Controlling Lassa Fever Transmission In Northern Part Of Edo State, Nigeria Using Sir Model

Ogabi[1], C.O., Olusa T.V., and Madufor M.A.

[1]Department of Physics, Lagos State University, Ojo, PMB 1087, Apapa, Lagos, Nigeria
[1]E-mail address: kunleogabi@yahoo.com or cornelius.ogabi@lasu.edu.ng

ABSTRACT: Some Virologists in the past had analysed and discussed the impact of Lassa fever in some endemic areas including the northern part of Edo State with high rate of infection on contact persons [4, 5]. This work shows how the activity of the disease in the northern part of Edo State can be controlled. This is achieved by reducing the transmission rate of the disease and see how the basic reproductive number can be reduced as will be illustrated by the solution of SIR model. The cumulative result of this control is to eventually eradicate the disease. In this paper, numerical solution of system of differential equations of SIR model will be used to analyse the control of transmission of the disease. SIR is an acronym which stands for **S**usceptible, **I**nfectious, and **R**ecovered groups in a given population. The relationship among the susceptible group, the infectious and the recovered groups will be analysed with the *three health policies* which consists of the choice of *three sets of the parameters;* B, D, λ, γ representing (the birth rate B, the natural death rate D, the transmission rate λ, and the recovering rate γ). The disease control as used here is based on the basic *reproductive number*, one of the variables that kick-starts the solution of the system of differential equations of our SIR model which, when it is less than one, means the disease is eradicated. In the endemic areas like the northern part of the Edo State, adequate health education should be put in place for the people to have a sound knowledge about the disease. The federal and the Edo State government need to embark on a low cost housing scheme project, to reduce the number of people in a room, this will enhance the reduction in its transmission rate.

[Ogabi, C.O., Olusa T.V., and Madufor M.A. **Controlling Lassa Fever Transmission In Northern Part Of Edo State, Nigeria Using Sir Model.** *N Y Sci J* 2012;5(12):190-197]. (ISSN: 1554-0200).
http://www.sciencepub.net/newyork. 32

Keywords: SIR Model, Lassa fever, Basic reproductive number, northern part of Edo State, Parameters, Control, Health polic

1.0 INTRODUCTION

In biological study of humans and their environment, it has been established that disease spread through four basic infectious agents which are *viruses, bacteria, protozoa* and *helminth* [4]. There are four basic methods of transmission of disease by these infectious agents. The methods are (i) Human to human, (ii) Reservoir to vector to human, (iii) Human to environment to human, (iv) Reservoir to humans. The term vector refers to insects and reservoir refers to other non-human vectors such as dogs, foxes and rats [4].

Lassa fever is transmitted by virus; it is under reservoir to human method as mentioned above.

The incubation period of Lassa fever is 6 to 21 days. The disease is endemic in West Africa including Nigeria. The earliest record of the disease was in the 1950s but the virus was isolated by the Centre for Disease Control (CDC), Atlanta, USA, in 1969, from a sample taken from a missionary worker in Lassa village in northern Nigeria [5]. A rat that is common in endemic areas, known as Mastomys natalensis is the natural host of the disease [5, 7, 14, [21]. Humans are infected with this disease by eating foods that is contaminated with saliva, urine or excreta of the hosted Lassa virus rat.

Nosocomial transmission may occur through droplets by person to person contact or the contamination of needles [5]. The symptoms and signs of the disease are similar to the symptoms and signs of malaria, typhoid and yellow fever. The symptoms and signs include fever, nausea, vomiting, chest pain, puffy face, puffy cheeks, oedema, dehydration, conjunctiva injection, fainting attacks, bleeding from orifices, hypotension, shock and coma [5, 6, 7, 10, 11, 14, 17, 18, 21]. Several cases of viral haemorrhagic fever from the northern part of Edo State, including Ekpoma, Uromi, Irrua, Igueben, Iruekpen, Igarra, Ibillo, Ozalla, Ubiaja, Agenebode, Auchi, Afuze, Akoko Edo, Ewu, Okpella and environs have been treated at the University of Benin Teaching Hospital, Benin City, from 1970 to 2000 with high fatality rate [5].

The health workers and policy makers have been battling with this disease in the above areas and looking for way to put an end to this problem. A mathematical model can be of great help to give better solution to this problem. The disease transmission can be represented by a dynamical nonlinear system.

