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To Alleviate the Ebola Virus Epidemic Diffusion

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Abstract: The emergence of new drug can stop Ebola and cure patients whose disease is not advanced. It optimizes the eradication of Ebola, or at least its current strain. For the sake of dealing with this problem, there are three models being developed.

Firstly, this paper establishes the model 1 on the basis of the classical model of SIR and diffusion characteristic of Ebola virus. It verifies the reduction of the spread of the virus, the improvement of the patient's cure rate and the effectiveness of three preventive measures which are significant in the formation of herd immunity. At the same time, we use linear programming to control the cost of drug delivery.

Model 2, namely, the model of SIR with pulse vaccination, provides a pulse vaccination therapy on the basis of model 1. Model 2 considers many factors comprehensively, such as the cycle of inoculation, vaccination rate, the birth rate, death rate and so on. We use differential equation models to get the critical condition of the number of susceptible people, vaccination rate, and the development of predicated estimate with the change of time.

Next, based on the model 2, we establish model 3 which not only considers many factors comprehensively, such as the amount of supply, the location of supply and so on, but also introduce 0-1 variable to combine the general linear programming with another linear programming which is not fixed but multi objectives so that we get the drug delivery network. Meanwhile, this paper obtains the best drug delivery program which has to spend the minimum cost on the condition of effectively controlling the epidemic. Also the result can alleviate serious situation of the Ebola virus epidemic diffusion through the drug delivery network.

This paper puts forward the improvement of the model by using the Self-Organizing Map neural network and cluster analysis to get the urgent degree of different epidemic areas and divide these areas into different priorities. We get a goal programming model based on different priority. Furthermore, we use the drug delivery model and Lingo to get a more reliable drug delivery program on the basis of the objective function of priority.

Key words: Ebola; SIR; Differential equation; Linear equation; Drug delivery network

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1. BACKGROUND

1.1 Ebola virus

Ebola virus disease (formerly known as Ebola hemorrhagic fever) is a severe, often fatal illness, with a case fatality rate of up to 90%. It is one of the most virulent diseases around the world. The infection is transmitted by direct contact with the blood, body fluids and tissues of infects animals or people. Severely ill patients require intensive supportive care. During an outbreak, those at higher risk of infection are health works, family members and others in close contact with sick people and deceased patients.

1.2 Historical Background

The ongoing Ebola outbreak in West Africa is the largest and most complicated that the world has ever seen. Since it was identified in the forecasted region of such eastern Guinea in March 2014, it has spread to Liberia. Sierra Leone, and Nigeria, and has now been declared a “public health emergency of international concern” by the World Health Organization. According to the latest official WHO figures more than 5,000 people have died and more than 13,703 have been infected with Ebola virus, although experts believe the real totals are much higher.

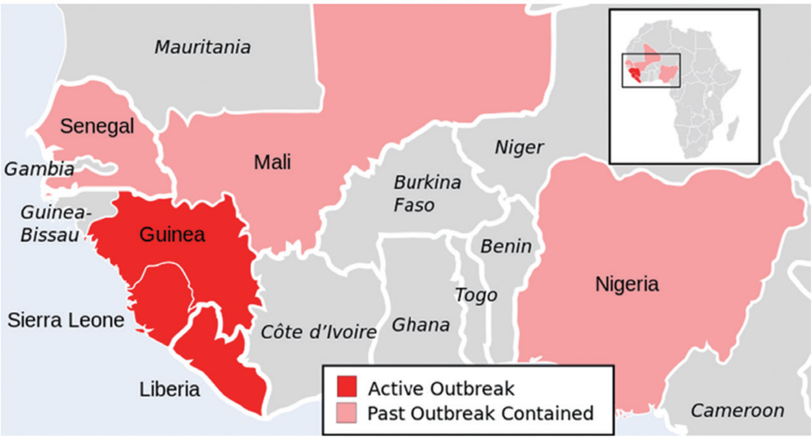

Figure 1
The Epidemic of Topographic Map in West African

1.3 Problems

Ebola often occurred in West African countries. It is a difficult problem in terms of developing and investing new drug. The world Medical Association has announced that their new medication could stop Ebola and cure patients whose disease is not advanced. Thus build a realistic, sensible, and useful model that considers the spread of the disease, the quantity of the medicine needed, possible feasible delivery systems, locations of delivery, and speed of manufacturing of the vaccine or drug in combination with reality to optimize the eradication of Ebola, or at least its current strain.

