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Mathematical Modeling of Category-1 TB in OndoState, Nigeria

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Abstract

A model for the control of category-1 tuberculosis in Ondo State, Nigeria, is formulated and analyzed. The values of the reproduction number of the category-1 TB of the models are observed to be greater than one which shows that the disease exist. The results of the simulated data collected from Federal Ministry of Health in Ondo state shows that infection are high but this can only be eliminated from the population if effective treatments are given to the infected category-1 TB patients in Ondo State.

Keywords: Mathematical model, Tuberculosis (TB), Steady state, Disease free equilibrium state and Reproduction number.

1.0 Introduction

Tuberculosis (TB), is a serious disease worldwide and therefore constitutes a growing threat to human survival. For this reason, efforts have been made by the World Health Organization (W.H.O) to find lasting solution to the problem. Tuberculosis (TB) is an air borne and infectious disease caused by Mycobacterium tuberculosis. The risk of infection depends directly on the closeness of the contact with infected persons e.g. overcrowded living condition and the ingestion of the bacilli through the consumption of infected milk and milk products. Poor ventilation in a TB ward may also aid the spread of the infection. The degree to which sputum, is positive on direct microscopic examination and general coughing patterns are also important parameters for the spread of the infection. In 2010, there were an estimated 8.5-9.2 million cases and 1.2-1.5 million deaths (including deaths from TB among HIV-positive people). WHO reported on TB has pointed to the fact that TB is the second leading cause of death from an infectious disease worldwide (after HIV, which caused an estimated 1.8 million deaths in 2008). Nigeria ranks 10th among the 22 high-burden TB countries in the world. WHO estimates that 210,000 new cases of all forms of TB occurred in the country in 2010, equivalent to 133/100,000 population. There were an estimated 320,000 prevalent cases of TB in 2010, equivalent to 199/100,000 cases. There were 90,447 TB cases notified in 2010 with 41,416 58 percent cases as new smear positives, and a case detection rate of 40 percent. The 83 percent of cases notified in 2009 were successfully treated. The main goal of Nigeria TB program is to halve the TB prevalence and death rates by 2015. TB death rates have declined from 11 percent in 2006 to 5 percent in 2010. [1, 2].

However, the focus of this research is on the spread and control of TB disease in Ondo State, Nigeria. Ondo state, with latitude of 7.17 (70 10’ 0N) and longitude of 5.08(50 4’ 6OE) situated 450 kilometers south-west of the capital Abuja. Ondo state was created in 1976 from the old western region, bounded in the east by Edo state, in the North by kwara and Kogi State, in the west by Ekiti, Oyo and Ogun State respectively and in the South by the Atlantic Ocean. The state has 18 local government areas (L.G) with population of 3,460,877 (Census (2006), see [3] with life expectancy of 40 years and 10,959 sq kilometers area.

2.0 Modeling of category-1 (CAT-1) tuberculosis

TB patients are classified into two categories, category 1 (CAT-1) and category 2 (CAT-2) respectively. The CAT-1 is again divided into two phases, they are intensive phase and continuation phase. Intensive phase are new patient discovered to be infected with TB and a patient in this category is placed on drugs (such as Rifampicin, Isoniazid, Ethambutol, Pyrazinamide) for two months after which the test is conducted, while continuation phase is when a patient is observed to be smear positive

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after the intensive phase, such a patient is placed on drugs (such as Isoniazid, and Ethambutol) for six months.
Efforts have been made using mathematical model to study the spread and control of Tuberculosis disease. In this paper, we formulate a mathematical model in order to study the transmission of category-l tuberculosis in a homogeneous population. We investigate the equilibrium point and carry out stability analysis of the model. In Ondo State, the most common infection of TB is the category 1. The model divides this infection into two groups: new case and re-treated.

