

Analysis on Regional Guidance Mechanism for Promoting Prevention Based on Combination of Traditional Chinese Medicine and Western Medicine

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Abstract. China's health strategy puts forward the requirement of giving priority to prevention and paying equal attention to Traditional Chinese Medicine (TCM) and Western Medicine. Government should guide the preventive actions with combination of TCM and Western Medicine at regional level. An evolutionary game model for regional strategy pattern of TCM and Western Medicine has been constructed, and the solution of the model has been numerically simulated and analyzed. The enlightenment of analysis conclusions mainly includes three aspects: prevention guidance mechanism that does not weaken therapeutic function of medical service system can be established; in current prevention system dominated by Western Medicine, the cost required to promote TCM prevention is affordable; guidance mechanism cannot avoid polarization between preventive actions of TCM and Western medicine in the long run, but it is possible to promote prevention of them at the same time at initial stage of mechanism implementation. Policy suggestions have been put forward on judgment method of service structure changes of TCM and Western Medicine and on effective influence to regional incomes of TCM and Western Medicine.

Keywords: Chinese medicine, Western medicine, Prevention, Mechanism.

1 Introduction

Aging, ecological environment problems, modern working environment, modern lifestyle and other factors make China face more and more complex health challenges. China has defined preventive health strategy themes such as "prevention first and take equal importance for TCM and Western Medicine", "early diagnosis, early treatment, and early rehabilitation", "whole population and whole life cycle" ("Healthy China 2030" Planning Outline).

TCM and Western Medicine have their own characteristics in prevention. In public health field, Western Medicine mainly studies occurrence and development laws and pathogenic factors of different diseases in population and responds to them through public health means. In clinical field, Western Medicine mainly conducts clinical prevention or early intervention

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against specific diseases. Based on professional analysis from a micro perspective and often considering to cost-effectiveness, Western Medicine can determine the feasibility of prevention activities [1–3], timing [4] and content [5].

The philosophy of TCM prevention is concentrated on “preventive treatment of disease”, which includes three meanings: “prevention before disease, prevention from exacerbating, and prevention from relapse”, especially “prevention before disease” [6]. With guiding ideology of “holism”, “preventive treatment of disease” emphasizes maintenance and promotion of good state of human body, and has special perspectives on early identification and disposal of health damage [7, 8]. TCM adopts a more distinctive individual intervention mode. Its intervention means are generally characterized by “simplicity, convenience, efficiency, affordable price”.

At present, the research on combining different resources to carry out medical prevention activities covers public health and clinical fields, but mainly focuses on combination of information technology [9], community management [10], social media [11] or other non-medical resources with medical resources. Only for a few specific events (such as the epidemic of coronavirus disease in 2019), relevant research on combined use of heterogeneous medical resources (such as TCM resources and Western Medicine resources) was carried out [12].

Combination of TCM and Western Medicine is the basic background of medical prevention actions in China. It is necessary to establish an appropriate coordination mechanism for actions of TCM and Western Medicine. Theories of TCM and Western Medicine are independent to each other, and when one of them dominates the actions, it is difficult to achieve effective coordination. In China, government controls investment and distribution of medical resources. As a third party, government can take guiding measures to coordinate development of prevention activities of TCM and Western Medicine.

For establishing a third-party guidance mechanism, two prerequisites need to be considered. Firstly, TCM and Western Medicine have their own theoretical independence and there have no universal connection for them from technical perspective. Guidance mechanism needs a non-technical perspective. Secondly, guiding measures should not be mandatory. A trend change at regional level should be based on independent actions of each medical service provider. Under these two premises, an incrementally and non-technical coordination mechanism of TCM and Western Medicine actions will be studied below.

2 Model

2.1 Evolutionary Game Explanation for Changing of Regional Strategic Pattern

We will look into a region where the scale of medical service audience is stable. In this region, the set of TCM service providers (hospitals and other medical institutions) will be recorded as A , and the set of Western Medicine service providers will be recorded as B . It is assumed that the action strategies of any medical service provider can be classified by long-term strategy and short-term strategy. The long-term strategy refers to the strategies giving priority to preventive actions, while the short-term strategy refers to the strategies giving priority to disease treatment actions.

