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Mathematical Model Approach for Describing the Dynamics of Drugs-Abuse and Its Non-Pharmacological Control Measures

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Abstract
There is prevailing problem of drugs-abuse in Bauchi statedespite existing control measureswhich renders the abusers psycho-socially and economically unproductive to self, and the state at large, and the fact that most of the control measures involve pharmacological interventions, the problem becomes more difficult to handle due to drugs complications and dependence on the prescribed drugs as alternative drugs for the abusers in treatment.To overcome the identified challenges and provide alternative controlmeans, this study uses the idea of the basic SIR model and pharmacokinetics and comes up with an ADME-based mathematical model that focuses on human population and ITE-based model that focuses on the body of the abusersmathematical model in form of differential equations. Based on the results from the modelsstability analyses, we consequently conclude that we can achieve drugs-abuse problems' eradication by adopting special dieting, psycho-social development programs and skills acquisition training of the patients. Also, the drugs of abuse's concentration in the patients' body system can be eliminated and they can gain back their healthy condition and the inferential statistical analysis reveals that the control measures areacceptable and practicable.Therefore we recommend that drugs-abusepatients in treatment should be: placed on a special diet that can catalyze the rate of drugs metabolism and removal from their body, made to undergo psycho-social development programs and economic-skills acquisition trainings amongst othersin order torevive them and maximize productivity in our populace in the stateat large.

Key words: Drugs-abuse, productivity, socio-economic development

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I. Introduction

The problem of drugs or psychoactive substances abuse has been a persistent unfortunate matter of health that needs to be addressed squarely for its destructive effects on economy, peace and humanity in general Public Administration Department PAD (2021). Despite several control strategies put in place, yet there is need for the discovery of more convenient alternative measure(s) for containing the spread of the disease in the fields of research. There have been many different approaches employed to come up with lasting solutions to the problem but the fact that some or most of the containment measures are partially or purely pharmacological (through the use of drugs) whether to control the problem directly or the drugs of abuse withdrawal syndrome, and that makes the treatment to some extent more problematic due to drugs complication or dependence on the treatment drugs as alternative drugs of abuse National Institute on Drug Abuse (NIDA, 2014). Therefore, in order to help provide alternative solution to the problem devoid of more complications realized through the use of other drugs in controlling the scourge of the disease, this study proposes and analyzes a mathematical model that describes the dynamics of the disease and by extension, its' related problems' (such as economic deprivations) alternative control strategies by considering non-pharmacological approach. The study comes up with a simple model that analyzes the impact which the control measure(s) adopted by the study can produce by considering three (3) important successive stages incorporated in the model thus:

i. There is need to isolate patient(s) under taking special dietaries, medical tests and observations for a while. We call it health development zone;
ii. There is need to keep patient(s) undergoing awareness, sensitization and other educative programs against drugs abuse for a while. We call it psycho-social development zone;
iii. There is need to keep patient(s) undergoing skills acquisition programs for a while. We call it economic development zone.

Problem of drug abuse has been an issue of concern for its growing trend world over. According to Salisu*et al*(2021), in the year 1956, World Health Organization (WHO) and American Psychological Association (APA) identified drug-abuse as a disease that can be treated National Institute on Drug Abuse (NIDA, 2014) which is

defined as the illicit administration of any naturally occurring or pharmaceutically prepared substance for the purpose of changing the manner in which a consumer feels, thinks, or behaves without understanding or considering the damaging physical and mental side-effects that are eventually caused.

Research revealed that there were 275 million people aged between 15-64 years who have used drugs worldwide and roughly, 20 million people were found to be past-year users of psychoactive substance in 2019. On the continent of African, it has been projected that the number of people who use psychoactive substances would grow by about 75% by the year 2030 United Nations Office on Drug and Crime (UNODC, 2021).

