A Bayesian Network and Genetic Algorithm-Based Theoretical Framework for Antibiotic Management in Clinical Settings

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Abstract: In this paper, we propose a novel theoretical framework to simulate antibiotic management phenomena. It is assumed that the antibiotic management system is closed. Markov model is used to predict the trend of the share of antibiotics in the fully competitive market. In addition, data sets of three types of drugs (antibiotics, high content of antibiotic medicines and other drugs) are selected from questionnaire. According to Markov model, the occupancy of drugs after k years could be obtained. Other than that, the management model is built based on Bayesian network to establish probability model for the use of antibiotics. It is necessary to use genetic algorithm to optimize the network.

Keywords: Antibiotic management system; Markov chain; Bayesian network; genetic algorithm

1. Introduction

Antibiotic management in clinical settings is a complex process that involves various factors such as patient demographics, drug resistance, and treatment efficacy. In recent years, the use of computational methods such as Bayesian network and genetic algorithm has gained attention as a means of optimizing antibiotic management. These techniques allow for the development of a theoretical framework that takes into account the various factors that impact antibiotic management, and provide a means of predicting optimal treatment strategies. This paper presents a novel theoretical framework that combines Bayesian network and genetic algorithm to improve antibiotic management in clinical settings. The proposed framework leverages the power of machine learning to identify the most effective treatment regimens, while considering patient-specific factors such as age, sex, and comorbidities. The aim of this paper is to provide a comprehensive review of the theoretical framework and to demonstrate its potential to improve antibiotic management in clinical settings.

2. Materials and Methods

2.1 Basic Methods of Markov Chain

Considering the PESTLE analysis, involved usual index as political, economic, sociological, technological, law and environment. To start with, the political attitudes towards antibiotics crisis was a court point, which the WHO have come to realize the severity of antibiotics. Yet the sociological ideas verge on a divergence, which some espoused it versus dissidents' thoughts. Doing an appropriate analogy, the bill is like the political; the environment the same as sociological. As for technology, breakthrough quickly is in a period seem to a daydream. The crisis is not owe much to the economy meanwhile. Thereby we attempt to unify the heterogeneous parts, via an special array, to reveal the harmony and gulf about the problem.

Naturally, a array is defined like this:

$$A=(a_1,a_2,a_3,a_4,a_5) \quad (1)$$

where an is the numerical values rely on element of the market. And then some factorssize, output, buying behavior, market share, and utilization rateand are selected representing for the mentioned "PESTLE". In advance, a series of data we need are intercepted from U.S. Bureau of Economic Analysis (BEA), thereby to get standardized values, the data is handled using the method of deviation standardization via Excel,whose formula are as below:

$$Ns=(N-N_{min})/(N_{max}-N_{min}) \quad (2)$$

As our research advanced, the problem of ensure the weight was necessary, which are of great variety -- for instance, expert interview method, Delphi method,etc. -- yet a new technique is helpful -- target optimization matrix table and it is widely used in target optimization and order of importance.

This method could transfer our fuzzy thinking into a simple 0-1 logical thinking, to figure the quantified outcome. First steps, authors visit several major experts, by their suggestions to acquire the weights of every modulus. In detail, compared the vertical axis with the horizontal axis, if the former is more significant, it is 1, else 0, finally added them and reordered. The weight can be calculated:

$$W=s/S*100\% \quad (3)$$

where s is for the importance of the index, S for all the indexes.

Above all, a special Markov model is built, with a interest chain which is represented for numerical characteristics (the array). Not only did it reveal the commercial interests and the sensitivity of parties, but predict the trend of antibiotics.

2.2 Results

2.2.1 Meaning Interpretation of Markov Chain

It is of importance to explain the factual sense of our Markov chain, especially for the series of problems in antibiotics. Thinking of the interest chain, it is realized that the array is abstract to understand, yet it play an important role in solving the problem. It is necessary not only to give the abstract expression of interest chain, but also explain a specific interest relationship, so that the role of the matrix is easy understanding. Through the funnel map, it is obvious that the antibiotic drugs manufacture from manufacturers, most hospitals and clinics, and even feed manufacturers, and some experts and patients refuse to use antibiotics, replaced by other drugs, there are also a number of interests into the government's tax, constituting the interests chain, which is the specific meaning of the matrix.

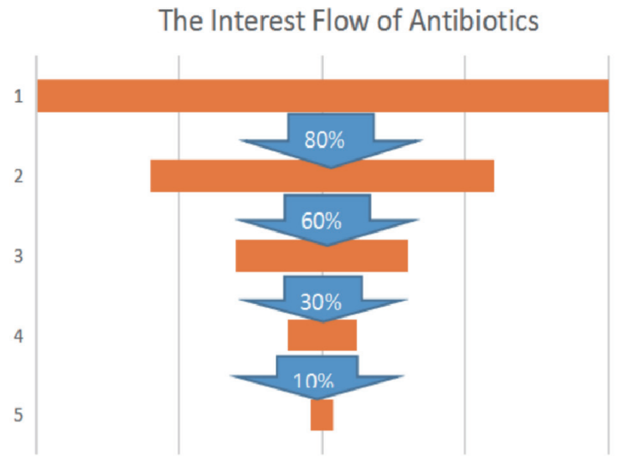

Figure 1 Results on the interest flow of antibiotics.

