Main Driving Factors and Prediction Model of Total Health Expenditure in China: A Study Based on Grey System Theory

Huanhuan Jia
Jilin University of public health https://orcid.org/0000-0003-4151-0915
Xihe Yu (xhyu@jlu.edu.cn)
Jianxing Yu
Jilin University School of Public Health
Zhou Zheng
Jilin University of public health
Yingying Li
Jilin University of public health
Fangying Song
Jilin University of public health
Hairui Jiang
Jilin University School of Public Health
Jingru Zhang
Jilin University of public health

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Abstract

Background: The continuous increase in total health expenditure has become a social issue of common concern in most countries. In China, the total health expenditure still maintains a fast growth trend which is much higher than the growth of the country's economy, although the new health system reform had been going on for 8 years until 2017. The aims of the current study were thus to investigate the main driving factors affecting total health expenditure and to establish a prediction model.

Methods: Gray system theory was employed to explore the correlation degree between total health expenditure and 13 hot spots from the fields of economy, population, health service utilization, and public policy using national data in China from 2009 to 2017. Besides, a prediction model was established using the main driving factors among the 13 hot spots.

Results: The main driving factors related to the changes of total health expenditure were public policy (ranked first), health development, economics, and aging, which correlation degrees were more than 0.7. The average error of the GM(1,7) model was 3.17%, the correlation degree, β, between the predicted simulation sequence and the original sequence was 0.78, the variance ratio, C, was 0.138, and the probability of residuals, P, was 1.0000. Therefore, the prediction model of total health expenditure with 6 main driving factors was excellent.

Conclusion:

The paper finds that since the new health system reform in China, government policies and social invest have contributed greatly to reducing the burden of health expenditure. However, the development of economic and the increase in the elderly population, which are main driving factors, will increase the total health expenditure, so improving the efficiency of investment and providing the precautionary health care and nursing for the elderly are crucial. Besides, the grey system theory had a good application in the field of health economics and policy.

Keywords

Total health expenditure; Driving factors; Prediction; Grey system theory

1 Introduction

Across economic development and health-care settings, it is increasingly recognized that improving living and health standards is equally important and improving health has become a growing concern. At the same time, the continuous growth in total health expenditure, as an internationally recognized indicator, has become a social issue of common concern in most countries [1-4], which reflects a country's investment and burden in the health field from a society-wide perspective. In this respect, better understanding of the main driving factors of the growth is necessary to enable the government to identify areas where measures can be taken to intervene in the future.

However, a country’s politics, economy, culture and population are fundamentally different from those of other countries. Moreover, the socialist system of China and the nature of a large population make the results of other scholars only have reference significance but not decisive significance. In China, the total health expenditure had grown considerably since economic reform started in 1978, and the growth rate of total health expenditure was higher than that of GDP [5], which placed a heavy burden on the government and residents. In 2009, due to the excessive increase in medical expenses and personal overburden, the Chinese government began to implement the new health system reform, and one of the main tasks is to reduce the burden of medical treatment for residents and alleviate the problem of "difficulty and high cost of getting medical treatment" [6]. As of 2017, the new health system reform had been implemented for 8 years, but the total health expenditure and per capita health expenditure were still growing fast—the average annual growth rate of total health expenditure in 2010-2017 was 11.84%, which was higher than the average annual growth rate of GDP (7.56%). The elasticity of health consumption during this period was 1.57, that is, for every 1% increase in GDP, the total health expenditure increased by 1.57%, and the total health expenditure accounted for 6.36% of GDP in 2017 [7]. Experts from China National Health Development Research Center pointed out that the elasticity of health consumption is around 1.2, which can guarantee the economic sustainability of health financing, and after analyzing the historical changes of the total health expenditure in China, and referring to the changes in the health financing development path and the proportion of total health expenditure to GDP in the OECD countries, the "8%" of total health expenditure to GDP was taken as the upper limit or warning value of the sustainability of the total health expenditure in China [8]. Therefore, the growth of the total health expenditure was at a fast rate, and what's more, if this trend of excessive growth would not be controlled in the future in China, it may exceed the affordability of the social and economic, and the sustainability of health funding would not be guaranteed.

Besides, for the new health system reform that only ran for 8 years in China, there was less available data and the growth of health expenditure was affected by objective and subjective factors, and its connotation and extension were not easy to measure, defined as Gray information—ie, its characteristics are not obvious and are difficult to analyze. But Deng's grey system theory is sufficient to realize the modeling, analysis, monitoring, and control of uncertain systems, so as to solve the problem of uncertain grey information, which has been widely used in the fields of economic, biological and environmental [9-11], but few studies in the field of health, so the correlation analysis and prediction model of the grey system theory were employed into the field of health economics to analyze the main driving factors of the increase in total health expenditure since the new health system reform in China in 2009, and based on the main driving factors, a model was established to predict the total health expenditure.

