

Gambling synonymous with betting refers to the act of foregoing a valuable property or money knowingly hoping to gain based on the outcome of an event like a game or a contest [1]. The outcome of the event is usually determined by chance or accident; hence the results might be unfavorable to the gambler. Gambling is a universal problem and is a global public health issue [1]. Most gamblers get into gambling for fun, and at that point the consequences are harmless. However, it drastically proceeds to unhealthy obsession that leads to addiction. Generally, gambling has been associated with negative outcomes to the gamblers and those around the gambler. Some of the negative outcomes include: suicide, substance abuse, mental health issues, poor job performance, poor financial management, strained relationships among other issues [2]. Gamblers have many gambling options like sports, casino, scratch cards, and online betting. Gambling addiction may push an individual to heavily borrow money running up to humongous debt or stealing to get what to use for betting.

Gambling addiction falls under impulse-control disorder.

*Corresponding author: hillary@aims.ac.za (Hillary Kiprop Kosgei)

Received: 8 October 2025; **Accepted:** 18 October 2025; **Published:** 31 October 2025

An addicted gambler is unable to control the urge to gamble despite being aware of the negative outcomes and consequences of their actions. Global statistics on gambling addiction is worrying [3, 4]. Approximately that 20 million Americans are either struggling with gambling related issues or at risk of the gambling related issues [4]. Additionally, the suicide rates among the gamblers have been shown to be 15 times higher compared to that of non-gamblers translating to a higher suicide risk among the gamblers [4]. Additionally, there is a disparity between women gamblers and men gamblers. Men are 1.5-2 times likely to be addicted to gambling compared to women [5]. More worrying is that 60% of gamblers smoke, while 26% take alcohol [5].

The African situation in regards to gambling is equally devastating. According to a survey conducted in 2021 by GeoPoll, Kenya, Nigeria and South Africa reported gambling participation of 84%, 78% and 74% respectively [7]. The issue of gambling in Kenya was first witnessed and reported in early 2010 [9]. Ever since, there has been steady increase not only in gambling but also the addicted gamblers [13]. Gambling in Kenya has changed from dingy betting parlors to high online betting. The rise in Kenya is attributed to increased access to technology such as smart-phones, internet connectivity, and mobile money [8]. Approximately 30% of Kenyans who engage in gambling are addicted to gambling. Suicide associated with gambling rates in Kenya was reported to be 6.1 per 100,000 [3].

The consequences of gambling affect many individuals negatively starting with the gambler to their family members and even friends [15]. Therefore, it is evident that gambling addiction is a societal issue. Therefore, there is need to find a solution and reduce the surging rates. There are several scientific solutions offered by researchers aimed at providing a solution to the gambling addiction problem [12]. Mathematical model is one of the effective solutions since it gives the dynamics of the gambling and the best interventions at every stage of gambling [11].

2. Gambling Addiction Mathematical Model Formulation and Analysis

The gambling addiction model partitions the total human population into six groups, that is, the susceptible individuals, S, those exposed to gambling due to their interaction with casual and heavy gamblers, E, casual gamblers, C, heavy gamblers, H, people who are under treatment, T, and those who have recovered from gambling addiction, R. The schematic flow of gambling is as shown in the figure below:

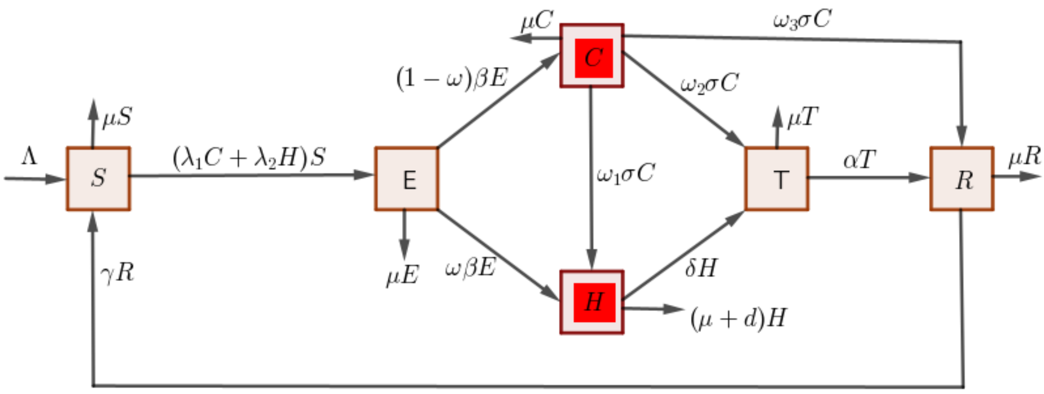

Figure 1. A Mathematical Model for Gambling Addiction.