2. INTRODUCTION

This paper starts from the diffusion model for general diseases based on the diffusion regulation of Ebola virus. It concentrates on the diffusion process of the Infectious disease and the threshold of SIR virus which has a character of Logistic growth. At the same time, we can get three ways to control the spread of the virus by collecting data in the recent Ebola virus in some countries to verify the model analysis. On the condition of stopping the virus diffusion, we obtain the best drug delivery program when the prevention cost is the minimum.

It is unrealistic to apply the traditional disposable inoculation to prevent the outbreak of the Ebola virus in complicated environment. So this paper considers the pulse vaccination when we established the model 2. This method is not only able to ensure the low vaccination rates, but also effectively controls the spread of the virus. Moreover, the model can get the estimates of the demanded drug before each inoculation.

By using the diffusion of the infectious disease's regulation to obtain the forecast of the needed goods, establishment of the infectious disease's threshold and so on. Then this paper takes advantage of these factors to study how to control the diffusion of the virus. Moreover, using Lingo to solve the problem under the guarantee of non-proliferation on the basis of the epidemic, combined with considering the distance between the demand for drugs drug inoculation method, the drug delivery locations and the number of drug supply, as well as the affected areas and the establishment of the reserve area between the drug distribution models. Finally we obtain the best drug delivery program at the minimum delivery cost.

3. MODEL

3.1 Model 1

3.1.1 Symbols and Definitions

Table 1
Symbols and Definitions

Symbol	Definition
N	Population
$i(t)$	The infected people at time t
$s(t)$	The susceptible population at time t
$r(t)$	The removals at time t
σ	Contact number
μ	Daily cure rate
γ	The speed of diffusion
s_0	The susceptible population at initial time
i_0	The infected people at initial time
r_0	The recoveries at initial time

3.1.2 Assumptions

(a) Study the spread of the disease in the area range without considering births, deaths, flowing and so on. The population is a constant N. Population divided into the following three categories: Susceptible people, its number percentage is $s(t)$ and it indicates a proportion that people are not infected but likely to be infected who account for the gross population. Infective people, its number percentage is $i(t)$ and it indicates a proportion that people not only have been infected but also be contagious. Recovered people, its number percentage is $r(t)$ and it indicates these people have been already removed from the infective people. (These people is not susceptible people or infective people, they are not contagious. They have withdrawn from the infected system.)

(b) The speed of diffusion of patients is λ, daily cure rate is μ, contact number is σ; They are all constants. Obviously the average infection cycle is $1/\mu$, the contact of the infection cycle is $\sigma=\lambda/\mu$. The disadvantage of this model is that the result go far away from the reality because of the constant of the effective infection rate.

3.1.3 The Foundation of the Model

From the over assumptions:

$$s(t)+i(t)+r(t)=1 \ . \tag{1}$$

Establish equations:

$$\begin{gathered} N[i(t+\Delta t)-i(t)]=\lambda Ns(t)i(t)\Delta t-\mu Ni(t)\Delta t \\ N[s(t+\Delta t)-s(t)]=-\lambda Ns(t)i(t)\Delta t \ . \end{gathered} \tag{2}$$

Assuming the susceptible people, infective people and recovery respectively is $s_0(s_0>0)$, $i_0(i_0>0)$, $r_0(r_0>0)$ at the initial time.

Convert equation to ordinary differential equation, we can get the Differential equations based on the model of SIR.

$$\begin{cases} \dfrac{\mathrm{d}i}{\mathrm{d}t}=\lambda si-\mu i \\ \dfrac{\mathrm{d}s}{\mathrm{d}t}=-\lambda si \\ \dfrac{\mathrm{d}r}{\mathrm{d}t}=\mu i \end{cases} \ . \tag{3}$$

It can not solve the $s(t)$ and $i(t)$ directly, we can estimate the regulation of $s(t)$ and $i(t)$ by numerical calculation.