It has been estimated that 14.4 % of the Nigeria's population or 14.3 million individuals aged between 15 and 64 years had used drugs, excluding alcohol and tobacco in 2017. Similarly,by2018 report on drug use in Nigeria, prevalence of drug use in the countryby geopolitical zones indicates that in the North-East zone 13.6% was observed and the equivalent number was 2,090,000 which placed the region as fourth with North-West being the highest. South-West zone was observed to have had 22.4% which is equivalent to 4,382,000. From the North-East, for instance in Bauchi state it was estimated that over 530,000 personswere observed with drug abuse equivalent to 16% compared to the other state in the zone with Gombe state being the highest with 21% prevalence of drug use Public Administration Department (PAD, 2021).

In pharmacological therapy, some medical drugs like nicotine replacement therapies, bupropion and varenicline (to curb tobacco withdrawal syndrome), methadone, buprenorphine and naltrexone (to contain opioids withdrawal syndrome) and naltrexone, disulfiram and acanprosate (to avoid alcohol and drug withdrawal syndrome) are produced to help patientsundergoing treatment ofdrugs addiction problems to adjust and get it easier with the withdrawal syndrome, however to make the disease more complex the patients also develop dependence on the therapeutic alternative drugs in the process of the medication (NIDA, 2014). Similarly, Simona*et al*, (2018) revealed that drug-drug interactions within the body are among the most frequent causes of adverse reactions during poly-pharmacy, or the chronic co-prescription of several drugs and it has also been estimated and reported that 6–30% of all side eff ects are caused by a pharmacological interaction.

Loss in productivity is the most cited impact that can occur when drug users are under the influence of drugs or are experiencing the consequences of their drug use. Studies have revealed that the costs of drug-related lost productivity at tens of billions of dollars (UNODC, 2013) and it has been reported that young people continue to use more drugs at higher level than adults in past generations, and children and youth that have been exposed to drugs at youthful age and/or are in particularly deprived circumstances, it is suggested that provision of educational opportunities, vocational skills acquisition and other socioeconomic support can be of great impact to rescue them (UNODC, 2022).

There have been continued efforts to curtail the problem of drug or psychoactive substances abuse but yet the problem remains disturbing and leading to poor or lack of productivity amongst the abusers who are mostly youths. For instance in Nigeria, there have been programs from government at different levels in trying to bring about human capital development, alleviate poverty in order to ensure meaningful socio-economic development through Agricultural and other social investment programs, but due to alarming prevalence of drug abuse as a social vice amongst our teeming youths that render them incapacitated across the country, however insignificant developments are always observed as a result of poor participation of youths in the developmental investment programs.Apart from rendering abusers functionally incapacitated and economically unproductive by resulting number of drugs abuse related illnesses and conditions especially mental disorders, psychoactive substances abuse has been responsible for the spread of many infectious diseases and violence as such, it is a serious matter of concern. Not only on human capital development but also, the damaging effects of drug abuse in our societies can never be over emphasized as it triggers spread of other diseases and violence (be it personal or inter personal) in our societies United Nations Office on Drug and Crime (UNODC, 2017).

Fikiri and Dmitry (2019),used epidemiological principles (social contact transmission process between susceptible and drug abusing persons) and proposed a new mathematical modeling framework to investigate the effects of drug use in community and obtained epidemic threshold $\Re_0$ for the drug-abusing individuals. They conducted sensitivity analysis on the threshold and then used it in examining the stability of the system where they also established condition (as conditions that permit the existence of one or more endemic equilibria) under which a backward bifurcation may exist and suggested that prevention of the problem is better than battling to cure it.

Jiahua*et al*, (2022) used myo-inositol (MI) dietary and investigated its effectiveness on carbohydrate metabolism during osmoregulation in tilapia fish subjected to sustained hypertonic stress where 6 diets containing different levels of carbohydrate were served to number of fishes for 8 weeks. They observed that MI supplement significantly encouraged growth and protein content but decrease the crude lipid content of the fish. Moreover fish that were not fed with the MI supplement were observed with health related signs and it was discovered that MI dietary promoted the rate of carbohydrate metabolism in the liver.