The dynamics of the gambling addiction model in Figure 1 is governed by the following system of non-linear differential equations:

$$\begin{cases} \frac{dS}{dt} = \Lambda + \gamma R - (\lambda_1 C + \lambda_2 H)S - \mu S \\ \frac{dE}{dt} = (\lambda_1 C + \lambda_2 H)S - (1-\omega)\beta E - \omega\beta E - \mu E \\ \frac{dC}{dt} = (1-\omega)\beta E - \omega_1\sigma C - \omega_2\sigma C - \omega_3\sigma C - \mu C \\ \frac{dH}{dt} = \omega\beta E + \omega_1\sigma C - \delta H - (\mu + d)H \\ \frac{dT}{dt} = \omega_2\sigma C + \delta H - \alpha T - \mu T \\ \frac{dR}{dt} = \alpha T + \omega_3\sigma C - \gamma R - \mu R \end{cases} \tag{1}$$

subject to the following six initial conditions: $S(0) = S_0, E(0) = E_0, C(0) = C_0, H(0) = H_0, T(0) = T_0$ and $R(0) = R_0$. At any given time (t), the total population is given by:

$$N(t) = S(t) + E(t) + C(t) + H(t) + T(t) + R(t) \tag{2}$$

Table 1. *Gambling Addiction Model Parameter Description.*

Parameter	Description
Λ	Recruitment rate of the human population
λ_1	Rate at which sober individuals get exposed to gambling habit due to their interaction with casual gamblers, class C
λ_2	Rate at which sober individuals get exposed to gambling due their interaction with heavy gamblers, class H
β	Rate of progression from class of those exposed to gambling habit, E to gambling compartments
ω	Proportion of those exposed to gambling, E becoming heavy gamblers, H
ω_1	Proportion of casual gamblers, C becoming heavy gamblers, H
ω_2	Proportion of casual gamblers, C moving to the treatment class, T
ω_3	Proportion of casual gamblers, C recovering from the gambling habit, R
δ	Rate of progression from heavy gambling class, H to treatment class, T
α	Rate of progression from treatment class, T to recovered class, R
γ	Rate of progression from recovered individuals' class, R to susceptible individuals' class, S
μ	Natural death rate
d	Death rate due to gambling addiction
σ	Progression rate out of casual gamblers class, C
η	Gambling control interventions to protect susceptible individuals from engaging in gambling
N	Total human population

2.1. Basic Properties of the Gambling Addiction Model

2.1.1. Boundedness of Model Variables

Theorem 1: *The domain* Γ *for gambling addiction computational model defined by* $\Gamma = \left\{(S, E, C, H, T, R) \in \mathbb{R}_+^6 \text{ such that } 0 \le S + E + C + H + T + R \le \frac{\Lambda}{\mu}\right\}$ *with initial conditions* $(S(0) \ge 0, E(0) \ge 0, C(0) \ge 0, H(0) \ge 0, T(0) \ge 0, R(0) \ge 0)$ *is non-negative for all* $\forall t \ge 0$.

The proof:

In absence of gambling related deaths, system (1) gives $\frac{dN}{dt} \le \Lambda - \mu N$, which upon integration yields $N(t) \le \frac{\Lambda}{\mu} + \left(N_0 - \frac{\Lambda}{\mu}\right) e^{-\mu t}$, where N_0 is the initial population evaluated at $S(0) = S_0, E(0) = E_0, C(0) = C_0, H(0) = H_0, T(0) = T_0$ and $R(0) = R_0$. As t tends to ∞, the total human population $N(t)$ approaches $\frac{\Lambda}{\mu}$ meaning that

$$0 \le S + E + C + H + T + R \le \frac{\Lambda}{\mu}$$

Therefore, the feasible region of the gambling addiction system (1) is:

$$\Gamma = \left\{(S, E, C, H, T, R) \in \mathbb{R}_+^6 : 0 \le S + E + C + H + T + R \le \frac{\Lambda}{\mu}\right\}$$

Hence, the solutions of the gambling addiction model are bounded.