Both of TCM and Western Medicine service systems have stable resource distribution and operation mode. Improving proportion of medical service providers who take long-term strategy, relying on endogenous power of A and B , may not only be slow, but also be difficult for coordination between TCM and Western Medicine actions. Facing the same service audience, TCM and Western Medicine have mutual influence to each other. A medical service provider may adjust its action strategy due to such influence. With properly use of such

Table 1. Names for TCM and Western Medicine strategies

	TCM service provider	Western Medicine service provider
Long-term strategy	give priority to preventive treatment of disease	give priority to prevention
Short-term strategy	give priority to treatment of disease	give priority to cure of disease

possibility by third party, it is expected to find a new way to change regional medical action strategy pattern.

It is assumed that each medical service provider can judge its income status level in its own set, and the lower the level, the more it hopes to improve its income by adjusting its action strategy. A medical service provider will take adjustment based on income expectations of different action strategies. It is difficult to form a reliable individual income expectation and a medical service provider is usually unable to catch the real-time changes of regional income of TCM or Western Medicine. The proportions of medical service providers choosing different strategies reflect strategy preference of *A* and *B*. When all medical service providers of a set have the same strategy, the strategy preference of this set can be called pure strategy preference.

Following assumptions are ones for income expectation of medical service providers.

Assumption 1: a medical service provider forms its income expectation according to the income judgments of the set it belongs to under different pure strategy preference.

Assumption 2: when *A* and *B* are all pure strategy preferences, for all preference combinations of *A* and *B*, a medical service provider can judge the relative income sizes of the set it belong to, and the judgments of medical service providers in one set are all same.

Under the above two assumptions, the strategy adjustment behavior of a medical service provider will be mainly related to the common cognition of income levels of the set it belong to under situations both TCM and Western Medicine having clear overall strategy tendency. At this time, all medical service providers in a set have same cognition about the consequences of interaction between TCM and Western Medicine, so the interaction between TCM and Western Medicine will have no difference in determining income expectation of them. Furthermore, pure strategy preference combination of TCM and Western Medicine can provide clear strategy adjustment directions for them.

The timings of initiating strategy adjustment of medical service providers are different. With successive implementation of strategy adjustment by medical service providers, incomes of *A* and *B* will change correspondingly and which will make the willingness of adjusting strategy of medical service providers change too. In this process, there are dynamic correlations between *A* and *B*'s strategy preferences and strategy adjustment behavior of medical service providers. This is an evolutionary game process between *A* and *B*. The regional strategy pattern of medical action will change accordingly.

2.2 Basic Assumptions on Payoff Matrix of Evolutionary Game

Different names are assigned to the two types of strategies of TCM and Western Medicine to distinguish them (table 1).

The roles of TCM and Western Medicine are not interchangeable, and the game between *A* and *B* is asymmetric game. The pure strategy payoff matrices of game players will be recorded as I_A and I_B (table 2 and table 3).

The elements of I_A or I_B correspondingly reflect relative size rather than absolute size of *A*'s income or *B*'s income under different strategy combinations of *A* and *B*. Following assumptions are ones for element values of I_A and I_B .

Table 2. Pure strategy payoff matrix I_A of TCM

	Give priority to prevention	Give priority to cure of disease
Give priority to preventive treatment of disease	i_{a1b1}	i_{a1b2}
give priority to treatment of disease	i_{a2b1}	i_{a2b2}

Table 3. pure strategy payoff matrix I_B of Western Medicine

	Give priority to preventive treatment of disease	Give priority to treatment of disease
Give priority to prevention of disease	i_{b1a1}	i_{b1a2}
Give priority to cure of disease	i_{b2a1}	i_{b2a2}

Assumption 3: income of a strategy in heterogeneous strategy portfolio is higher than that in similar strategy portfolio.