Sergi*et al*, (2022) considered two biological samples (urine and saliva) and used chromatographic and electrophoretic method and came up with a new phase of drug abuse testing approach unlike other existing

methods that the biological matrices can contain various other compounds that affect the analysis and the desired result.

Simona*et al*, (2018) studied problematic drug interactions in the body due to poly-pharmacy they reviewed data available in literature regarding the relevant drug–drug interactions of the medications currently approved in United States and in some European countries for the treatment of alcohol use disorder (AUD). Drugs such as benzodiazepines, acamprosate, baclofen, disulfiram, nalmefene, naltrexone and sodium oxybate were considered and observed that the class of benzodiazepines and disulfiram are involved in numerous pharmacological interactions, while they are not conspicuous for acamprosate while other drugs are relatively safe for pharmacological interactions, excluding the opioid withdrawal syndrome caused by the combination of nalmefene or naltrexone with an opiate medication. With the development, clinicians are aided in understanding and managing the pharmacological interactions in AUDs, especially in patients under multi-drug treatment, in trying to eliminate or reduce the risk of a negative interaction and to improve the treatment outcomes.

Relentless efforts are put in place through scientific and other ways (as literatures show) to control or eliminate the problem of drug abuse disease from our societies yet the problem is thriving with the unfortunate growth of the problem in Bauchi state where not less than 530,000 individuals were found to be involved in the practice of drug abuse in the state. Therefore based on the PAD (2021) recommendations that to control the menace of drug abuse, there should be a holistic approach, show of care to the infected, and embrace mass awareness hence the need for more alternative control strategies which this research work intends to address so as to provide more understanding of the dynamics, and more convenient, control measure(s) of the disease for meaningful socio-economic development, peaceful, safer and healthier living in the state and the country at large.The research objectives are to:obtain a mathematical model for the dynamics and control of drugs abuse disease, carry out stability analyses of the model and prove the effectiveness of the control measure(s) of the disease adopted by the research.

II. ADME-Based Model Formulation

The model is formulated by considering the entire human population assumed to be sub-divided into 5 different cohorts and the disease transmits in a frequency dependent manner, the population under study is homogeneously mixed, every individual is born susceptible and migration effect is mitigated where the (assumed) state variables and parameters used are defined in Table 1.

Table 1: Variables and Parameters of the Model

Variables/Parameters	Descriptions
$S(t)$	Is the population of susceptible individuals at time t
$A(t)$	Is the population of drug Abusers(infected persons) at time t
$M(t)$	Is the population of infected persons in Medication (called Health Development Zone) at time t
$R(t)$	Is the population of Recovered persons (in Psycho-Social Development Zone) at time t
$T(t)$	Is the population of individuals in skills acquisition or Training(in Economic Development Zone) at time t
$N(t)$	Is the total sum of the sub-populations under the study at time t
β	Is the rate of recruitment or birth of the population
μ	Is the natural death rate in the entire population
δ_1	Is disease induced death rates of the infected sub-population A
δ_2	Is disease induced death rate in medication class M
α	Is convincing rate from S to A
γ	Is the rate of entering medication zone
σ	Is the rate of recovering from the disease
λ	Is the rate of joining skills acquisition training from recovery
θ	Is the rate at which transformed ones become susceptible again

2.1The ADME-Based Model Equations

$$\frac{dS}{dt} = \beta + \theta T - \left(\alpha \frac{A}{N} + \mu\right) S$$
$$\frac{dA}{dt} = \alpha S \frac{A}{N} - (\gamma + \mu + \delta_1) A$$
$$\frac{dM}{dt} = \gamma A - (\sigma + \mu + \delta_2) M \quad (1)$$
$$\frac{dR}{dt} = \sigma M - (\lambda + \mu) R$$
$$\frac{dT}{dt} = \lambda R - (\mu + \theta) T$$

where $N(t) = S(t) + A(t) + M(t) + R(t) + T(t)$ (2)

subject to the initial conditions as:

$S(0) = S_0, A(0) = A_0, M(0) = M_0, R(0) = R_0, T(0) = T_0$ (3)

2.2 The ADME-Based Model Dynamics

$$\frac{dS}{dt} = \beta + \theta T - \left(\alpha \frac{A}{N} + \mu\right) S$$

Susceptible persons' compartment increases by the inflow of individuals through birth rate and re-susceptibility rate; while it decreases by- the rate at which persons are convinced to join drug abuse, and the rate at which they die naturally.

$$\frac{dA}{dt} = \alpha S \frac{A}{N} - (\gamma + \mu + \delta_1) A$$

Abusers' population increases by the inflow of people at the convincing rate of joining the practice of drug abuse; however it decreases by- the rate at which individuals go for medication, the rate at which individuals die naturally and the rate at which individuals die as a result of the disease.

$$\frac{dM}{dt} = \gamma A - (\sigma + \mu + \delta_2) M$$

Those in medication class increase by the rate at which persons go for medication; but decreases due to- persons going for psycho-social development, the rate at which persons die naturally and the disease induced death rate.

$$\frac{dR}{dt} = \sigma M - (\lambda + \mu) R$$

Recovered persons' population increases by incoming of persons due to joining psycho-social development programs; but decreases due to natural death rate and the rate at which people go for skills acquisition trainings.

$$\frac{dT}{dt} = \lambda R - (\mu + \theta) T$$

Trainees' population increases by the inflow of individuals who come for skills acquisition programs; but decreases due to natural death rate and the rate at which persons become susceptible to the disease again.

2.3The ADME-Based ModelAnalysis

The model is analyzed based on the following:

2.3.1 Posotivity of the model solution

Positivity of the model solution is proved using the method adopted by (Lawrence *et al*, 2018).

Theorem 1: Let the initial solution set $\{(S, A, M, R, T)(0) > 0\} \in \mathbb{R}^5_+$ then the solution set $\{(S, A, M, R, T)(t)\}$ for the system (1) is positive $\forall t > 0$.

Proof: From $\frac{dS}{dt} = \beta + \theta T - \left(\alpha \frac{A}{N} + \mu\right) S$

Then, $\frac{dS}{dt} \geq -\left(\alpha \frac{A}{N} + \mu\right) S$ (4)

Equation (4) can be rewritten in the form,

$$\frac{dS}{dt} + \left(\alpha \frac{A}{N} + \mu\right) S \geq 0$$

(5)

Integrating Factor $I.F. = e^{h} = e^{\int \left(\alpha \frac{A}{N} + \mu\right) dt}$,

$$S \geq e^{-\int \left(\alpha \frac{A}{N} + \mu\right) dt} \left(\int e^{\int \left(\alpha \frac{A}{N} + \mu\right) dt} . 0 + C \right) \quad (6)$$

$$S(t) \geq Ce^{-\int \left(\alpha \frac{A}{N} + \mu\right) dt} \quad (7)$$

Equation (7) implies that $S(t)$ is always positive as time progresses. Following the same procedure on the other equations in system (1), shows that the solutionset $\{S(t), A(t), M(t), R(t), T(t)\}$ is positive for all time and hence the proof.

2.3.2Invariant region of the model solution

Invariant region or region of bound of the model solution is proved using the method employed by (Mafuta, Mushanyu and Nhawu, 2014).

Theorem 2: If the initial solution set for the model system (1), $\{(S, A, M, R, T)(0) > 0\} \in \Omega$ then the solution set $\left\{(S, A, M, R, T)(t) > 0 : N \leq \frac{\beta}{\mu}\right\} \in \Omega \ \forall t > 0$.