3.1.4 Numerical Calculation

This paper selects the data of Ebola epidemic in Congo in 2003: The initial infections are 143, the gross population of Congo is 354 millions. Assuming $\lambda=1$ $\mu=0.3$ $i_0=0.0004$ $s_0=0.99996$, and then using MATLAB to calculate and draw a picture.

Initial Value: $i_0=0.0004$ $s_0=0.99996$. When the t is increasing, (s, i) move from right to left along with the movement of trajectory.

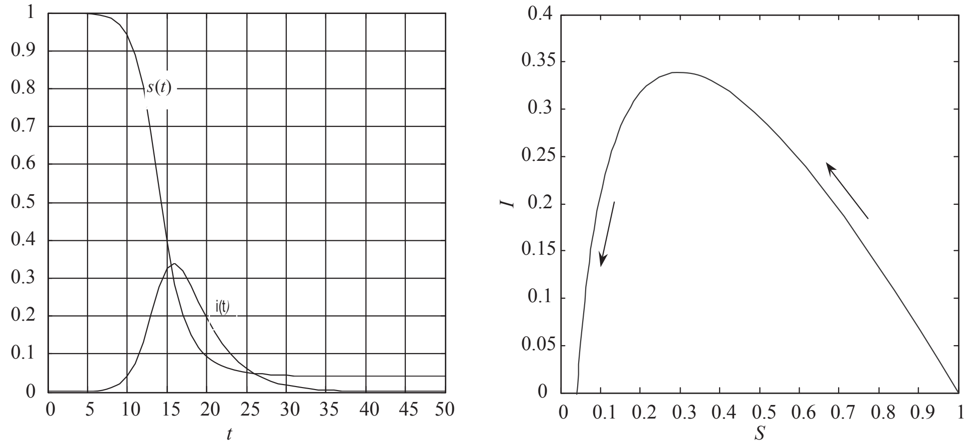

Figure 2
The Spread of the Virus

3.1.5 Analyze the Phase trajectories of SIR Model

The use of phase trajectories $i(t)$, $s(t)$ to discuss the nature of the phase trajectories of SIR model based on the numerical and graphical observation:

$$i(s) = (s_0 + i_0) - s + \frac{1}{\sigma}\ln\frac{s}{s_0} \quad . \tag{4}$$

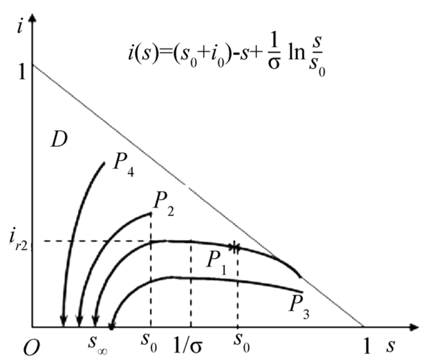

Figure.3
(*s*, *i*) Changes

We can get the estimate：

$$\sigma = \frac{\ln s_0 - \ln s_\infty}{s_0 - s_\infty} \, . \tag{5}$$

Then compare s_0 with $1/\sigma$:

If s_0 is greater than $1/\sigma$, the infectious diseases are unable to control in the natural environment, it that means the infectious diseases spread.

If s_0 is not greater than $1/\sigma$, the infectious diseases are able to control in the natural environment, it that means the infectious diseases do not spread.

3.1.6 The Analysis of the Model

This paper selects $s_0<1/\sigma$ to analyze how to prevent the spread of infectious diseases.

(a) Increase Threshold $1/\sigma$: In order to not only increase $1/\sigma$ but also decrease daily contact λ and daily cure rate μ, we could consider raising health level on the one hand, such as keeping patients away from other people safely to decrease the speed of diffusion; On the other hand, we should improve medical standard to accelerate the pace of the drug research to provide a better treatment. Besides these, the epidemic areas also need the financial support.

(b) Decrease s_0: Improve people immunity by the vaccination in order to decrease susceptible people.

