RESEARCH PAPER

Mathematical Analysis of the Causes of Examination Malpractices in Nigeria: An Epidemic Modelling Approach

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Abstract

Examination malpractice is a social disease that derails the entire process, conduct and outcome of examinations. In this study, the entire causes of examination malpractice in Nigeria are categorised into four and a deterministic compartmental mathematical model is built around the four classes in order to identify the factors to be addressed to curb the menace of examination malpractice in the country. The solutions of the model are proved to exist, unique and positive. The equilibrium analysis is conducted and the stability theory of nonlinear differential equations is employed to show that the examination malpractice endemic equilibrium of the model is locally asymptotically stable. The societal disposition reproductive ratio, a quantity that measures the rate at which societal values influence the rate of indulgence in examination malpractices, is also derived following the approach of epidemic modelling and the results obtained from the study reveal that the causes of examination malpractice in Nigeria can be brought under control if there is a radical change in the norms and institutions of the society as well as drastic reduction in the population of examination contractors.

Keywords: Examination Malpractice, Model, Equilibrium Analysis, Reproductive Ratio, Examination Contractors

INTRODUCTION

Examination and interview are the commonest methods of assessing individuals' abilities in a particular field or discipline. Examination is an established technique that presents an individual with a set of questions or tasks designed towards validating the individual's acquired skills and knowledge (Oko & Adie, 2016). In schools and colleges, examination is a practical or spoken test especially a necessary one which one needs to do so as to get a qualification. Examination malpractice, on the other hand, is any intentional act of wrong doing different from the rules of the examination formulated to place a candidate at an undue advantage. It is an illegal act which candidates take during examinations in order to obtain good results by cutting corners. Kamau & Kiprop (2017) describes examination malpractice as any form of cheating that derails the objective of examination. Also, Akinferon et al. (2016) sees examination malpractice as any form of cheating

perpetrated by the examination candidates single-handedly or in conjunction with other individuals; before, during or after the examination, to enjoy undue advantage over other candidates. Examination malpractice in the Nigerian educational system has been extensively discussed and is being regarded as a major challenge not only to the examination bodies but also to the entire education system, the school administrators, the government and the society at large.

Examination malpractices are of different forms, caused by different factors and accomplices and candidates have different reasons for indulging in them. Although the objective of the act, by the perpetrators, could be realised, there are grave consequences to the institution, the individual and even to the country at large; whether the perpetrators are caught or not. Examination malpractice could be in the form of leakages- illegal securing of examination questions before the time of examination; impersonation- representing and writing a particular examination for another individual; cheating- violating any rules that regulate the conduct of examinations; plagiarism-presenting another person's work, as yours, without due acknowledgement (Achio et al., 2012). Examination malpractice enters Nigeria in 1914 when the Cambridge examination papers were leaked but it became epidemic afterwards which gave birth to Alexander Commission in 1967 to look into the incidences of examination malpractices in Nigeria (Hounvenou & Hounvenou, 2015). Also, in 1977 there was prevalent examination malpractice in the West Africa School Certificate Examination (WASCE) that provoked the government to take a drastic step (Achio et al., 2012).

Examination malpractice has been attributed to imbalance in the sectors of the economy. In Nigeria today, high rate of unemployment necessitates a grave need for job creation, yet a good number of sectors of the economy lack adequate manpower. In order to bridge the gap, many students are forced to go in for courses which they do not have what it takes in terms of enough background knowledge to perform in the areas of studies (Kawugana & Wayopwa, 2017). This may be connected with the emphasis which Nigerian society places on success goals without emphasis on the means of attaining the goals (Achio et al., 2012). It is now a tradition in Nigeria that everything is motivated by the yearning for success regardless of the method used to facilitate it (Omemu, 2015). The Nigerian society as it is composed today is set up on faulty fragile political, educational, social and economic environment which may not guarantee a better future for the younger and present generation (Kamau & Kiprop, 2017). A society which lays grave emphasis on goal achievements without emphasis on the institutionalised method of attaining the goals is sure to exert pressure on the sectors of the society which may finally result to the use whatever means of becoming successful.