The aims and objectives of this work are to show how a nonlinear mathematical model will aid in implementing health policy and to show the rate of

spread of Lassa fever in northern part of Edo State. Also, how the solution of system of ordinary differential equations of SIR model can be used to control the spread of Lassa fever in these areas.

2.THEORETICAL BACKGROUND

Epidemics models had help in implementing vaccination, shows the rate at which Susceptible individuals are immunized and percentage of Susceptible left unprotected even if vaccinated [2].One of the good epidemic models use for disease transmission and control is SIR model. Nonlinear vaccination model is also used to develop control strategy against the spread of carrier infectious diseases in human population [15].

The SIR model has three different population groups: The Susceptible group population, the Infectious group population and The Recovered group population [4, 19].

This is achieved by use of basic reproductive number R_o. The basic reproductive number is the number of secondary cases generated by a primary infectious individual during its entire period of infectiousness in a complete susceptible population [1, 4, and 19].

There are different approaches to estimate the basic reproductive number, the control tool of mathematical models but the estimation of the basic reproductive number by fitting epidemic curve data is probably the most widespread approach [3, 9, 22,]. Another common approach to estimate the basic the basic reproductive number consists in estimating first the initial exponential growth rate characteristics of most human infectious diseases of rapid dissemination. Then the basic reproductive number can be estimated by substituting the estimate of the initial exponential growth rate into formula derived from the linearization of the deterministic epidemic model [1, 12, 13, 16, 12,].

2.1 THE SIR MODEL

The SIR model can be represented by a system of ordinary differential equations as follows:

$$\begin{aligned} \frac{dS}{dt} &= -\lambda SI + B - DS \\ \frac{dI}{dt} &= \lambda SI - (\gamma + D)I \\ \frac{dR}{dt} &= \gamma I - DR \end{aligned} \qquad (1)$$

Where S represents the Susceptible group, I is the Infectious group, R is the Recovered group, B is the birth rate, D is the death rate, λ is the transmission rate of the disease and γ is the recovering rate of the infectious group after vaccination.

2.2 THE BASIC REPRODUCTIVE NUMBER

The basic reproductive number (R_O) is the parameter determine if the disease will be eradicated or not, this serves as the control of the mathematical model. For the SIR model with vital dynamics, Ro is defined as the product of birth rate B with transmission rate λ and the duration of infectious period $\frac{1}{(D+\gamma)}$ and divide by death rate D. $R_O = \frac{B\lambda}{D(D+\gamma)}$. It is a fundamental parameter that governs the spread of disease, and relates to long term behaviours and the level of vaccination necessary for eradication [19].

2.3MATERIALS

Reliable materials from the researchers and support from authorities of northern part of Edo State were used in carry out modelling of this work. The two Senatorial Districts made up of eleven Local Government Areas (LGAs) and with a population of about two million are in the epicentre of the epidemic in southern Nigeria. The high

Incidence of Lassa fever in these Senatorial Districts may be partly due to common practice of drying food items notably garri, in the sun on the ground, thus exposing them to contamination with infected rodents and their excrements which contain the Lassa fever virus [8] . Each year at least 32.26% (4,096) of patients with febrile illness that come Irrua Specialist Teaching Hospital (ISTH) have Lassa fever [5]. With these some assumptions were made in carry out the modelling to control the spread of Lassa fever in northern part of Edo State.

2.4 ASSUMPTIONS

Base on the information of the materials discussed above, in this work some assumptions will be applied as follows. The total population of the areas will be taken as two million, and divided into three groups, Susceptible group, Infectious group, and Recovered group.

The Susceptible population group (S), those that can get disease but not yet infected at the initial time will be taken as 50% of the total population. The Infectious population group (R), the people that can transmit disease to other will be taken as 32.26% of the total population.

The Recovered population group (R), the people that are removed from the susceptible infective interaction they recover with immunity or isolated will be taken as 17.74% of the total population.

The birth rate and death rate will be of the same rate and of different rate in some cases.

The total population (N) was transformed to unit, $N = 1 = S + I + R$.

So $S(0) = 0.5000, I(0) = 0.3226$, and $R(0) = 0.1774$.

