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DYNAMICS OF EXAMINATION MALPRACTICE AMONG THE KEY PLAYERS IN NIGERIA

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Abstract: Examination malpractice is a social disease whose menace is crippling the quality of education in Nigeria. In this work, a new deterministic compartmental mathematical model was proposed to analyse the dynamics of examination malpractice among the key players in Nigeria. The positivity and boundedness of solutions of the model were established; the stability analysis was conducted using the linearization approach and the reproductive menace was derived via the next generational matrix method. Numerical simulation was carried out to investigate the effect of the key parameters on the reproductive menace. The result of the simulation showed that examination malpractice was more rampant when the rate of leakages of the examination questions was high. It was, therefore, suggested that for the control of examination malpractice to be effective in Nigeria, efforts must be geared towards blocking the channels of leakages of examination questions.

Keywords: *Examination; model; reproductive menace; key players; simulation.*

1. INTRODUCTION

The major objective of education in Nigeria is to enable the young ones to cope with future challenges and prepare them to meet the country's manpower requirements. Educational institutions have to conduct examinations as measures for assessment. The examination is the commonest way of assessment in the school system. The examination is defined in [1] as a way to measure the amount of a subject matter which a candidate has mastered in a certain field of study. Adewuye [2] also defined examination as the method through which candidates are tested or evaluated to determine the quality of knowledge the candidates have gained within a specified time especially in the form of answering various questions or practical exercises. Examinations could take various forms. It could be internal or external. It may be oral, written or both. Internal examinations are in the form of continuous assessment, semester, terminal, annual or promotion examinations. External or public examinations in Nigeria include the placement test into Junior Secondary Schools, School Certificate Examinations conducted by the National Examination Council (NECO) and the West African Examination Council (WAEC). Admission tests into tertiary institutions are conducted by the Joint Admissions and Matriculation Board (JAMB) while professional examinations are conducted for teachers and technicians by the National Business and Technical Examination Board (NABTEB).

Examination malpractice is wrongdoing before, during or after the examination. Wilayat as cited in [3] defined examination malpractice as intentional wrongdoing which contravenes the official examination rules and regulations formulated to place a candidate or candidates at an undue advantage or disadvantage. Fasasi [4] opines that examination malpractice is an improper practice or misconduct before, during or after an examination by either the examinees or other persons to obtain good grades by fraudulent means. Examination malpractice is defined by WAEC [5] as any irregular act or behaviour exhibited by either the candidate or anyone saddled with the responsibility of administering examination in or outside the examination hall, before, during or after the examination with the sole aim of taking unfair advantage. From all the definitions, it is deduced that examination malpractice is unethical because it promotes mediocrity in the sense that candidates who succeed through the unorthodox means might be rated equal to the candidates who labour on their own to attain academic excellence. Examination malpractice has a long history in Nigeria and is as old as the country itself. The first case was reported in 1914 when the Senior Cambridge Local Examination papers were leaked before the scheduled date of examination [6]. Examination malpractice is a global phenomenon which has been reported in Pakistan, Japan, India, Great Britain, Kenya and Malawi [3] and [7]. Although examination malpractice occurred in the past, the current trend in Nigeria is alarming as the act is now advertised and celebrated with positive blatancy.

The government of Nigeria had, on several occasions, attempted to rid the Nigerian educational system of examination malpractice. For instance, in 1984, the federal military government promulgated Decree 20 to stamp out examination malpractice in Nigeria. Part of Decree 20 as contained in [1] goes thus: "*Any person who fraudulently or with intent to cheat or*

secure any unfair advantage to himself or any other person or in abuse of his office produces, sells or buys or otherwise deal with any question paper intended for the examination of persons at any examination or commits any of the offences specified in section 3(27)(c) of this Decree, shall be guilty of an offence and on conviction be sentenced to twenty-one years imprisonment". However, the Decree had been revised by the Examination Malpractice Act 33 of 1999 which now stipulates a fine ranging from ₦50 000 to ₦100 000 or imprisonment for a term of 3 – 4 years with or without an option of fine as punishment for whoever is caught in the act of examination malpractice. The Examination Malpractice Act 33 of 1999 came into existence due to the inability of previous administrations to enforce Decree 20 of 1985. Despite all the laws and measures, examination malpractice continues to wax stronger which may be attributed to the non-implementation of the measures. Examination malpractice according to [1] and [8] is attributed to low moral standard especially in schools, candidates' lack of confidence, inadequate preparation, candidates' fear of failure, laziness and "419" syndrome that has become the order of the day in the society.