2 Methods

1.1 Method of grey correlation analysis

Grey correlation analysis was used to evaluate the main driving factors of total health expenditure, and it measures the degree of correlation among the factors in the system based on the similarity or dissimilarity of the development trend. The comparative analysis of factors in the system includes the geometric shapes of several curves, and when the geometry shapes of the curves are approximate, the correlation degree among the factors is significant, and the similarity degree among the objects is considerable. Besides, the grey correlation analysis does not require too many samples, the typical distribution rules are irrelevant in the analysis too, and the accurate knowledge of the system can be realized by partially known information [12].

The procedure of the grey correlation analysis was described in detail as follows and SPSS Statistics (version 20.0) was used for the calculation.

Step1: Determination of reference sequence

Let X_0= {$X_0(k)$, k = 1, 2… m} be the original reference sequence which reflects the total health expenditure in China in 2010-2017, and let X_i= {$X_i(k)$, i = 1, 2…, n } be the original comparative sequence which reflects the driving factors such as economy, population, health service utilization, and policies.

Step2: Initialization process

First, the original sequence was interpreted by dimensionless processing to avoid the effect of unit inconsistency on correlation analysis and this paper used the way of mean value processing. The sequences processed by initialization were denoted as $x'(k)$ and expressed as shown in Eqs. (1) and (2).

$$x_i'(k) = \frac{x_i(k)}{\bar{x_i}} \quad \text{Eq. (1)}$$

$$\bar{x_i} = \frac{1}{m}\sum x_i(k) \quad \text{Eq. (2)}$$

Step3: Calculation of grey correlation coefficients of each sequence

Then, the calculation method of the grey correlation coefficient was shown in Eq. (3), and where ξ was the resolution coefficient (within the [0–1] interval; the value is usually 0.5), $\triangle_{max}$ was the maximum difference between two sequences, and $\triangle_{min}$

was the minimum difference.

$\varepsilon_i(k)$=$\frac{\triangle_{min}+\xi*\triangle_{max}}{\triangle_i(k)+\xi*\triangle_{max})}$ Eq. (3)

Step4: Determination of correlation grade

At last, the value of the correlation degree was β_i which was shown as Eq. (4) and the rank of the correlation degree among the driving factors was γ_i.

β_i=$\frac{1}{m}\sum\varepsilon_i(k)$ Eq. (4)

1.2 Method of GM(1, N)

GM model is the basic model of the grey prediction theory, and it can find the inherent laws in the irregular original data through the grey generation function and the differential fitting method in the case of poor information, so it needs a small number of experimental data (at least four) for accurate prediction and low data distribution requirements [13]. GM(1, N) represents the first-order grey model that has *N* variables, including a total number of (*N*−1) independent variables and one dependent variable.

Suppose that there are a total of *N* variables denoting by $X_i^{(0)}$, and each variable has *M* original sequences, as presented in Eq. (5).

$X_i^{(0)}(k) = \{x_i^{(0)}(1), x_i^{(0)}(2), \ldots, x_i^{(0)}(m)\}$ (*i*=1,2,…, *n*; *k*=1,2,…, *m*)

Eq. (5)

The model of GM(1, N) is described in detail as follows and the software of DATA PROCESSING SYSTEM(DPS) was used for calculation. The procedure for predicting the total health expenditure under various conditions by using GM(1, N) was shown in Fig. 1.

Step 1: 1-accumulated generating operation (1-AGO).

First, the original sequences of each variable can be processed by using 1-AGO, then $X_i^{(1)}$ as the 1st-order AGO sequence of $X_i^{(0)}$, the method of 1-AGO and $X_i^{(1)}$ was shown in Eqs. (6) and (7).

$$x_i^{(1)}(k) = \sum_1^k x_i^{(0)}(k) \qquad \text{Eq. (6)}$$

$$x_i^{(1)} = \{x_i^{(1)}(1), x_i^{(1)}(2), \cdots, x_i^{(1)}(m)\} \qquad \text{Eq. (7)}$$

Step 2: Determining the driving parameters.