2.1.2. Non-negativity of Model Solutions

Theorem 2: *Given* $\Gamma = \{(S, E, C, H, T, R) \in \mathbb{R}_+^6$ *such that* $(S(0) \ge 0, E(0) \ge 0, C(0) \ge 0, H(0) \ge 0, T(0) \ge 0, R(0) \ge 0)\}$ *then the solutions for system (1),* $\{S(t), E(t), C(t), H(t), T(t), R(t)\}$ *are non-negative for* $\forall t \ge 0$.

The proof:

Considering the first equation of system (1):

$$\frac{dS}{dt} = \Lambda + \gamma R - (\lambda_1 C + \lambda_2 H)S - \mu S$$
$$\frac{dS}{dt} \geq -(\lambda_1 C + \lambda_2 H + \mu)S$$

Upon integration, we obtain

$$S(t) \geq S_0 exp\left\{-\left(\mu t + \lambda_1 \int_0^t C(t)dt + \lambda_2 \int_0^t H(t)dt\right)\right\}$$

Clearly, $\lim_{t\to\infty} \inf S(t) \geq 0$.

It can be shown using the same principle that $E(t), C(t), H(t), T(t), R(t) \geq 0$.

Therefore, system (1) is well-posed epidemiologically and mathematically.

2.2. Steady States and Reproduction Number

2.2.1. Gambling Free Equilibrium (GFE)

At the GFE, we assume that the population has not engaged in any gambling practice. Therefore, the GFE state of system (1) becomes:

$$G_0 = (S^0, E^0, C^0, H^0, T^0, R^0) = \left(\frac{\Lambda}{\mu}, 0, 0, 0, 0, 0\right) \tag{3}$$

2.2.2. Reproduction Number ($\mathfrak{R}_0$) for Gambling Addiction

The next generation matrix approach defined in Van den Driessche, P., & Watmough (2002) [14] is utilized to generate $\mathcal{R}_0$. Now considering the compartments that contribute to gambling, the matrices of new gamblers, $\mathcal{F}$ and transitions, $\mathcal{V}$ are:

$$\mathcal{F}_i = \begin{pmatrix} (\lambda_1 C + \lambda_2 H)S \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \tag{4}$$

$$\mathcal{V}_i = \begin{pmatrix} \beta E + \mu E \\ (\omega_1\sigma_1 + \mu)C - (1-\omega)\beta E \\ (\delta + \mu + d)H - \omega\beta_1 E - \omega_1 \sigma C \\ (\alpha + \mu)T - \omega_2\sigma C - \delta H \end{pmatrix} \tag{5}$$

Evaluating the matrices for the new gambling and transition states at the GFE are given by

$$F = \begin{pmatrix} 0 & \lambda_1\frac{\Lambda}{\mu} & \lambda_2\frac{\Lambda}{\mu} & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \tag{6}$$

$$V = \begin{pmatrix} \beta_1 + \mu & 0 & 0 & 0 \\ -(1-\omega)\beta_1 & (\omega_1\sigma_1 + \mu) & 0 & 0 \\ -\omega\beta_1 & -\omega_1\sigma_1 & (\delta + \mu + d) & 0 \\ 0 & -\omega_2\sigma_1 & -\omega_2\sigma_1 & -\omega_2\sigma_1 \end{pmatrix} \tag{7}$$

As it was computed in the study of Kosgei (2022) [6], the matrix's FV^{-1} spectral radius gives the reproduction number, $\mathcal{R}_0$

$$\mathcal{R}_0 = \frac{[((1-\omega)\lambda_1 + \omega\lambda_2)\mu + \lambda_2\omega_1\sigma + (1-\omega)(\delta+d)]\beta\Lambda}{\mu(\beta+\mu)(\delta+\mu+d)(\omega_1\sigma+\mu)} \tag{8}$$

When appropriate gambling control measures such as self-exclusion programs, therapy, counselling, education campaigns, family and community support, η is taken, the quantity of secondary gamblers reduce. Therefore, the effective threshold value that takes into consideration the effect of gambling interventions is given as

$$\mathcal{R}_g = \frac{[((1-\omega)\lambda_1 + \omega\lambda_2)\mu + \lambda_2\omega_1\sigma + (1-\omega)(\delta+d)](1-\eta)\beta\Lambda}{\mu(\beta+\mu)(\delta+\mu+d)(\omega_1\sigma+\mu)} \tag{9}$$

From equation (9), it can be seen that the quantity of secondary gambling cases reduces when $\eta \neq 0$. Hence, the application of gambling interventions is effective.