The scourge of examination malpractice started becoming rampant at the tail end of the 1980s and in the 1990s during the military era when the educational sector at all levels was reduced to embarrassing states [9]. Previous administrations in those years bastardised the school system and starved the education sector of necessary funds, maltreated the academic and made the students hopeless and helpless, out of the campuses on several occasions. Institutions of learning at all levels were ill funded and allowed to decay. Public schools were reduced to learning centres just to cater for the less privileged. Teachers at all levels were owed salaries for several months despite the meagre emoluments. Industrial action became the order of the day and when the strike was called off the academic calendars were altered just for the students to quickly jump into another semester or a new academic year depending on the situation at hand [10]. The year of entry into the university could only be known while the year of graduation remained uncertain. Academic and non-academic staff of the universities went on strikes on a regular basis which left the students to spend the larger part of the academic calendar at home.

Teachers in the dilapidating primary and secondary schools, and poorly remunerated as well, often went to schools only when they felt to do so, and always left to attend to other businesses during the school hours to make both ends meet, therefore unable to cover the scheme of work within the specified time. Based on these challenges, the need for private schools became a necessity and private schools began to spring up here and there in major cities and towns in Nigeria. The emergence of private schools revolutionised and exacerbated the situation. To begin with, most private schools do not have a standard for admission. Anybody regardless of his background or level is eligible for admission as long as money is paid with the hope of performing "the miracle" at the Senior School Certificate Examinations. Emphasis is no longer on standard but money and the candidates of these schools do have intimidating results with chains of distinction [11]. The schools are "miracle centres" where success at examinations is guaranteed. The business flourishes and the proprietors remain relevant in the name of examination malpractice.

Hounvenou and Hounvenou [12] attributed the rise in examination malpractice in Nigeria to the following key players: parents, the students, proprietors of private schools and the government. The parents' aid examination malpractice by:

(i) impersonation (hiring a person to sit for the examination for their wards or children);
(ii) bribing invigilators or supervisors to write or solve current examinations for their children or candidates;
(iii) arranging "miracle centres" for their children and;
(iv) buying leaked examination questions for their children.

A pupil becomes vulnerable to examination malpractice once he is introduced to it at the early stage and finds it difficult to resist as he progresses in his school life. Private schools proprietors perpetrate examination malpractice for fear of mass failure which they believe may reduce the number of enrolments of their students and consequently harms their profit margin. As for the government, it may be unacceptable but bitter truth that the government has been playing politics with education, which has led to the emergence of private schools in towns and cities in Nigeria. In the same vein, the poor motivation of teachers has brought about unending strikes that jeopardise the quality of education in Nigeria. Government at all levels has neglected education and is far from reaching the United Nations Education Scientific and Cultural Organisation (UNESCO) stipulation of 26% of the total annual national budget to the education sector while the meagre amount voted for it, is diverted, grossly misused and unaccounted for. The government's insensitivity to discharge its responsibilities in the education sector has made various stakeholders neglect their expected roles thereby allowing a total collapse of the whole system.

A mathematical model is a representation of real-life phenomena with mathematical concepts and language to forecast their future behaviour [13], [20] and [21]. The process of developing mathematical models is termed mathematical modelling. This work aims to study the dynamics of examination malpractice in Nigeria among the key players via a deterministic compartmental mathematical model. As far as it is known, the analysis of examination malpractice through the use of a mathematical model is rare in the literature.