Assumption 4: when one side’s strategy is given, income of the other side’s short-term strategy is higher than that of its long-term strategy.

Assumption 5: income of Western Medicine in any strategy combination is higher than income of TCM in any strategy combination.

With above assumptions, there are such relations of

$$\begin{cases} i_{a1b1} < i_{a1b2}, i_{a2b1} > i_{a2b2}, i_{a1b1} < i_{a2b1}, i_{a1b2} < i_{a2b2} \\ i_{b1a1} < i_{b1a2}, i_{b2a1} > i_{b2a2}, i_{b1a1} < i_{b2a1}, i_{b1a2} < i_{b2a2}. \end{cases}$$

At the same time, i_{a1b1} and i_{b1a1} are the smallest elements of their matrixes respectively, i_{a2b1} and i_{b2a1} are the largest elements of their matrixes respectively with $i_{a2b1} < i_{b2a1}$.

Taking $i_{a2b1}=12, i_{b2a1}=100, i_{a1b1}=6, i_{b1a1}=50$, a payoff matrix conforming to assumptions 3, 4 and 5 is constructed shown in Example 1.

$$Example1 : I_A = \begin{pmatrix} 6 & 8 \\ 12 & 10 \end{pmatrix}, I_B = \begin{pmatrix} 50 & 65 \\ 100 & 80 \end{pmatrix}$$

In Example 1, the Nash equilibrium game results for A and B are respectively pure strategy “give priority to cure of disease” and “give priority to treatment of disease”, that is, both of them will take short-term strategy as priority action strategy.

The guidance mechanism should take both long-term and short-term strategies into account. It is assumed that the guidance mechanism will pay subsidy for long-term strategy and then assumption 4 will be changed into the following two assumptions.

Assumption 4-1: when one side adopts short-term strategy, the other side will receive long-term strategy subsidy which will make its long-term strategy income higher than its short-term strategy income.

Assumption 4-2: when one side adopts long-term strategy, the other side’s short-term strategy income is higher than its long-term strategy income.

Based on assumption 4-1, the subsidy will make $i_{a1b2} > i_{a2b2}$ and $i_{b1a2} > i_{b2a2}$. Example 2 is derived from Example 1 conforming to assumptions 3, 4-1, 4-2 and 5.

$$Example2 : I_A = \begin{pmatrix} 6 & 11 \\ 12 & 10 \end{pmatrix}, I_B = \begin{pmatrix} 50 & 90 \\ 100 & 80 \end{pmatrix}$$

For Example 2, the Nash equilibrium game result under pure strategy cannot be obtained. Both TCM and Western Medicine need to optimize their incomes through mixed strategy approach, which means that action strategies of medical service providers in A and B will be differentiated, and the differentiation result is determined by evolutionary game process of A and B .

Table 4. Action ways of guidance mechanism under balanced subsidy

	Subsidy for TCM	Subsidy for Western Medicine
Balanced subsidy	way1: $i_{a1b2} > i_{a2b2}$	way2: $i_{b1a2} > i_{b2a2}$

2.3 Evolutionary Game Model

Use the two components of function vector $x = (x_1(t), x_2(t))$ represent the probabilities of strategy of “giving priority to preventive treatment of disease” and strategy of “give priority to treatment of disease” in A ’s mixed strategy, and there is $x_1(t) + x_2(t) = 1$. Use the two components of function vector $y = (y_1(t), y_2(t))$ represent the probabilities of strategy of “giving priority to prevention of disease” and strategy of “give priority to cure of disease” in B ’s mixed strategy, and there is $y_1(t) + y_2(t) = 1$.