3. RESULT AND DISCUSSION

Numerical solution of equation (1) produced various results as shown in the figures and tables in appendix I and II. In the figure 1a and table 1, the birth rate and death rate are of different rates. The birth rate B is 0.6 and the natural death rate D is 0.5, these values have effect on the basic reproductive number R_O which is calculated to be 0.55. Also the transmission rate λ and recovering rate γ are important parameters with values; 0.5 and 0.7 respectively. With the choice of these parameters $B, D, \lambda, \gamma = [0.6\ 0.5\ 0.5\ 0.7]$, the *first health policy* is in place the Lassa fever should be eradicated in northern part of Edo State at twenty third months after the *health policy* has been implemented since $R_o < 1$, we expect a reduction effect on infectious population at eighth month of the implementation.

The clarification of the effect of this health policy can be seen in the figure 1(b), figure 1(c) and figure 1(d); these show the relationship among the three groups. Figure 1(a) gave information on how the susceptible group interact with the infectious group, the infectious group population reducing in number as susceptible group population increase in number. At a time the infectious group population reduced to zero at the highest population value of the susceptible group. This means that the Lassa fever has been eradicated from the areas, and its effect can't be noticed anymore. The figure 1(b) is graphical information on relationship between infectious group and recovered group. The recovered group population was increasing in number as infectious group decreasing in number, at a particular period of time the trend change, the recovered group is reducing in population as infectious is reducing in population. In some months later after implementation of this health policy, both population groups reduced to zero. This implied that the vaccine given to the Lassa fever's patients and other control measures put in place to check the spread of the disease were very much effective in controlling the transmission of the Lassa fever. In figure 4.1c, it can be noticed that the recovered group was increasing in population as the susceptible group increasing in population for some months. Later the infectious group was decreasing and reduced to zero at the highest value population number of the susceptible group, after some months. In this graph, the reason of infectious and recovered group population reduced to zero can be seen clearly. All people in the areas are now in the susceptible group, meaning no one infected by the Lassa fever and no need of vaccine. But they are likely to be infected in future; if they do not follow any preventive measures given to them, not to allow the cause of the Lassa fever come in to their communities.

From figure 2a and table 2 the birth rate B and natural death rate D are of the same rate, 0.5 each. The transmission rate λ is 0.5, the recovering rate is 0.7, and the basic reproductive number R_O is 0.46.With the choice of these parameters $B, D, \lambda, \gamma = [0.5\ 0.5\ 0.5\ 0.7]$, the *second health policy* is in place. The Lassa fever should be eradicated at twenty second month of implementation of second health policy, since $R_o < 1$, we expect a reduction effect on infectious population at sixth month of the implementation. The basic reproductive numbers of figure1 and figure 2a are less than one; this is help to eradicate the Lassa virus from the population. The birth rate higher than the natural death rate in figure1 pushes the population upward by 0.2 or 20% after two years or twenty four months of the health policy implementation.

How effective is the health policy represented by figure 2a? This can be seen in figure 2(a), figure 2(b) and figure 2(c), as the relationship among the three population groups was discussed one by one with the graphs. In figure 2(a), the infectious group decreasing in population as susceptible group was increasing, and after some months it reduced to zero when susceptible group was at the highest value of the population. It clearly shown, the disease eradicated from the population and the transmission rate was highly control to reduce to minima. In figure 2(b), at early months of the implementation of the health policy the recovered group was increasing in population as the infectious group decreasing in population. But after some months the recovered group was reducing in population as infectious group was decreasing in population, and both reduced to zero. This implied that there is no more disease in the areas, so need to purchase more drugs on this type of disease any longer. From figure 2(c), we can see that at early months the recovered group population was increasing as the susceptible group population was increase, after some months the trend change. The recovered group population was reducing and reduced to zero at highest value of the population of the areas. The whole population is in the susceptible group now. These show that health policy represented by figure 2(a) is so much effective in eradicate the Lassa fever out of the endemic areas.

In figure 3(a) and table 3, the birth rate B is 0.46, the natural death rate D is 0.31, the transmission rate λ is 0.62 and recovering rate γ is 0.17. With the choice of these parameters $B, D, \lambda, \gamma = [0.46\ 0.31\ 0.62\ 0.17]$, the *third health policy* is in place. The basic reproductive number R_O is 1.92, greater than one. The transmission rate is almost four times greater than recovering rate.