2. MODEL FORMULATION

The model categorises the entire players into four compartments denoted by *BACR*. The *BACR* model is partitioned into *B(t), A(t), C(t)* and *R(t)* where *B(t)* is the compartment for the examination bodies, *A(t)* is the compartment for the examination agents (School proprietors, teachers, supervisors, examiners, moderators, etc), *C(t)* is the compartment for the examination candidates while *R(t)* is the compartment for all the individuals who do not engage in examination malpractice which may be as a result of personal conviction, orientation or barriers to perpetrate the act. Each of the compartments is a function of time meaning that the population of individuals in each compartment can fluctuate with time. Recruitment rates into *B(t), A(t), C(t)* and *R(t)* are π_1, π_2, π_3 and π_4 respectively. These are the rates at which each of the compartments is increased through influx from society. θ and ρ are rates of leakage of the examination papers to the examination agents and examination candidates respectively. σ is the rate at which examination agents aid examination malpractice during examination through the compromise of examination rules and regulations. This factor has an increasing effect on the population of candidates because more people will be willing to sit for an examination when the chance of passing is high. The population of individuals who do not participate in the examination malpractice *R(t)* increases through the influx of individuals from compartments *B(t), A(t)* and *C(t)* who do not engage in examination malpractice at the rates β, α and τ respectively. Since examination malpractice is an offence punishable under the law, it is assumed that those who are caught left each of the compartments at the same rate μ and never return to the game again. The movement from *B(t)* to *A(t)* and *C(t)* does not imply that the staff of examination bodies becomes examination agents or examination candidates but the rates at which their action and inaction influence the population of both examination agents and examination candidates. Likewise, the movement from *A(t)* to *C(t)* does not make the examination agents becomes examination candidates but the rates at which their action and inaction influence the population of examination candidates. The transmission dynamics of examination malpractice among the key players *B(t), A(t), C(t)* and *R(t)* is described in *Fig. 1*.

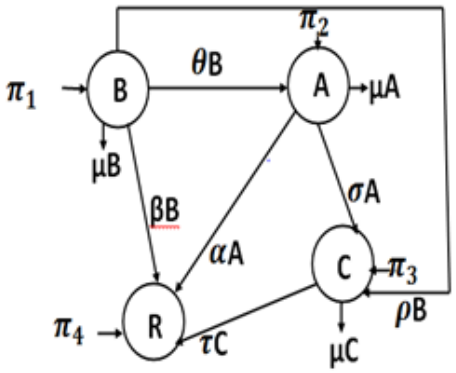

Fig. 1. Transfer Diagram of the Model

Following the above assumptions and flow diagram, the following set of first-order ordinary differential equations is derived.

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$$\frac{dB}{dt} = \pi_1 - \theta B - \beta B - \rho B - \mu B \quad (1)$$

$$\frac{dA}{dt} = \pi_2 + \theta B - \alpha A - \sigma A - \mu A \quad (2)$$

$$\frac{dC}{dt} = \pi_3 + \sigma A + \rho B - \tau C - \mu C \quad (3)$$

$$\frac{dR}{dt} = \pi_4 + \beta B + \alpha A + \tau C \quad (4)$$

Equation (4) shall be dropped and the analysis shall be based on the reduced system (1) – (3) since individuals in compartment *R* do not participate in examination malpractice. Besides, there is no outflow from *R* to either *B*, *A* or *C* [23].

The numerical values assigned to the parameters to conduct the simulations are presented in Table I.

Table I: Parameters' Description and Values

Parameters	symbols	Values
Rate of influx from the society into B(t)	π_1	0.01
Rate of influx from the society into A(t)	π_2	0.05
Rate of influx from the society into C(t)	π_3	0.1
Rate of leakage of exam papers to A(t)	θ	0.01
Rate of influx from *B(t)* into *R(t)*	β	0.1
Rate of influx from *A(t)* into *R(t)*	α	0.1
Rate at which *A(t)* aids exam malpractice	σ	0.01
Rate of influx from *C(t)* into *R(t)*	τ	0.01
Rate of apprehensions	μ	0.001
Rate of leakage of exam papers to *C(t)*	ρ	0.001

2.1 Basic Properties of the Model

In this subsection, the essential features of the system (1) – (3) shall be verified.