At time t , A ’s mixed strategy income will be

$$u_A = x \cdot I_A y = x_1(t)(i_{a1b1}y_1(t) + i_{a1b2}y_2(t)) + x_2(t)(i_{a2b1}y_1(t) + i_{a2b2}y_2(t)). \tag{1}$$

At time t , B ’s mixed strategy income will be

$$u_B = y \cdot I_B x = y_1(t)(i_{b1a1}x_1(t) + i_{b1a2}x_2(t)) + y_2(t)(i_{b2a1}x_1(t) + i_{b2a2}x_2(t)). \tag{2}$$

At time t , A or B will turns to a particular strategy only when its income expectation under this pure strategy is higher than that under mixed strategy, otherwise it will deviate from this particular strategy. The evolution mechanism can be represented by following ordinary differential equations M .

$$M : \begin{cases} \dot{x}_1 = \frac{u_A^{e1} - u_A}{u_A} x_1 \\ \dot{x}_2 = -\dot{x}_1 \\ \dot{y}_1 = \frac{u_B^{e1} - u_B}{u_B} y_1 \\ \dot{y}_2 = -\dot{y}_1. \end{cases} \tag{3}$$

Where $u_A^{e1} = (1, 0) \cdot I_A y = i_{a1b1}y_1(t) + i_{a1b2}y_2(t)$ represents the income expectation of pure strategy “represents the income expectation of pure strategy” of TCM at time t , $u_B^{e1} = (1, 0) \cdot I_B x = i_{b1a1}x_1(t) + i_{b1a2}x_2(t)$ represents the income expectation of pure strategy “give priority to prevention of disease” of Western Medicine at time t .

3 Numerical Simulation and Analysis

The nonlinear ordinary differential equations M cannot obtain an analytical solution. The following is numerical simulation and analysis of solution of M .

Assumption 4-1 gives a subsidy mode which can be called balanced subsidy. That is, when one side takes short-term strategy, the mechanism will subsidize the other side’s long-term strategy to make long-term strategy has payoff advantage over its short-term strategy, so that long-term strategy will become its priority and ultimately achieve balanced development of long-term strategy and short-term strategy on the whole. There are two action ways of guidance mechanism under balanced subsidy mode (table 4).

Table 5. Numerical analysis cases according to action ways of guidance mechanism

Case of way 1: $i_{a1b2} = 1.1 \times i_{a2b2}$	Case of way 2: $i_{b1a2} = 1.1 \times i_{b2a2}$
$I_A = \begin{pmatrix} 6 & 11 \\ 12 & 10 \end{pmatrix}, I_B = \begin{pmatrix} 50 & 65 \\ 100 & 80 \end{pmatrix}$	$I_A = \begin{pmatrix} 6 & 8 \\ 12 & 10 \end{pmatrix}, I_B = \begin{pmatrix} 50 & 88 \\ 100 & 80 \end{pmatrix}$

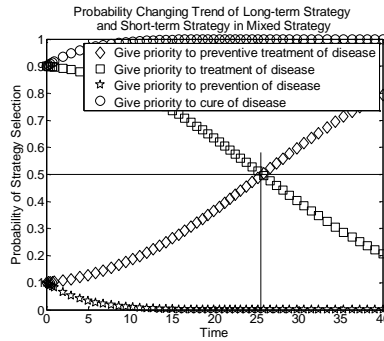


Figure 1. Numerical simulation result of case for way 1

3.1 Effectiveness of Balanced Subsidy

The numerical analysis case shown in table 5 is obtained by modifying Example 1 according to ways in table 4.

I_A and I_B in case of way 1 are substituted into M to obtain the following equations:

$$\begin{cases} \dot{x}_1 = \frac{x_2(-6y_1+y_2)}{x_1(6y_1+11y_2)+x_2(12y_1+10y_2)}x_1 \\ \dot{x}_2 = -x_1 \\ \dot{y}_1 = \frac{y_2(-50x_1-15x_2)}{y_1(50x_1+65x_2)+y_2(100x_1+80x_2)}y_1 \\ \dot{y}_2 = -y_1. \end{cases} \quad (4)$$

Equations from case of way 2 can also be obtained similarly. For simplicity, these equations are omitted here.