The effect of this type health policy was computed for seventy months, the result showing in figure 3(a) and table 3 implies that the Lassa fever will never be eradicated in these areas since $R_o > 1$. From forty seventh month downward in the table, the Susceptible population group, the Infectious population group and the Recovered population group are constant, it resulted to the spread of the disease in the areas. This model is a typical situation of northern part of Edo State.

In most African communities, at least 4 persons sleep in a room or live closely in a house (the average student population in Ekpoma University in a room is 8 per room), in effect infected person would have had at least 4 contacts [5]. Like most African societies, the northern part of Edo State believes in communal life style, where extended family relationship is being observed. In these areas the level of literacy is very low, and thus become more superstitious imagine a belief that severe illness means that such person is being attacked or punished for wrong deeds by their gods. The health workers are not helping out; they do not take proper procedures in carrying out their jobs, because records show that a large number of health workers that were infected were resulted to death.

The effect of the health policy represented by figure 3(a), would be understood when looking to the relationship among the three population groups one by one. This is being analysed with figure 3(a), figure 3(b) and figure 2(c). In figure 3(a), four effects were noticed. (i) At early months the infectious group was decreasing in population as the susceptible group was increasing in population. (ii) The infectious group later increasing in population as the susceptible increasing in population. (iii) There was a change after some months, the susceptible group was decreasing as the infectious group was increasing. (iv) At a time both susceptible group and infectious group were constant in their population. Three effects can be noticed in figure 2(b). (i) The recovered group was decreasing in population as the infectious group was decreasing in population. (ii) After some months both the recovered group and infectious group were increasing in their population. (iii) Some months later, both recovered group and infectious group were neither increase nor decrease in their population. In figure 4.3c, four effects were noticed among the recovered group and susceptible group. (i) The recovered group was decreasing in population as the susceptible group was increasing in population. (ii) After some months the recovered group was increasing as the susceptible group was increasing. (iii) Some months later the susceptible group was decreasing in population as the recovered group was increasing population. (iv) At later months both groups neither increase nor decrease in population. From figure 3(a), figure 3(b) and figure 3(c), the nonlinearity relation of the three groups' population is very high. And the disease will never be eradicated because the infectious group population not reduce to zero, due to the basic reproductive number that is higher than one.

4. CONCLUSION

It clearly shown in this work that to control the spread of Lassa fever in the endemic areas the basic reproduction number R_O must brought below 1, if it is more than 1 the disease will not die out from the area. This is achieved if the transmission rate is very low compared to the recovering rate. In the endemic areas the contacts to every sick individual is too high, this causes the high-level of the transmission rate of the Lassa fever.

In the endemic areas like the northern part of the Edo State, adequate health education should be put in place for the people to have a sound knowledge about the disease.

The federal and the Edo State government need to embark on a low cost housing scheme project, to reduce the number of people in a room, this will enhance the reduction in transmission rate.

Good health policy must be implemented, this must start with the health personnel, by educating how to treat patient of Lassa fever. For every health worker there must be adequate protective wears and high level hygiene during and after their consultation with their Lassa fever patients. Adequate equipment for Lassa fever test must be provided. Every Lassa fever patient must be isolated from other patients in hospitals, with proper monitoring and vaccination to increase the rate of recovery.

Following all these recommendations the rate of transmission will reduce, and resulted in a very low basic reproductive number and thus eradicate the disease in the areas.

The people will be more energetic to contribute to the commercial and financial growth of Edo State and Nigeria at large.

4. REFERENCES

1. Anderson R.M. and May R.M., 1991, Infectious Disease of Humans, Oxford University Press, Oxford.
2. Buonomo B and Lacitignola D., 2011, the Backward Bifurcation of a

Vaccination Model with Nonlinear Incidence, Nonlinear Analysis: Modelling and Control, 2011, Vol. 16, No. 1, 30-46.
3. Chowell G, Shim E, Brauer F, Diaz-Duenas P, Hyman J.M, Castillo-Chavez C, 2003, Modelling and Transmission Dynamics of Acute