Defined Eq. (8) as the whitening differential equation of the GM(1, N) model.

$$\frac{dx_1^{(1)}(k)}{dt} + ax_1^{(1)}(k) = b_1 x_2^{(1)}(k) + b_2 x_3^{(1)}(k) + \cdots + b_{n-1} x_n^{(1)}(k) \qquad \text{Eq. (8)}$$

Then the grey differential equation can be obtained, as presented in Eq. (9).

$$x_1^{(0)}(k) + az_1^{(1)}(k) = b_1 x_2^{(1)}(k) + b_2 x_3^{(1)}(k) + \cdots + b_{n-1} x_n^{(1)}(k) \qquad \text{Eq. (9)}$$

In which, $z_1^{(1)}(k)$ was defined as Eq.(10)

$$z_1^{(1)}(k) = \frac{1}{2}[x_1^{(1)}(k) + x_1^{(1)}(k-1)] \qquad \text{Eq. (10)}$$

Where a represented the system development parameter, and b_i represented the driving parameter. Besides, the affecting polarity and extent of the i-th variable on the dependent variable can be reflected by b_i. It means that the increase of the value with respect to the independent variable, i, benefits the dependent variable if b_i>0, and vice versa.

Then, Y, B, and β were defined as Eq. (11) and $Y = B * \beta$.

$$Y = \begin{bmatrix} x_1^{(0)}(2) \\ x_1^{(0)}(3) \\ \vdots \\ x_1^{(0)}(m) \end{bmatrix} \quad B = \begin{bmatrix} -\frac{1}{2}\left[x_1^{(1)}(1) + x_1^{(1)}(2)\right] & x_2^{(1)}(2) & \cdots & x_n^{(1)}(2) \\ -\frac{1}{2}\left[x_1^{(1)}(2) + x_1^{(1)}(3)\right] & x_2^{(1)}(3) & \cdots & x_n^{(1)}(3) \\ \vdots & \vdots & \vdots & \vdots \\ -\frac{1}{2}\left[x_1^{(1)}(m-1) + x_1^{(1)}(m)\right] & x_2^{(1)}(m) & \cdots & x_n^{(1)}(m) \end{bmatrix}$$

$$\beta = \begin{bmatrix} a \\ b_1 \\ b_2 \\ \vdots \\ b_{n-1} \end{bmatrix} \qquad \text{Eq. (11)}$$

In GM(1, N) models, Y and B were known quantities and β was the pending parameter. The grey parameter, P_N, represented the vector composed by the system development parameter and the driving parameters can be obtained according to the least square method according to Eq. (12).

$$\hat{\beta} = (B^T B)^{-1} B^T Y = \begin{bmatrix} \hat{a} \\ \hat{b}_1 \\ \vdots \\ \hat{b}_{n-1} \end{bmatrix} \qquad \text{Eq. (12)}$$

Step 3: Prediction by using the inverse accumulated generating operation.

Then, the solution of the equation can be obtained by substituting the grey parameter into Eq. (8), as presented in Eq. (13).

$$\hat{x}_1^{(1)}(k+1) = \left[x_1^{(0)}(1) - \frac{1}{\hat{a}} \sum_{i=2}^{n} \hat{b}_{i-1} \hat{x}_i^{(1)}(k+1) \right] e^{-\hat{a}k} + \frac{1}{\hat{a}} \sum_{i=2}^{n} \hat{b}_{i-1} \hat{x}_i^{(1)}(k+1)$$

Eq. (13)

Finally, the $k+1$-th predictive value can be obtained, $\hat{x}_1^{(0)}(k+1)$, through the inverse accumulated generating operation, as presented in Eq. (14).

$$\hat{x}_1^{(0)}(k+1) = \hat{x}_1^{(1)}(k+1) - \hat{x}_1^{(1)}(k) \qquad \text{Eq. (14)}$$

Step 4: The Model test of GM(1, N).

There were three aspects to the model test of the GM (1, N), including the residual test, the correlation test, and the posterior-variance test.

1) The residual test

Let $\varepsilon^{(0)}(k) = \left(\varepsilon^{(0)}(1), \varepsilon^{(0)}(2), \cdots \varepsilon^{(0)}(m)\right)$ be absolute residual sequence of the predicted simulation sequence, $\hat{x}^{(0)}(k)$, and the original sequence, $x^{(0)}(k)$, and we can get relative residual sequence, ϕ_i, and average relative residual, ϕ, as shown in Eqs. (15), (16) and (17).

$$\varepsilon^{(0)}(k) \quad = |\, x^{(0)}(k) - \hat{x}_0(\mathrm{k})| \qquad \text{Eq. (15)}$$

$$\phi_i = \frac{\varepsilon^{(0)}(k)}{x^{(0)}(k)} * 100\% \qquad \text{Eq. (16)}$$

$$\bar{\phi} = \frac{1}{n} \sum \phi_i \qquad \text{Eq. (17)}$$

2) The correlation test

According to the grey correlation analysis procedure, the correlation coefficient between the prediction simulation sequence $\hat{x}^{(0)}(k)$ and the original sequence$x^{(0)}(k)$ was calculated, and then we defined *r* as the correlation degree.