Given initial conditions $x_1(0) = 0.1, x_2(0) = 0.9, y_1(0) = 0.1, y_2(0) = 0.9$, the equations corresponding to the two cases in table 5 are numerically simulated using MATLAB software, and the results are shown in following figures.

Figure 1 and figure 2 show that when one side chooses short-term strategy, the probability of choosing long-term strategy by the other side influenced by subsidy increases from 10% to 50% in about 25 time periods, and the willingness of non-subsidized side to adopt short-term strategy does not affected, which indicates that the balanced subsidy is effective.

3.2 Influence of Alternative Effect Between Long-term Strategies on Subsidy

Because of the same prevention purpose, there is interaction between long-term strategies. With initial conditions $x_1(0) = 0.1, x_2(0) = 0.9$ of TCM is given, figure 3 shows the numerical simulation results of case of way 1 which shows that the time point of $x_1(t) = 0.5$ of TCM is kept postponing with $y_1(0)$ increasing from 0.1 to 0.4.

When initial conditions $y_1(0) = 0.1, y_2(0) = 0.9$ of Western Medicine is given, figure 4 shows the numerical simulation results of case of way 2 which shows that the time point of $y_1(t) = 0.5$ of Western Medicine is kept postponing with $x_1(0)$ increasing from 0.1 to 0.4.

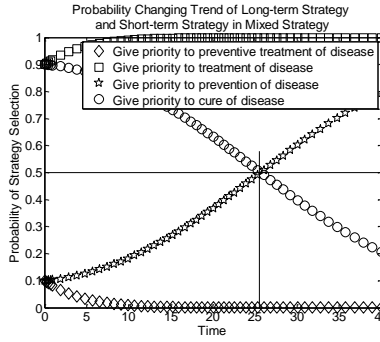


Figure 2. Numerical simulation result of case for way 2

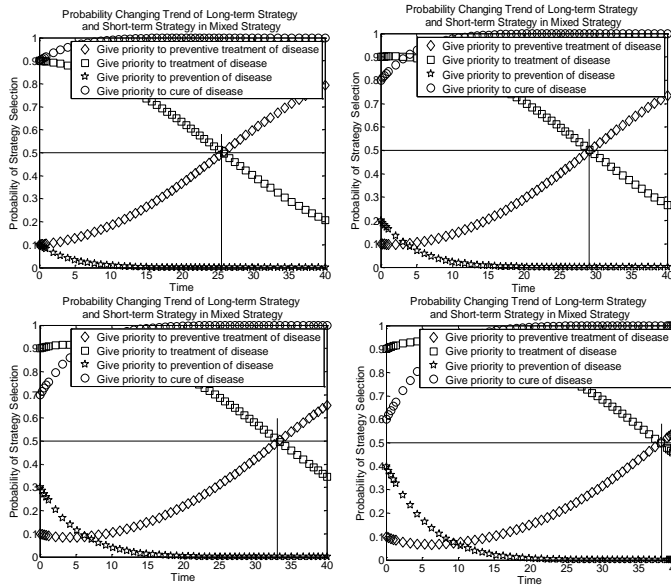


Figure 3. Influence of long-term strategy of Western Medicine on long-term strategy of TCM

As shown in figure 3 and figure 4, when there is initial difference between long-term strategies of TCM and Western Medicine, the alternative effect between long-term strategies will hinder the efforts who used to despise long-term strategy made to enhance long-term strategy under subsidy. Meanwhile, figure 3 and figure 4 show that the delayed speeds of TCM and Western Medicine have no significant difference. That means, based on payoff matrixes, for the same delay consequences, the cost of subsidizing long-term strategy of TCM is significantly lower than that of subsidizing long-term strategy of Western Medicine. It will be more effective to subsidize long-term strategy of TCM.

