

The Most Expensive is not the Best

This paper concerns the performance of health care systems of all the countries. Motivated by evaluating current systems accurately, we analyze the existing evaluation methods. Then we find that most of these methods mainly focus on the outcomes and that their metrics often ignore the characters inside the healthcare systems.

Based on the discussion to the existing methods, we devise two methods which are the improved WHO's method and the comprehensive evaluation method.

Improved WHO's method makes use of the same metrics of WHO, which are also determined by the outcomes of the health care system. Our improvement is using grey comprehensive evaluation and the principle of minimum loss of information to combine the metrics rather than a simple linearization way.

In our comprehensive evaluation method, we redefine 5 new metrics which concern both outcomes and characters of the healthcare system itself, including the effect of the government, the basic situation of a country and so on. Then, we use the equal interval method to get the final score. Compared with other methods, we find this one really does a better job in dipartite degree and sensitivity.

After comparing with other 4 countries which can represent the four main modes of healthcare systems in the world, we make a conclusion that the most important reason why the highest cost can't make America the best is the unfairness in the healthcare system.

Afterward, we use the neural network algorithm to predict what will happen to the US if some values of the metrics have a change. We conclude that the US can get the greatest benefit after improving the fairness of its health care system.

We finally consider a policy change—medical insurance voucher—as a method to increase the insurance coverage and reduce the unfairness.

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1 Introduction

Healthcare systems have been a major concern of policy makers for many years. Many countries have recently introduced reforms in the health sector with the explicit aim of improving performance [Colin D, 2001. Mathers C 2000]. There exists an extensive literature on health sector reform, and recent debates have emerged on how best to measure performance so that the impact of reforms can be assessed [Goldstein H 1996]. Measurement of performance requires an explicit framework defining the goals of a healthcare system and a suitable method to make a compelling evaluation.

So our goal is pretty clear:

- Devise some metrics which can be used to evaluate the effectiveness of a country's healthcare system.
- Based on the existing evaluation method, devise a method to evaluate the healthcare system effectively.
- Make comparisons between several representative countries.
- Restructure the healthcare system of the US and build predictive models to test the changes.

Our approach is:

- Analyze the factors which can affect the performance of a healthcare system.
- Search the information about the existing evaluation methods on internet and find the shortcomings of them.
- Develop a comprehensive evaluation method which only asks existing data or the data is easy to measure and collect.
- Collect experimental data that can be used in our method.
- Compare current different methods and determine what characters they have.
- Make a sensitivity analysis of variations of our models.
- Make comparisons among the healthcare systems of several representative countries.
- Restructure the healthcare system of the US and build a model based on the neural networks to test the changes.
- Make further discussions based on our works.

2 Background

There is considerable demand for health system metrics from countries, international organizations, donors and global health partnerships to guide resource allocation, enhance accountability, and monitor progress. The goal of the health system metrics is to meet the needs of all users with the same approach.

The health care system metrics work includes **(a)** a clear measurement strategy including data collection, synthesis of data from different sources and estimation, **(b)** a parsimonious set of core indicators that resonate with the target audiences, **(c)** integration of monitoring of health systems and their performance into health information systems and so on. While building upon existing data collection and reporting mechanisms is a core principle, there are major gaps in health system metrics that need to be addressed in a systematic way. The emphasis should be on the ability to detect change and to show progress in health system strengthening. Both level and distribution of inputs and outputs should be addressed.

Building upon a WHO/World Bank meeting held in 2004 and existing health system frameworks several health system components have been identified as relevant for health system metrics, including financing, human resources, information, governance and policy, service delivery (infrastructure, procurement, logistics and supply and quality), and coverage of services.

According to WHO's estimation method, we can use it as a guideline to make a comparison between countries and it also can give some advice on the different country's health care system. But there're also some flaws and contradictions existing, e. g. The weights placed on each dimension were somewhat arbitrary. Nowadays, more and more scholars have brought up their ideas which are against the WHO's method, and at the same time, they build up their own metrics and estimation method.

In the paper entitled "Evaluating Health-care System", the author A.M. Best analyzes the whole system in a view of economics and the divides the whole evaluating process into six parts. He thinks that most data were not available for most countries; the WHO report makes heavy reliance on extrapolation. So the paper uses a more simple way to evaluate the metrics: translate all the things into money. Maybe it can make the process simple, but we think it is too rough for people to accept.

In another paper named "Comparative efficiency of national health systems: cross national econometric analysis" written by David B Evans, it shows that estimated efficiency varied from nearly fully efficient to nearly fully inefficient. Countries with a history of civil conflict or high prevalence of HIV and AIDS were less efficient. Performance increased with health expenditure per capita through estimation of the relation between levels of population health and the inputs used to produce health. And it got a conclusion that

increasing the resources for health systems is critical to improving health in poor countries, but important gains can be made in most countries by using existing resources more efficiently

And in other relevant paper, the balance between simpleness and efficiency is also not made so well. They often have the problems of hard data collection, bad practical effect and so on.

In our paper, our target is to make some improvement to the estimation method to make the method easier to collect the data and more effective.

3 About Healthcare Systems

3.1 Framework

Basic health system monitoring focuses on the inputs, processes and outputs of the healthcare system. These inputs and processes include human resources, finances, governance and leadership, information, infrastructure, procurement, logistics and supplies, which influence the outputs: service delivery, including availability and quality of services. These outputs affect the utilization of the services by those who need it (coverage) which, if the interventions are effective, should lead to improvements in health outcomes.

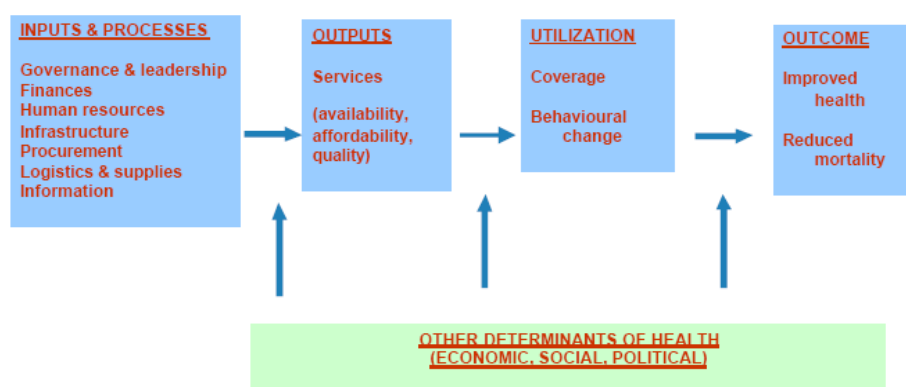


Figure 1 The Framework of the Healthcare System[Glion.2006]

In most countries of the world, the healthcare system runs in the same way as shown in **Figure 1**.

3.2 Four Representative Healthcare Systems in the World

The healthcare system, as an important part of the social security system is essential to promote the stabilization of society as well as reflecting the justice of the current systems. Due to the different histories cultures and status of human fights protection the healthcare system is specifically different in different countries.

In the world, there're four representative healthcare systems existing.

- National healthcare insurance. The main countries using this system are UK, Eastern Europe, Soviet Russia and so on. Its character is the government dominants, healthcare for free, consummate medical treatment and a full coverage. But it doesn't a high efficiency, make use of the market and it makes a heavy burthen to the government.
- Commercial healthcare insurance. The US is the main country using this system. It makes the market as the guideline of the healthcare system. It makes a high cost and result in letting a large number of people fail to pay the money.
- Social healthcare insurance. It has a force, fairness, sociality and uncertainty as in Japan, German and Canada. Its character is having a high cost to run it and it can't make a good healthcare in time.
- Savings healthcare insurance. Singapore is the representative country. Its main disadvantage is having a low service efficiency, cost rapidly raise, and it can't make a full coverage.

4 Estimation Method of WHO

In WHO's method, it mainly focuses on the outcomes of the healthcare system in different countries to make the evaluation. As a result, we can see most metrics of the WHO are also based on the outcomes.

4.1 Conceptual Framework

The WHO framework for health care system performance assessment identifies three main goals on which health care systems should be evaluated:

- Health

The defining goal for the health care system is to improve the health of the population. Health includes both premature mortality and non-fatal health outcomes. In WHO's framework, it is concerned both with the average level of population health and with the distribution of health within the population,

namely health inequalities.

- Responsiveness

The second main goal is to enhance the responsiveness of the health system to the legitimate expectations of the population for the non-health improving dimensions of their interaction with the health system. Responsiveness expressly excludes the expectations of the public for the health improving dimensions of their interaction, as this is fully reflected in the first goal of population health.

Responsiveness has **seven** key sub-components: respect for persons and client orientation. Respect for persons captures aspects of the interaction of individuals with the health system that often have an important ethical dimension and is comprised of:

- a)** Respect for the dignity of the person. **[Lisbon. 1995].**

- b)** Respect for the autonomy of the individual to make choices about his/her own health. **[Brock D.1993]**

- c)** Respect for confidentiality. **[Rylance G 1999 Beauchamp T 1989].**

The second sub-component, client orientation, includes the major components of consumer satisfaction that are not a function of health improvement:

- d)** Prompt attention to health needs.