3) The posterior variance test

The mean square difference between the original sequence, $X^{(0)}$, and the absolute residual sequence $\varepsilon^{(0)}$ were S1 and S2, respectively, then we named *C* was variance ratio, and *P* was the probability of residuals, that was, *P* was a value obtained by dividing the number of events satisfying $|\varepsilon^0(k) - \bar{\varepsilon}|<0.6745S_1$ by *m*, as shown in Eqs. (18) and (19).

$$C = S_2/S_1 \qquad \text{Eq. (18)}$$

$$P = P(|\varepsilon^0(k) - \bar{\varepsilon}| < 0.6745 S_1) \qquad \text{Eq. (19)}$$

The results of each indicator and the accuracy of the model were shown in Table 1.

3 Data

Research on total health expenditure were extensive and such methods were varied, including demographic factors(eg, population aging [14], age structure, and population size), economics (eg, per capita income and GDP [15-16]), as well as disease (eg, diseases epidemic [8]and population health), etc. Other scholars analyzed the relationship between education and health expenditure, air and health expenditure, environment and health expenditure [17-18]. Therefore, the generation and change of health expenditure was affected by many factors such as social economy, demographic changes, social system, etc. Because of the characteristics of China's medical system and the availability of data, 13 hotspots were discussed in this paper, including the economy, population, health service utilization, and public policy. The introduction of each driving factor was 3.1-3.5 and the abbreviation, unit, and source of the variables are shown in table 2.

3.1 Demography

Demographic factors included population growth and aging in this paper after considering the availability of data, practical possibilities and interrelationships among the factors. The growth of the population increased the number of potential users of medical services, which will definitely affect the change in the total health expenditure. The aging of the population has an impact on the increase in total health expenditure too, because the life expectancy is increasing while birth rates are declining, resulting in population aging, and aging is associated with a higher risk of chronic diseases, mild disability, and cognitive decline, etc. [19-20]. Moreover, the prevalence of multimorbidity increased substantially with age and was present in most people aged 65 years and older [21]. And, one study conducted that the elderly (+65 years) demand health services 3.2 times more than the community average [22], so, along with the increased elderly population, the challenges for medical services and social policy will increases. Scholars from all over the world investigated the aging of the population as an important driving factor when researched the changes in total health expenditure [23-26]. Therefore, the natural population growth rate and the proportion of population aged 65 years and above were selected as the population factor to discuss its relationship with the change of total health expenditure.

3.2 Economics

The relationship between GDP and health expenditure is the subject of a large literature in health economics [27-28] and was also an important factor in measuring the demand for health care services. Besides, the GDP deflator was selected to reflect the impact of price trends on total health expenditure. Besides, in China, the relationship between urbanization and total health expenditure was significant, which can promote economic development and narrow the gap between urban and rural areas. Thus, the accessibility of geographical and economic of residents' utilization to health services can be improved, and the accessibility of health services is one of the important factors affecting the utilization of health services, so the urbanization promoted residents' utilization of health services. Therefore, the urbanization rate was selected to explore the relationship between urbanization and total health expenditure.

3.3 Public policy

The cyclical response of government health expenditure can affect a countries' health sectors and subsequently their health outcomes in several ways, such as the provision of public health services and coverage of medical services [29].

Moreover, under the Chinese medical and health system, the government plays an irreplaceable leading role in the health service market, playing an important role in providing public goods, improving income distribution, and promoting social equity, so its health investment deeply reflects the government's emphasis on health care and people's livelihood issues such as residents' health and medical burden. At the same time, the implementation of various policies in the new health system reform requires the government to assume the responsibility of providing financial security. Therefore, government health expenditure was selected to reflect the government's emphasis on the field of health. Also, the social medical security fund has an impact on health services utilization and expenditure [30], which reflect the contribution of various social medical security systems such as urban and rural medical insurance, urban workers' medical insurance, new rural cooperative medical insurance and enterprise employee medical and health expenses, etc. Finally, the proportion of out-of-pocket expenditure (OOP) was selected to reflect the health burden of residents.