2.2.3. Local Stability of the GFE

Theorem 3: *The GFE of system (1) is locally asymptotically stable whenever* $\mathcal{R}_0 < 1$, *and unstable stable otherwise.*

The proof:

The linearization matrix of system (1) at the GFE is given by

$$L = \begin{pmatrix} -\mu & 0 & -\lambda_1\frac{\Lambda}{\mu} & -\lambda_2\frac{\Lambda}{\mu} & 0 & \gamma \\ 0 & -(\beta+\mu) & \lambda_1\frac{\Lambda}{\mu} & \lambda_2\frac{\Lambda}{\mu} & 0 & 0 \\ 0 & (1-\omega)\beta & -(\sigma+\mu) & 0 & 0 & 0 \\ 0 & \omega\beta & \omega_1\sigma & -(\delta+\mu+d) & 0 & 0 \\ 0 & 0 & \omega_2\sigma & \delta & -(\alpha+\mu) & 0 \\ 0 & 0 & \omega_3\sigma & 0 & \alpha & -(\mu+\gamma) \end{pmatrix} \tag{10}$$

We will compute trace and determinant of the Jacobian matrix and check their signs.

$$\text{Trace} = -\mu - (\beta+\mu) - (\sigma+\mu) - (\delta+\mu+d) - (\alpha+\mu) - (\mu+\gamma) \tag{11}$$

From equation (11) the trace of matrix L is negative.

The determinant of matrix L is given as

$$\text{Det }(L) = \frac{[((1-\omega)\lambda_1+\omega\lambda_2)\mu+\lambda_2\omega_1\sigma+(1-\omega)(\delta+d)]\beta\Lambda}{\mu(\beta+\mu)(\delta+\mu+d)(\omega_1\sigma+\mu)} < 1 \quad (12)$$

Therefore, the GFE is locally asymptotically stable whenever the threshold value $\mathcal{R}_0 < 1$ and unstable if $\mathcal{R}_0 > 1$.

2.2.4. Global Stability of the GFE

We will use the Metzler matrix approach to analyze global stability of the GFE. Let f_n represent vector of classes that cannot contribute to gambling, f_g represent vector of compartments that can influence sober individuals to engage in gambling, and f_{GFE} represent vector of gambling free point.

$$\begin{pmatrix} \Lambda+\gamma R+(\lambda_1 C+\lambda_2 H+\mu)S \\ \omega_3\sigma C+\alpha T+(\mu+\gamma)R \\ (\lambda_1 C+\lambda_2 H+\mu)S-\beta E-\mu E \\ \omega_2\sigma C+\delta H-(\alpha+\mu)T \end{pmatrix} = M_1\begin{pmatrix} S-\frac{\tau}{\omega} \\ R \\ E \\ T \end{pmatrix} + M_2\begin{pmatrix} C \\ H \end{pmatrix} \quad (13)$$

and

$$\begin{pmatrix} (1-\omega)\alpha E-(\omega_1\sigma+\omega_2\sigma+\omega_3\sigma+\mu)C \\ \omega\alpha E+\omega_1\sigma C-(\delta+\mu+d)H \end{pmatrix} = M_3\begin{pmatrix} C \\ H \end{pmatrix} \quad (14)$$

where

$$M_1 = \begin{pmatrix} -\mu & \gamma & 0 & 0 \\ 0 & -(\mu+\gamma) & 0 & \delta \\ 0 & 0 & -(\beta+\mu) & 0 \\ 0 & 0 & 0 & -(\alpha+\mu) \end{pmatrix} \quad (15)$$

$$M_2 = \begin{pmatrix} -\lambda_1\frac{\Lambda}{\mu} & -\lambda_2\frac{\Lambda}{\mu} \\ \omega_3\sigma & 0 \\ \lambda_1\frac{\Lambda}{\mu} & \lambda_2\frac{\Lambda}{\mu} \\ \omega_2\sigma & 0 \end{pmatrix} \quad (16)$$

$$M_3 = \begin{pmatrix} -(\sigma+\mu) & 0 \\ \omega_1\sigma & -(\delta+\mu+d) \end{pmatrix} \quad (17)$$

The GFE is globally asymptotically stable when the threshold value $\mathcal{R}_0 < 1$ and unstable whenever $\mathcal{R}_0 > 1$

since M_3 is a stable Metzler matrix and the eigenvalues of matrix M_1 are real and negative.