3.1.7 The Model of Drug Delivery Based on the Linear Programming

Assumptions: The drug will control Ebola virus infection and cure the infected people when the new one put into production.

Tariff: Assuming the distance of 5 African countries is proportion to their average transportation cost. We choose the distance table as tariff (as shown below);

Drug demand: Knowing the estimates of the infected people from model 1 as the demanded number in every supply area.

Table 2
Distance

Distance (Mile)	Guinea	Liberia	Sierra leone	Nigeria	Senegal
Guinea	0	275.2	186.281	1191.3	382.32
Liberia	275.2	0	216.43	1300.53	668.21
Sierra Leone	186.281	216.43	0	1316.19	440.16
Nigeria	1191.3	1300.53	1316.19	0	1509.37
Senegal	382.32	668.21	440.16	1509.37	0

This paper selects 5 West Africa countries as demand and supply areas. These countries are almost the most serious epidemic areas. We establish Linear programming model in combination with the results of the model 1.

3.1.7.1 The Foundation of the Model

Assumptions:A_1, A_2,...,A_m represents m kinds of reserve areas for drug; B_1, B_2,...,B_n represents n kinds of demanded drugs for the most serious epidemic areas; s_i represents the amount of reservation in A place; d_j represents the amount of demanding in B place; c_{ij} represents the average transportations price of drug from reserve area A to demanding area.

$$\min f = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}\,.$$

$$s.t\begin{cases} \sum_{j=1}^{n} x_{ij} = s_i & i = 1,\cdots,m \\ \sum_{i=1}^{m} x_{ij} = d_i & j = 1,\cdots,n \\ x_{ij} \geq 0, i = 1,\cdots,m, j = 1,\cdots,n & \end{cases}. \qquad (6)$$

This paper gets the best transportation program under the minimum cost condition by using Lingo. In this case, we can find the best emergency assistance program to optimize the eradication of Ebola, or at least its current strain.

3.1.7.2 The Analysis of the Model

From the establishment and analysis of the model, we can find the current work against the Ebola virus is to stop the diffusion, treat the infected people, ensure essential services, preserve stability and prevent outbreak in countries currently unaffected. It has to spend much cost in terms of improving the health care, developing new drug and transportation when the Ebola outbreak in a short time in some West African countries. UN and epidemic areas of infectious disease appeal to public together: Launch global financial assistance, called for more international aid. WHO and the UN Mission for Ebola Emergency Response set the target of the so-called "70-70-60 plan", which aimed to try to get 70% of the cases isolated and treated, and 70% of the deceased safely buried within 60 days from the beginning of October to December 1. Two months ago the deadly Ebola disease is escalating in many places and exponential growth was seen in term of new cases, which drove by the shortage of treatment beds as well as burial teams. There were no longer seeing exponential growth and in some areas we were seen declining disease. These phenomenons indicate the effectiveness of the model.

3.2 *Model 2*

3.2.1 Symbols and Definitions

Table 3
Symbols and Definitions

Symbol	Definition
N	The number of population
a	The birth rate and natural mortality of the population
b	The coefficient of spreading of the virus
c	The cure rate of the patient
p	The introduction of vaccination rates
D_k	The demand forecasting of the drug develops with the time

3.2.2 Assumptions

For the model 1, some reasonable assumptions are as follows:

Parameters N,a,b,c are positive, c assumed to obey a distributed random variables.

b) This model has no population movement and died of illness , the number of population is unchanged.

3.2.3 The Foundation of the Model

The model of SIR with pulse vaccination:

$$\begin{cases} \dfrac{\mathrm{d}S}{\mathrm{d}t} = aN - (bI + a)S(t) \\ \dfrac{\mathrm{d}I}{\mathrm{d}t} = bS(t)I(t) - (a + c)I(t) \\ \dfrac{\mathrm{d}R}{\mathrm{d}t} = cI(t) - aR(t) \end{cases} . \qquad (7)$$

Among them

$$t \neq t_n,\ t_{n+1} = t_n + T.$$

The introduction of vaccination rates p

$$\begin{cases} S(t) = (1-p)S(t_-) \\ I(t) = I(t_-) \qquad\qquad t = t_n \qquad n = 0,1,2...... \\ R(t) = R(t_- + pS(t_-)) \end{cases} \quad (8)$$

For the conventional disposable inoculating apply in the real prevention and control of the sudden outbreak of the Ebola virus which is not practical. But the medical methods of pulse can ensure lower vaccination rates and control the spread of the virus effectively.