- e)** Basic amenities, such as clean waiting rooms or adequate beds and food in hospitals are aspects of care that are often highly valued by the population **[Bernhart MH 1999]**

- f)** Access to social support networks for individuals receiving care. **[Gilson L 1994]**

- g)** Choice of institution and individual providing care.

As with health, society is concerned not only with the average level of responsiveness but also with inequalities in its distribution. This means that WHO is implicitly interested in differences related to social, economic, demographic and other factors.

- Fairness of financial contribution

The third main goal of health systems is fairness in financing and financial risk protection for households **[Murray CJL 2000]**. To be fair, financing of the health system should address two key challenges. First, households should not become impoverished or pay a catastrophic share of their permanent non-subsistence income to obtain health care. Second, poor households should pay in absolute terms less towards the health system than rich households. Every household should pay a fair share towards the costs of the health system.

WHO is only concerned with the distribution of the financing mechanism across households. The average level of financing is not an intrinsic goal for the health system; rather, WHO considers it one of the key policy choices for society. The level of resources invested in the health care system is the variable against which goal attainment is compared in order to measure

performance.

4.2 Measuring Goal Attainment

In order to assess overall effectiveness and make the comparison, the method was to combine the individual attainments on all five goals of the health system into a single number, which we call the composite index. The composite index is a weighted average of the five component goals specified above. First, country attainment on all five indicators (i.e., health, health inequality, responsiveness-level, responsiveness-distribution, and fair-financing) were rescaled restricting them to the **[0,1]** interval. Then the following weights were used to construct the overall composite measure:

$\alpha_1 = 25\%$ for health (DALE), $\alpha_2 = 25\%$ for health inequality, $\alpha_3 = 12.5\%$ for the level of responsiveness, $\alpha_4 = 12.5\%$ for the distribution of responsiveness, and $\alpha_5 = 25\%$ for fairness in financing. These weights are based on a survey carried out by WHO to elicit stated preferences of individuals in their relative valuations of the goals of the health system.

WHO adopted the simplest form of a composite measure of goal attainment based on the following additive model:

$$\text{Composite} = \alpha_1 \text{Health} + \alpha_2 \text{HealthInequality} + \alpha_3 \text{Responsiveness} + \alpha_4 \text{ResponsivenessInequality} + \alpha_5 \text{Fairness of Financial Contribution}$$

Where the sum of the alphas is set equal to one.

4.3 Make Comparison between Existing and Potential Systems

In this WHO's method, it chooses the Murray and Frenk's way to make comparisons between existing and potential systems.

To illustrate the concept, in **Figure 2** the goal of the health system is measured on the vertical axis (which is labeled health) while the inputs to producing the goal are on the horizontal axis. The upper line represents the frontier, or the maximum possible level of the goal (health) that could be obtained for a given level of inputs.

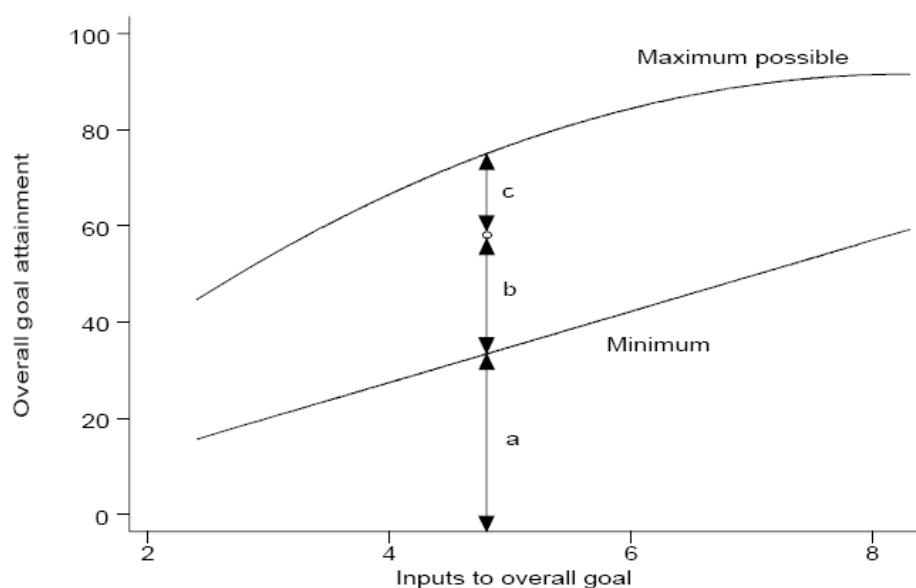


Figure 2 Health System Performance (Overall Efficiency) [David B Evans 2000]

On a farm, for example, output would be zero in the absence of inputs, but in the health sector, health levels would not be zero (i.e., the entire population would not be dead) in the absence of health expenditures and a functioning health system. The lower “frontier” in **Figure 2** is defined as the health level that would occur in the absence of the system. Assume that a country is observed to have achieved $(a+b)$ units of health. Murray and Frenk defined system performance as $b/(b+c)$. This indicates what the system achieves compared to its potential. The challenge for health sector reform is to find a way of measuring health system performance in a systematic way, to allow comparison across countries and within countries over time. That is the purpose of this method.

4.4 A Partial Analysis

In the WHO's methods, we can see that it always focus on the outcomes of the healthcare system without measure so as to ignoring any characters of system itself. Then it really has some strength in evaluation but also bring a lot of suspects.

● Strengths

The metrics which the WHO makes to evaluate the healthcare system aim to measure the goal attainment of the countries. It really can reflect the situation of one's healthcare system in a way. And it contains most of the outcomes which a healthcare system should produce. Besides, it also can give some advice of which aspect one country should to strengthen to improve its healthcare system.

● Weaknesses

1. The weights placed on each dimension were somewhat arbitrary.
2. The approach also heavily penalized countries with epidemic disease unrelated to a health care system.
3. This approach did not look at how health system were organized and managed.
4. The WHO 2000 rankings do not look at access, utilization, quality, cost-effectiveness or most other dimensions of health systems.
5. The measure of health inequalities does not reflect concerns about equity.
6. Important methodological limitations and controversies are not acknowledged.
7. The multicomponent indices are problematic conceptually and methodologically; they are not useful to guide policy, in part because of the opacity of their component measures.
8. Primary health care is declared a failure without examining adequate evidence, apparently based on the authors' ideological position.
9. These methodological issues are not only matters of technical and scientific concern, but are profoundly political and likely to have major social consequences.
10. The approach can not distinguish all the countries obviously.

5 Improved WHO's Method

In the WHO's methods, the weights used in the construction of the composite index have been used consistently, without considering uncertainty in the valuations of the different components. So it is somewhat arbitrary.

In this section, we use grey comprehensive evaluation to improve the WHO's method to make the evaluation more believable.

5.1 Methodology

Suppose $c_{ik}(i=1,2,\dots,n;k=1,2,\dots,m)$ is the raw data of the metric k in the country i . So the matrix of the raw data can be described as $C=(c_{ik})_{n \times m}$, which is $n \times m$. We suppose c_k^* is the best value in metric k , so $C^*=(c_k^*)=(c_1^*,c_2^*,\dots,c_m^*)$ is the best situation in this system.

Making $C^*=(c_1^*,c_2^*,\dots,c_m^*)$ as a reference data list,

$C_{ik} = (c_{i1}, c_{i2}, \dots, c_{im}) (i=1, 2, \dots, n)$ as a comparative list, we can use the function below to get the relation coefficient between C_{ik} and C^* :

$$\xi_i(k) = \frac{\min_i |c_k^* - c_{ik}| + \rho \max_i |c_k^* - c_{ik}|}{|c_k^* - c_{ik}| + \rho \max_i |c_k^* - c_{ik}|}$$

Where ρ is a differentiate coefficient, $\rho \in (0, 1)$, generally, we can make $\rho = 0.5$.

So using $\xi_i(k) (i=1, 2, \dots, n, k=1, 2, \dots, m)$, we can get the evaluation matrix $E = (\xi_i(k))_{n \times m}$.

Suppose $W = (w_1, w_2, \dots, w_m)$ is a weight distribution matrix of m metrics.

Where $w_k (k=1, 2, \dots, m)$ is the weight of the metric k . And $\sum w_k = 1$.

Based on the discussion above, we can get the grey comprehensive evaluation model.

$$R = W \cdot E^T = (r_1, r_2, \dots, r_n)$$

Where $r_i = \sum_{k=1}^m w_k \xi_i(k)$ is the relating degree and E^T is the transpose of E .

As shown in the model, $R = (r_1, r_2, \dots, r_n)$ is the final score of n countries' healthcare system. The larger the relating degree r_i is, the better the country's healthcare system is. According to this principle, we can get the order of all the countries' healthcare system.

5.2 How to Determine the Weights

In the discussion above, we can see that the weight vector is undetermined. In our opinion, we want to determine in a way which is more credibly.