Proof: Differentiating equation (2), making appropriate substitutions and simplifying gives,

$$\frac{dN}{dt} = \beta - \delta_1 A - \delta_2 M - \mu N$$

$$\frac{dN}{dt} \leq \beta - \mu N$$

Separating the variables integrating and simplifying gives,

$$N \leq \frac{\beta}{\mu} - \frac{e^{-\mu(t+c)}}{\mu}$$

Taking limit as time, $t \to \infty$ gives,

$$N \leq \frac{\beta}{\mu} \quad (8)$$

Taking limits as time, t tends to infinity, the total population, $N \to \frac{\beta}{\mu}$

The solution of the Drug-Abuse sub-system will be studied in the positive invariant region $\Omega = \Omega \subset \mathbb{R}^5_+$ with

$$\Omega = \left\{(S, A, M, R, T) \in \Re^5_+ : N \leq \frac{\beta}{\mu}\right\} \quad (9)$$

To establish the positive invariance of the region Ω, the solutions of the system remain in Ω for all time, $t > 0$.

2.3.3 Drug-free equilibrium point of the ADME-based model

To obtain the drug-free equilibrium point we set the rate of changes and the state variable of system (1) to 0 except the susceptible S to get,

$$E_0 = (S, A, M, R, T) = \left(\frac{\beta}{\mu}, 0, 0, 0, 0\right)$$

(10)

2.3.4Basic reproduction numberand local stability of the drug-free equilibrium point of the ADME-based model

Basic reproduction number is obtained by next generation matrix approach proposed by (Driessche and Watmough, 2002).

Theorem 3: The basic reproduction number of the system is $\Re_0 = \frac{\alpha}{(\gamma + \mu + \delta_1)}$ and the drug- free equilibrium of the system is locally asymptotically stable if $\alpha < (\gamma + \mu + \delta_1)$.

Proof: From system (1) considering the diseased compartment, the transmission and transition matricesare obtained thus:

$$F_i = [F_1] = \left[\alpha \frac{A}{N} S\right] \quad (11)$$

$$F = \frac{\partial F_1}{\partial A} = \left[\alpha \frac{S}{N}\right]$$

(12)

$$V_i = [V_1] = \left[(\gamma + \mu + \delta_1)\right]$$

(13)

$$V = \frac{\partial V_1}{\partial A} = \left[(\gamma + \mu + \delta_1)\right]$$

(14)

$$V^{-1} = \left[\frac{1}{(\gamma + \mu + \delta_1)}\right] \quad (15)$$

$$\left[FV^{-1}\right] = \left[\frac{\alpha}{(\gamma + \mu + \delta_1)}\right]$$

(16)

$$\left|FV^{-1} - \lambda_0\right| = \left|\frac{\alpha}{(\gamma + \mu + \delta_1)} - \lambda_0\right| = 0 \quad (17)$$

$$\lambda_0 = \frac{\alpha}{(\gamma + \mu + \delta_1)} = \Re_0$$

Therefore the basic reproduction number is $\Re_0 = \frac{\alpha}{(\gamma + \mu + \delta_1)}$ (18)

For local asymptotic stability of the system, $\Re_0 = \frac{\alpha}{(\gamma + \mu + \delta_1)} < 1$ or

$$\alpha < (\gamma + \mu + \delta_1)$$

(19)

From the condition in (19) the system is locally asymptotically stable if the rate at which susceptible individuals are convincedto start drug-abusing is kept less than the total sum of the rates at whichdrug-abuse infected persons join medication zone, die naturally and die as a result of the infection.

2.3.5Global stability of the ADME-based model

Global stability of the model is proved using the technique by (Castillo-Chavez, Feng and Huang, 2001).