2.1 Model Formulation

The population is divided into five compartments (see Fig. 1), the susceptible class S (a class of individuals who are not yet infected with either new case CAT-1 TB or re-treated (*rrt*) CAT-1 TB. I is a group of individuals who are infected with new case CAT-1 TB while ϕ_1 represent a group of people who recovers from new case CAT-1 TB as a result of successful treatment and verified being sputum negative but has not yet regain immunity and I_2 denote the population of those who are infected with re-treated (*rrt*) CAT-1 TB case but come from the susceptible class a result of inhaling Tubercule bacilli. Again, ϕ_2 represent those who recovered from (rrt) CaT-1 TB. Individualin groups Φ_1 and Φ_2 and respectively are liable to die naturally or return back to be susceptible by regaining immunity as a result of successful treatment. In the susceptible class, any individual that belongs to this group can die or can be infected with either new case or re-treated category 1 TB as a result of inhaling a dose of tubercule bacilli. The class I_1 (infected with category 1 TB), this class is liable to die or recover as a result of successful treatment.
Births occur at a constant rate into the uninfected classes S. Death in the model is natural. Individuals in the susceptible and infected populations $(S, I_1, I_2, \Phi_1, \Phi_2)$ die from all-cause deaths at constant rate θ while individuals in CAT-1 TB are infected with disease at contact rate β. The default rate of the infected group of the new case CAT-1 TB is λ_1 while the default rate of the re-treated (*rrt*) group of the new case CAT-1 TB is λ_2. Again, the rate at which the infected population of the new case of CAT-1 TB die out of the system is υ_1 while the death rate of the re-treated (*rrt*) population of the new case CAT-1 TB is υ_2. In like manner, γ_1 denote the rate at which new case CAT-1 TB recovers from the TB disease after treatment but yet to regain immunity while the rate at which the re-treated (*rrt*) individuals recovers from the CAT-1 TB is γ_2 but yet to regain immunity. More so, we define ρ_1 as the recovery rate at which the treated new case CAT-1 TB individual returns to the susceptible class after regaining full immunity while ρ_2 is taken as the recovery rate at which the re-treated (*rrt*) individuals of CAT-1 TB is re-absorbed into the susceptible population due to successful treatment. In this paper we assumed that a child cannot be infected with any of the two strains of categoryl TB (new-case of CAT-1 TB and ((*rrt)* CAT-1 TB), before or during birth except inhaling a dose of Tubecule bacilli which is after birth.

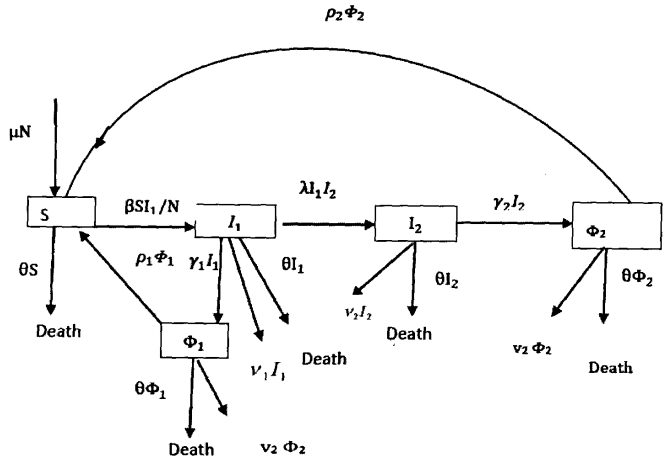

Fig 1: The biological compartment of the category 1 TB.

The system of five nonlinear, ordinary differential equations to model the dynamics of transmission of category 1 TB with homogeneous population are:

$$\frac{dS}{dt} = \mu N - \frac{\beta S I_1}{N} + \rho_1 \Phi_1 + \rho_2 \Phi_2 - \theta S \quad (1)$$

$$\frac{dI_1}{dt} = \frac{\beta S I_1}{N} - \frac{\alpha I_1 I_2}{N} - \lambda_1 I_1 - \lambda_1 I_1 - \theta I_1 - \upsilon_1 I_1 \quad (2)$$

$$\frac{dI_2}{dt} = \frac{\alpha I_1 I_2}{N} - \lambda_2 I_2 - \lambda_2 I_2 - \theta I_2 - \upsilon_2 I_2 \quad (3)$$