3.4 Health service utilization

At the same time, across economic development and health-care settings, it is increasingly recognized that improving living and health standards is equally important, and people are beginning to invest more on health. Therefore, the proportion of health expenditure was selected in the household consumption expenditure to reflect the residents' attention and actual use to health care services.

3.5 Health development

The health development included the development of health institutions and services in this paper. The development of health institutions improved accessibility from the perspective of providers of health services, affecting the provision and utilization of health services. Therefore, the number of beds and health technicians was selected to reflect the impact of the development of medical institutions on total health expenditure. Infant mortality is an important indicator of a country's health, which is associated with a variety of factors such as maternal health, quality of service, and access to medical care, socioeconomic conditions, and public health practices [31-32], which can reflect the development of health services.

The original sequences for the total health expenditure and the main driving factors for 2010-2017 are shown in Table 3. The total health expenditure still increased year by year, with an increase of 118.90% in 8 years, and the average annual growth rate is 11.84% after adjusting for GDP Deflator. Besides, the elderly accounted for 8.9% of the population in 2010 and increased to 11.4% in 2017, with an increase of 2.5%. At the same time, the health investment from government and social continually increased, especially for social medical security, and the increase in quotas made OOP show a trend of decreasing year by year, and by 2017, OOP was 28.8% which was very close to the target of 28% set in China's 13th five-year (2016-2020) health and wellness plan.

4 Results

4.1 The results of main driving factors analysis

Table 4 shows the correlation degree between the driving factors and the total health expenditure. The public policy factors were most closely related to the changes in total health expenditure and the correlation degree between government health expenditure and total health expenditure, social medical security funds, and total health expenditure was 0.965 and 0.954, and the rank of the correlation degree among the driving factors was 1st and 2nd respectively, which showed that the government had played a critical role in regulating the development of total health expenditure and played a leading role in the health industry. Also, the government had made some impacts on the total health expenditure through social policies. Unsurprisingly, the relationship between the improvement of the economic and total health expenditure, the development of health service providers and total health expenditure were also at a high level, because over the past four decades, China has seen rapid demographic and epidemiological transitions, along with an economic boom that has already lifted millions out of poverty[23], and the concern for their health gradually increased, the willingness to obtain more and better quality health services was stronger, and at the same time the service accessibility was increasing which had promoted the provision and utilization of health services and had an vital impact on total health expenditure. Also, the correlation degree between aging and the total health expenditure was 0.719 which proving that the aging of the population was an important driving factor affecting the total health expenditure, consistent with other research results [24-26]. The correlation degree between other factors and total health expenditure were less than 0.7.

4.2 The prediction model of total health expenditure

To improve the simplicity and accuracy of the model, seven variables were included in the model, including the total health expenditure for the dependent variable and 6 driving factors for independent variables which correlate degree with the total health expenditure were 0.7 or more, that were THE, ABOVE65, GDP, PROs, BEDs, GOV.EXP and SOC.EXP.

Running the DPS data processing system, the grey parameter can be obtained as shown in Eq. (20) and Fig. 2.

$\hat{\beta}$=(a, $b_1, b_2, b_3, b_4, b_5, b_6)^T$

=(2.435842,3513.69094,0.21954,-119.09104,-96.81039,9.47188,-2.70699) Eq.（20）

Since $|b_1|>|b_3|>|b_4|>|b_5|>|b_6|>|b_2|$, the affecting extent of the six factors is: ABOVE65>PROs>BEDs> GOV.EXP> SOC.EXP>GDP.

Moreover, the driving coefficients of ABOVE65, GDP, and GOV.EXP were greater than zero, to some extent, it means that the increased of elderly population, economic and government health expenditure would increase total health expenditure. Besides, the maximum was ABOVE65 among all the driving coefficients, so, in the context of the increasing number of older people, strategies targeting preventive care and rehabilitation care, particularly in medical and nursing for the elderly, should be prioritized in the health system reform. Meanwhile the driving coefficients of BEDs and PROs were less than zero, which reason may be that since the new health system reform in 2009, a graded diagnosis and treatment system has been committed to implementing by the Chinese government, the medical technology level and the number of beds in primary health care institutions were increasingly valued [6]. At the same time, part of patients who had a common disease or were in recovery were guided by the government to go to the primary health institutions, rather than large health institutions, and the cost of medical treatment in a large hospital was much higher than that of a primary health institution when we have a common illness or need rehabilitation, so, the implementation of the graded medical system had reduced the medical expenses to a certain extent. At last, the driving coefficients of SOC.EXP was also less than zero, indicating that the increase in social security funds in China had contributed to reducing the government burden and improving the efficiency of the medical and health system, which may reduce the total health expenditure.