Theorem 4: The equilibrium point $E_0 = \left(\frac{\beta}{\mu}, 0, 0, 0, 0\right)$ is globally asymptotically stable if the following condition holds:

$$\frac{dX}{dt} = P(X, I)$$
$$\frac{dI}{dt} = Q(X, I), Q(X, 0) = 0 \quad (20)$$

Proof: $X = (S, M, R, T) \in \mathbb{R}^4$, $I = (A) \in \mathbb{R}$, $Q(X, 0) = \left(\frac{\beta}{\mu}, 0, 0, 0, 0\right) = E_0$

$$Q(X, I) = \left[Q_1(X, I)\right] = \left[\alpha A\left(1 - \frac{S}{N}\right)\right] \quad (21)$$

Since initially all individuals in the population stand to be susceptible $(0 \le S \le N)$ then,

$$Q(X, 0) = \left[Q_1(X, 0)\right] = \left[\alpha A\left(1 - \frac{S}{N}\right)\right] = 0 \quad (22)$$

Hence the equilibrium point is globally asymptotically stable.

III. The ITE-Based Model Equation

The model equation is given by:

$\frac{dC}{dt} = \tau - \omega C$ which can be rewritten as,

$$\frac{dC}{dt} + \omega C = \tau \quad (23)$$

From the model in (23) the body gets more concentration of drugs due to the injection rate τ; while the concentration decreases due to outflow of the drug at the excretion rate ω.

3.1The ITE-Based Model Analysis

Equation (23) is a typical of first order linear non-homogeneous ODE of the form: $\frac{dy}{dx} + py = r$.

The integrating factor, $I.F = e^{\int \omega dt} = e^{\omega t}$

From $C\ I.F = \int \tau\ I.F\ dt + K$, where K is the constant of integration.

$$C\, e^{\omega t} = \int \tau\, e^{\omega t} dt + K$$
$$Ce^{\omega t} = \tau\left(\frac{1}{\omega} e^{\omega t}\right) + K$$
$$C = \frac{\tau}{\omega} + \frac{K}{e^{\omega t}}$$

where, $\lim_{t\to\infty} C = \lim_{t\to\infty}\left(\frac{\tau}{\omega} + \frac{K}{e^{\omega t}}\right)$

then, $C = \frac{\tau}{\omega}$ (24)

Which implies that at long run, the concentration of drug in the body reduces to $C = \frac{\tau}{\omega}$ and

$$\lim_{\omega \to \infty} C = \lim_{\omega \to \infty} \left(\frac{\tau}{\omega} \right)$$

$$C \to 0 \qquad (25)$$

From equation (25) it is obtained that total elimination of the drugs of abuse's concentration can be done.

IV. Validation of the Containment Measures Adopted

After the patient(s) or the experimental group have gone through the containment measures adopted by the model and then would be compared with those patients or the control group who did not go through to evaluate the experimental or practical effectiveness of the containment strategies adopted by the ADME-based model. Moreover, to evaluate the control measures of the disease adopted by the research, we designed a questionnaire and extracted information from more vulnerable participants (youths) and then analyzed the data generated based on the following research questions as follows:

4.1 Analysis of the responses to the research questions

Here we present the analysis of the response to the research questions based on the information extracted and testing of the formulated hypotheses as follows:

Question one: Do you accept the control measures (improved dieting as medication, psycho-social and skills acquisition) adopted by the research?

H_0: There is no significant relationship between acceptability and the control measures adopted by the researchers.

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	85.613	1	.000
Likelihood Ratio	96.926	1	.000
Linear-by-Linear Association	19.428	1	.000
N of Valid Cases	400		

At 5% level, $\alpha = 0.05$

The degree of freedom, V, is: $v = (c-1)(r-1) = (2-1)(2-1) = 1$

The critical value corresponding to the degree of freedom is:

$$\chi^2_{\alpha,v} = \chi^2_{0.05,1} = 0.0039$$

Decision Rule: Reject the null hypothesis if the calculated value is greater than the critical value and accept otherwise.

There is significant relationship between acceptability and the control measures adopted by the researcher because the calculated value (85.613) is greater than the critical value (0.0039) which lead to the rejection of the null hypothesis.