Examination malpractice in Nigeria is a function of decay in the value system and orientation of the society. The Nigerian society today celebrates mediocrity and considers cheating as being smart. The society does not care about how an individual attains success. In fact, examination malpractice is a product of the wrongs and corruption in the entire society. The politicians adopt rigging at election and occupy enviable political offices and so do students perpetrate cheating from elementary to tertiary institutions to promote from one educational level to another. All kinds of wrong doings occur inside and around the venues of examinations to take advantage of the whole process and attain success. The situation becomes worse when candidates alone are not involved in the act. Teachers, school heads, business centers around and inside venues, parents, and examination officers all connive with candidates to perpetrate the misconduct (Akaranga & Ongong, 2013). The society must be blamed for the incidences of examination malpractices. In a situation where corrupt practices become norms in a society and the school as a subset of the society must reflect the customs in the wider society. Omemu (2015) clearly stated that cheating is one of the products of a society that encourages mediocrity where cheats do turn into celebrities. It is an

indication of the moral decadence in the country where armed robbers, pen robbers, drug barons and smugglers are praised by the virtue of their ill-gotten wealth.

The loop holes that may prompt candidates to cheating may include among other things: the role of government, political undertone and government insensitivity to educational needs, rising cost of education, general economic ailment and level of income, the supervisory role of school administrators, employment requirement and the value system of the society. Each of these loop holes shall be discussed one after the other. To start with, government agencies and officials in charge of examination and education like the education ministries, supervisors, examination bodies and invigilators together with the law enforcement agents contribute in various ways to examination malpractice. These bodies and agencies in one way or the other conspire, aid and abet examination malpractice. Furthermore, the Nigerian political landscape since 1960 has been characterised by instability, inconsistency and economic malpractice. Corruption has been the curse of the Nigerian polity since independence. It has resulted into a situation where lazy people are found in the positions of importance due to their ill-gotten naira power. The naira power automatically brings honour and respect to personalities who do not actually deserve such honour. As a result, the spirit of excellence and hard work is aborted or truncated. Apart from this, the government in its policies does not see the greatness of the country in the classrooms as American and Japanese do. The government of Nigeria does sacrifice her educational needs and issues on the altar of ethnicity, nepotism, selfishness and politics. Hence, like the government's practices, the society sees examination as one of those useless routine exercises that have nothing to do with the development and future progress of the country and of the child. As a result, the society does not see any vital role an examination is out to play in the economic future of the child therefore there is no need ensuring the validity and reliability of any examination.

Education, like other goods, is now expensive in Nigeria. The costs of maintenance, books and other incidental costs are increasing, particularly with the emergence of private schools coupled with inflation. The financial implication of failure is great therefore; parents and students will like to resist failure at all cost. In addition, due to the battered economy in Nigeria, individuals seize every chance to make both ends meet. The general belief is that money is the answer to everything therefore some officials of the examination bodies being Nigerians, do use their positions to make money during examination period by selling life question papers. The economic hardship has given birth to many problems in the society which leads to an environment inducing some teachers, guidance, students, parents and some other individuals to examination malpractice. Some students are involved because they wish to succeed and graduate, parents may get indulged because they want good placement for their children while teachers may get involved to argument poor and inconsistent salaries so as to improve their living standard which is nothing to write home about in the present Nigeria. Inadequate supervision of teaching and learning process results in truancy by students and teachers which gives birth to examination malpractice. Generally, students and teachers are poorly motivated and poorly supervised by the school authorities. The inspectorate division of the education ministry together with the school heads occasionally performs their supervisory roles. Today, the inspectors visit schools with the aim of collecting 'kola' and 'envelopes' without carrying out their primary assignments. Also, school heads spend so much time every school day in collecting various forms of levies. As a result, the provision of necessary teaching materials, supervision of teachers and students and marking of lesson notes become secondary assignment to be delegated to the displeased subordinates.

The major parameter used to fill vacancies in the labour markets is qualifications. Therefore, the most important desire of many prospective applicants is to obtain the certificates. In Nigeria, the job is secured as long as there is connection together with the availability of certificates. The