The comparison of the predicted simulated sequence and the original sequence of the total health expenditure was shown in Table 5, and the similarity between the two data was depicted in Fig. 3. The average error of the GM(1,7) model was 3.17%, and the curve of predicted simulated sequence and the original sequence was very close. The correlation degree, β, between the predicted simulation sequence and the original sequence was 0.78, and some scholars also pointed out that the model accuracy is excellent if the resolution coefficient, ξ, was 0.5 and the correlation degree was greater than 0.6 [33]. The posterior variance test of the model showed the variance ratio, C, was 0.138, and the probability of residuals, P, was 1.0000, so, the model of GM(1,7) was excellent.

Considering the fact that the model was established in terms of only 8 groups of data and the predicted simulated sequence for the training data were also very close to the original sequence, it can be concluded that GM(1, N) model can predict the health expenditure fairly accurately in the situation of "poor information".

5 Discussion

This paper analyzed the driving factors of the growth of total health expenditure by using only 8 years' data from 2009 to 2017 in China and established a prediction model of total health expenditure, which was crucial for the formulation of effective, strategic, and health service policies to facilitate the progress of the reform of China's new health system reform.

When the government proposed a new health system reform in China in 2009, it required to increase the input of government at all fields, accelerate the establishment and improvement of a multi-level medical security system covering urban and rural residents, and improve the primary health service system to promote the fairness and efficiency of the medical and health industry [6]. As far as our research results are concerned, the total health expenditure is highly correlated with the government expenditure and social medical security expenditure, which shows that through the formulation of policies, the government and society have invested heavily in health care, which played a vital role, and the fairness and efficiency of the health care system had improved, and the out-of-pocket health expenditure showed a downward trend year by year. To some extent, the medical burden of residents had been reduced, but there was still a gap between the current and the target set in China's 13th five-year (2016-2020) health and wellness plan. Therefore, improving the allocation efficiency of government health expenditure and the role of the social in the risk sharing of heath expenditure are valuable research for controlling the growth of total health expenditure and health system planning.

The primary health care institutions, operated by government, are the cornerstone of China’s urban health-care reform [34] and the Chinese government has also implemented various policies to promote the primary health care institutions as the first choice of patients. However, many residents in urban and rural continue go to tertiary hospitals first when they are sick [35] and the survey found that, more than 40% of patients bypassed the primary health care institutions and went directly to a university hospitals or other large hospitals to obtain high-level medical services [36]. One of the main reasons is that the residents are skeptical about the technical level of primary medical institutions and have a low level of trust in the quality of medical services [37].With the new health system reform, policies was adopted such as increasing the number of beds, training general practitioners and guiding medical staff to work in primary medical institutions, which have improved the technical level and service quality of primary medical institutions and led some patients to seek medical services in primary medical institutions. The implementation of the graded diagnosis and treatment system has been effective and should be pursued continually.

The population is aging fast as a result of the baby boom, the One Child Policy and a declining mortality rate, and the demographic structure of households is gradually turning into a “4–2-1” or “4–2-2” formula [38], meaning the elderly population will continue to increase. Moreover, this paper demonstrated that ageing was closely related to the growth in total health costs. Therefore, this paper proposes that aging provided more opportunities for the growth of total health expenditure and it was a carrier, which can combine the improvement of the economy, the medical insurance, and the medical science with the health of the population and turn them into health expenditure.

Therefore, it is urgent to pay more attention to the health of the elderly and provide preventive health care services for the elderly and formulate corresponding insurance strategies.

In addition, no standard approach for the measurement of the driving factors, and selection and definition of driving factors to include were inevitably partly subjective and dependent on the data available, but the 13 hotspots selected in this paper from five areas comprehensively reflected the driving factors of total health expenditure in China, and the accuracy of the grey prediction model using 6 main driving factors, namely GM (1,7), was excellent.

6 Conclusion

Given this study's analysis, the following conclusions can be drawn. Firstly, since the implementation of China's new health system reform in 2009, the policies and investment of the government and social have played a crucial role in reducing the burden on people. Besides, the graded diagnosis and treatment system has been effective, and the out-of-pocket has been gradually decreasing year by year. Secondly, the improvement of economic and the aging, which are closely related to the total health expenditure, increases the demand for health services, leading to the total health expenditure rising continually, so how to improve the efficiency of investment and provide the precautionary health care and nursing for the elderly is crucial. Thirdly, only few data were available from 2009 to 2017, but the GM(1, N) model achieved good accuracy, so GM(1, N) model can successfully simulate and predict the total health expenditure in the case of poor information and can provide a basis for policy formulation.