2.1.1 Positivity of Solutions

Theorem 1. The model (1) – (3) has positive state variables and its solutions are positive as well for all $t \geq 0$ if and only if the initial conditions of the state variables are positive.

Proof.

Suppose $\{B(A), A(t), C(t)\}$ are the solutions of the system for all $t \geq 0$ with positive initial conditions $\{B(0) \geq 0, A(0) \geq 0, C(0) \geq 0\}$.

From (1),

$$\frac{dB}{dt} \geq -\{\theta + \beta + \rho + \mu\} B \tag{5}$$

Using variable separable method,

$$\ln B \geq -\{\theta + \beta + \rho + \mu\} t + k_1, \tag{6}$$

where k_1 is the constant of integration,

$$\therefore B(t) \geq B_0 e^{-\{\theta+\beta+\rho+\mu\}t} \geq 0, \tag{7}$$

Following the same approach, the non-negativity of $A(t), C(t)$ is established and the results are:

$$A(t) \geq A_0 e^{-\{\alpha+\sigma+\mu\}t} \geq 0, \tag{8}$$

$$C(t) \geq C_0 e^{-\{\tau+\mu\}t} \geq 0. \tag{9}$$

Hence, the solutions of the system remain positive at all time provided that the initial conditions are positive since e^q is positive for all real values of *q*.

2.1.2 Boundedness of Solutions

Theorem 2. The solutions to the model remain bounded in the region Ω defined by

$$\Omega = \left\{ (B, A, C) : 0 \leq B + A + C \leq \frac{\pi_1 + \pi_2 + \pi_3}{\mu} \right\}$$

Ω is the region of attraction for the model which attracts every solution initiating in the interior of the positive octant.

Proof.

The sum of the players is

$$P(t) = B(t) + A(t) + C(t) \tag{10}$$

Therefore,

$$\begin{aligned} &\frac{d}{dt}\left(B(t) + A(t) + C(t)\right) = \pi_1 + \pi_2 + \pi_3 \\ &-\left(\beta B(t) + \alpha A(t) + \tau C(t)\right) \\ &-\mu B(t) - \mu A(t) - \mu C(t) \end{aligned} \tag{11}$$

$$\begin{aligned} &\Rightarrow \frac{d}{dt}\left(B(t) + A(t) + C(t)\right) \leq \pi_1 + \pi_2 + \pi_3 \\ &-\mu\left(B(t) + A(t) + C(t)\right) \end{aligned} \tag{12}$$

By taking limit supremum

$$\lim_{t\to\infty} Sup\left(B(t) + A(t) + C(t)\right) \leq \frac{\pi_1 + \pi_2 + \pi_3}{\mu} \tag{13}$$

3. MODEL ANALYSIS

The equilibrium points of the model shall be obtained in this section before performing other qualitative analyses.

3.1 Equilibrium Analysis

The equilibrium solutions to a system of first-order differential equations are the points at which the first derivatives are equal to zero. The examination malpractice free equilibrium (EMF) does not exist

since there is no time since 1914 when the examination is free from malpractice in Nigeria [14]. However, the situation has grown from bad to worse over the years and it is now epidemic. The epidemic equilibrium of the examination malpractice model shall, therefore, be discussed in the next subsection.

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3.2 Existence of Epidemic Equilibrium of Examination Malpractice

This is the equilibrium when the examination is plagued with malpractice. The contribution of each player at this point is obtained when the right-hand side of the system (1) – (3) is equated to zero thus

$$B = \frac{\pi_1}{m_1} \tag{14}$$

$$A = \frac{\pi_1\theta + \pi_2 m_1}{m_1 m_2} \tag{15}$$

$$C = \frac{\pi_3 m_1 m_2 + \sigma\left[\pi_1\theta + \pi_2 m_1\right] + \rho\pi_1 m_2}{m_1 m_2 m_3} \tag{16}$$

where

$$m_1 = \theta + \beta + \rho + \mu,\ m_2 = \alpha + \sigma + \mu,\ m_3 = \tau + \mu$$