Hemorrhagic Conjunctivitis: Application to the 2003 Outbreak in Mexico, Stat. Med. (in Press).
4. Enns R.H, LLC 2011, It's a Nonlinear World, Springer Science+Business Media DOI 10, 1007/978-0-387-75340-9-10.
5. Eze K. C, Salami T.A.T, Eze I. C, Pogoson A. E, Omordia N, Ugochukwu M. O, 2010, High Lassa fever Activity in Northern Part of Edo State, Nigeria: Re-analysis of Confirmatory Test Results, African Journal of Health Sciences, Vol. 16, No. 3-4, 52-56.
6. Fisher-Hoch S.P, Hutwagner L, Brown B, McCormick J.B, 2000 Effective Vaccine for Lassa fever, Journal of Virology, 74: 6777-6783.
7. Fisher-Hoch S.P, Tomori O, Nasidi A, Perez-Oronoz G.I, Fakile Y, Hutwagner L, McCormick J.B, 1995Review of Cases of Nosocomial Lassa fever in Nigeria: The High Price from Poor Medical Practice, British Medical Journal, 311: 857-859.
8. Five-Year Strategic Plan 2007-2011, Centre of Excellence for the Management and Control of Lassa fever, Irrua Specialist Teaching Hospital, Irrua, Edo, Nigeria.
9. Gani R. and Leach S., 2001 Transmission Potential of Smallpox in Contemporary Populations, Nature 414, 748-751.
10. Lassa fever-Nigeria (Edo), 2004 Feb 14, (Cited 2004 Dec 8), Available from http://www.promedmail.org, archive number 20040214.0487
11. Lassa fever, Suspected-Nigeria (Edo), 2001 March 19 (Cited 2004 Dec 8), Available from http://www.promedmail.org, archive number 20010319.0552.
12. Lipsitch M, Cohen T, Cooper B, et al, 2003 Transmission Dynamics and Control of Severe Acute Respiratory Syndrome, Science 300 , 1966-1970.
13. Lloyd A.L, 2001, the Dependence of Viral Parameter Estimates on the Assumed Viral Life Cycle: Limitations of Studies of Viral Load Data, Proc. R. Soc. B 268, 847-854.
14. McCormick J.B, King I.J, Webb P.A, Scribner C.L, Craven R.B, Johnson K.M, Elliot L.H, Belmont-Williams R, 1986, Lassa fever. Effective Therapy with Ribavirin. New England Journal of Medicine, 314: 20-26.
15. Naresh R, Surabli P, Misra A.K, 2008 Analysis of Vaccination Model for Carrier Infectious Disease with Environmental Effects, Nonlinear Analysis: Modelling and Control, Vol. 13, No. 3, 331-350.
16. Nowak M.A, Lloyd A.L, Vasquez G.M, et al, 1997, Viral Dynamics of Primary Viremia and Antiretrovial Therapy in Simian Immunodeficiency Virus Infection, J. Virol. 71 (1997), 7518-7525.
17. Okoror L.E, Esumeh F.I, Agbonlahor D.E, Umolu D.I, 2005, Lassa virus: Seroepidemiological Survey of Rodents Caught in Ekpoma and Environs, Tropical Doctor, 2005; 35: 16-17.
18. Omilabu S.A, Badaru S.O, Okokhere P, Asogun D, Drosten C, Emmerich P, Becker-Zaija B, Schmitz H, Gunther S, 2005 Lassa fever, Nigeria 2003 and 2004, Emerging Infectious Diseases, 11: 1642-1644.
19. Pathak S, Maiti A, Samanta G.P, 2010, Rich Dynamics of an SIR Epidemic Model, Nonlinear Analysis: Modelling and Control, Vol. 15, No. 1, 71-81.
20. Prevention of Plague: Recommendations of the Advisory Committee on Immunization Practices, Morbidity and Mortality Weekly Report, 45 (RR-14), 1996, 1-15.
21. Richmond J.K and Baglole D.J, 2003, Lassa fever: Epidemiology, Clinical Features and Social Consequences, British Medical Journal 327:1271-1275.
22. Riley S, Fraser C, Donnelly C.A, et al, 2003, Transmission Dynamics of the Etiological Agent of SARS in Hong Kong: Impact of Public Health Interventions, Science 300, 1961-1966.
23. Wallace R.B, 2007, Public Health and Preventive Medicine, McGraw-Hill Medical, 2007.