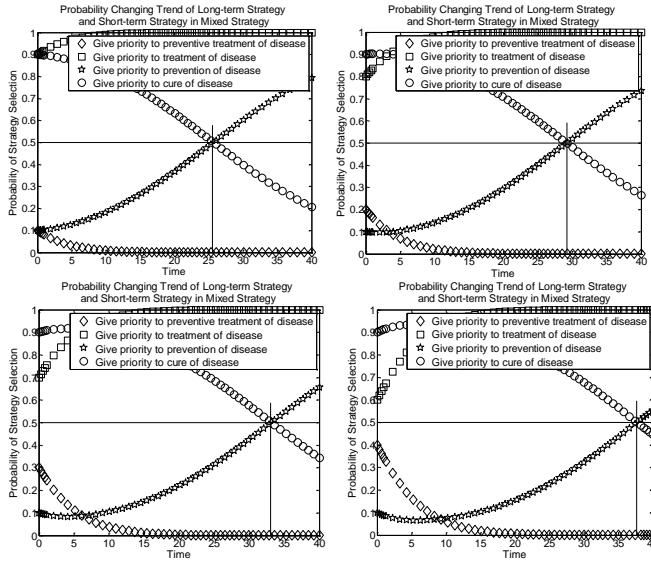


Figure 4. Influence of initial condition of TCM on long-term strategy of Western Medicine

Table 6. Numerical analysis cases of way 3

case3-1: $i_{a1b2} = 1.1 \times i_{a2b2}$ and $i_{b1a2} = 1.1 \times i_{b2a2}$ $I_A = \begin{pmatrix} 6 & 11 \\ 12 & 10 \end{pmatrix}, I_B = \begin{pmatrix} 50 & 88 \\ 100 & 80 \end{pmatrix}$	case3-2: $i_{a1b2} = 1.1 \times i_{a2b2}$ and $i_{b1a2} = 1.12 \times i_{b2a2}$ $I_A = \begin{pmatrix} 6 & 11 \\ 12 & 10 \end{pmatrix}, I_B = \begin{pmatrix} 50 & 89.6 \\ 100 & 80 \end{pmatrix}$
case3-3: $i_{a1b2} = 1.15 \times i_{a2b2}$ and $i_{b1a2} = 1.15 \times i_{b2a2}$ $I_A = \begin{pmatrix} 6 & 11.5 \\ 12 & 10 \end{pmatrix}, I_B = \begin{pmatrix} 50 & 92 \\ 100 & 80 \end{pmatrix}$	

3.3 Time Window for Bringing into Play the Complementarity of Long-term Strategies

TCM and Western Medicine are, to a certain extent, both fungible and complementary. Guidance mechanism should give full play to the complementarities of TCM and Western Medicine. By combining way 1 and way 2, way 3 of making $i_{a1b2} > i_{a2b2}$ and $i_{b1a2} > i_{b2a2}$ will stimulate long-term strategies of TCM and Western Medicine at the same time.

Table 6 shows some numerical analysis cases of way 3 and for initial conditions $x_1(0) = 0.1, x_2(0) = 0.9, y_1(0) = 0.1, y_2(0) = 0.9$, numerical simulation results of these cases are shown in following figure 5, figure 6 and figure 7.

In figure 5, figure 6 and figure 7, the two curves of probabilities of long-term strategies will finally open. This indicates that alternative effect makes long-term strategies of TCM and Western Medicine cannot coexist ultimately. Even though, the polarizing process can be different depending on subsidy schemes.

When incentives are same, long-term strategy of TCM will change more positive (figure 5 and figure 7). The probability curve of long-term strategy of TCM evolves upward while the corresponding curve of Western Medicine evolves downward. Only when subsidy intensity for long-term strategy of Western Medicine is greater than that of TCM, the curve of Western Medicine long-term strategy evolve upward and the corresponding curve of TCM evolve