We can determine the weights according to the principle of the minimum loss[Wang Xuebiao 2000]. Because our metrics $u_j (1 \leq j \leq m)$ provide the evaluating information from different aspects, if we combine all the metrics in

a linearization way, this will loss a lot of evaluating information according to entropy theory in informatics. In our opinion, we hope to determine the weights without losing so much information from the inside of the data. We should reserve the information in a maximum way just like analyzing the bases in the multi variate statistical analysis. So we choose the most classical method to calculate variance which can represent information, the larger the variance is, the more the information is.

According to discussion above, we can see that the final score $d = w^T u$, then we should choose the best weight w to make the variance of d reach the maximum.

$$D(d) = w^T D(u) w$$

Where $D(d)$ is the variance matrix of d . When $w^T w = 1$, $D(d)$ reach the maximum.

$$\text{Suppose } \varphi(w, \lambda) = w^T D(u) w - \lambda(w^T w - 1)$$

$$\text{Then } \begin{cases} \frac{\partial \varphi}{\partial w} = 2D(u)w - 2\lambda w = 0 \\ \frac{\partial \varphi}{\partial \lambda} = w^T w - 1 = 0 \end{cases}$$

$$\text{Solve the function above, we can get } \begin{cases} D(u)w = \lambda w \\ w^T w = 1 \end{cases}.$$

So λ is the eigenvalue of $D(u)$, and w is its eigenvector. When $w^T w = 1$, to make $D(d) = w^T D(u) w = \lambda w^T w = \lambda$ to reach the maximum, we should make the λ as the max eigenvalue of $D(u)$, then w is the eigenvector of max eigenvalue of $D(u)$.

In the real calculation, $D(u)$ is unrealized, so we can use the variance matrix $\hat{D}(u) = (\hat{\sigma}_{ij})$ of the sample $(c_{1j}, c_{2j}, \dots, c_{nj})$ of u_j to represent it.

$$\hat{\sigma}_{ij} = \frac{1}{n} \sum_{k=1}^n (x_{ki} - \bar{x}_i)(x_{kj} - \bar{x}_j)$$

$$\text{Where } \bar{x}_j = \frac{1}{n} \sum_{i=1}^n x_{ij} (1 \leq i, j \leq p)$$

The variance matrix $\hat{D}(u)$ is a nonnegative symmetry real matrix, so all the eigenvalue are real number. From the character of Rayleigh's entropy, we can get

$$\lambda_0 = \max_{w \neq 0} \frac{w^T \hat{D}(d) w}{w^T w} = \max_{\|w\|=1} \frac{w^T \hat{D}(d) w}{w^T w}$$

Where λ_0 is the maximum eigenvalue of $\hat{D}(u)$, and the eigenvector w of $\hat{D}(u)$ is weights vector which we pursue for.

5.3 A Partial Discussion

The improved WHO's method do not change the view which focus on the outcomes of the healthcare system. Its improvement is making the evaluation more believable.

We can't make a decision that this kind of methods is a bad way, it makes its own sense that it really can reflect the goal which the healthcare systems reach, but it can't reflect the inside. For example, a country which has a epidemic often get a low score in WHO's evaluation method, but maybe this is not the problem of the healthcare system.

So a new method which reflects the inside is needed to be brought up.

6 Comprehensive Evaluation Method

In this section, we bring up a new method to evaluate the healthcare systems which has been mentioned in an article[Ding Chun,2005]. And this method concerns both the outcomes and characters of systems themselves. It really makes sense, because it is not fair if only using outcomes metrics. This doesn't mean that the WHO's method is unuseful. WHO's method can measure the goal attainment, and this method can measure overall effectiveness.

6.1 Metrics to Evaluate the Overall Effectiveness

To make an overall comparison between countries' health care systems more impersonally, fairly and quantitatively, metrics must be made well. As to the goals of the health care system, the World Bank has made a specific definition.

- Improve the health of the population, promote the general weal.

- Fairness and health care coverage.
- Make good use of resource to get a satisfied economic efficiency.
- Strength the clinic benefits.
- Raise the quality of the health care and the satisfaction of the customers.
- Insure the finance could be persistent.

According to this definition, we can make five metrics for the overall health care system.

- Efficiency. This means the proportion between inputs and outcomes, cost and incomes. And it also can be divided into technical efficiency, economic efficiency and allocative efficiency. But in this problem, we don't care about the apportion problem, so we choose the technical efficiency.
- Fairness. It contains the fairness both in the medical treatment and raising money.
- Responsiveness. The non-health improving dimensions of the interactions of the populace with the health system, and reflects respect of persons and client orientation in the delivery of health services, among other factors.
- The effect of the government. Indubitably, the government plays an important role in the health care system.
- The basic situation of a country. This means a composite index of the lots of sectors which include economy, education, scientific research, population and so on.

6.2 Choose the Index

- Efficiency index.
 1. The anticipated life-span flexibility. This means a proportion between increasing rate of the health care and the extending rate of the anticipated life-span in a time segment.
 2. The mortality flexibility. The proportion between the decreasing mortality of the children under 5 years old and the increasing cost of the health care.
- Fairness index.
 1. The fairness in providing medical treatment.
 - (1) The coverage of the health care.
 - The number of doctors per thousand people. This reflects the manpower resource coverage of the health care service.
 - The number of sickbed per thousand people. This reflects coverage the coverage of the medical establishment.
 - The probability to get the necessary medicine. The proportion of the people who can get the basic medicine reflect the probability for a resident to get the medicine.
 - The probability to share health care establishment. This reflects the satisfaction of the basic living condition.

- Childbirth with a doctor. This reflects the level of a country's health care to women and infants.
 - (2) The fairness in satisfying the health care requirement.
This is mainly reflected by the coverage of the health insurance.
 - (3) The fairness in raising money for health care.
- Responsiveness index.
 - 1. Finance pressure
 - (1) The supporting proportion. This means the proportion between the people who're of the right age to work and the others.
 - (2) The increasing rate of people who're over 65 years old. The larger the rate is, the heavier the economic burden will be.
 - (3) The changing range of the proportion of the health care cost in GDP. A steady proportion means a good health care reform.
 - 2. Technical efficiency.
In this aspect, we can choose the average time in hospital as a criteria to measure it.
- Government index.
 - 1. The responsibility and contribution to the overall health care system. We can use the proportion of government in the overall health care cost.
 - 2. The responsibility to health care education.
 - 3. The effect of the government in the aspect of medical training, medicine and scientific research.
 - 4. The action of the government in improving the circumstance.
- The basic situation index.
 - 1 Economic situation.
 - (1) The average GDP. This reflects the economic size and the income level.
 - (2) The unemployment degree. This often reflects the proportion of losing health insurance.
 - 2 the social development
 - (1) Gini Coefficient. We choose this index to reflect a country's income and fortune distribution, the larger the coefficient is; the less average the social fortune is. This can also affect the difference of the anticipated life-span.
 - (2) Urbanization. We can use the probability of the population in the city to represent it.
Generally speaking, the resident in the city can get better service than in the country.
 - 3 The anticipated life-span. This index reflects the composite result of a country's health care system's development.
 - 4 Public health care.
In this index, we use the coverage of safe drink water as the most important one.
 - 5 Education

Net enrolment rate of the middle school is the one which we use to represent the education level

6 Scientific research

The number of patent, this mainly reflects the innovation ability of a country.

7 Circumstance

(1) The air pollution. Average CO₂ emission is a good choice.

(2) The water pollution. The organic water contamination emission is also the one we choose.

8 life style and behavior

The proportion of the smokers in the population. The higher the proportion is, the worse the country's health condition is.

6.3 The Model to Deal with the Index and Data

6.3.1 Choose the Operation Model

After ensuring the five metrics to evaluate the overall effectiveness and its sub-metrics, we choose the method of equal interval which is also used in HDI by UN to make the comparison between countries. On one side, we use the method of equal interval to combine all the indexes, on the other side, we should solve the problem of how to determine the weights.

6.3.2 The Equal Interval Method

The Operating Process

- Divide all the sub-indexes into positive indexes and negative indexes
- Use different algorithms to make the standardization to the two kinds of indexes.
- According to the sub-indexes, we can get the five main indexes' composite value.
- Calculate the final score of different countries based on the five metrics' value.

The Classification of the Indexes

- Classification

Positive index: the higher the value is, the better the health care system will be, for example, the coverage of safe drink water.

Negative index: the higher the value is, the worse the health care system will be. For example, the proportion of the smoker.

- Standardization

The indexes have different units, so we should make standardization before calculating the final score. After the classification, we can deal with the two kinds of indexes differently.

Positive index: $F_{ij} = [(R_{ij} - R_{i/min}) / (R_{i/max} - R_{i/min})] \times 100$

Negative index: $F_{ij} = [(R_{i/max} - R_{ij}) / (R_{i/max} - R_{i/min})] \times 100$

Where i is one of the five metrics, j is the sub-index of the metric i . j is the one of the countries.

$R_{i/min}$ is the minimum value of the sub-index j of the metric i in the statistical data.