2.2.2 Solving model

When k approaches infinity is found, the outcome stabilize a figure, in the other word, the market share is stable. In fact, under the situation that costumers' flow direction is a longterm stability, after a period, the market share of every drug reach the equilibrium state, in a nutshell, shoppers' flow direction is unrelated to the market share. This conclusion seems to be amazing, let's explore the secret of the market share.

When the perfect competitive market is under a balanced state, in terms of

$$S^K=S^U*P^K=S^{K-1}*P \quad (4)$$

An equation is easy to acquire:

$$S=S*P \quad (5)$$

Due to a basic property: $\sum_{k-1}^{3} p_k = 1$, The final answer is P_1=0.61, P_2=0.21, P_3=0.18, by Matlab.

Considering some dynamic factors in this model, for antibiotics and other drugs, the weight of factors for example, PESTLE varied. Authors have a survey over people in different state, then got the total number of their choices about antibiotics.

Next, the weight of factors are ensured by target optimization matrix table, which is mentioned. $A_1=(0.40, 0.65, 0.54, 0.60, 0.00, 0.70)^T$ is the rate of support for antibiotics; $A_2=(0.30, 0.20, 0.17, 0.24, 0.00, 0.20)^T$ is for drugs contained it over 50% ; while $A_3=(0.30, 0.15, 0.29, 0.16, 0.00, 0, 10)^T$ is for other drugs.

Based on these three matrices, the support rate for each drug can be calculated. Then the obtained support rate is normalized, and the maximum value of the support rate is used as the unit, and the 0-1 standardization is carried out. It can be: P_1=0.70, P_2=0.25, P_3=0.07.

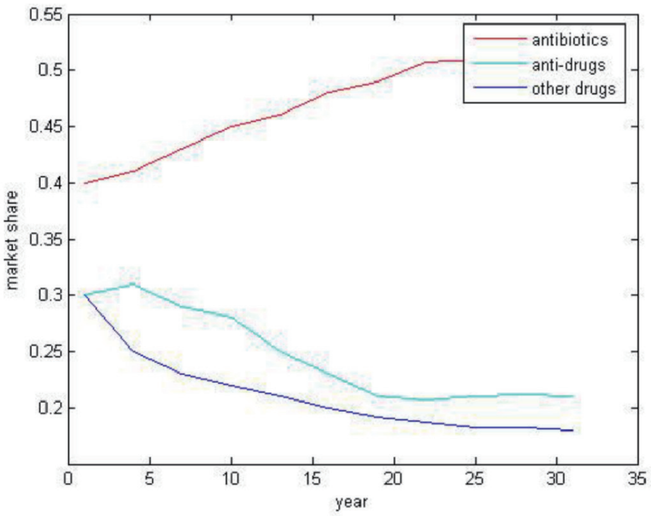

Figure 2 The predictive market share with respect to time (years).

2.2.3 Running Genetic Algorithm in Matlab

Based on Matlab, genetic algorithm is used to optimize the results. And the NiceBasic code is available in Github (https://github.com/). The result is shown as follows.

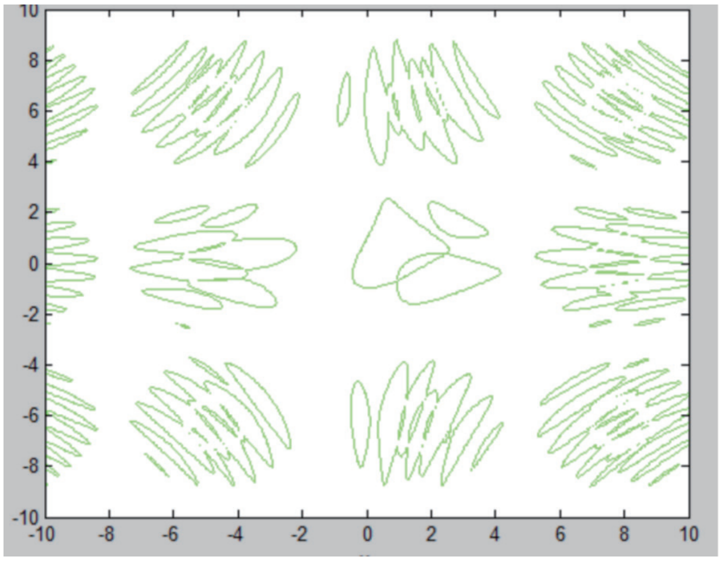

Figure 3 This caption shows the effectiveness of genetic algorithm.

Conclusion

Markov model is effective for predicting the state of the process, people can analyze the share of antibiotics in the fully competitive market and get the trend of the share by using it. Yet it is not suitable for long-term system prediction. Bayesian network is an important tool to deal with uncertain information. It is used to represent the variable set of connection probability of the graphics model, provides a method of causality information. Genetic Algorithm can optimize the model and enhance the accuracy of the model.

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