5. Appendix I

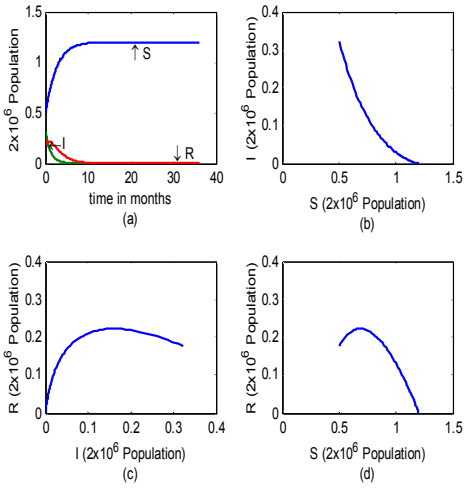

Figure 1: (a) the first health policy is the choice of; $B, D, \lambda, \gamma = [0.60\ 0.50\ 0.55\ 0.70]$ *, in this case the basic reproductive number* $R_o = 0.55 < 1$ *.(b) , (c) and (d) depict the relationship among the three population groups.*

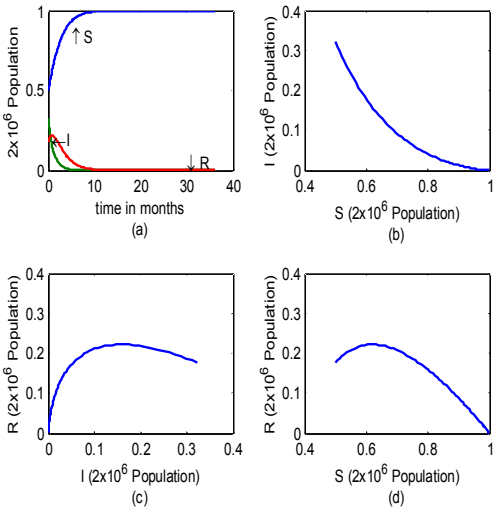

Figure 2: (a) the first health policy is the choice of; $B, D, \lambda, \gamma = [0.50\ 0.50\ 0.55\ 0.70]$ *, in this case the basic reproductive number* $R_0 = 0.46 < 1$ *.(b) , (c) and (d) depict the relationship among the three population groups.*

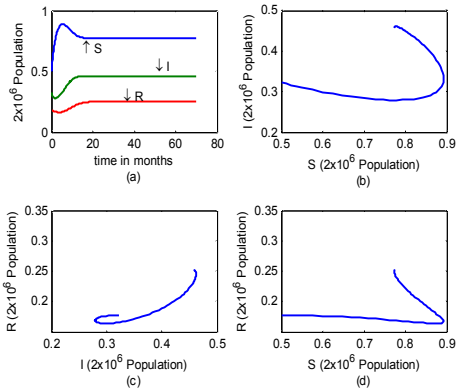

Figure3: (a) the first health policy is the choice of; $B, D, \lambda, \gamma = [0.46\ 0.31\ 0.62\ 0.17]$ *, in this case the basic reproductive number* $R_0 = 1.92 > 1$ *.(b) , (c) and (d) depict the relationship among the three population groups.*