2.2.5. Gambling Endemic Equilibrium (GEE)

From system (1), we have

$$\Lambda-\mu(S+E+C+H+T+R)-dH = 0 \quad (18)$$

which implies that $\Lambda = \mu N + dH$.

Since $\Lambda > 0, \mu > 0$, and $d > 0$, it follows that $\mu N > 0$ and $d > 0$. Therefore, $S > 0, E > 0, C > 0, H > 0, T > 0$, and $R > 0$. This indicates the existence of gambling-persistent equilibrium state of the gambling addiction model.

2.2.6. Global Stability of the GEE

We use Korobeinikov method to study the global stability of the GEE. Let the Lyapunov candidate function for global stability be described by

$$K = \sum g_{i(V_i - V_i^* \ln V_i)}$$

where g_i is suitably chosen non-negative constant, V_i represent population of the i^{th} compartment type, and V_i^* is the critical state.

$$K = L_1(S-S^*\ln S)+L_2(E-E^*\ln E)+L_3(C-C^*\ln C)+L_4(H-H^*\ln H)+L_5(T-T^*\ln T)+L_6(R-R^*\ln R)$$

where $L_1, L_2, \ldots L_6$ are non-negative, differentiable, and continuous Lyapunov constants in space Γ.

$$\frac{dK}{dt} = L_1\left(1-\frac{S^*}{S}\right)\frac{dS}{dt}+L_2\left(1-\frac{E^*}{E}\right)\frac{dE}{dt}+L_3\left(1-\frac{C^*}{C}\right)\frac{dC}{dt}+L_4\left(1-\frac{H^*}{H}\right)\frac{dH}{dt}+L_5\left(1-\frac{T^*}{T}\right)\frac{dT}{dt}+L_6\left(1-\frac{R^*}{R}\right)\frac{dR}{dt}$$

$\frac{dK}{dt}$ at the GEE is given as

$$\frac{dK}{dt} = -L_1\left(1-\frac{S^*}{S}\right)^2-L_2\left(1-\frac{E^*}{E}\right)^2-L_3\left(1-\frac{C^*}{C}\right)^2-L_4\left(1-\frac{H^*}{H}\right)^2-L_5\left(1-\frac{T^*}{T}\right)^2-L_6\left(1-\frac{R^*}{R}\right)^2+G(S,E,C,H,T,R),$$

where $G(S,E,C,H,T,R)$ is negative. It follows that if $G(S,E,C,H,T,R) \le 0$ for all S,E,C,H,T,R then $\frac{dK}{dt} \le 0$ for all S,E,C,H,T,R. $\frac{dK}{dt} = 0$ if and only if $S = S^*, E = E^*, C = C^*, H = H^*, T = T^*, R = R^*$. Clearly, E^* is the largest invariant compact set in $\Gamma: \frac{dK}{dt} = 0$. Therefore, E^* is globally asymptotically stable by LaSalle's invariant principle.

3. Results and Discussion

In this section, the numerical simulation and analysis of the gambling addiction model is carried out to reveal the dynamical behavior of the gambling habit in the community over a certain period of time.

3.1. Parameter Estimation

The parameter values used for simulation in the gambling addiction model are presented in Table 2.

Table 2. Parameter Description.

Parameter	Value	Source
Λ	5	Assumed
λ_1	0.0001	Assumed
λ_2	0.0003	Assumed
β	0.039	Assumed
ω	0.2	Assumed
ω_1	0.4	Assumed
ω_2	0.3	Assumed
ω_3	0.3	Assumed
α	0.0051	Assumed
γ	0.0089	Assumed
μ	0.02	Assumed
d	0.059	Assumed
σ	0.0301	Assumed