$R_{i/max}$ is the maximum value of the sub-index j of the metric i in the statistical data.

F_{ij} is the value of the sub-index j of the metric i after Standardization.

Determine the Weights

We can get the value of every metric using the function below.

$$F_i = [\sum_{j=1}^n (F_{ij})^\alpha / n]^{1/\alpha}$$

Where n is the number of sub-index in the metric i .

α is a weight of the metric i .

Get the Final Score of the Evaluated Country

Based on the discussion above, we can get the function below.

$$S = \{ [\sum_{i=1}^k (F_{ij})^\alpha] / K \}^{1/\alpha}$$

Where k is the number of metrics, in this problem, $k = 5$.

6.4 A Partial Discussion

In this section, we bring up a comprehensive evaluation method. All the metrics and indexes are given based on the goals of the healthcare system and characters of itself. This method concerns both outcomes and inside of the healthcare system.

Using this method, we can get a composite score of all the countries. Though comparing with these metrics, we can also give some advice to the different countries easily.

7 Comparisons between Methods

Before the comparison, each component measure was rescaled on a 0 to 100 scale: for healthy life expectancy, $H = [(Health - 20) / (80 - 20)] \times 100$, for health inequality, $HI = (1 - HealthInequality) \times 100$, for responsiveness level, $R = Responsiveness / 10 \times 100$, for responsiveness inequality, $RI = (1 - ResponsivenessInequality) \times 100$, for fairness in financing, $FF = FairnessofFinancingContribution \times 100$. The overall composite was, therefore, a number on the interval 0 to 100, with 100 being the highest possible level of attainment.

7.1 Dipartite Degree Analysis

As we know, a good metric should do well in the dipartite degree, so the evaluation should. But the WHO's method can reach a good dipartite degree in the responsiveness distribution as shown in **Table 1**. To evaluate the dipartite degree, we also design an index to describe it.

$$DD = \sqrt{n_1^2 + n_2^2 + \dots + n_i^2}$$

Where n_i is the number of countries which can't be distinguished in the

team i . The smaller DD is, the better the dipartite degree is. When $DD = 0$, all the objects can be distinguished obviously.

For example, suppose two methods both make evaluation to 8 countries and give the order as following.

A:1,2,3-6,7,8; (3-6 means that these 4 countries can't be distinguished.)

B:1,2,3-4,5-6,7,8

We can see $DD_A = \sqrt{(6-3+1)^2} = 4$

$$DD_B = \sqrt{(4-3+1)^2 + (6-5+1)^2} = 2\sqrt{2}$$

$DD_A > DD_B$, So B method has a better dipartite degree than A.

Table 1 List of Countries Which can't be Distinguished in WHO's Method

The countries which can't be distinguished by responsiveness distribution in WHO's method.	The WHO's method gives the 36 countries the same order in the metric of responsiveness distribution.
Argentina, Australia, Austria, Bahamas, Bahrain, Belgium, Barbados, Brunei Darussalam, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Luxembourg, Malta, Monaco, Mauritius, Netherlands, New Zealand, Norway, Qatar, Saint Kitts and Nevis, San Marino, Singapore, Spain, Sweden, Switzerland, United Kingdom, United States of America,	The same order:3-38

7.1.1 Monte-Carlo Simulation

To test the dipartite degree of every method, we use the Monte-Carlo simulation to make a small change to every different metrics. Because the value of the metrics we get must contain some error. The process can be described as below.

Firstly, we use the Beta distribution to determine the changes of every metrics. Because While the beta distribution is restricted to the interval $[0,1]$, a linear function of a beta-distributed random variable can be used to scale the sampling interval appropriately.

Beta distribution can be described as below:

$$f(x) = \begin{cases} \frac{\Gamma(\alpha + \beta)}{\Gamma(\alpha)\Gamma(\beta)} x^{\alpha-1} (1-x)^{\beta-1} & 0 < x < 1 \\ 0 & \text{others} \end{cases} \quad (\alpha > 0, \beta > 0)$$

Where Γ distribution is:

$$f(x) = \begin{cases} \frac{1}{q^p \Gamma(p)} x^{p-1} e^{-x/q} & x > 0 \\ 0 & \text{others} \end{cases} \quad (p > 0, q > 0)$$

And the anticipation of the Beta distribution is $E(x) = \frac{\alpha}{\alpha + \beta}$.

Suppose $x_{ij} (1 \leq i \leq 191, 1 \leq j \leq 10)$ is the metric j in country i , so x_{ij} has a distribution $(x_{ij} - 1) + 2\text{Beta}(2, 2)$ in $[x_{ij} - 1, x_{ij} + 1]$, and its anticipation is:

$$E[(x_{ij} - 1) + 2\text{Beta}(2, 2)] = x_{ij} - 1 + 2E[\text{Beta}(2, 2)] = x_{ij}$$

We use Monte-Carlo simulation to create 1000 numbers randomly which are all in the interval $[x_{ij} - 1, x_{ij} + 1]$. We can only pick the numbers between 10 and 90 percents, then calculate the confidence interval (95%) for the rest numbers which is the interval of x_{ij} .

7.1.2 Have a Test

We can choose the WHO's metrics Responsiveness level as an example. And the US with RL=81 is the country which we choose to test. The RL of the US has a distribution of $80 + 2\text{Beta}(2, 2)$, as shown in **Table 2**.

Table2 Responsiveness Level of the US

Metric	Median	Mean	Confidence Interval (95%)
Responsiveness level	81,0264	81.0241	[80.2109, 81.7845]

Using the same method, we can make a simulation to other metrics. After that, we can get these intervals to make an order of all the countries, at last, dipartite degree could be calculated out.

We can see the different dipartite degrees in **Table 3**.

Table 3 Different Dipartite Degrees in Different Methods

WHO's method	Health level	Health distribution	Responsiveness level	Responsiveness distribution	Fairness in financial contribution
dipartite degree (DD)	0	15.0665	38.3406	19.5192	0
Improved WHO's Method	Health level	Health distribution	Responsiveness level	Responsiveness distribution	Fairness in financial contribution
dipartite degree (DD)	0	9.4868	12.4097	10.6771	0
Comprehensive evaluation method	Efficiency	Fairness	Responsiveness	The effect of the government	The basic situation of a country
dipartite degree (DD)	3.6056	2.8284	2.8284	3.4641	2.8284

7.1.3 Analysis of Results

From the table above, we can see that after our improvement, the dipartite degree has been improved obviously. For example, dipartite degree of responsiveness has grown a lot. As to comprehensive evaluation method, the dipartite degree in every metric are all so good that only 4-5 countries can be distinguished. Above all, the comprehensive evaluations do the best in dipartite degree of the three methods.

7.2 Sensitivity Analysis

7.2.1 About the Values of the Metrics

In this part, we change the values of the metrics and keep the weight to how can this change to affect the evaluation result. Then we can get the most important metric which can affect the final score acutely. According to this, we can give the suitable advice to the healthcare system.

Suppose G_p and G_q are the final score of the country p and country q respectively, $G_p > G_q$. U_{qr} is the value of metric q in country r . Change it to make $G_p = G_q$, then we can get the marginal value U_{qr}^B using the function below.

$$U_{qr}^B = U_{qr} + \frac{G_p - G_q}{w_r}$$

We can make the sensitivity analysis to the values of the metrics following the process below.

If U_{qr}^B is outside of the allowable interval, whatever it changes, it won't change the order of the two country. Then, r is a value insensitive metric.

When U_{qr} is close to U_{qr}^B , changing the value will change the order of the two country. Then, r is a value sensitive metric.

7.2.2 About the Weights

In this part, we change the weights and keep the values of the metrics to how can this change to affect the evaluation result. Then we can get the most important weight which can affect the final score acutely.

As we know, $\sum_{j=1}^m w_j = 1$ ($j = 1, 2, \dots, m$), $w_j \geq 0$

When a weight changes, it must affect the value of others. To make a simple analysis, when a weight changes, only one another changes at the same time, and others keep fixed.

Suppose the weights' value before they change are $\overline{w_j}, \overline{U_{ij}}, \overline{G_j}$, after changing, those are w_j, U_{ij}, G_j .

Suppose the changing weights are r and s .

So, $w_r + w_s = \overline{w_r} + \overline{w_s}$

Obviously, the changing interval of w_r and w_s is $[0, \overline{w_r} + \overline{w_s}]$. When they change, maybe there's a situation that the final score of a country will be equal to the other. Suppose the two countries are p and q . Then we can get the marginal weight.

$$w_r^B = \frac{\overline{G_p} - \overline{G_q}}{(\overline{U_{pr}} - \overline{U_{qr}}) - (\overline{U_{ps}} - \overline{U_{qs}})}$$

$$w_s^B = (\overline{w_r} + \overline{w_s}) - w_r^B$$

When the two countries have a same score, we can get w_r and w_s .

$$w_r = \overline{w_r} - w_r^B, w_s = \overline{w_s} - w_s^B$$

We can make the sensitivity analysis to the weights following the process below.