6. Appendix II

Table 1 Showing Lassa fever control, $R_O = 0.55$

T	S	I	R	B	D	λ	γ
1	0.5000	3.23E-01	1.77E-01	0.6	0.5	0.6	0.7
2	0.7613	2.42E-02	3.15E-01	0.6	0.5	0.6	0.7
3	0.9705	5.29E-03	1.74E-01	0.6	0.5	0.6	0.7
4	1.0824	1.77E-03	9.08E-02	0.6	0.5	0.6	0.7
5	1.1402	6.98E-04	4.66E-02	0.6	0.5	0.6	0.7
6	1.1696	2.98E-04	2.38E-02	0.6	0.5	0.6	0.7
7	1.1846	1.32E-04	1.21E-02	0.6	0.5	0.6	0.7
8	1.1922	5.97E-05	6.15E-03	0.6	0.5	0.6	0.7
9	1.1961	2.72E-05	3.12E-03	0.6	0.5	0.6	0.7
10	1.1980	1.25E-05	1.58E-03	0.6	0.5	0.6	0.7
11	1.1990	5.72E-06	7.97E-04	0.6	0.5	0.6	0.7
12	1.1995	2.63E-06	4.03E-04	0.6	0.5	0.6	0.7
13	1.1997	1.21E-06	2.03E-04	0.6	0.5	0.6	0.7
14	1.1999	5.55E-07	1.02E-04	0.6	0.5	0.6	0.7
15	1.1999	2.55E-07	5.16E-05	0.6	0.5	0.6	0.7
16	1.2000	1.17E-07	2.60E-05	0.6	0.5	0.6	0.7
17	1.2000	5.40E-08	1.31E-05	0.6	0.5	0.6	0.7
18	1.2000	2.49E-08	6.57E-06	0.6	0.5	0.6	0.7
19	1.2000	1.14E-08	3.30E-06	0.6	0.5	0.6	0.7
20	1.2000	5.26E-09	1.66E-06	0.6	0.5	0.6	0.7
21	1.2000	2.42E-09	8.34E-07	0.6	0.5	0.6	0.7
22	1.2000	1.11E-09	4.19E-07	0.6	0.5	0.6	0.7
23	1.2000	5.12E-10	2.10E-07	0.6	0.5	0.6	0.7

24	1.2000	2.35E-10	1.05E-07	0.6	0.5	0.6	0.7
25	1.2000	1.08E-10	5.29E-08	0.6	0.5	0.6	0.7
26	1.2000	4.98E-11	2.65E-08	0.6	0.5	0.6	0.7
27	1.2000	2.29E-11	1.33E-08	0.6	0.5	0.6	0.7
28	1.2000	1.05E-11	6.66E-09	0.6	0.5	0.6	0.7
29	1.2000	4.85E-12	3.34E-09	0.6	0.5	0.6	0.7
30	1.2000	2.23E-12	1.67E-09	0.6	0.5	0.6	0.7
31	1.2000	1.03E-12	8.38E-10	0.6	0.5	0.6	0.7
32	1.2000	4.72E-13	4.20E-10	0.6	0.5	0.6	0.7
33	1.2000	2.17E-13	2.10E-10	0.6	0.5	0.6	0.7
34	1.2000	9.99E-14	1.05E-10	0.6	0.5	0.6	0.7
35	1.2000	4.59E-14	5.27E-11	0.6	0.5	0.6	0.7
36	1.2000	2.11E-14	2.64E-11	0.6	0.5	0.6	0.7

Table 3 Showing Lassa fever control, R_O=1.92

T	S	I	R	B	D	λ	γ
1	0.5000	3.23E-01	1.77E-01	0.5	0.3	0.6	0.2
2	0.7050	2.68E-01	1.77E-01	0.5	0.3	0.6	0.2
3	0.8294	2.56E-01	1.68E-01	0.5	0.3	0.6	0.2
4	0.9005	2.65E-01	1.59E-01	0.5	0.3	0.6	0.2
5	0.9334	2.86E-01	1.55E-01	0.5	0.3	0.6	0.2
6	0.9386	3.14E-01	1.56E-01	0.5	0.3	0.6	0.2
7	0.9249	3.46E-01	1.61E-01	0.5	0.3	0.6	0.2
8	0.8998	3.78E-01	1.70E-01	0.5	0.3	0.6	0.2
9	0.8698	4.08E-01	1.81E-01	0.5	0.3	0.6	0.2
10	0.8402	4.32E-01	1.95E-01	0.5	0.3	0.6	0.2
11	0.8147	4.50E-01	2.08E-01	0.5	0.3	0.6	0.2
12	0.7950	4.61E-01	2.20E-01	0.5	0.3	0.6	0.2
13	0.7813	4.67E-01	2.30E-01	0.5	0.3	0.6	0.2
14	0.7729	4.69E-01	2.38E-01	0.5	0.3	0.6	0.2
15	0.7686	4.69E-01	2.44E-01	0.5	0.3	0.6	0.2
16	0.7670	4.67E-01	2.48E-01	0.5	0.3	0.6	0.2
17	0.7672	4.65E-01	2.51E-01	0.5	0.3	0.6	0.2
18	0.7682	4.63E-01	2.52E-01	0.5	0.3	0.6	0.2
19	0.7696	4.61E-01	2.52E-01	0.5	0.3	0.6	0.2
20	0.7710	4.60E-01	2.53E-01	0.5	0.3	0.6	0.2
21	0.7722	4.59E-01	2.52E-01	0.5	0.3	0.6	0.2
22	0.7731	4.58E-01	2.52E-01	0.5	0.3	0.6	0.2
23	0.7737	4.58E-01	2.52E-01	0.5	0.3	0.6	0.2
24	0.7741	4.58E-01	2.52E-01	0.5	0.3	0.6	0.2
25	0.7744	4.58E-01	2.52E-01	0.5	0.3	0.6	0.2
26	0.7745	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
27	0.7745	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
28	0.7745	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
29	0.7744	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
30	0.7743	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
31	0.7743	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
32	0.7743	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
33	0.7742	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
34	0.7742	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
35	0.7742	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2
36	0.7742	4.58E-01	2.51E-01	0.5	0.3	0.6	0.2