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Figures

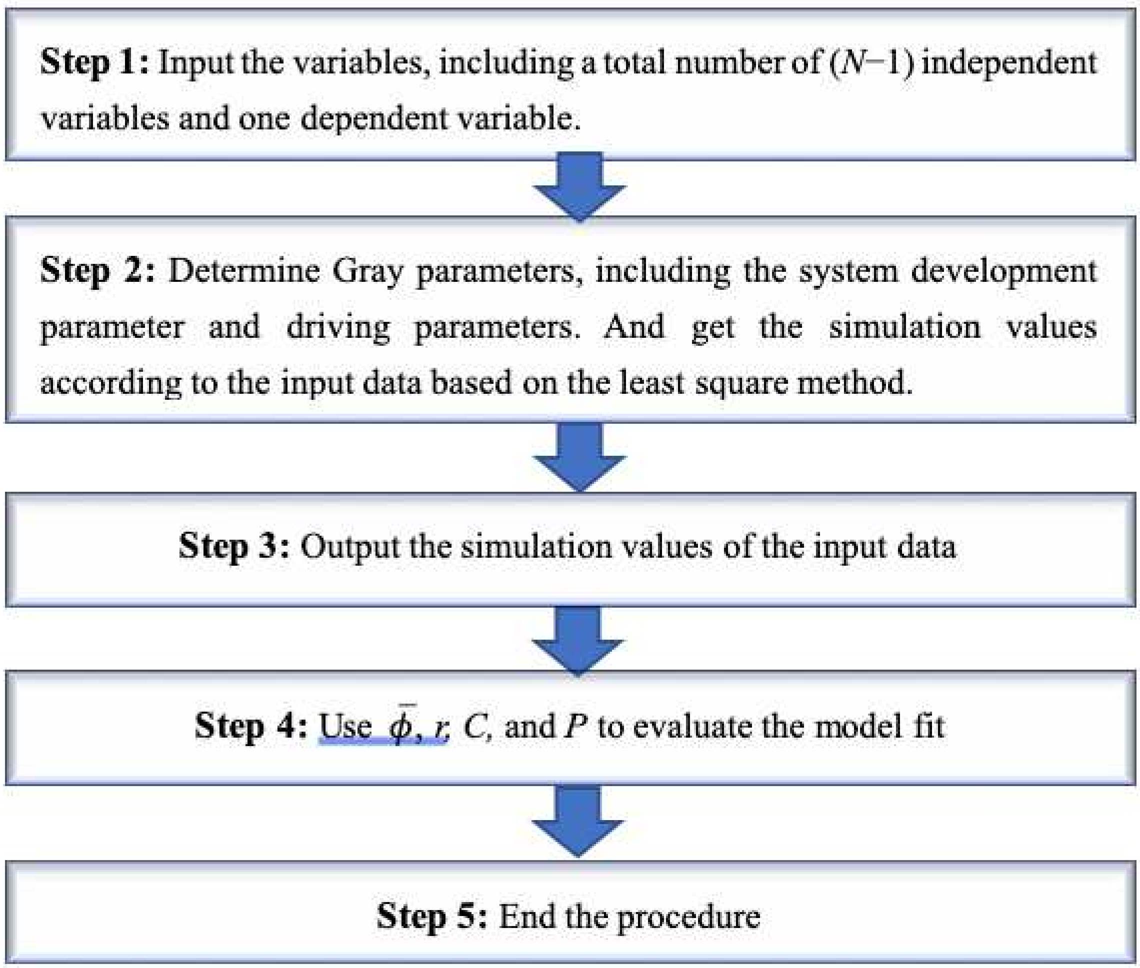

Figure 1

Programming diagram of GM(1, N) models to predict the total health expenditure.