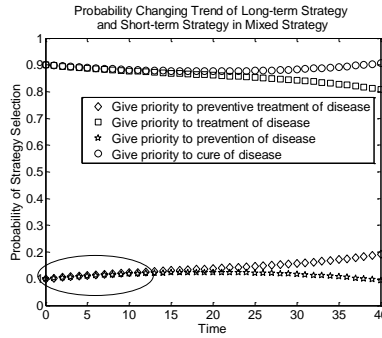


Figure 5. Numerical simulation result of case 3-1

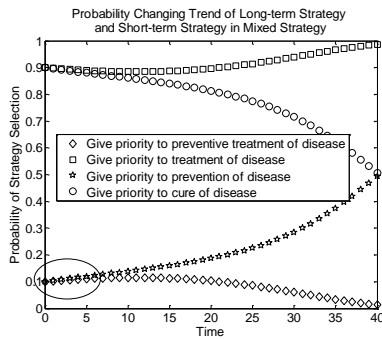


Figure 6. Numerical simulation result of case 3-2

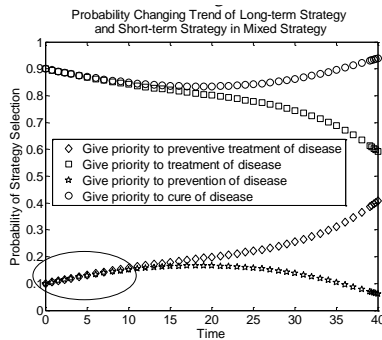


Figure 7. Numerical simulation result of case 3-3

downward (figure 6). This shows that when both sides are subsidized at the same time, it is more difficult to motivate the long-term strategy of Western Medicine.

No matter which curve is upward in the end, figure 5, figure 6 and figure 7 all show a simultaneous rising period at the initial stage of the both curves. This means it is possible that long-term strategies of TCM and Western Medicine be positive at the same time and provide an operating space for giving play to complementarity of TCM and Western Medicine.

4 Conclusion

Combination of TCM and Western Medicine is the basic background for medical services in China. China's health strategy requires social health level to be generally improved and strategic guidance focusing on prevention has been given. A regional prevention guidance mechanism integrating TCM and Western Medicine needs to be developed.

An evolutionary game model for regional strategy pattern of TCM and Western Medicine is constructed, and the solution of the model is numerically simulated and analyzed. The analysis conclusions are mainly shown in three aspects: (1) when one side of TCM and Western Medicine adopts short-term strategy, subsidy for the other side's long-term strategy will be effective, that is, the number of medical service providers adopting long-term strategy will gradually increase; (2) the alternative effect between long-term strategies will delay the effect of subsidy, but when delay consequences are same, the cost of subsidizing long-term strategy of TCM is significantly lower than that of Western Medicine; (3) subsidizing long-term strategies of TCM and Western Medicine at the same time cannot avoid polarization of them in the long run. However, in initial stage of subsidy, there is a period TCM and Western Medicine both paying attention to long-term strategy.

The enlightenment of the analysis conclusions for policy makers lies in: (1) with non-subsidized side adopting short-term strategy, prevention guidance mechanism will not weaken therapeutic function of medical service system in general; (2) in current prevention system dominated by Western Medicine, overall income of TCM is far lower than that of Western Medicine and prevention business in Western Medicine service system is not significant. Taking account of these situations, subsidy cost for promoting long-term strategy of TCM is affordable; (3) guidance mechanism cannot avoid polarization between preventive actions of TCM and Western medicine in the long run, but it is possible to promote prevention of TCM and Western medicine at the same time at initial stage of mechanism implementation.

Policymakers need to influence the changes of regional business structure of TCM and Western Medicine. Two issues should be paid attention to. First issue is the method of judging changes. The method might be set up based on analysis of both supply side and demand side of medical services. On supply side, not only medical activities, but also changes of use structure of medical resources should be monitored. On demand side, some typical correlation modes between public health level and different types of medical services maybe exist. Based on these correlation modes, changes of medical services can be found by analyzing public health level.

Second issue is how to influence regional incomes of TCM and Western Medicine. Guidance mechanism need to influence regional income of TCM and (or) Western Medicine through subsidy measures for medical service providers. Therefore, subsidy measures should be beneficial for prevention promotion and should be easily associated with medical behavior and medical management by medical service providers.

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