3.3 Stability Analysis of the Model

The stability property of the model shall be investigated by the linearization approach. The Jacobian matrix corresponding to the system (1) - (3) is given as

$$J = \begin{pmatrix} -m_1 & 0 & 0 \\ \theta & -m_2 & 0 \\ \rho & \sigma & -m_3 \end{pmatrix} \tag{17}$$

The necessary and sufficient condition for the epidemic equilibrium of the model to be locally asymptotically stable is for the eigenvalues of (17) to be all negative. On solving, (17) has the eigenvalues:

$\lambda_1 = -m_1,\quad \lambda_2 = -m_2$ and $\lambda_3 = -m_3$

Since all the eigenvalues are negative, the epidemic equilibrium of the model is locally asymptotically stable.

3.4 The Reproductive Menace, R_m

In epidemic models, the reproductive number R_0 measures the average number of secondary infections generated when an infectious individual gets into the population of completely susceptible individuals. The quantity R_0 can be computed by using the next generational matrix method formulated by [15].

However, in the present study, the reproductive number R_0 is used to mean reproductive menace R_m of examination malpractice which is the average number of secondary examination malpractices reported as the key players perpetrate the act. It is the threshold quantity that governs the outbreak and the level of escalation of the examination malpractice. In disease models, the outbreak of a disease will not take off in the population as long as $R_0 < 1$ but it will take off if $R_0 > 1$ [16], [17], [18] and [22]. In the present analysis where R_0 is taken to mean R_m, if 0 < R_m < 0.5, the rate of perpetration of examination malpractice is so low that it is not noticed in the country. Also, if 0.4 < R_m < 0.95, the rate of perpetration of the act is limited but if 0.94 < R_m ≤ 1.0, the country experienced widespread examination malpractice. The quantity R_m is derived following a similar approach as in computing R_0 by considering the system (1) – (3) starting with equation (2) followed by equations (1) and (3). These classes are considered because the outbreak of examination malpractice depends majorly on them. The examination malpractice is generated into the compartments and flows between the compartments, the scenario which is represented by the following associated next generational matrices.

$$F = \begin{pmatrix} \theta & 0 & 0 \\ 0 & 0 & 0 \\ \rho & \sigma & 0 \end{pmatrix},\ V = \begin{pmatrix} \theta+\beta+\rho+\mu & 0 & 0 \\ 0 & \alpha+\sigma+\mu & 0 \\ 0 & \sigma & \tau+\mu \end{pmatrix} \tag{18}$$

The inverse of the matrix V is obtained as

$$V^{-1} = \begin{pmatrix} \frac{1}{\theta+\beta+\rho+\mu} & 0 & 0 \\ 0 & \frac{1}{\alpha+\sigma+\mu} & 0 \\ 0 & 0 & \frac{1}{\tau+\mu} \end{pmatrix} \tag{19}$$

The product of matrices F and V^{-1} is :

$$FV^{-1} = \begin{pmatrix} \frac{\theta}{\theta+\beta+\rho+\mu} & 0 & 0 \\ 0 & 0 & 0 \\ \frac{\rho}{\theta+\beta+\rho+\mu} & \frac{\sigma}{\alpha+\sigma+\mu} & 0 \end{pmatrix} \quad (20)$$

The reproductive menace is thus obtained as the spectral radius (largest eigenvalue) of the above matrix, which is:

$$R_m = \frac{\theta}{\theta+\beta+\rho+\mu} \quad (21)$$

4. SIMULATION AND DISCUSSION

The parameter values displayed in Table I are the base values which are used to evaluate the initial reproductive menace. The values of some of these parameters are then varied to investigate the effect of changes in their values on the reproductive menace, the result of which is presented in Table II.