Symmetric Measures

		Value	Asymp. Std. Error	Approx. T	Approx. Sig.
Interval by Interval	Pearson's R	.630	.027	.443	.000
Ordinal by Ordinal	Spearman Correlation	.680	.027	.214	.000
N of Valid Cases		400			

By symmetric measures, result indicated that the relationship (r = 0.630) is positive and significant (p = 0.000). This shows that the two variables are going in the same direction, meaning that an increase in one variable might lead to an increase on the other variable and vice–versa. In other word, both the control measures adopted by the researcher were generally acceptable as the strategy to reduce the impact of drug abuse.

Question two: Do you think the control measures are practically feasible?

H_0: Applicability and the control measures are not practically feasible.

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	131.507	1	.000
Likelihood Ratio	161.801	1	.000
Linear-by-Linear Association	.144	1	.004
N of Valid Cases	400		

At 5% level, $\alpha = 0.05$
The degree of freedom, V, is: $v = (c-1)(r-1) = (2-1)(2-1) = 1$
The critical value corresponding to the degree of freedom is:

$$\chi^2_{\alpha,v} = \chi^2_{0.05,2} = 0.0039$$

Decision Rule: Reject the null hypothesis if the calculated value is greater than the critical value and accept otherwise.
Result indicated that applicability of the control measures are practically feasible since the calculated value (131.507) is greater than the critical value (0.0039), we reject the null hypothesis based on the analysis made thereof.

Symmetric Measures

		Value	Asymp. Std. Error	Approx. T	Approx. Sig.
Interval by Interval	Pearson's R	.711	.327	.380	.004
Ordinal by Ordinal	Spearman Correlation	.795	.327	.231	.001
N of Valid Cases		400			

Result from the symmetric measures indicated the applicability of the control measures are practically feasible since the correlation coefficient (r = 0.711) is positive and significant.
The two variables are going in the same direction, indicating that applicability of the adopted control measures influenced the control strategy and is practically feasible.

V. Discussion of Results

Considering the ADME-based model, the solution for the model or system of equations is obtained to be positive at any time on long run. The biological region of feasibility of the solution for the system has also been obtained since the system is bounded from above. Since the effort is to eradicate the problem and enhance productivity, then based on the basic reproduction of the disease, it has been obtained that eradication of the problem is possible upon satisfying a condition established with the local stability analysis of the model where the condition is that the rate at which individuals join drug-abuse should be kept less than the sum of the rates at which abusers go for medication, individuals die naturally and individuals die due to drugs-abuse. It has also been obtained that global stability is of the drugs-free population is feasible. It has been obtained from inferential statistical analysis that the containment strategies adopted by the model are acceptable and practically doable. Considering the ITE-based model, the effort here is to eliminate drugs or substances of abuse's concentration in the body of the abuser, and it has been obtained that the concentration can be eliminated at a point in time on long run.

VI. Conclusion

Based on the findings realized, it is therefore concluded that the escalating problem of drugs-abuse in our population can be contained or even eliminated by other means devoid of having risks of drug complications as a result of adopting pharmacological measures of control. Instead of pharmacological means however, we can achieve drugs-abuse problems' eradication by adopting special dieting, psycho-social development programs and skills acquisition training of the patients. Also, the drugs of abuse's concentration in the patients' body system can be eliminated and they can gain back their healthy condition and become socially and economically productive for self, societal and national development at large.Based on the conclusions made, we therefore recommend that non-pharmacological strategy can be adopted in controlling drug-abuse problem where patients would be placed on a special dietary, psycho-socially and skillfully trained to avoid its spread and negative effects of pharmacological measures. While undergoing the containment protocols, patients should be kept away from interacting with drug-abusers in order to avoid relapsing to the bad act of abuse and complicate the treatment. Patients should be placed on the special dietary that can catalyze the rate of drugs metabolism in the body for excreting it out of the body so that the drugs removal or elimination rate is enhanced. Security organizations and drugs-related law enforcement bodies should gear up their efforts towards apprehending and persecuting of drugs traffickers and abusers in our population. Above all, staying away from starting drugs-abuse is the best way in terms of its control as prevention is always better than cure especially in the case of drugs-abuse.

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Conflict of interest

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