Table 2 Showing Lassa fever control, R_O=0.46

T	S	I	R	B	D	λ	γ
1	0.5000	3.23E-01	1.77E-01	0.5	0.5	0.6	0.7
2	0.6613	2.42E-02	3.15E-01	0.5	0.5	0.6	0.7
3	0.8218	3.96E-03	1.74E-01	0.5	0.5	0.6	0.7
4	0.9091	9.98E-04	8.99E-02	0.5	0.5	0.6	0.7
5	0.9541	2.99E-04	4.56E-02	0.5	0.5	0.6	0.7
6	0.9769	9.73E-05	2.30E-02	0.5	0.5	0.6	0.7
7	0.9884	3.28E-05	1.16E-02	0.5	0.5	0.6	0.7
8	0.9942	1.13E-05	5.81E-03	0.5	0.5	0.6	0.7
9	0.9971	3.91E-06	2.92E-03	0.5	0.5	0.6	0.7
10	0.9985	1.36E-06	1.46E-03	0.5	0.5	0.6	0.7
11	0.9993	4.76E-07	7.31E-04	0.5	0.5	0.6	0.7
12	0.9996	1.66E-07	3.66E-04	0.5	0.5	0.6	0.7
13	0.9998	5.82E-08	1.83E-04	0.5	0.5	0.6	0.7
14	0.9999	2.03E-08	9.16E-05	0.5	0.5	0.6	0.7
15	1.0000	7.12E-09	4.58E-05	0.5	0.5	0.6	0.7
16	1.0000	2.49E-09	2.29E-05	0.5	0.5	0.6	0.7
17	1.0000	8.72E-10	1.15E-05	0.5	0.5	0.6	0.7
18	1.0000	3.05E-10	5.73E-06	0.5	0.5	0.6	0.7
19	1.0000	1.07E-10	2.86E-06	0.5	0.5	0.6	0.7
20	1.0000	3.74E-11	1.43E-06	0.5	0.5	0.6	0.7
21	1.0000	1.31E-11	7.16E-07	0.5	0.5	0.6	0.7
22	1.0000	4.58E-12	3.58E-07	0.5	0.5	0.6	0.7
23	1.0000	1.60E-12	1.79E-07	0.5	0.5	0.6	0.7
24	1.0000	5.61E-13	8.95E-08	0.5	0.5	0.6	0.7
25	1.0000	1.96E-13	4.48E-08	0.5	0.5	0.6	0.7
26	1.0000	6.87E-14	2.24E-08	0.5	0.5	0.6	0.7
27	1.0000	2.41E-14	1.12E-08	0.5	0.5	0.6	0.7
28	1.0000	8.42E-15	5.59E-09	0.5	0.5	0.6	0.7
29	1.0000	2.95E-15	2.80E-09	0.5	0.5	0.6	0.7
30	1.0000	1.03E-15	1.40E-09	0.5	0.5	0.6	0.7
31	1.0000	3.61E-16	6.99E-10	0.5	0.5	0.6	0.7
32	1.0000	1.26E-16	3.50E-10	0.5	0.5	0.6	0.7
33	1.0000	4.42E-17	1.75E-10	0.5	0.5	0.6	0.7
34	1.0000	1.55E-17	8.74E-11	0.5	0.5	0.6	0.7
35	1.0000	5.42E-18	4.37E-11	0.5	0.5	0.6	0.7
36	1.0000	1.90E-18	2.19E-11	0.5	0.5	0.6	0.7

11/19/2012