Table II. Effect of Variations in the Values of θ and ρ on R_m

S/No	θ	β	ρ	μ	R_m	Remark
1	0.01	0.1	0.001	0.001	0.83	Limited
2	0.02	0.1	0.002	0.001	0.87	Limited
3	0.03	0.1	0.003	0.001	0.88	Limited
4	0.04	0.1	0.004	0.001	0.89	Limited
5	0.06	0.1	0.006	0.001	0.90	Limited
6	0.1	0.1	0.006	0.001	0.93	Limited
7	0.2	0.1	0.007	0.001	0.96	Widespread
8	0.3	0.1	0.008	0.001	0.97	Widespread
9	0.4	0.1	0.009	0.001	0.98	Widespread
10	0.001	0.1	0.001	0.001	0.33	Unnoticed
11	0.0001	0.1	0.0001	0.001	0.08	Unnoticed

The numerical results in Table II are complemented with *Fig.* 2 – *Fig.* 7. The parameter values in Table I are the initial values for the parameters to plot the curves while the initial values for the state variables are: *B(0)*=3, *A(0)*=5000, *C(0)*=1000000.

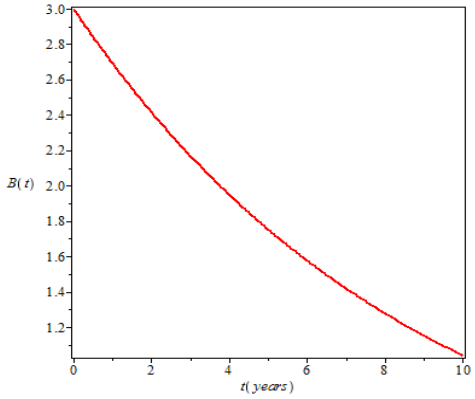

Fig. 2. Graph of B(t) against time. Parameters' values remain as in Table I

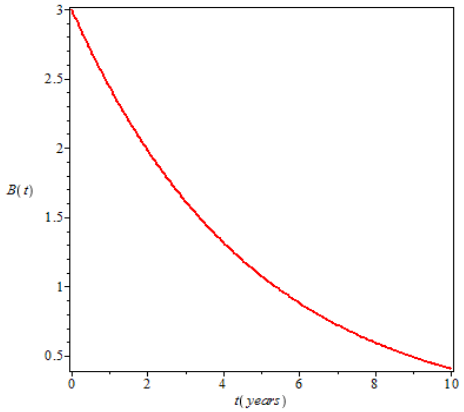

Fig. 3. Graph of B(t) against time with changes only in exam malpractice terms ($\theta = 0.1$, $\rho = 0.01$).

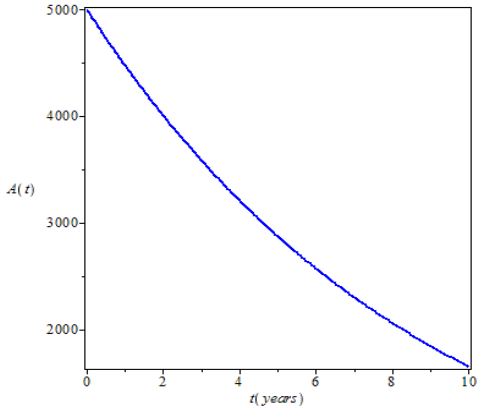

Fig. 4. Graph of A(t) against time. Parameters' values remain as in Table I.

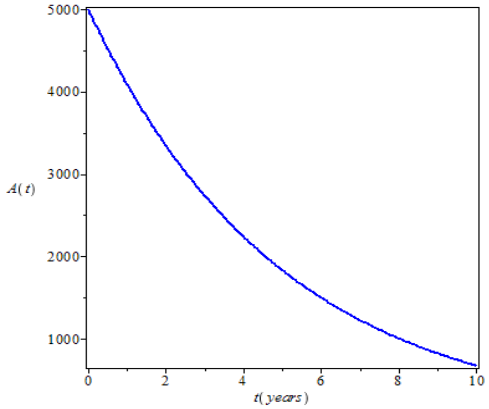

Fig. 5. Graph of A(t) against time with changes only in exam malpractice terms ($\theta = 0.1$, $\sigma = 0.1$).