consequence is that getting a good job is a function of good certificates therefore; candidates who are bent on good jobs but weak academically employ all sorts of methods including examination malpractice to obtain good certificates. Another factor which has given birth to examination malpractice in Nigeria is the value system and the madness to get rich and obtain everything with ease. The societal emphasis on achievement, regardless of the means of reaching the success has prompted some irresistible individuals in the education sector to design various illegitimate means of achieving academic success in collaboration with the appropriate authority (Makaula, 2018). The school, like other social institutions, does not occur in a vacuum; rather it occurs within a geographical set up of the society. Societal factors are functions of moral disposition of the society therefore; whatever affects the society affects every subset of the society. The social and economic affairs of the country are built around intense exhibition of materialism and capitalism. The orientation in Nigeria today is the acquisition of wealth to the extent that money is the measure of status symbol. Most Nigerians are of the opinions that money is everything and there is dire need to acquire it. The mentality has dislodged honesty and hard work from being the yardstick of success and achievement. The principle of Machiavellian which is "the end justifies the means" is now the guiding principle in the contemporary Nigerian society. Consequently, corrupt practices are embraced in the society and the schools as subsets of the society reflect the customs in the larger society.

Studies on the causes of examination malpractices are numerous (Omemu, 2015; Davie & Eluwa, 2016; Amadi & Opuiyo, 2018; Osadebe & Bini, 2018; Okey and Ewa, 2019) but the use of Mathematical Modelling to conduct the analysis of the causes of examination malpractices is rare in the literature. It is on this note that the present study is aimed at conducting the analysis of the causes of examination malpractices in Nigeria via Modelling approach.

MATERIALS AND METHODS

A deterministic compartmental model SECL is adopted to analyse the causes of examination malpractices in Nigeria. The flow between the compartments *S(t), E(t), C(t), L(t)* is depicted in Figure 1.

In Figure 1, *S(t)* is the compartment for the societal disposition which considers all forms of malpractices as being smart. *E(t)* is the class for socio-economic factor. The simultaneity of increase in unemployment rate in Nigeria and inadequate manpower in some sectors has created yearnings to bridge the gap. As a result, many students force themselves into studying courses which they do not have ability to cope in the field of study. *C(t)* is the compartment for the examination contractors. These are the people that enable the candidates succeed in examination malpractices e.g. school proprietors, teachers, supervisors etc. Lastly, *L(t)* is the class for the loop holes. The compartment *L(t)* represents every form of laxity in the examination conduct and administration. Recruitment rates into compartments *S(t), E(t), C(t)* and *L(t)* are π_1, π_2, π_3 and π_4 respectively. θ, α and σ are the rates at which societal value through undue emphasis on paper qualification increases: laxity in the examination conduct *L(t)*, population of the examination contractors *C(t)* and the gaps between the unemployment and the need for job creation *E(t)* respectively. τ is the rate at which examination contractors increase the gap between unemployment and the need for job creation. The reason is that most of the products of examination malpractices at high schools will find it difficult to go in for competitive courses in the higher institutions which will bring about shortage of labour in those areas but excess supply of labour in

other areas where they troop into. γ is the rate at which the gap between the unemployment and the need for job creation increases the population of examination contractors.
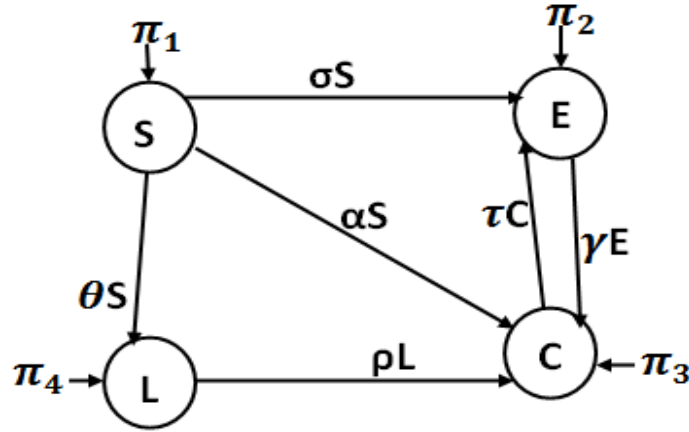

Figure 1. Flow diagram of the model

As a result of employment opportunities and juicy packages that are attached to some professions, candidates are mad to study courses that are related to those professions. Therefore, they hire the services of examination contractors to achieve their aims. ρ is the rate at which laxity in the examination conduct increases the population of examination contractors. Examination contractors will be increasing when the atmosphere is conducive for examination malpractices. Societal disposition (S) influences and grows other three variables (E), (C) and (L) irrespective of whether they are human or non human. Therefore, σS, αS and θS are taken from (S) and added to (E), (C) and (L) respectively. However, while ρS is taken from (L), it does not add to (C). (L) can only influence (C). It cannot add to the population of (C) because while (L) is non human, (C) is human. The same argument is true for γE and τC. The following set of first order ordinary differential equations is derived based on the above flow diagram and assumptions.

