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Optimization of medical insurance actuarial based on biometric data

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Abstract: Only a detailed study of the insured in long-term health insurance can better avoid risks and further serve the insured. Biostatistics is a discipline that applies the principles and methods of statistics to study life sciences, reveals the inevitable laws in a large number of random phenomena from the quantitative aspect, and is the application of probability theory and mathematical statistics in the biological field. The research results provide new ideas and methods for actuarial science of social health insurance in China.

1. Introduction

The reform of China's social medical insurance system has entered a new period of consolidation and perfection. The main tasks of this period are: first, to enhance fairness, deepen reform, improve the system, and strengthen overall planning and institutional integration; The second is to enhance the scientific nature, improve the mechanism and improve the efficiency and accessibility of management services [1]. Because the insurance period is too long, it also brings challenges to the risk assessment. At the same time, there is also a delay period in long-term health insurance, which is often longer than the period of disability. Its purpose is to observe the health status of the insured in order to facilitate underwriting claims. It can be seen that only by conducting detailed research on the insured in long-term health insurance can we better avoid risks and further serve the insured. Therefore, there will always be many problems in the specific implementation process in China, such as the actuarial work of social medical insurance in the actuarial system of medical insurance. This paper discusses its related contents one by one and puts forward the optimization of medical insurance actuarial based on biometric data.

2. Importance of actuarial work of social medical insurance

The so-called "actuarial" technology refers to the use of mathematics, financial management and statistics to calculate the proportion of social insurance funds. In the process of implementing social medical insurance system in all countries in the world, there is a commonality, that is, part of the insurance cost is borne by the government, and the other part is shared by individuals and employers. As a basic civil policy of the government, social medical insurance has an important impact on the daily life of the public. Although the social medical insurance funds are under-utilized, they are generally covered by the government's financial institutions, but the government funds are raised and

enjoyed by the people [2-3]. As far as the medical insurance in a co-ordination area is concerned, actuaries need to study and analyze the frequent diseases, disease spectrum, treatment cost and other contents in this area, and on this basis, use statistical analysis to explore the loss distribution.

The risk control of medical insurance is to classify and distinguish the risk elements in medical insurance by using the basic risk management ideas and theoretical basis, and calculate the odds of medical insurance and the degree of risk influence in advance. With the development of the times and the progress of society, the actuarial method of medical insurance has gradually attracted people's attention. Whether it is social medical insurance or commercial medical insurance, the accounting method of insurance business needs to be implemented by specific means. Therefore, in order to promote the development of the whole medical cause, it is necessary to study these aspects as soon as possible.

Actuarial technology belongs to the core technology of insurance management, and any insurance system cannot be separated from actuarial technology [4]. In social medical insurance, if there is no actuarial technology, financing cannot be scientific and reasonable, the fund budget cannot be carried out accurately, the government's responsibility for the fund is unclear, and the performance of the social medical insurance system is doubtful.

3. Actuarial model of medical insurance

Social medical insurance is closely related to the government financial department. How to scientifically use and plan the fund-raising of social medical insurance is closely related to the financial institutions of government departments and related policies. Because the insurance premium is determined by two factors: the payment base and the rate, the insurance premium collected is different if the payment base is determined in different ways; Different rates will lead to different insurance premiums [5-6]. The new rural cooperative medical system and the basic medical insurance for urban residents mainly adopt the pay-as-you-go system, and few places have established personal accounts.

In essence, actuarial science is to analyze and price the contingent claim, which mainly depends on the possible state of some specific random events in the future [7]. Theoretically, the pure premium of medical insurance is the expected loss that the insurer bears the health risk of the insured, that is, $P = E(S)$, in which the random variable S is the future loss.

Since the loss S is a function of the number of losses N and the amount of each loss S_i, there are:

$$P = E(S) = E_N\left[E_S(S|N)\right] = E_N\left[NE(S_i)\right] = E(N)E(S_i) \tag{1}$$

Payment by project is usually estimated by dividing it into outpatient health care expenses, hospitalization medical expenses, drug treatment expenses, oral health care expenses and medical technology costs according to the categories of medical services [8-9]. However, it should be noted that the implementation of the new plan will stimulate the utilization of medical services, and the influence of this factor should be considered when establishing the model, that is, the influence of insurance factor should be included. As China is in a period of rapid increase in medical expenses, the influence of the growth rate of medical expenses and unexpected risks on the cost of insurance plan can not be ignored. In addition, the influence of compensation ratio on medical expenses is also one of the factors to be considered.

Once the income and cost of the social health insurance plan are estimated, the financing ratio can be easily obtained according to the principle of income-cost balance. For example, the financing ratio of the pay-as-you-go social health insurance plan can be expressed as:

$$PAYGR(t)=[TE(t)-OI(t)]/TAB(t) \tag{2}$$

Among them, $PAYGR(t)$ represents the pay-as-you-go contribution rate of the insurance plan in the t year. $TE(t)$ represents the total cost of the insurance plan in the t year; $OI(t)$ represents the non-premium income of the insurance plan in the t year; $TAB(t)$ represents the sum of the payment bases of all the payers of the insurance plan in the t year.