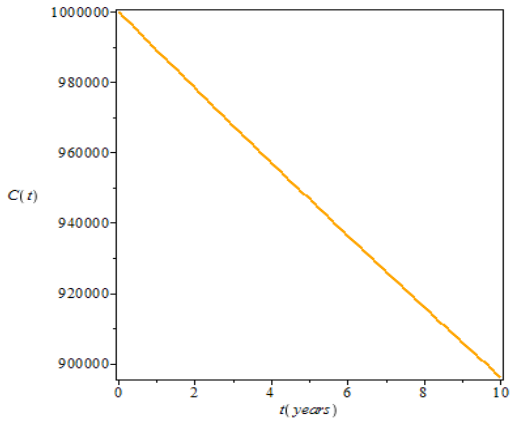

Fig. 6. Graph of C(t) against time. Parameters' values remain as in Table I

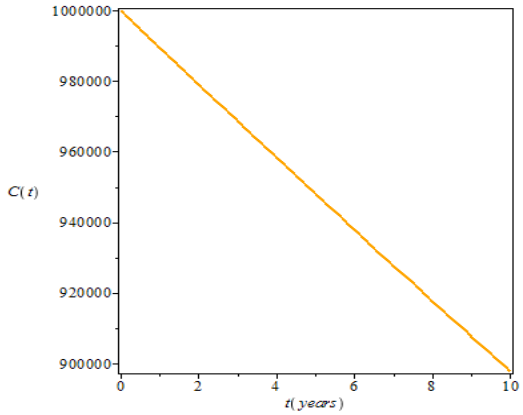

Fig. 7. Graph of C(t) against time with changes only in exam malpractice terms ($\rho = 0.01, \sigma = 0.1$).

The epidemic equilibrium of the model has been proved to be locally asymptotically stable in subsection 3.3. The stability of the epidemic equilibrium of the examination malpractice model is that examination malpractice is sustained in the society which is the current situation in Nigeria. As for the menace of examination malpractice, in Table II, it is deduced that examination malpractice is limited when the examination questions are not leaked to more than one out of ten agents and more than six out of a thousand candidates (Row 1 – 6 in Table II) otherwise examination malpractice escalates (Row 7 – 9 in Table II). Examination malpractice is not noticed and there is sanctity and integrity in examination conduct when the rate of leakage of the examination questions is as low as one out of a thousand agents and candidates (Row 10– 11 in Table II). This was the situation in Nigeria before the 1990s [18]. The values of the parameters θ and ρ are varied while others are fixed in Table II because examination agents and candidates are at the centre of the whole examination system. The leakages of examination questions to one or both of them destroy the examination integrity.

Fig. 2, *Fig. 4* and *Fig. 6* which are derived from the initial parameter values in Table I together with the stated initial variable values under Table II show that examination malpractice has a negative effect on the population of each key player over the time. The negative effect is associated with the integrity of the players. WAEC was a name which every candidate trembled at its mentioning in those days when examination malpractice was not common in Nigeria. Teachers also lost their glories and worth when they did not see anything wrong in solving examination questions for the students they had taught. As for the candidates, the certificates issued to them are questionable and do not worth more than the papers on which they are written. *Fig. 3*, *Fig. 5* and *Fig. 7* show that the negative effect of examination malpractice on the integrity of the key players aggravates when the examination malpractice terms θ, ρ and σ are increased ten times.

5. CONCLUSION

In this paper, the dynamics of examination malpractice among the key players in Nigeria had been analysed via a deterministic compartmental mathematical model. The positivity and boundedness of solutions of the model were established and the stability of the epidemic equilibrium of the model was proved. The threshold quantity R_m of the model was derived and the numerical values of the quantity were computed by using various values of the parameters. From the simulation, it is observed that examination malpractice escalates when the rate of leakages of examination papers is high. It is, therefore, suggested that for the control of examination malpractice to be effective in Nigeria, efforts must be geared towards blocking the leakages of examination papers most especially from the examination bodies.

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