$$\frac{dS}{dt} = \pi_1 - \theta S - \sigma S - \alpha S \tag{1}$$

$$\frac{dE}{dt} = \pi_2 + \sigma S - \gamma E \tag{2}$$

$$\frac{dC}{dt} = \pi_3 + \alpha S - \tau C \tag{3}$$

$$\frac{dL}{dt} = \pi_4 + \theta S - \rho L \tag{4}$$

The definition for each parameter is stated in Table1.

Table 1. Parameters description

Parameters	Symbols
Rate of increase in *S(t)*	π_1
Rate of increase in *E(t)*	π_2
Rate of influx from the society into *C(t)*	π_3
Rate of increase in *L(t)*	π_4
Rate at which *S(t)* increases *L(t)*	θ
Rate at which *S(t)* increases *E(t)*	σ
Rate at which *S(t)* increases *C(t)*	α
Rate at which *E(t)* increases *C(t)*	γ
Rate at which *C(t)* increases *E(t)*	τ
Rate at which *L(t)* increases *C(t)*	ρ

The Model Analysis

Existence and uniqueness of solutions of the model

We shall show that the solutions for the model exist and unique following popular Derrick and Grossman theorem which has been used in numerous studies (Ayoade *et al*., 2019a; Ayoade, Folaranmi & Latunde, 2020a; Ayoade *et al*., 2021).

Theorem 1. (Derrick & Grossman, 1976**)**

Let Ω represent a region

$$|t - t_0| \le m, \ \|x - x_0\| \le n, x = (x_1, x_2, \cdots, x_n), \ x_0 = (x_{10}, x_{20}, \cdots, x_{n0}).$$

Also, assuming the Lipschitzian criterion $\|f(t, x_1) - f(t, x_2)\| \le k \|x_1 - x_2\|$ is fulfilled by $f(t, x)$, whenever (t, x_1) and (t, x_2) is in Ω, where k is nonnegative. Then, there exists a unique continuous vector solution $x(t)$ in the interval $t - t_0 \le \delta$ such that $\delta > 0$.

Proof. Let Ω represent the region $0 \le \alpha \le R$, we desire to establish that the partial derivatives of the model are continuous and bounded in Ω.

Let the model be represented as

$$\left.\begin{array}{l} W_1 = \pi_1 - \theta S - \sigma S - \alpha S \\ W_2 = \pi_2 + \sigma S - \gamma E \\ W_3 = \pi_3 + \alpha S - \tau C \\ W_4 = \pi_4 + \theta S - \rho L \end{array}\right\} \quad (5)$$

Hence, the partial derivatives of Eq. (5) are as follows:

$$\left\|\frac{\partial W_1}{\partial S}\right\| = |-(\theta + \alpha + \sigma)| < \infty, \ \left\|\frac{\partial W_1}{\partial E}\right\| = |0| < \infty, \ \left\|\frac{\partial W_1}{\partial C}\right\| = |0| < \infty, \ \left\|\frac{\partial W_1}{\partial L}\right\| = |0| < \infty . \quad (6)$$

$$\left\|\frac{\partial W_2}{\partial S}\right\| = |\sigma| < \infty, \quad \left\|\frac{\partial W_2}{\partial E}\right\| = |-\gamma| < \infty, \quad \left\|\frac{\partial W_2}{\partial C}\right\| = |0| < \infty, \quad \left\|\frac{\partial W_2}{\partial L}\right\| = |0| < \infty. \tag{7}$$

$$\left\|\frac{\partial W_3}{\partial S}\right\| = |\alpha| < \infty, \quad \left\|\frac{\partial W_3}{\partial E}\right\| = |0| < \infty, \quad \left\|\frac{\partial W_3}{\partial C}\right\| = |-\tau| < \infty, \quad \left\|\frac{\partial W_3}{\partial L}\right\| = |0| < \infty. \tag{8}$$

$$\left\|\frac{\partial W_4}{\partial S}\right\| = |\theta| < \infty, \quad \left\|\frac{\partial W_4}{\partial E}\right\| = |0| < \infty, \quad \left\|\frac{\partial W_4}{\partial C}\right\| = |0| < \infty, \quad \left\|\frac{\partial W_4}{\partial L}\right\| = |-\rho| < \infty. \tag{9}$$

From Eqs. (6), (7), (8) and (9), it is established that the partial derivatives of the model exist, finite and are bounded. Hence, the model has a unique solution.