3.2.4 Solution to the Problem

This article assumes that $I(t)$ is a decreasing function,.

Where

$$\frac{dI}{dt} < 0 .$$

We can get the critical value:

$$S_c = \frac{a+c}{b} > \frac{(aT-p)(e^{aT}-1)+apT}{aT(p-1+e^{at})}.$$

Similarly

$$p_c = \frac{aT(a+c-b)(e^{aT}-1)}{aT(b-a-c)+b(1-e^{aT})} . \quad (9)$$

When

$$p > p_c .$$

The system gets a stable disease-free period. From the over model, the Ebola virus infection is regular.

We can get the drug demand forecast along with the change of the time:

$$D_k = pS(T_{K-}) . \quad (10)$$

3.3 Model 3

3.3.1 Symbols and Definitions

Table 4
Symbols and Definitions

Symbol	Definition
D_{ik}	When the k-th pulse vaccination, the demand of the I epidemic area of infectious disease, k=1,2,......,r i=1,2,....,n
x_j	The maximum amount of the reserve areas j=1,2,.....,L_k
L_{bk}	The distance of the threshold of the k th pulse vaccination
L_{ji}	The distance from the jth reserve area to ith epidemic area of infectious disease
C_{1ik}	When kth pulse vaccination, the average cost of the jth reserve area
C_{2ik}	The average transportation costs when the kth Pulse Vaccination
U	Carrying capacity of per vehicle
α_k	Expansion coefficient for covered distance when exceed the time limitation
N_k	The number of the reserve area within the coverage of the distance threshold
$N_{\alpha k}$	The number of the reserve area $(1+\alpha_k)L_{bk}$ within the coverage of the distance threshold

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Symbol	Definition
N_{pk}	Alternative number of the reserve areas
x_{jik}	The number of the medicine deliveries from the jth reserve area to ith epidemic area of infectious disease

3.3.2 Assumptions

For the model 1, some reasonable assumptions are as follows:

A. If the Ebola virus outbreak in an area, this area is isolated. (Ignore the flow of the population)

B. The distance between each drug reserve area and epidemic area of infectious disease is measurable and known. The rescue time is in direct proportion to the distance.

C. Before inoculation, the drug reserve areas of the epidemic area of infectious disease meet the demand for drugs. Before the next inoculation, the timely supply of the each drug reserve area can meet the demand of the next inoculation.

D. Taking the special nature of the spread of the Ebola virus into account, we select the delivery system not only account for the time but also the cost. Namely the following:

(a) When select the maximum amount of reserve areas is greater than or equal to the demand of the infected areas in specific time, we should optimize the repository distribution amount to decrease the cost.

(b) When selecting the maximum amount of reserve areas is less than the demand of the infected areas in specific time, it is not necessary to control the time strictly. Similarly, the coverage areas over the drug reserve areas increase a proportion to expand the coverage area of the drug.

3.3.3 The Foundation of the Model

Suppose TC is the total cost of the emergency goods:

$$\min\ TC=\sum_{k=0}^{N_k}\left[v\left(\sum_{j=1}^{N_k}x_j-D_k\right)\times\left(\sum_{i=1}^{n}\sum_{j=1}^{N_k}C_{1jk}x_{jik}+\sum_{i=1}^{n}\sum_{j=1}^{N_k}C_{2jk}\left[\frac{x_{jik}}{U}\right]L_{ji}\right)\right]$$
$$+\sum_{k=0}^{N_k}\left[v\left(D_k-\sum_{j=1}^{N_k}x_j\right)\times v\left(\sum_{j=1}^{N_{\alpha k}}x_j-D_k\right)\times\left(\sum_{i=1}^{n}\sum_{j=1}^{N_k}C_{1jk}x_{jik}+\sum_{i=1}^{n}\sum_{j=1}^{N_k}C_{2jk}\left[\frac{x_{jik}}{U}\right]L_{ji}\right)\right]. \tag{11}$$

Where $[f]$ is Integer upper bound of x equal to select the smallest integer which is not less than x.

$$v(x)=\begin{cases}0 & x\le 0\\ 1 & x\ge 0\end{cases}. \tag{12}$$

Constraint condition 1 should ensure the amount of the distribution of the reserve area is not more than the maximum number of this reserve area.