$$\frac{d\Phi_1}{dt} = \gamma_1 I_1 - \theta \Phi_1 - \rho_1 \Phi_1 - \upsilon_1 \Phi_1 \quad (4)$$

$$\frac{d\Phi_2}{dt} = \gamma_2 I_2 - \theta \Phi_2 - \rho_2 \Phi_2 - \upsilon_2 \Phi_2 \quad (5)$$

where, $N(t) = S(t) + I_1(t) + I_2(t) + \Phi_1(t) + \Phi_2(t)$. The model in (1)-(5) is derived from the compartmental diagram in Fig. 1. Our assumption here is that if there is no reinfection at all $(\alpha = 0)$ otherwise reinfection implies $(\alpha = \beta)$.

Equation (1): Susceptible population change due to increase caused by the incoming of new susceptible by birth (μ N), reduction occur as a result of infection caused by new case CAT-1 TB $\left(\frac{BSI_1}{N}\right)$, further reduction occur as a result of natural death (θS). Another increase occur due to recovered from new case CAT-1 TB $(\rho_1 \Phi_1)$, and rrt CAT-1 TB $(\rho_2 \Phi_2)$.

Equation (2): The new case CAT-1 TB population (I_1) changes due to infection in the susceptible class $\left(\frac{BSI_1}{N}\right)$, reduction occur due to infection caused by rrt TB $\left(\frac{\alpha I_1 I_2}{N}\right)$ and recovery $(\gamma_1 I_1)$, natural death (θI_1), death as a result of the new case cat 1 TB infection $(\upsilon_1 I_1)$ and further reduction is due to default in the new case TB $(\lambda_1 I_1)$.

Equation (3): Infectious population of rrt CAT-1 TB (I_2), change due to in coming of infection on the intensive by CAT-1 TB $\left(\frac{\alpha I_1 I_2}{N}\right)$. Decrease occurs as a result of recovery after treatment $(\gamma_2 I_2)$, natural death (θI_2) and death as result of the rrt TB infection $(\upsilon_2 I_2)$ and further reduction is due to default in the rrt CAT-1 TB $(\lambda_2 I_2)$.

Equation (4): Recovery (in the case of category 1) change due to increase caused by infection of those who moved out of the class of (I_1) as a result of recovery after completion of treatment $(\gamma_1 I_1)$, reduction occur as a result of natural death $(\theta \Phi_2)$ gaining of natural immunity after declarefree of the infection $(\rho_1 \Phi_1)$and further reduction is due to death as a result of new case CAT-1 TB infection $(\upsilon_1 \Phi_1)$.

Equation (5): Shows the rate of change of the recovery (Φ_2) population of the re-treated (rrt) CAT-1 TB group with $(\gamma_2 I_2)$, reduction occur due to the regaining of immunity after declared free of the infection $(\rho_2 \Phi_2)$ due to successful treatment and they reabsorbed back into the susceptible class and further reduction occurs as result of natural death $(\theta \Phi_2)$ or death as result of the re-treated (rrt) CAT-i TB infection $(\upsilon_2 \Phi_2)$.

3.0 Determining the basic reproduction number, R_0

In epidemiological modeling, the major tool to determine whether an infection will be eliminated from the population or become endemic is the basic reproduction number R_0 [4, 5]. The basic reproduction number, R_0 is defined as the average number of secondary infections produced by an infected individual in a completely susceptible population [6]. According to Murphy et al [5], R_0 is simply a normalized bifurcation (transcritical) condition for epidemiological models, such as $R_0>1$ implies that the endemic steady state is stable (i.e. the infection persists), and $R_0\leq 1$ implies that the uninfected steady state is stable (i.e. the infection can be eliminated from the population). Setting equations (1)-(5) to zero and solving the resulting system of nonlinear equations yields the uninfectious steady state as

$$S^0 = \frac{\mu N}{\theta}, \quad I_1^0 = 0, \quad I_2^0 = 0, \quad \Phi_1^0 = 0, \quad \Phi_2^0 = 0. \tag{6}$$