Positivity of solutions

The initial conditions of the model are assumed nonnegative since the model considers physical phenomenon, and also we showed that the solutions of the model are also nonnegative.

Theorem 2. Let $\Omega = \{(S, E, C, L) \in \Re_+^4 : S_0 > 0, E_0 > 0, C_0 > 0, L_0 > 0\}$; then the solution of $\{S, E, C, L\}$ is positive for $t \geq 0$.

Proof. From Eq. 1

$$\frac{dS}{dt} = \pi_1 - \theta S - \sigma S - \alpha S \Rightarrow$$

$$\frac{dS}{dt} \geq -(\theta + \sigma + \alpha) S \Rightarrow$$

$$\frac{dS}{S} \geq -(\theta + \sigma + \alpha) dt \Rightarrow$$

$$\int \frac{dS}{S} \geq -\int (\theta + \sigma + \alpha) dt$$

Solving the above by separation of variables method and using the initial condition, we obtain

$$S(t) \geq S_0 e^{-(\theta + \sigma + \alpha)t} \geq 0 . \tag{10}$$

Taking Eq. 2,

$$\frac{dE}{dt} = \pi_2 + \sigma S - \gamma E \Rightarrow$$

$$\frac{dE}{dt} \geq -\gamma E \Rightarrow$$

$$\frac{dE}{E} \geq -\gamma dt \Rightarrow$$

$$\int \frac{dE}{E} \geq -\int \gamma dt \Rightarrow$$

$$E(t) \geq E_0 e^{-\gamma t} \geq 0. \tag{11}$$

Also, considering Eq. 3, that is,

$$\frac{dC}{dt} = \pi_3 + \alpha S - \tau C \Rightarrow$$

$$\frac{dC}{dt} \geq -\tau C \Rightarrow$$

$$\frac{dC}{C} \geq -\tau dt \Rightarrow$$

$$\int \frac{dC}{C} \geq -\int \tau dt$$

$$C(t) \geq C_0 e^{-\tau t} \geq 0. \tag{12}$$

Lastly, we consider Eq. 4,

$$\frac{dL}{dt} = \pi_4 + \theta S - \rho L \Rightarrow$$

$$\frac{dL}{dt} \geq -\rho L \Rightarrow$$

$$\frac{dL}{L} \geq -\rho dt \Rightarrow$$

$$\int \frac{dL}{L} \geq -\int \rho dt \Rightarrow$$

$$\therefore \ L(t) \geq L_0 e^{-\rho t} \geq 0. \tag{13}$$

Since $e^n > 0$ for all real values of n then it is sufficient to conclude that the solutions for each state variable, $S(t)$, $E(t)$, $C(t)$ and $L(t)$ of the model are positive for all positive values of the initial conditions.

The examination malpractice free equilibrium
The society will be free from examination malpractice if societal disposition is devoid of malpractice and if examination contractors are virtually non existence. However, the conduct and administration of examination may not be 100% perfect. Besides, existence of socio-economic factor in terms of imbalance in the sectors of the economy which will place some professions at advantage over others cannot be overlooked in Third World countries like Nigeria. Therefore, to find the examination malpractice free equilibrium, the right hand side of the system (1) – (4) is equated to zero, evaluating it at $S=C=0$ and solving for the loop holes and socio-economic factor to obtain

$$M_0 = \left(0, \frac{\pi_2}{\gamma}, 0, \frac{\pi_4}{\rho} \right) \tag{14}$$

The examination malpractice endemic equilibrium

Examination malpractice becomes endemic when the society is disposed to every form of malpractice. The equilibrium point for the endemic examination malpractice is obtained by solving Eqs. (1) – (4) and the solutions are:

$$S^* = \left(\frac{\pi_1}{\alpha + \theta + \sigma} \right) \tag{15}$$

$$E^* = \left(\frac{\sigma \pi_1 + (\alpha + \theta + \sigma)\pi_2}{\gamma(\alpha + \theta + \sigma)} \right) \tag{16}$$

$$C^* = \left(\frac{\alpha \pi_1 + (\alpha + \theta + \sigma)\pi_3}{\tau(\alpha + \theta + \sigma)} \right) \tag{17}$$

$$L^* = \left(\frac{\theta \pi_1 + (\alpha + \theta + \sigma)\pi_4}{\rho(\alpha + \theta + \sigma)} \right) \tag{18}$$

The stability analysis of the endemic equilibrium

Theorem 3. The endemic equilibrium of the model is stable if all the eigenvalues of the characteristic equation of the model are negative.