Constraint condition 2 should ensure the medicine from the alternative reserve area of the epidemic area of infectious disease can meet the demand.

Constraint condition 3 D_k is a demand forecasting model which is derivate from the model 2.

$$\begin{cases} \sum_{i=1}^{n} x_{jik} \le x_j \\ \sum_{i=1}^{N_{pk}} x_{jik} \ge D_{ik} \\ D_k = \sum_{i=1}^{n} pS(T_{K-}) \end{cases} . \quad (13)$$

3.3.4 Solution to the Problem

This paper assumes that each drug reserve area can cover the epidemic area, namely each reserve area can provide the drug to the epidemic areas of infectious disease in order to simplify the calculation process and reflect the process of humanitarian assistance.

(a) Assuming that the Ebola virus epidemic outbreak in *A* and *B* areas. But there are drug reserve areas around the two epidemic areas of infectious disease which can supply the drugs. Given the parameters and initial values (as shown in model 1) shown in the following table. Assuming the cycle of the pulse vaccination T equal to 30 and using the MATLAB to get the following table as a solution.

Table 5
The Parameters of Ebola Virus Epidemic

Parameters	*a*	*b*	*c*	*P*	*T*
Number	0,00008	0.00002	0.009	0.1	30

Table 6
The initial value in A and B

Initial value	*S*	*I*	*R*
A epidemic area of infectious disease	1,200	200	0
B epidemic area of infectious disease	950	100	0