We compute the reproduction number (R_0) for the proposed model in (Eqs. (1)-(5)) using the nextgeneration operator method discussed in [6]and [7]. Let $F_i(x)$ be the rate of appearance of new infections in compartment i and $V_i(x)$ as all other transfer interactions into and out of compartment *i*. From (Eqs. (1)-(5)) we obtain

$$F_i(x) = \begin{pmatrix} \frac{BSI_1}{N} \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \quad V_i(x) = \begin{pmatrix} \frac{\alpha I_1 I_2}{N} + \gamma_2 I_2 + \gamma_2 I_2 + \theta I_2 + \upsilon_2 I_2 \\ \frac{-\alpha I_1 I_2 I_2`}{N} + \gamma_1 I_1 + \lambda_1 I_1 + \theta I_1 + \upsilon_1 I_1 \end{pmatrix} \tag{7}$$

Calculating the Jacobian matrics $F_i'(x) = F \text{ and } V_i'(x) = V$ than evaluating each Jocobian at the uninfectious steady state in (6) gives

$$F = \begin{pmatrix} \frac{\beta S}{N} & 0 \\ 0 & 0 \end{pmatrix}, \quad V = \begin{pmatrix} \gamma_2 + \lambda_2 + \theta + \upsilon_2 & 0 \\ 0 & \gamma_1 + \lambda_1 + \theta + \upsilon_1 \end{pmatrix} \tag{8}$$

The next generation operator FV^{-1} has only two eigenvalues: $\varsigma_1 = 0$ and non-zero eigenvalue $\varsigma_2 = \frac{\beta S}{N(\theta + \gamma_1 + \upsilon_1 + \lambda_1)}$. The reproduction number R_0 is the spectral radius of FV^{-1} where $S = S^0$ and is thus

$$R_0 = \frac{\beta\mu(\theta + \upsilon_1 + \gamma_1 + \lambda_1)}{\theta} \tag{9}$$

If $R_0 < 1$, the disease state is asymptotically stable and this implies that the infection can be eliminated from the population and if $R_0 > 1$, this implies that the endemic steady state is stable (i.e. the infection persists).

3.1 Sub –model without recovery after treatment

In this section we consider a situation where the necessary treatments are given to the infected individuals, yet no one recovers from the TB. The model governing such situation is

$$\frac{dS}{dt} = \mu N - \frac{\beta S I_1}{N} - \theta S \tag{10}$$

$$\frac{dI_1}{dt} = \frac{\beta S I_1}{N} - \frac{\alpha I_1 I_2}{N} - \lambda_1 I_1 - \theta I_1 - \upsilon_1 I_1 \tag{11}$$

$$\frac{dI_1}{dt} = \frac{\alpha I_1 I_2}{N} - \lambda_2 I_2 - \theta I_2 - \upsilon_2 I_2 \tag{12}$$

Setting equations (10) – (12) to zero and solving the resulting system of linear equation gives the following uninfectious steady state as

$$S^0 = \frac{\mu N}{\theta}, 1_1^0 = 0, 1_2^0 = 0, \tag{13}$$

$$S^0 = \frac{N(\theta + \lambda_2 + \upsilon_2)}{\beta}, 1_1^0 = -\frac{N\theta}{\beta} + \frac{\mu N}{\theta + \lambda_2 + \upsilon_2}, \quad I_2^0 = 0, \tag{14}$$

$$S^0 = \frac{\alpha\mu N}{\theta(\alpha+\beta)+\beta(\lambda_2+\upsilon_2)}, 1_1^0 = \frac{N(\theta+\lambda_2+\upsilon_2)}{\alpha},$$

$$I_2^0 = \frac{N(\theta+\lambda_1+\upsilon_1)}{\alpha} + \frac{\beta\mu N}{\theta(\alpha+\beta)+\beta(\lambda_2+\upsilon_2)} \tag{15}$$

Following the idea in Section 3, we evaluate the Jacobian matrix F and V of the model in (Equs. (10)-(12)) at the uninfectious steady state (13) only and compute the spectral radius of the next generation operator FV^{-1} to obtain the reproduction number, $R_0 = \frac{\mu\beta}{\theta(\theta+\lambda_1+\upsilon_1)}$.The results in (Equs. (14) and (15)) shows that the equilibrium points are not suitable for further investigation since the infectious variables, I_1 and I_2 are not equal to zero respectively. Following the threshold condition in Section 3, we observed that the disease state will be asymptotically stable if the reproduction number, $R_0 < 1$ and unstable if $R_0 > 1$.