Because the changing interval of w_r and w_s is $[0, \overline{w_r} + \overline{w_s}]$, if w_r and w_s is outside the interval, it means the change between won't affect the final order of the two countries. The metrics of r and s are insensitive.

If not, it means that this change may affect the final order of the two countries.

(1) If $w_r > \overline{w_r}$, when the weight of metric r is bigger than $\overline{w_r}$, the final of the two countries will be changed, then r is a weight insensitive metric to the country which has a low order.

(2) If $w_r < \overline{w_r}$, when the weight of metric r is smaller than $\overline{w_r}$, the final of the two countries will be changed too, then s is a weight insensitive metric to the country which has a low order.

7.2.3 Analysis to the US

Here, we just use the US as an example to make the sensitivity analysis.

Firstly, we make the sensitivity analysis to the values of the Metrics using improved WHO's method and comprehensive evaluation method.

Table 4 The Sensitivity Analysis about the Value of Metrics to the US

	Improved WHO's method					
metrics	Health level	Health distribution	Responsiveness level	Responsiveness distribution	Fairness in financial contribution	Overall health attainment
Germany	85.4	88.4	80.7	90.5	91.2	86.507
United States of America	84.9	87.2	83.5	90.7	86.3	86.478
Iceland	85.6	87.9	79.2	90.3	87.6	86.384
The upper limit of U_{qr}^B	84.5	86.8	82.9	90.1	85.9	
The lower limit of U_{qr}^B	85.0	87.3	83.7	90.9	86.4	

	Comprehensive evaluation method					
metrics	Efficiency	Fairness	Responsiveness	The effect of the government	The basic situation of a country	Final score
Australia	42.423	81.453	57.456	53.092	79.544	62.7936
United States of America	42.553	80.862	60.351	49.361	78.394	62.3042
Germany	41.342	79.432	58.534	54.545	76.342	62.039
The upper limit of U_{qr}^B	41.227	79.536	59.025	48.035	77.068	
The lower limit of U_{qr}^B	45	83.309	62.798	51.808	80.841	

Date source: OECD Health Data 2005

From the table above, we can find that Health level and distribution、Fairness in financial contribution have a high sensitivity in the improved WHO's method, and the changing interval is small. This is because they three have a high weight. Some more, every values often have a bigger space to go down, that's the reason why the US get a score closed to the German. As to comprehensive evaluation method, the changing interval of all the metrics are the same, and it has a little space to go down. Above all, the comprehensive evaluation method has better behavior in sensitivity to the values of the metrics.

Then, we go on to make the sensitivity analysis to the weights.

Table 5 The Sensitivity Analysis about the Weights to the US

	Improved WHO's method				
Weight	w_1 and w_2	w_2 and w_3	w_3 and w_4	w_4 and w_5	w_5 and w_1
$\overline{w_r}$	0.23	0.24	0.15	0.16	0.22
w_r	0.27	0.23	0.16	0.14	0.24
$\overline{w_s}$	0.24	0.15	0.16	0.22	0.23
w_s	0.20	0.16	0.15	0.24	0.21

Which is more sensitive	w_1	w_3	w_3	w_5	w_5
	Comprehensive evaluation method				
Weight	$w_1 \text{ and } w_2$	$w_2 \text{ and } w_3$	$w_3 \text{ and } w_4$	$w_4 \text{ and } w_5$	$w_5 \text{ and } w_1$
$\overline{w_r}$	0.2	0.2	0.2	0.2	0.2
w_r	0.05	0.34	0.27	0.01	-0.18
$\overline{w_s}$	0.2	0.2	0.2	0.2	0.2
w_s	0.35	0.06	0.13	0.39	0.58
	w_2	w_2	w_3	w_5	

Date source: OECD Health Data 2005

From the table above, we can see that in the healthcare system of the US, health level、responsiveness level、fairness in financial contribution have a higher sensitivity using improved WHO's method. And in comprehensive evaluation method, fairness, responsiveness and the basic situation of a country have a higher sensitivity. Above all, we can see that fairness has a higher sensitivity in both of the methods. So fairness is the most important problem in the healthcare system of the US.

8 Comparisons between Some Countries

8.1 Horizontal Comparison

In this section, we choose German, UK, Singapore, and India to compare with the US. During the five countries, German, UK, Singapore and the US are the representative countries of four healthcare system in the world, India's healthcare system is worse than the US obviously. As following, we use the improved WHO's method and comprehensive evaluation method to make the comparison.

Firstly, we calculate the value of all the metrics in **Table 6**.

Table 6 The Values of Different Metrics in Three Methods

	Improved WHO's method					
Metrics	Health level	Health distribution	Responsiveness level	Responsiveness distribution	Fairness in financial contribution	Overall health attainment
United States of America	84.1	85.2	81.5	90.3	84.3	90.8
Germany	86.4	88.4	80.7	90.5	97.2	91.8
India	60.8	61.5	60.3	67.3	89.1	70.4
Singapore	76.5	84.3	79.4	90.2	78.8	89.7
United Kingdom	87.0	91.3	78.2	90.2	86.5	92.6
	Comprehensive evaluation method					
Metrics	Efficiency	Fairness	Responsiveness	The effect of the government	The basic situation of a country	Final score
United States of America	42.553	80.862	60.351	49.361	78.394	63.438
Germany	56.482	91.429	68.846	57.341	80.471	71.639
India	36.762	87.864	43.274	44.633	63.531	50.335
Singapore	33.472	85.328	66.316	26.975	83.412	66.742
United Kingdom	30.225	86.439	70.326	66.853	78.345	70.563

Date source: OECD Health Data 2005

In the **Figure 3** and **Figure 4**, we can also get an intuitionistic view.

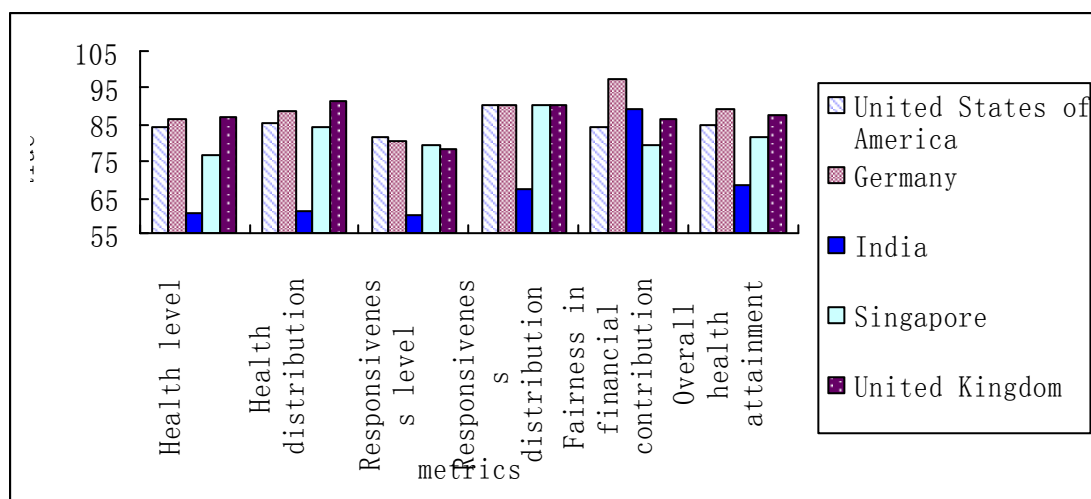


Figure 3 Comparison in WHO's Method

In these five metrics which only focus on the outcomes, we mainly analyze the health level, health distribution. The two methods both have the metric of fairness, so we will talk about it later. First of all, in health level, UK is the best, US in the middle, India is the worst, and this is determined by many aspects of the country, e. g. economic development and medical treatment. As to health distribution, we can see that it is proportional to the health level. It's obvious that no good health level, let alone distribution.