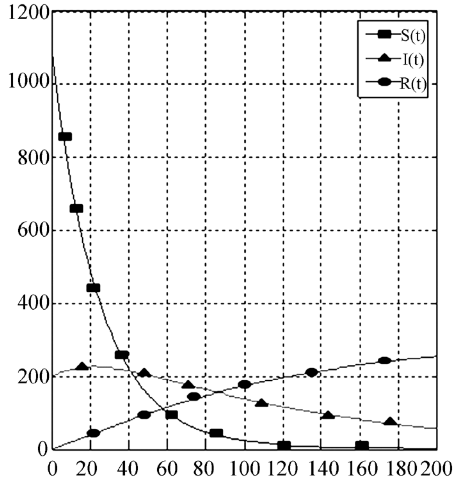

Figure 4
Spread of the Virus in a Unvaccinated Area

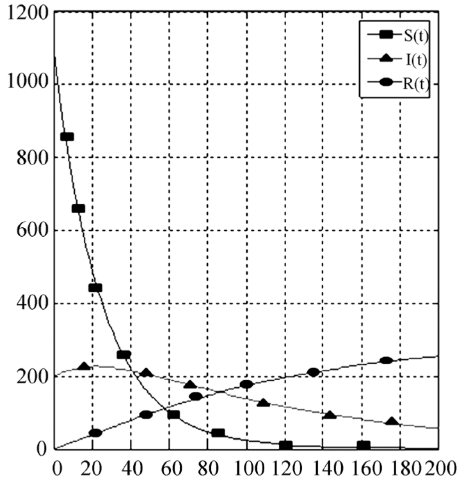

Figure 5
Spread of the Virus in a Vaccinated Area

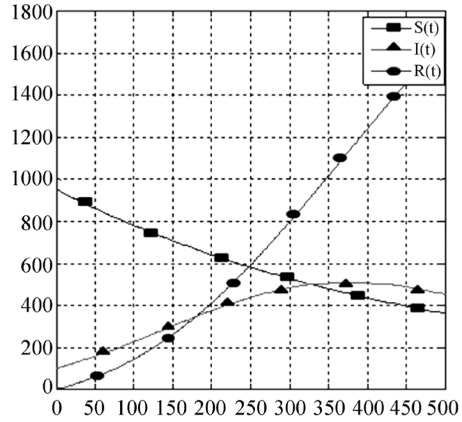

Figure 6
Spread of the Virus in B Unvaccinated Area

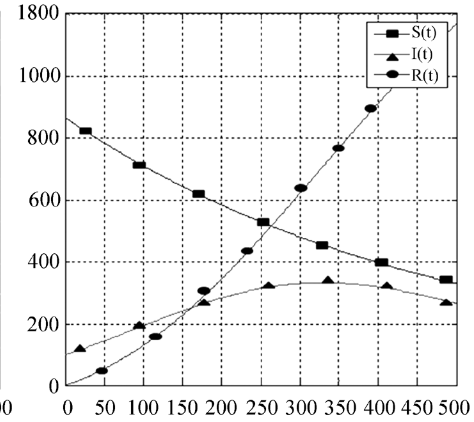

Figure 7
Spread of the Virus in B Vaccinated Area

We can see the infected people and the susceptible people decline faster in the case of pulse vaccination when compare the Figure 4 with the Figure 5 The same to the comparison between Figure 6 and Figure 7 This indicates that the pulse vaccination can more effectively control the spread of infectious diseases. This paper takes the model of SIR as a basis for the research which is concentrated on the Ebola virus diffusion network and drug distribution network.

(b) Base on the pulse vaccination of SIR model, we can get each demand of the vaccines. This paper uses this demand forecasting as an entrance of the drug delivery model so as to optimize the solution of drug distribution model. Selecting the demand for the first three pulse vaccination finds the solution (as shown). Table 4 shows the distance between reserve area and epidemic area. Table 5 shows the maximum capacity of each reserve area.

Table 7
The Top Three Numbers of the Vaccinations

Frequency	1	2	3
A epidemic area of infectious disease	120	108	98
B epidemic area of infectious disease	95	86	77

Table 8
The Distance From Reserve Areas to Epidemic Areas

Reserve areas	I	II	III	IV	V
Reserve areas A	4	1	4	5	6
Reserve areas B	4	3	2	7	3

Table 9
The Maximum Inventory of the Reserve Areas and the Average Inventory

Reserve areas	I	II	III	IV	V
Inventory cost	50	53	48	20	18
The maximum inventory	45	51	40	46	50

Assuming U equal to 20 and applying Lingo to solve the model, we can get the different delivery program from every reserve area to every epidemic area.

Table 10
The Drug Delivery Program and the Total Cost

The time of the inoculation	1		2		3	
Epidemic areas of infectious disease	A	B	A	B	A	B
Ⅰ	45	0	45	0	45	0
Ⅱ	46	5	51	0	51	0
Ⅲ	0	40	4	36	2	38
Ⅳ	29	0	8	0	0	0
Ⅴ	0	50	0	50	0	39
Supply	120	95	108	86	98	77
Total cost	27,008		26,954.5		26,916	

From the above table, we can draw the reserve area I, reserve area II, reserve area III, reserve area Ⅳand reserve area V Delivery the Vaccine to A area and B area. The demanded number of the epidemic area equal to the deliveries from the five reserve areas to A and B .This indicates the effectiveness of the emergency goods which are based on the Infectious diffusion regulation. Similarly, the formation of the drug delivery network is driven by the Ebola virus diffusion networks.

(c) On the basis of the above model for the numerical simulation of the spread of infectious diseases, we increase vaccine inoculation rate to 0.05. In that case, we get the vaccine number of each pulse vaccination .The first demand shows in the table. This paper uses the Lingo to find the number of vaccine deliveries from every reserve area to epidemic area which is also shown in the table.