3.2 Submodel when there is a unique recovery class $\Phi = \Phi_1 + \Phi_2$

Here, we considered the behaviour of the two infected linearly recovery compartments model obtained from Fig. 1. The so-called two infections linearly recovery compartments model is

$$\frac{dS}{dt} = \mu N - \frac{\beta S I_1}{N} + \rho\Phi - \theta S \tag{16}$$

$$\frac{dI_1}{dt} = \frac{\beta S I_1}{N} - \frac{\alpha I_1 I_2}{N} - \lambda_1 I_1 - \gamma I_1 - \theta I_1 - \upsilon_1 I_1 \tag{17}$$

$$\frac{dI_2}{dt} = \frac{\alpha I_1 I_2}{N} - \lambda_2 I_2 - \gamma I_2 - \theta I_2 - \upsilon_2 I_2 \tag{18}$$

$$\frac{d\phi}{dt} = \gamma I_1 - \gamma I_2 - \theta\Phi - \rho\Phi - \upsilon\Phi \tag{19}$$

Equating (16)-(19) to zero and solving the resulting system of linear equations gives

$$S^0 = \frac{\mu N}{\theta}, \quad I_1^0 = 0, \quad I_2^0 = 0, \quad \Phi = 0 \tag{20}$$

Following the procedures in Sections 3.0 and 3.1, we have the reproduction number, $R_0 = \frac{\mu\beta}{\theta(\theta+\lambda_1+\upsilon_1)}$.The larger the value of the reproduction number (R_0) the difficulties to control the epidemic disease.

4.0 Simulation of collected data

In this section, our numerical experiment is based on the application of the proposed model in Section 3, Subsections 3.1 and 3.2 respectively on the data collected from the Ondo state hospital management board on TB for the year 2008. Also, investigations revealed that due to the landscape nature of Ondo state, people built their houses in such a manner that it accommodate large families such that in a house where TB patient lives in, there is high tendency for large member of a family to contact the disease. Again, in all the houses visited where TB patient's lived, our survey shows that an average number of 2 persons were diagnosed of the disease which was passed on to them by a TB patient who lives among them. Hence the contact number of TB patient in Ondo state is2. From the study, we observe that, out of the 3,460,877 people in Ondo state, 11,000 children are alive newly born babies while 15,000 people died naturally [8]. Using the cohort form in the appendix we compute the following rates:

1. $S(t) = N(t) - \left(I_1(t) + I_2(t) + \phi_1(t) + \phi_2(t)\right)$ = 3460045 where, 1 = 7, I = 0, 1 822 and 2 = 3. See the cohort form in the appendix.
2. Default rate of new case category 1 TB (λ_1) = (total number of new case category 1 TB)/(total cases of TB disease for investigation),
3. Default rate of retreated category 1 TB (λ_2) = (total number of retreated category 1 TB)/(total cases of TB disease for investigation),
4. Death rate of new case category 1 TB (v_1) = (total number of patient who died of new case category 1 TB)/(total cases of TB disease for investigation),
5. Death rate of new case category 1 TB (v_2)= (total number of patient who died of retreated category 1 TB)/(total cases of TB disease for investigation),
6. Recovery rate of new case category 1 TB (γ_1) = (total number of patients who has complete treatment of new case of category 1 TB)/(total cases of TB disease for investigation),
7. Recovery rate of retreated category 1 TB (γ_2) = (total number of patients who has complete treatment of retreated cases of category 1 TB) / (total cases of TB disease for investigation),
8. Recovery rate of new case category 1 TB back to the susceptible class (ρ_1)= (total number of patients cured of new category 1 TB and back to the susceptible class)/(total cases of TB disease for investigation),
9. Recovery rate of retreated category 1 TB back to the susceptible class (ρ_2)= (total number of patient cured of retreated cases of category 1 TB and back to the susceptible class)/(totalcases of TB disease for investigation),
10. (μ) is the natural birth rate of Ondo state people =(number of live births during the year2008)/(total population at the end of the year 2008),
11. θ is the natural death rate of Ondo state people =(number of people who died naturally during the year 2008)/(total population at the end of the year 2008).