3.2. Simulations and Discussion

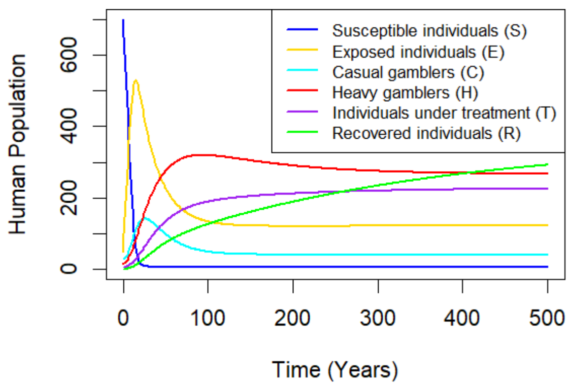

Figure 2. Dynamics of Gambling Addiction behavior in Human Population.

Figure 2 clearly captures the behavioral dynamics of the human population in the presence of gambling problem within the community. The figure shows the behavior of the population when no gambling control mechanisms are taken to mitigate or eradicate the menace. Numerical simulation reveals a sharp increase of both casual and heavy gamblers. Notably, this rapid increase correspondingly decreases the susceptible population since numerous individuals get exposed to the gambling problem. Therefore, the frequent and sustained contact between the susceptible population and gamblers increases the likelihood of initiation into gambling practice. As a result, the rise in the number of gamblers intensifies contact rates between susceptible population and gamblers thus further increasing gambling problem within the community. The results of Figure 2 indicates that as the influence of gambling habit intensifies, the number of exposed individuals increases, and the number of individuals recruited into the vice rises rapidly. Therefore, contact rate between susceptible individuals and both casual and heavy gamblers contribute to the spread and persistence of gambling behavior in the society. This perfectly agrees with the study conducted by Noel et al. (2024) [10], which indicate that increased exposure to gambling behaviors raises the likelihood of habit initiation, especially among youth. Similarly, the work of Wardle et al. (2024) [16] emphasizes that social contagion and peer influence contribute to gambling participation. Hence, gambling control interventions that can modify interaction patterns or reduce interaction between susceptible individuals and both casual and heavy gamblers could mitigate gambling prevalence in the community.

In Figure 2, no serious attention is applied to reduce gambling initiation, however, limited efforts such as establishment of rehabilitation centers do exist. The system in Figure 2 predicts a steady rise in the number of both casual and heavy gamblers, which also increases the number of those taken to rehabilitation centers for treatment, and hence a rise in those who recover from the habit. Figure 2 also shows an increase of the number heavy gamblers overtime since casual gamblers becomes heavy gamblers due to delayed treatment in rehabilitation centers. Therefore, in absence of gambling control mechanisms such as awareness campaigns, regulatory enforcement, or counseling programs people become highly susceptible to gambling initiation from both casual and heavy gamblers. Control strategies play a pivotal role in mitigating gambling behavior in the society.

Figure 3 shows the effect of gambling control mechanism on reducing gambling habit. The number of heavy gamblers rises slightly over time before it reduces because as the number of casual gamblers reduces, some will transition to become heavy gamblers. Exposed and casual gamblers reduce in number over time indicating that gambling control mechanisms are effective.

In Figures 4 and 5, we simulated the model under three levels of gambling control efforts, that is when there is no intervention (0% control effort), partial prevention (50% control effort), full prevention (100% control effort) to assess the effect of different levels of intervention strategies. Here, the control efforts comprise of treatment-based and preventive measures such as counseling, regulatory policies, and campaign awareness aimed at minimizing contact rates between susceptible individuals and gamblers The findings highlight very interesting results on the impact of varying gambling control mechanisms. It indicates that the effectiveness of control strategies depends on the effort devoted to it, that is, higher effort leads to greater reduced number of both Casual and Heavy gamblers. Under 0% control effort, that is, when there is no gambling intervention, the number of both Casual and Heavy gamblers remains high throughout the numerical simulation period. Here, susceptible individuals in contact with both casual and gamblers are likely to adopt gambling behavior leading to the rise in the number of gamblers. When the interventions are moderately applied (50% control effort), the contact rate between susceptible individuals and both casual and heavy gamblers are partially reduced leading to a slightly slower spread of the gambling problem. Partial control efforts such as limited counseling sessions, moderate regulatory enforcement, and periodic awareness programs slightly reduce the gambling behavior in the society. Full implementation of gambling interventions (100% control effort) produces the most effective results as it drives the population of both casual and heavy gamblers to the lowest levels. Therefore, strong gambling control measures such as comprehensive awareness and education programs, accessible treatment and rehabilitation services, and strict regulation of gambling activities are effective in minimizing gambling addiction in the population.