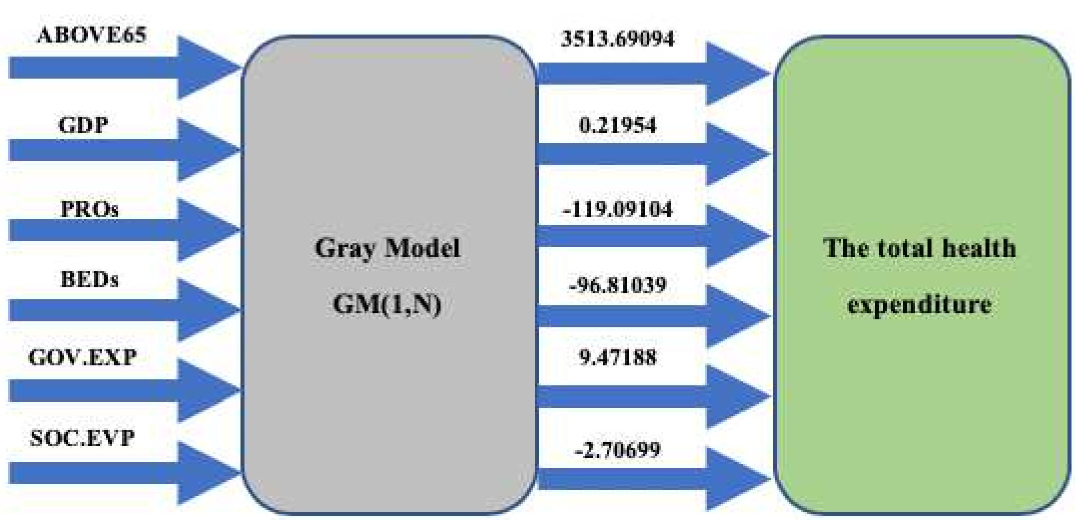

Figure 2

Driving coefficients of the driving factors. The driving coefficients are calculated by GM(1, N)

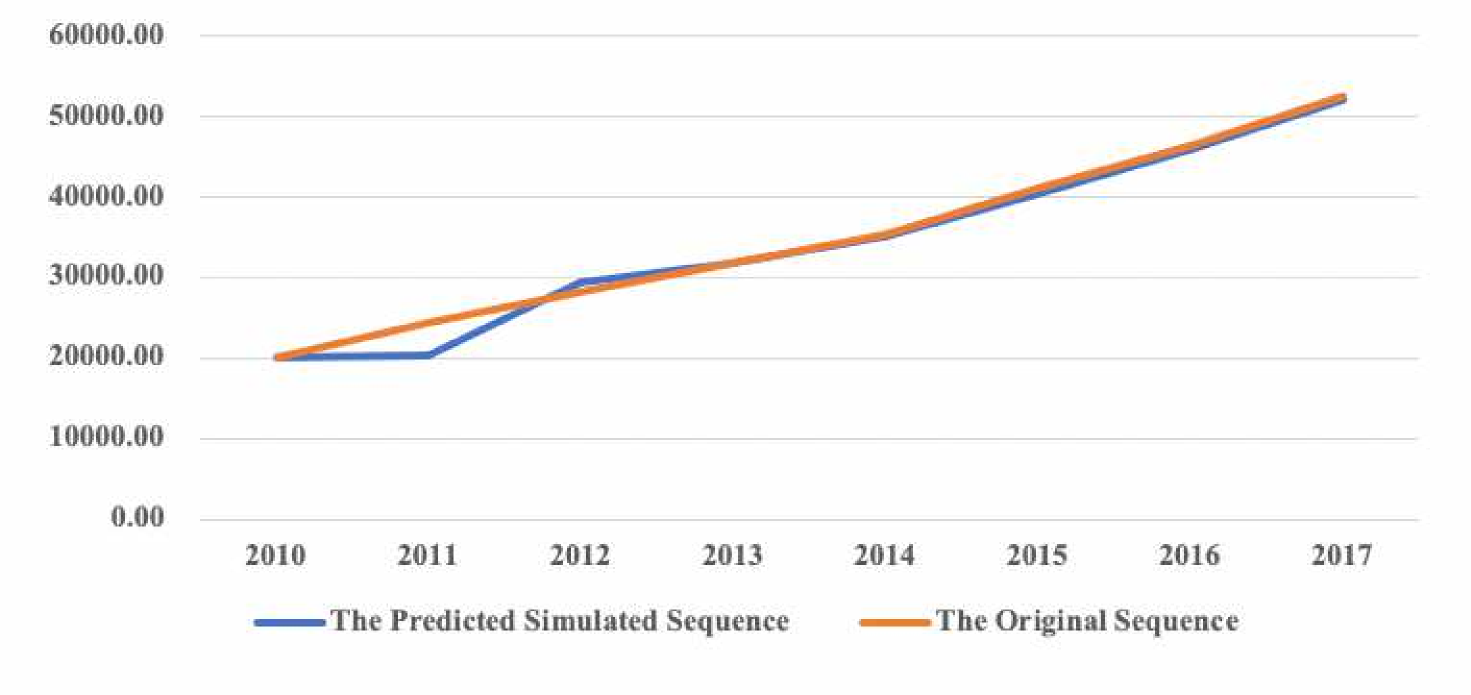

Figure 3

The similarity between the predicted simulated sequence and the original sequence.