For practical computing of the above mention parameters see ([9], pp. 46-69). For example, using the cohort form in the appendix, the total cases of TB disease for investigation total cured + total completed treatment + total number of patient smear positive + those who died prior to testing + defaulted patients + those under treatment before been transferred out to another state. Hence, the total cases of TB disease for investigation is 1019. Styblo [10] defined contact number as the total number of secondary infections caused by one infectious case placed in an uninfected population and again defined TB transmission rate as the average number of infections produced by a typical infectious individual during one year. Estimates of this rate are in the range 10-15. Again, see ([10], sec. 6.2.2). Hence, the contact number of TB disease in Ondo state is 15 which corroborate the range of estimate given in [10]. From equation (9) we estimatethe contact rate (β) to be 15.9365 with reinfection rate (α) equal to β . Table 1 shows the value of the parameters used in the proposed model while Table 2 in the appendix shows the TB cohort form that give the details of treatment outcome for category 1 patients registered in Ondo state for year 2008.

Table 1: The value of the parameters used in the model.

Parameters	Description	Values	Units
β	transmission rate	15.9365	year^{-1}
α	reinfection rate	15.9365	year^{-1}
λ_1	default rate of new case category 1 TB	0.0843965	year^{-1}
λ_2	default rate of retreated category 1 TB	0	year^{-1}
v_1	death rate of new case category 1 TB	0.0696762	year^{-1}
v_2	death rate of retreated category 1 TB	0.0009814	year^{-1}
γ_1	completed treatment rate of new case category 1 TB	0.0127576	year^{-1}
γ_2	completed treatment rate of retreated category 1 TB	0	year^{-1}
ρ_1	recovery rate of new case category 1 TB	0.866732	year^{-1}
ρ_2	recovery rate of retreated category 1 TB	0.0029	year^{-1}
μ	natural birth rate	0.0031784	year^{-1}
θ	natural death rate	0.0043342	year^{-1}

Note that the result is based on the model structure and the choice of parameter values. However, the application of the three models considered in Section 3 and Subsections 3.1 and 3.2 respectively give the values of the reproduction number (R_0^1, R_0^2, R_0^3) = (2, 73, 68) where R_0^1 denote the reproduction number for the epidemiological model in Section 3 while R_0^2 is the computed value of reproduction number of the model in Subsection 3.1 and R_0^3 represent the value of the reproduction number of the model in Subsection 3.2. Observe that the values of R_0^1, R_0^2 and R_0^3 are greater than one respectively. Hence, the rate of spread of the TB disease in Ondo state is very high and for total elimination of the disease, 99 percent of Ondo state people must be vaccinated with TB preventive drugs.