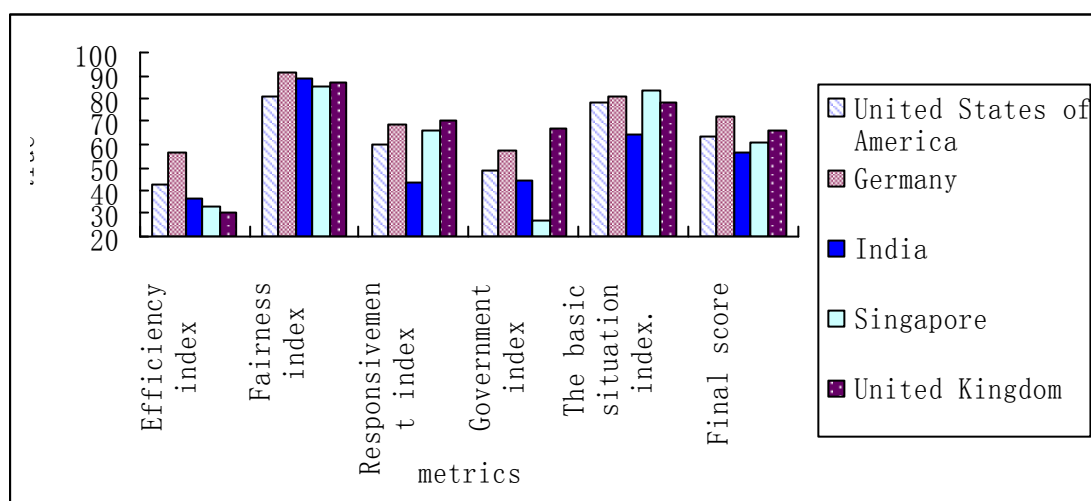


Figure 4 Comparisons in the Comprehensive Evaluation Method

From the **Figure 4** above, we can see that German has a best Efficiency, then US, UK is the worst. That's because the German adopt the Social healthcare insurance which has a unite system, classification administration and encourage competition. It has a lot of advantage in the real. In German, legal healthcare system and private healthcare system work together to make a complement to each other. Seen from the inside running of legal healthcare

system and private healthcare system, this can avoid the monopolization, and the competition which encourage raising the effectiveness and promote the service quality can make a good result to the society. In the US, the commercial insurance dominant, and it really has a better effectiveness under the working of the market. But there're still 16% population not having the insurance. As to India, people can enjoy the free medical treatment in public hospital, but the institution is so bad that there're lots of patients waiting for the medical care so that the effectiveness is very low.

As to the second index, German do the best in the fairness, this is because social insurance system has the character of fairness. At the same time, the US do the worst in the fairness, American healthcare system is running by the market with the same to the commercial system, and the most serious is rapidly raising cost. On one side, the US has the best medical technique and treatment, on the other side, there's a lot of patient without enough money, so bad fairness is the result. Besides, though India has low score in the Health, but it can get a high score in the fairness, this is because the healthcare in India is full coverage.

After that, the US also doesn't do well in responsiveness, a high healthcare cost make it.

- The cost is higher in the US with the commensurate workload.
- Hospitalization expense is higher than other countries.
- The expensive technique is adopted than the other countries.

At last, the effect of the government is brought up, we find that Singapore get a low score in this index, this is because the insurance system in Singapore is national provident fund schemes. And the government makes no contribution to this aspect.

Based on the discussion, we make a conclusion that the healthcare systems of the UK and German are better than the US, and the other two are a little worse.

8.2 Vertical Comparison

To make a vertical comparison between countries, we can get the data in **Table 7** after calculation.

Table 7 The changes of the final score in two method

	Improved WHO's method				
	1997	1999	2000	2001	2003
United States of America	90.8	90.3	90.5	90.5	90.1

Germany	91.8	91.4	92.0	92.3	92.1
India	70.4	68.2	70.4	70.4	71.7
Singapore	89.7	89.4	89.9	90.5	90.4
United Kingdom	92.6	92.3	93.6	93.5	93.6
	Comprehensive evaluation method				
	1997	1998	2000	2001	2002
United States of America	63.438	65.357	67.538	67.457	68.356
Germany	71.639	71.342	72.575	72.581	72.746
India	50.335	50.432	52.643	53.270	53.735
Singapore	66.742	66.864	68.756	68.436	68.873
United Kingdom	70.563	70.885	71.768	71.530	72.063

In **Figure 5** and **Figure 6**, we can get an intuitionistic view..

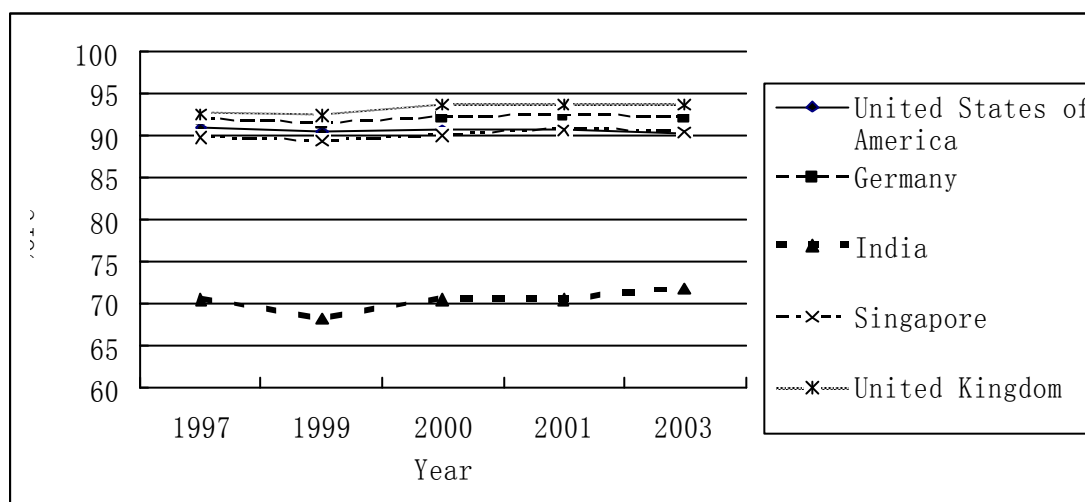


Figure 5 The Changes of the Final Score in Improved WHO's Method

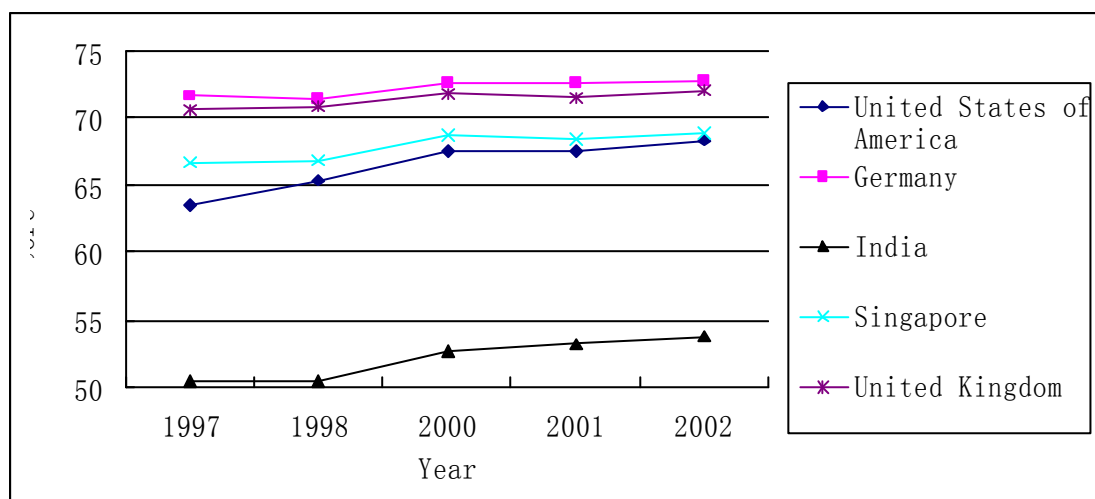


Figure 6 The Changes of the Final Score in Comprehensive Evaluation Method

From the figure above, we can find that the overall healthcare system level of all the countries is always rising up because of the reforms. Besides, we also analyze the investment of the countries.