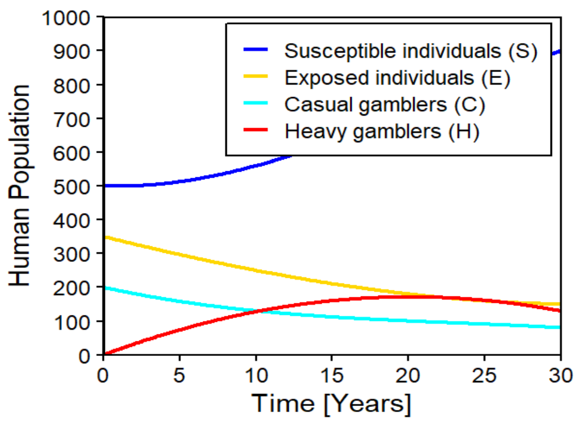

Figure 3. *Impact of Gambling control mechanisms on susceptible individuals, exposed individuals, casual gamblers, and heavy gamblers.*

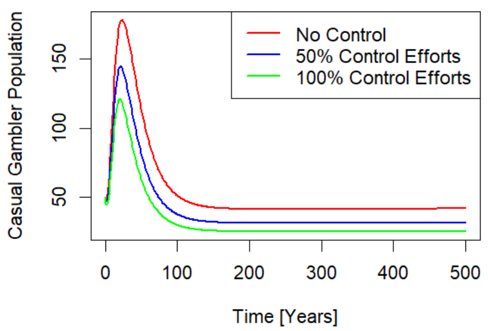

Figure 4. *Impact of varying level of control strategies in casual gamblers.*

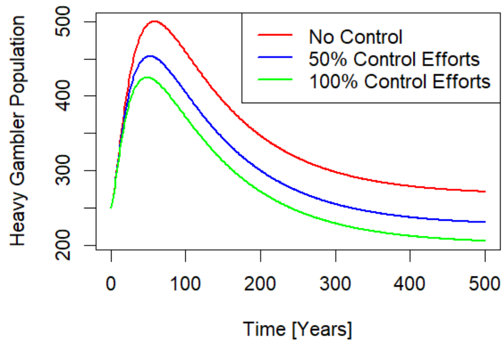

Figure 5. *Impact of varying level of control strategies in heavy gamblers.*

4. Conclusions

The article presents a gambling addiction mathematical model to assess the effectiveness of control mechanisms. We developed and analyzed the gambling addiction model. The analytical results indicate that the model is mathematically and epidemiologically meaningful in the feasible region Γ. We also established the conditions for existence of steady states, that is, gambling free equilibrium and gambling endemic equilibrium. We found the that both equilibrium states were locally and asymptotically stable whenever the threshold value $\mathcal{R}_0 < 1$ and unstable if $\mathcal{R}_0 > 1$. Simulation results indicate an increase in casual gamblers, heavy gamblers and exposed population when no control effort is devoted to mitigate gambling problem. Results also show a significant decrease of casual gamblers, heavy gamblers, and exposed population when control effort is applied, this leads to an increase in the susceptible population.

The findings of this study further highlights that effective results of gambling addiction control strategies depend on the level of invested effort. For instance, higher effort increases the chances of overcoming the challenge and vice versa. The gambling control mechanisms reduces the progression rate of casual gamblers to heavy gamblers. Therefore, there is a need to invest in gambling treatment and other control measures to reduce gambling habit in the society.

We acknowledge that the mathematical model for gambling addiction presented in this paper has some limitations. For instance, it assumes homogeneous mixing of population and overlooks heterogeneity in gender, socio-economic status, or age, which influence gambling behavior. Similarly, the model does not capture stochastic fluctuations, which is crucial especially when dealing with small populations. We note that future study that adopts stochastic modelling approach with gambling intervention data could address these shortfalls.