Table 11
The Top Three Number of the Vaccinations

Frequency	1	2	3
A epidemic area of infectious disease	105	117	104
B epidemic area of infectious disease	90	108	105

Table 12
The Drug Delivery Program and the Total Cost

Frequency	1		2		3	
Epidemic area of infectious disease	A	B	A	B	A	B
Ⅰ	45	0	45	0	45	0
Ⅱ	51	0	33	18	36	15
Ⅲ	0	40	0	40	0	40
Ⅳ	9	0	39	0	23	0
Ⅴ	0	50	0	50	0	50
Supply	105	90	117	108	104	105
Cost	26,953		27,046		27,003	

Under the conditions of inoculation rate *P* equal to 0.1, the maximum demand of the pulse vaccination is the first time. The optimal result of the drug delivery model which is shown in Table 9: The alternative reserve area of the first pulse result can meet the later demand of the pulse vaccinations. Therefore, if the first alternative reserve area meets the demand, the remaining areas can complete the remaining pulse vaccination requirements. This result shows us that the vaccine has not been exerting its maximum utility to control the Ebola virus. So we can increase the supply of the drug delivery to control the Ebola virus effectively. As shown in Table 8, using the Numerical Simulation of Matlab to get the number of the vaccine from every reserve area to every epidemic area (as show in Table 9). With the improvement of supplement of drug delivery network, the immune person become fewer and fewer in the region of Ebola virus infection and similar crowds will tend to zero. This indicates infectious disease can be controlled well in a short time. The drug delivery can control the spread of Ebola virus diffusion network effectively.

3.3.5 The Analysis of the Model

In summary, by introducing the model of the pulse vaccination of SIR which is consistent with reality firstly and we can know the predicting number of demanded drug D_k;Then we should consider the method of injection ,the location of the drug delivery and supplement of drug in combination with the demand for drug to establish a virus diffusion network and a drug delivery network. This indicates the pulse vaccination controls the spread of the infectious disease better. At last, we take advantage of the numerical simulation to prove the formation of the drug delivery network is driven by the Ebola virus diffusion networks and at the same time the drug delivery network controls the virus diffusion effectively based on the above conclusions.

3.4 The Evaluation of the Model

3.4.1 The Advantages of Model

(a) As for the models of Infectious disease: SIS, SIR, SIRS. This paper establishes the correct models and the reasonable assumptions based on the characters of the Ebola virus. We also make research gradually by promoting the model of SIR to the model of SIRS.

(b) This paper chooses the true and reliable data from WHO, The United States CDC and National Geographic network.

(c) All models give reasonable assumptions and use many methods to solve the problems, such as MATLAB, LINGO and so on. In this case, this paper can ensure the result is rationality and effectiveness.

(d) The models use many numerical simulations to analyze the outcome, combined with the reality. During the process, we apply tables to explain the comparisons between different pictures.

3.4.2 The Disadvantages of Model

(a) Not consider the impact of geographic factors on the average transportation price in the transportation model. There is an error because of using the distance to measure the average transportation price.

(b) There is an error in the numerical simulation model because of the limited data sources.

(c) This paper just comes up with some ideas for the improvement of the model. In other words, this paper needs more detailed solutions.

4. FUTURE WORK

We did not consider the severity and timing of outbreaks as well as the urgency of the assistance. In order to deliver the drug more rational among the epidemic areas based on the severity. Firstly, we should calculate the demand forecasting of the goods on the basis of the model of SIR. Next, we are supposed to obtain the urgency value of every endemic area based on the cluster analysis in combination with the SOM neural networks.

Assuming: Take $w^s_j(t)$, s=1, 2, 3 as input vectors of the SOM neural networks

(a) $w^1_j(t)$ represents the percentage of susceptible people in epidemic areas in the total population. The value becomes higher; the corresponding epidemic area becomes more urgent

(b) $w^2_j(t)$ represents the percentage of infective people in epidemic areas in the total population. The value becomes higher; the corresponding epidemic area becomes more serious.

(c) $w^3_j(t)$ represents the percentage of immune people in epidemic areas in the total population. Children and the aged are immune people.

We get the urgency of different epidemic areas in combination with cluster analysis by using SOM algorithm to calculate the weight of different attributes. At the same time, this paper takes advantage of the different priority to establish an objective function. Then on the basis of these conclusions can obtain the more reliable transportation dispatching program.

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