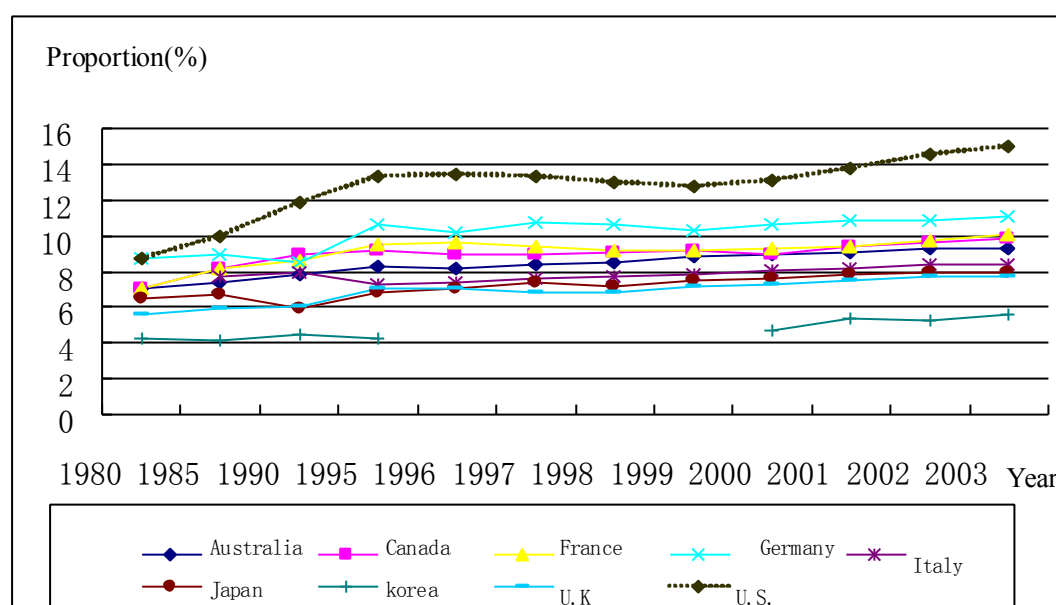


Figure 7 The Proportion of Healthcare Cost in GDP of Different Countries

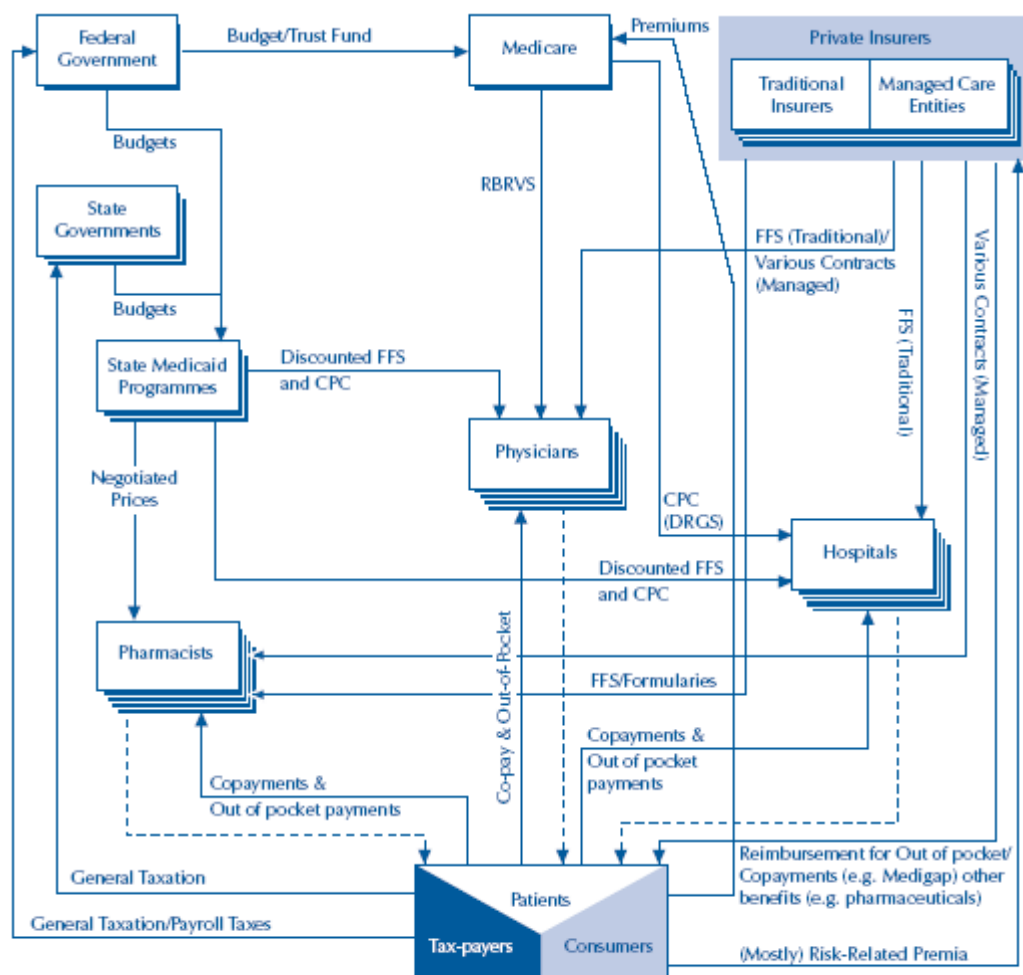
Data source: OECD Health Data 2005

From the figure shown above, we can see that the proportion of healthcare cost in GDP has rose in different degree. During the countries, the US is the largest which reaches 15% in 2003, then the German which reaches 11.1 % in 2003. France, Australia, and Canada are in a middle level, Korea and UK is a little lower.

9 Analysis of American Healthcare System Based on the Neural Networks

9.1 Healthcare System of the US

The healthcare system of the US develops a school of its own during all the countries in OECD. It makes full use of market both in healthcare insurance and medical service. We can see the main characters of American healthcare system in **Figure 8**. As shown in the figure, the principal part to financing is the hospitalization insurance which is running by the companies. Nowadays, the problem in the healthcare system of the US is more and more obvious.



Source: *Financing Health Care, Volume II*, Hoffmeyer et al., 1994

Figure 8 The Healthcare System of the US [James Robertson 2003]

Though the healthcare system is running by the market, the government

of the US also did two hospitalization insurances which are Medicaid and Medicare to lighten the pressures of fairness. But the effect is not so satisfied, unfairness is still the most serious problem in the healthcare system of the US.

The outcomes of the healthcare system are high cost, high technique and high quality. Though the medical technique of the US is more developed than the other countries, cost is much higher too. The healthcare system also doesn't make a full coverage under such a large cost. Figure is just a lash to the American healthcare system.



Figure 9 Perspectives on U.S. Healthcare System (www.msnbc.msn.com)

9.2 Explore the Model to Test the Changes

The cost of the healthcare system of the US is the highest in the world, but the Americans are not satisfied. According to the sensitivity analysis above, we think the failure in financial contribution is the main reason. So we will discuss the American healthcare system with it in the following text.

As shown in **Figure 8**, the healthcare system of the US is a complex system. The existing model can't be described accurately. With these issues, neural networks may be a good choice.

BP network is a feedforward network consisted of the non-linear nerve cell which makes error Back-propagation algorithm as its learning algorithm. It recognizes the error in the outcomes as the mistakes in the joining weight, then put the error back to the input layers to get the new joining weight after adjustment, at last output the satisfied outcomes under adjusting the joining weights adaptively. This network has a good ability of dealing with information in a lot of aspect, just as classification, recognition and analysis, and it has a good character of robustness. BP network is composed of input layer, output layer and some hidden layers. The network shown in the **Figure 10** is a BP network with a single hidden layer.

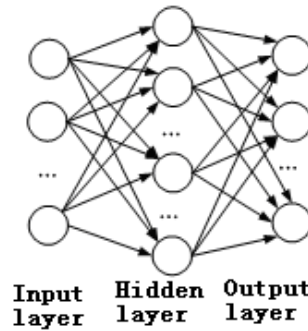


Figure 10 The Structure of the Neural Networks

9.3 The Design of the BP Network

Because of the difficulty of the data collection, we just choose satisfaction and seven indexes as the inputs of the BP network which are health expenditure per capita, the number of doctors per thousand people, the number of sickbed per thousand people, the anticipated life-span, infant mortality, the proportion of the health care cost in GDP, the coverage of the health care. So, the network should have 7 nerve cells in input layer, and 15 ($2 \times 7 + 1$) nerve cells in middle layer. We choose the satisfaction to be the target of the network, there's just one nerve cell in the output layer. According the principles to design the BP network, the passing function as the middle layer is sigmoid function. We can use the following code to create a BP network in MATLAB.

```
Threshold=[0 1;0 1; 0 1; 0 1; 0 1; 0 1; 0 1];
Net=newff(Threshold,[15,1],{'tansig','logsig'},'traingdx');
```

Where Threshold makes the interval of the input vectors, and the training function is 'traingdx', its learning speed is determined adaptively.

9.4 Training and Test of the BP Network

we just choose satisfaction(as shown in **Figure 11**)and seven indexes as the inputs of the BP network which are health expenditure per capita, the number of doctors per thousand people, the number of sickbed per thousand people, the anticipated life-span, infant mortality, the proportion of the health care cost in GDP, the coverage of the healthcare insurance (source: **OECD Health Data 2005**) .

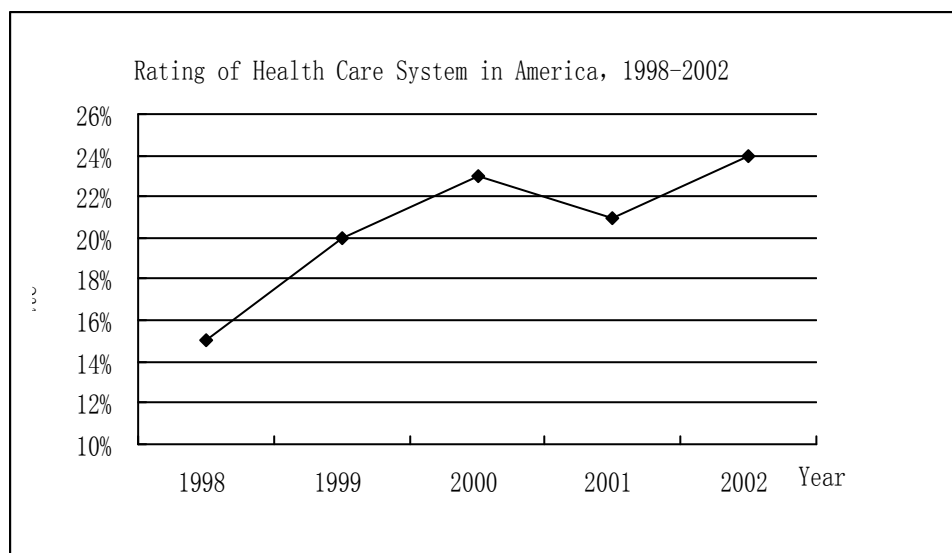


Figure 11 The Changes of Satisfaction to Healthcare System in America

Source: Employee Benefit Research Institute and Mathew Greenward & Associates. Inc. 1998-2003 Health Confidence Survey.