Abbreviations

GFE	Gambling Free Equilibrium
GEE	Gambling Endemic Equilibrium

Author Contributions

Hillary Kiprop Kosgei: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing

Phylis Jerotich Kibet: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Validation, Visualization

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Allami, Y., Hodgins, D. C., Young, M., Brunelle, N., Currie, S., Dufour, M., Flores-Pajot, M. C., & Nadeau, L. (2021). A meta-analysis of problem gambling risk factors in the general adult population. *Addiction (Abingdon, England)*, *116*(11), 2968–2977. https://doi.org/10.1111/add.15449

[2] Bitanihirwe, B. K. Y., Adebisi, T., Bunn, C., Ssewanyana, D., Darby, P., & Kitchin, P. (2022). Gambling in Sub-Saharan Africa: Traditional Forms and Emerging Technologies. *Current addiction reports*, *9*(4), 373–384. https://doi.org/10.1007/s40429-022-00449-0

[3] Chóliz, M., Marcos, M., & Lázaro-Mateo, J. (2021). The risk of online gambling: A study of gambling disorder prevalence rates in Spain. International Journal of Mental Health and Addiction, 19(2), 404–417. https://doi.org/10.1007/s11469-019-00067-4

[4] Dellosa, G., & Browne, M. (2024). The influence of age on gambling problems worldwide: A systematic review and meta-analysis of risk among younger, middle-aged, and older adults. *Journal of behavioral addictions*, *13*(3), 702–715. https://doi.org/10.1556/2006.2024.00051

[5] Hayano, S., Dong, R., Miyata, Y., & Kasuga, S. (2021). The study of differences by region and type of gambling on the degree of gambling addiction in Japan. *Scientific reports*, *11*(1), 13102. https://doi.org/10.1038/s41598-021-92137-8

[6] Hillary Kiprop Kosgei. (2022). Modelling HIV/AIDS Infection Dynamics in the Presence of Interfered Interventions. *Journal of Advances in Mathematics and Computer Science*, *37*(4), 31-52. https://doi.org/ 10.9734/jamcs/2022/v37i430447

[7] Lugina, N. A., & Kytun, A. P. (2019). A Person with a Game Addiction as a Victim of the Crime of Gambling. *JE Eur. L.*, 136. https://doi.org/10.5281/zenodo.3608058

[8] Maina, M. M. (2020). *Factors influencing growth of gambling activities in Kenya* (Doctoral dissertation, Strathmore University). http://hdl.handle.net/11071/10425

[9] Miriti, A. G. (2020). *Prevalence of gambling disorder among patients seeking psychiatric treatment at Mathari national teaching and referral hospital in Nairobi, Kenya* (Doctoral dissertation, University of Nairobi). http://erepository.uonbi.ac.ke/handle/11295/154031

[10] Noel, J. K., et al. (2024). Internet, app-based, and casino gambling: Associations with problem gambling symptoms among U.S. young adults. https://doi.org/10.1007/s10899-024-10284-9

[11] Romeu, R. J., Haines, N., Ahn, W. Y., Busemeyer, J. R., & Vassileva, J. (2020). A computational model of the Cambridge gambling task with applications to substance use disorders. *Drug and alcohol dependence*, *206*, 107711. https://doi.org/10.1016/j.drugalcdep.2019.107711

[12] Serna, C., García-Perales, J., & Martínez, I. (2023). Protective and risk parenting styles for internet and online gambling addiction. *Human Behavior and Emerging Technologies*, *2023*(1), 6674541. https://doi.org/10.1155/2023/6674541

[13] Ssewanyana, D., & Bitanihirwe, B. (2018). Problem Gambling among Young People in Sub-Saharan Africa. *Frontiers in public health*, *6*, 23. https://doi.org/10.3389/fpubh.2018.00023

[14] Van den Driessche, P., & Watmough, J. (2002). Reproduction numbers and sub-threshold endemic equilibria for compartmental models of disease transmission. *Mathematical biosciences*, *180*, 29–48. https://doi.org/10.1016/s0025-5564(02)00108-6

[15] Van den Ende, M. W. J., Epskamp, S., Lees, M. H., van der Maas, H. L. J., Wiers, R. W., & Sloot, P. M. A. (2022). A review of mathematical modeling of addiction regarding both (neuro-) psychological processes and the social contagion perspectives. *Addictive behaviors*, *127*, 107201. https://doi.org/10.1016/j.addbeh.2021.107201

[16] Wardle, H., et al. (2024). The Lancet Public Health Commission on gambling. The Lancet Public Health. https://doi.org/10.1016/S2468-2667(24)00167-1