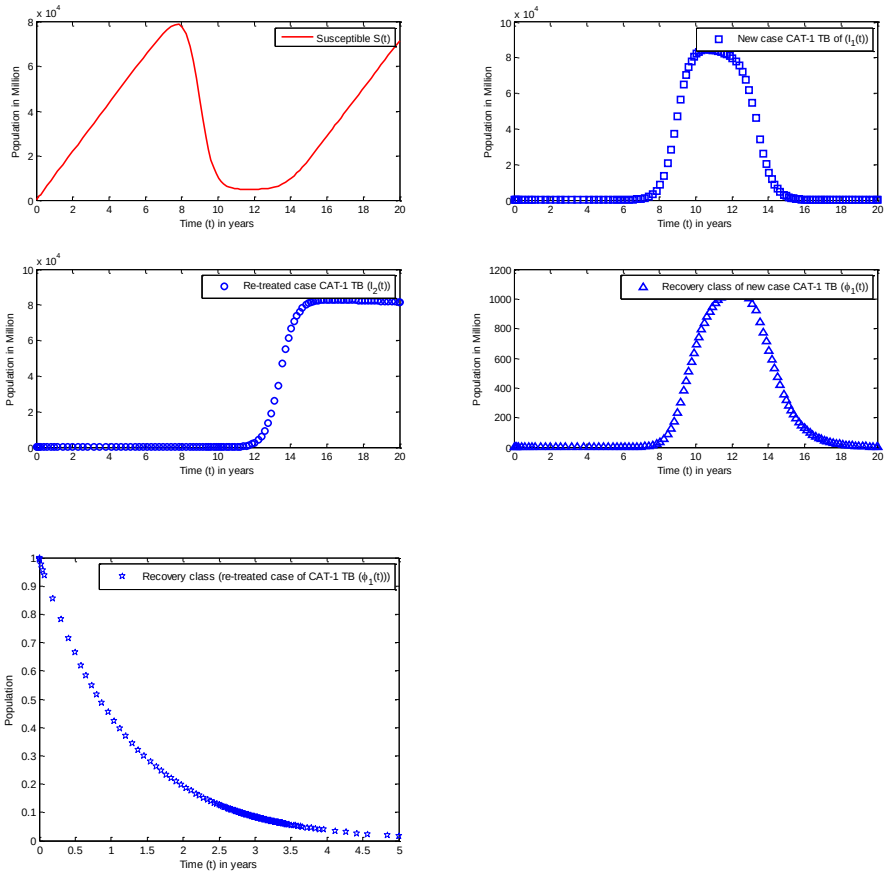

Figure 1: The simulation of the model in section 3.0.

In the susceptible (S(t)) class marked 'thick line' in Fig. 1 we observed that Ondo state population grow rapidly but later decline as a result of the invasion of the new case CAT-1 TB disease (I_1) marked 'square' but gradually decayed to zero as many infected people got cured after completing their respective drugs. See the trend of the recovery class of the new case CAT-1 TB (ϕ_1) marked 'triangle') in Fig. 1. The population in the retreated case of CAT-1 TB (I_2) marked 'o' also increase dramatically because of the reinfection the retreated group get from the new case CAT-1 TB. Effective treatment of the retreated case of CAT-1 TB (I_2) also reduces the number of this group suffering from this diseases. See the marked 'o' line in Fig. 1.

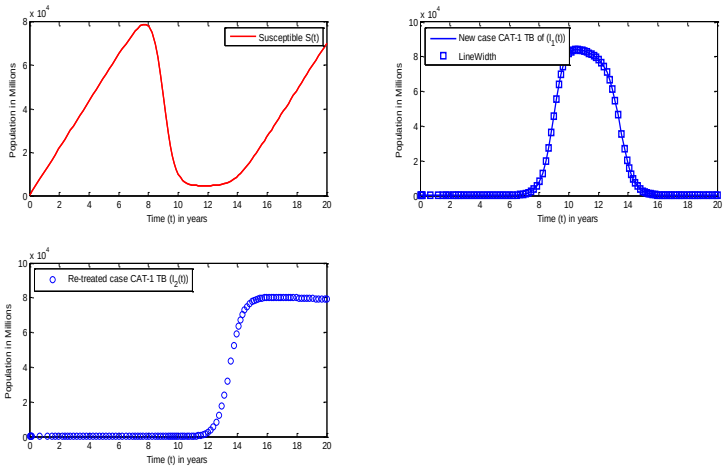

Figure 2: The simulation of the model in section 3.1.

From Fig. 2 observe that those infected in both new and retreated cases never recover. The linearity in the model in section 3.2 has stabilized the recovery class to behave like the retreated case. See the line marked 'square' in Fig. 3.