Proof. To prove the theorem, the Jacobian matrix of the system (1) – (4) is obtained as follows:

$$J = \begin{pmatrix} -(\theta + \sigma + \alpha) & 0 & 0 & 0 \\ \sigma & -\gamma & 0 & 0 \\ \alpha & 0 & -\tau & 0 \\ \theta & 0 & 0 & -\rho \end{pmatrix} \tag{19}$$

The characteristic equation of Eq. (19) is

$$(\rho + \lambda)(\tau + \lambda)(\gamma + \lambda)(\theta + \sigma + \alpha + \lambda) = 0 \tag{20}$$

On solving Eq. (20)

$$\lambda_1 = -\rho, \quad \lambda_2 = -\tau, \quad \lambda_3 = -\gamma \text{ and } \lambda_4 = -(\theta + \sigma + \alpha)$$

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

The societal disposition basic reproductive ratio R_d

In epidemiological modelling, the quantity R_0 is the basic reproduction number which is a non-dimensional quantity that measures the average number of infections produced when a typical infectious agent is introduced into the population of susceptible individuals (Ayoade, Agboola &

Ibrahim, 2019b). In the present analysis, the societal disposition basic reproductive ratio R_d measures the rate at which societal value influences the rate of indulgence in examination malpractices. Unlike in epidemic modelling, if $R_d > 1$, the societal value does not encourage examination malpractice and we should expect sanctity in examination process and conduct. On the other hand, if $R_d < 1$, the societal value favours examination malpractice and we should expect widespread cheating in examinations. Since schools are subsets of the society, they are bound to suffer the rots in the larger society. Hence, in deriving R_d, we consider the compartment for societal disposition S(t) and follow a similar approach as in Ayoade & Farayola (2020b) and Ayoade & Farayola (2021) therefore,

$$R_d = \frac{\sigma}{\sigma+\theta+\alpha} . \tag{21}$$

RESULTS AND DISCUSSION

The numerical aspect of the study is omitted due to the difficulties in quantifying the variables and parameters of the model. It is difficult to give numerical values to some variables of the model due to their abstractness, e.g., the societal disposition (S), the gaps between the unemployment and the need for job creation (E) and the laxity in the examination conduct and administration (L). However, the analytical outcomes of the study have given the picture of dimension of examination malpractice in a society that is built around the model variables S(t), E(t), C(t) and L(t). The theoretical results of the study also offer some possible solutions to the menace of examination malpractice in Nigeria. For instance, it was established in Eq. 20 that the examination malpractice endemic equilibrium of the model was locally asymptotically stable. The implication of the examination malpractice endemic equilibrium of the model being stable is that examination malpractice will persist in Nigeria as long as the societal norms and institutions accommodate all the four variables of the model. As regards the result for R_d in Eq. 21, it is observed that the quantity R_d rises as α and θ fall while the quantity falls as α and θ rise. The implication of the result is that to bring examination malpractice causes under control in Nigeria, efforts must be geared towards ensuring radical change in the institutions of the country so that the rate of laxity in the examination conduct and the rate of increase in the population of the examination contractors are reduced to the barest minimum. Widespread cheating in examinations can become a thing of the past in Nigeria if parameters α and θ are handled with all seriousness by the stakeholders in education.

CONCLUSION

The causes of examination malpractice in Nigeria have been examined mathematically. A mathematical model was designed, and the model was proved to have positive solutions at all time for all positive initial values of the state variables. The equilibria analysis was performed and both the examination malpractice-free and the examination malpractice endemic equilibria of the model were obtained. The stability analysis of the examination malpractice endemic equilibrium was later conducted, and the societal disposition basic reproductive ratio was derived. The study found an improvement in the institution of the country as well as drastic reduction in the population of the examination contractors as the way out of examination malpractice in Nigeria.

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