The network should be trained. The training parameters are shown in the **Table 8**, make others as default value.

Table 8 The Training Parameters

The number of training	The target of training
1000	0.01

The code of the training is:

```
net.trainParam.epochs=1000;
net.trainParam.goal=0.001;
net=train(net,P,T);
```

where P is the input vector: $P = (p_{ij})_{5 \times 7}$, p_{ij} is the value of the index j in

the i year. T is the target vector, $T = t_i$, t_i is the satisfaction in the i year.

After training, we should use the data of the 7 indexes in 2003 to have a test to get output of the BP network.

Then we can get the anticipated satisfaction, and real satisfaction after comparing with the anticipated error of the network.

Table 9 The Anticipated Error

Real satisfaction	Anticipated satisfaction	Anticipated error
0.28	0.2837	0.0037

From the table above, we can see that the anticipated error is small, so the result is believable.

9.5 Application of the BP Network

To check up the effect to the satisfaction when an index change, we make one of them rise by 20%, and the others keep unchanged. After that, we can get the satisfaction of every year as shown in **Figure12**.

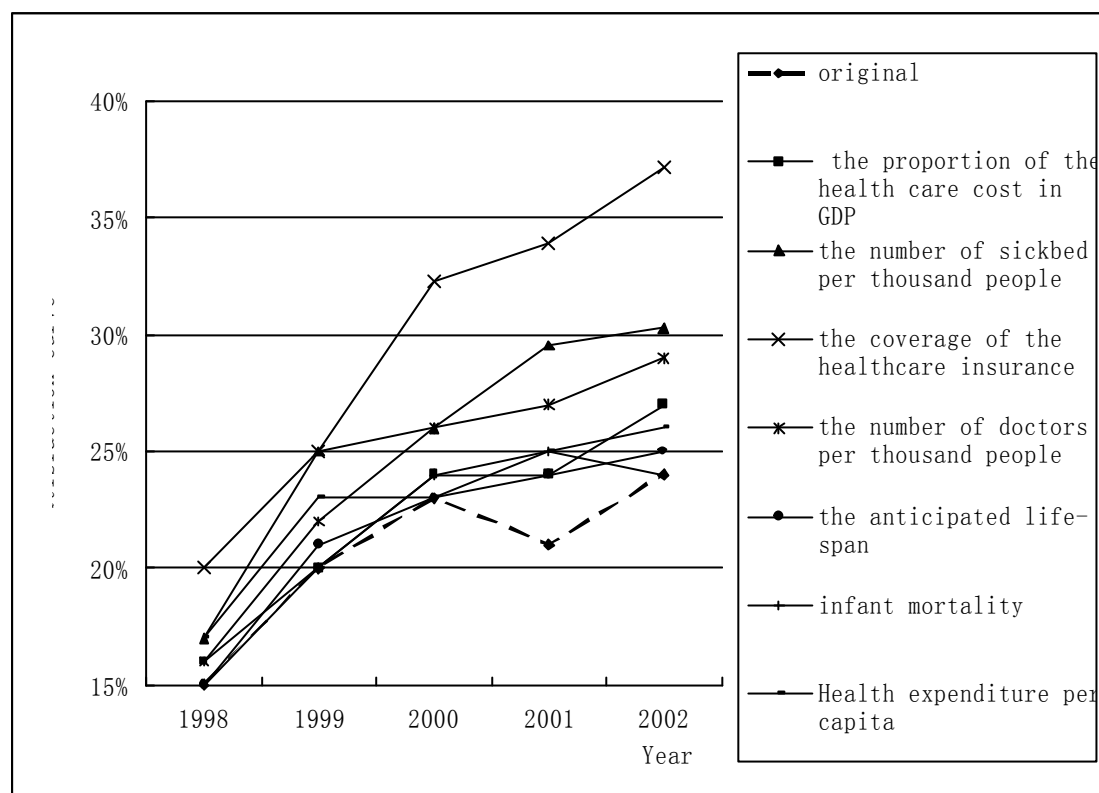


Figure 12 The Satisfaction Curve after Adjustment

As shown in the figure above, the satisfaction has a rising trend when an index rises up. And the coverage of the healthcare insurance improves the result in a largest degree. So increasing the coverage of the healthcare insurance is a good way to improve the performance of American healthcare system.

10 Advice to the Healthcare System of the US

According to the analysis above, the most important problem in the

healthcare system of the US is the coverage of the healthcare insurance. The direct reason of most of the problems in the American healthcare system is the poor coverage of the healthcare insurance. Though the government has established two insurance to help the olds and the children, a lot of people still fail to buy such expensive insurance. Universal healthcare coverage will not only do good to fairness in healthcare, but also encourage the insurance institution making better service. Based on this, we bring up a plan of “medical insurance voucher” to make the US reach the level of universal healthcare coverage rapidly. The plan can be described as below.

We suggest the government should run some insurance institution itself, at the same time, encourage the commercial healthcare insurance institution developing. After that, the government put out the same “medical insurance voucher” to residents. Residents can choose a healthcare insurance institution to participate in if the qualification is satisfied. As to the fund of medical insurance voucher, we think revenue may be a good way. Besides, we suggest that impose a tax to the smoker and drinker, that's because some research indicates that these are bad for health, and it would rise up the cost of the healthcare. If medical insurance voucher is accepted, every one should answer for his behavior and not aggravate the weight of the society.

The difference between the insurance item mainly exists in the service and the cost. The government should provide the basic medical care. In another word, the government should provide the lowest service. The commercial insurance should have more service and better condition, so the cost can be a little higher. Of course, if a resident participate in a commercial insurance, he should pay a little more beside the medical insurance voucher, this is the right of the residents. When the universal healthcare coverage comes true, people only pay a small part to get the healthcare. As the discussion above, we should encourage the institution exploring more style to pay the bill to make the reform easier to run.

The plan of “medical insurance voucher”, bring up a cheap way to the universal healthcare coverage which solve the problem of inverse choice. Besides, there're some advantages as below.

- The plan designs the competition relationship between insurance institutions. This would make the institution to do their best to reduce the cost and improve the quality of the healthcare. Finally, this would improve the effectiveness of the healthcare system.
- The competition relationship exists in the social insurance and commercial insurance. This would do good to each other. In some country, the social insurance dominants so that it make two problems, one is the requirement can't be satisfied, the other is low effectiveness. If there's no competition, the requirement often can't be cared in time, so the level of the medical service can't be improved rapidly. Besides, social insurance as a lowest one, it can not only make the commercial insurance institutions to improve themselves, but also make an adjustment in a national view.

- Collect the medical insurance voucher by taxes, this also can solve the problem of fairness. The fairness asks the healthcare system not to provide the medical care by income but requirement. The tax system has a target of reallocating the incomes, and it also can be used to solve the problem of fairness.
- This plan protect the choosing right of residents. And it is the base to realize the universal healthcare coverage. In this plan, we combine the competition and human rights, it makes a balance between the two important problems.

11 Further Discussion

In **section 9**, we bring a model based on the neural network to evaluate the effectiveness of the American healthcare system. This is because in this model, we think there're a lot of complex relations inside the system which are hard to describe. But if we simply structure of the system as shown in **Figure 13**, which only include households, government, business and providers, the system will be simple enough to deal with it under the **game theory**. After that, the relationship among them will clear. And it will much easier for us to give advice to improve it.

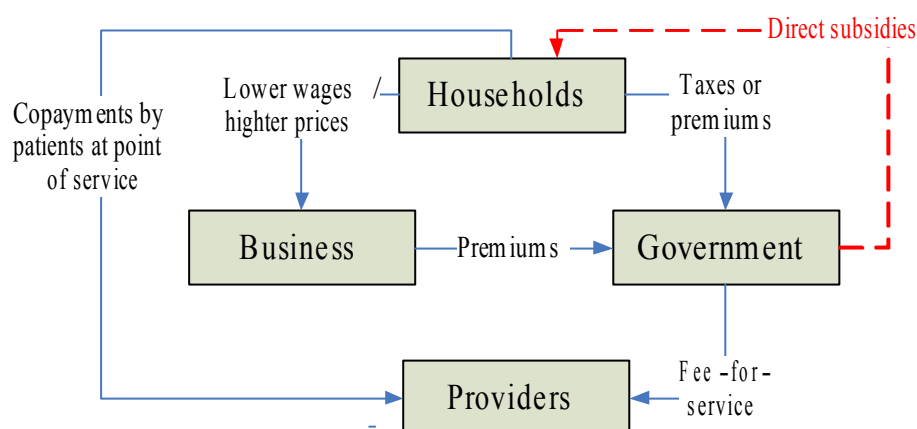


Figure 13 The Simplified Healthcare System of the US

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