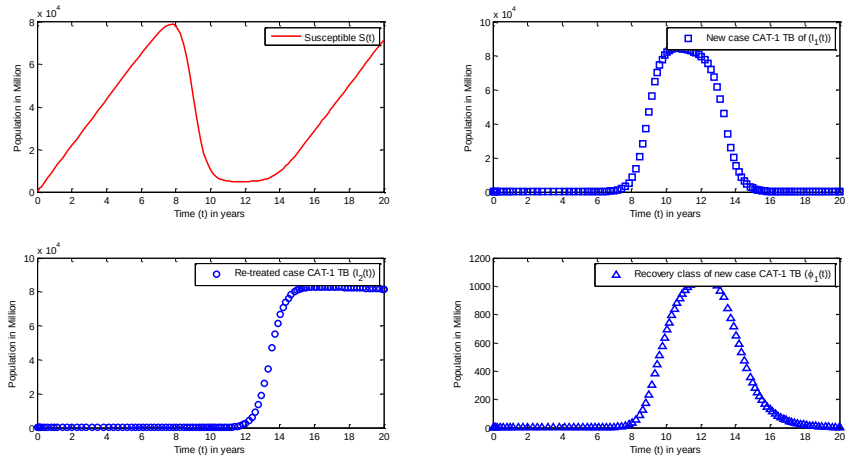

Figure 3: The simulation of the model in section 3.2 .

5.0 Conclusion

In this study we have used epidemiological models to investigate treatment of new and re-treatment cases of category 1 TB. The values of the basic reproduction number, R_0^1 , R_0^2 *and* R_0^3 based on values of the epidemiological parameters show that infectionsare high but can be eliminated from the population if effective treatments are given. The aim of the Ondo State Ministry of Health should not just cover treatment alone but emphasis should be placed on using the dynamic nature of the program to screen close contact of infected cases of TB in order to know how many of these could be living with category 1 TB. The estimations used for the computer simulations of the model shows that there are high TB treatment failure rate under the scheme of the tuberculosis and leprosy control strategy by the Ministry of Health in Nigeria [11] the high number of cases detected under this scheme remains a setback to the long term success of the TB control in Nigeria, because the vast majority of undetected cases are actually leading to an increase in the number of new infectious cases in the country and by implication leads to complex cases such as category 2 TB, drug resistance and multi-drug resistance etc. The government should also publish the program through the mass media, making it known to the populace the havoc caused by TB and its consequences to the health. The government officials should improve the case detection rate which will help in curbing TB prevalence in the country.

Appendix

TABLE 2: TREATMENT OUTCOME FOR CAT 1 PATIENTS REGISTERED IN 2005TB COHORT FORM

LGA	CURED		TRTCOMPLETED		SM + VE		DIED		DEFAULTED		T.O.	
	NEW	RRT	NEW	RRT	NEW	RRT	NEW	RRT	NEW	RRT	NEW	RRT
Akoko N/E	29	0	2	0	0	0	9	0	14	0	1	0
Akoko N/W	8	0	0	0	0	0	0	0	0	0	0	0
Akoko S/E	13	0	0	0	0	0	0	0	0	0	0	0
Akoko S/W	40	0	0	0	1	0	4	0	3	0	0	0
Akure N.	12	0	0	0	0	0	2	0	3	0	0	0
Akure S.	40	0	1	0	0	0	1	0	12	0	0	0
Eseodo	40	0	0	0	0	0	1	0	0	0	0	0
Idanre	62	1	0	0	0	0	0	0	0	0	0	0
Ifedore	47	0	0	0	1	0	2	0	2	0	0	0
Ilaje	41	0	1	0	0	0	4	0	5	0	3	0
Ifeoluji	29	0	0	0	0	0	3	0	4	0	2	0
Irele	76	0	0	0	0	0	0	0	2	0	0	0
Odigbo	90	0	0	0	0	0	1	0	13	0	0	0
Okitipupa	58	0	3	0	3	0	13	0	10	0	0	0
Ondo E.	5	0	0	0	0	0	0	0	0	0	0	0
Ondo W.	66	0	0	0	0	0	15	0	2	0	0	0
Ose	16	0	2	0	0	0	6	0	2	0	0	0
Owo	50	2	0	0	0	0	4	1	5	0	9	1
Ref. Ctr.	100	0	4	0	2	0	5	0	9	0	16	0
Total	822	3	13	0	7	0	70	1	86	0	1	1

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