On the basis of knowing the potential loss, the pure premium depends on the probability distribution of the insured's accumulated medical expenses S_T rising above the deductible X. Option pricing model assumes that the price process of assets obeys lognormal distribution.

Although the accumulated medical expenses are different from the asset price, it can be considered that the accumulated medical expenses $S(t)$ of the insured meet the lognormal distribution in the case of a considerable number of insured persons, namely:

$$\ln S(t) \sim N\left(\left(\mu-\frac{\sigma^2}{2}\right)t,\sigma^2 t\right) \tag{3}$$

Where $\mu,\sigma>0$ is a constant, μ represents the expected instantaneous increase rate of accumulated medical expenses, and σ represents the instantaneous standard deviation of accumulated medical expenses. Under the risk-neutral condition, the expected rate of increase μ should be equal to the risk-free interest rate.

According to Pareto optimal premium theorem, the optimal premium is a certain percentage of pure premium, and the final optimal premium π is:

$$\pi=\lambda B(S(t),t),\lambda>1 \tag{4}$$

4. Optimization of medical insurance actuarial

In most insurance companies, actuarial work mainly includes rate determination, reserve provision and product design. According to the design and management services of China's social medical insurance system, actuarial technology can play its important role in the following links. Because all types of social medical insurance need to be paid by the insured, especially the basic medical insurance for employees needs to be paid by the employer, and although there are many ways to pay by the employer, it is ultimately related to the number of employees in the unit, so we must accurately grasp the number of participants in all types of insurance, especially the paying population and its changes. Fund balance analysis needs to be combined with financing analysis and payment analysis, and all kinds of factors affecting the fund should be fully considered.

Biostatistics is a discipline that applies the principles and methods of statistics to study life sciences, reveals the inevitable laws existing in a large number of random phenomena in terms of quantity, is the application of probability theory and mathematical statistics in the biological field, and is the improvement of the course of field experiment and statistical analysis in agricultural production. In the future, biostatistics will be closely combined with information technology, with less emphasis on traditional mathematical statistics, and more attention will be paid to data analysis, especially the processing of large databases. This paper uses biometric data to establish a stochastic process model for this problem and study related issues of long-term health insurance.

Longitudinal data refers to repeated observation data of each individual in a group over time, which often appears in biology, medical clinical trials and other scientific fields. Mixed effect model

is a powerful tool to fit the relationship between response variables and covariates in longitudinal data. Among them, linear and nonlinear mixed effect models are the two most commonly used models [10].

The mixed effect model we consider is as follows:

$$y_i = f(x_i, \beta) + z_i b_i + \varepsilon_i, i = 1,2,\cdots,m \tag{5}$$

Where $y_i = \{y_{i1},\cdots,y_{in_i}\}$ is the vector of $n_i * 1$, representing the response value of the i-th individual, x_i is the design matrix of the i-th individual fixed effect part $n_i * s$, z_i is the design matrix of the i-th individual random effect, and the dimension is $n_i * q$.

We estimate the estimators of β, and β by the ordinary least square method, which is obtained by minimizing the following expressions:

$$Q_m(\beta) = \frac{1}{m}\sum_{i=1}^{m}(y_i - f(x_i,\beta))^T(y_i - f(x_i,\beta)) \tag{6}$$

Our main purpose is to estimate the variance estimation of random effects and errors. Therefore, we choose the most easily implemented ordinary least square method to get the consistent estimate of β.

Considering the comparability of goodness of fit of various methods, the traditional χ^2-test is chosen as the method of goodness of fit test in this study. χ^2-goodness-of-fit test is the most widely used goodness-of-fit test method, which can test both continuous and discrete data. The statistical test quantity is:

$$\chi^2 = \sum_{i=1}^{k}\frac{(O_i - E_i)^2}{E_i} \tag{7}$$

Among them, O_i represents the actual observation frequency of the i section of the histogram, E_i represents the expected theoretical frequency of the i section of the histogram, and k represents the number of sections of the histogram.

5. Application example

Because social medical insurance institutions have advantages in the collection and management of medical insurance funds and residents' credit, they can effectively protect risks and reduce the burden on enterprises and employees, which is an ideal choice at this stage. This section applies the option pricing model to the determination of community rates.

The basic idea is to obtain the level of per capita medical expenses in China over the years from the Information Center of the Ministry of Health as sample data, and use the actuarial model of medical insurance based on biometric data to calculate the community rate that urban and rural residents need to pay in China, so as to provide theoretical reference for the premium calculation of urban community health service system and new rural cooperative medical system in China.

A total of 42 sample data S_i from 2010 to 2020 are selected, and whether the samples conform to the lognormal distribution is tested by hypothesis. After the test is passed, the option price model is used to calculate the option fee. The nonparametric hypothesis χ^2 test is carried out by goodness of fit

test.

Firstly, take the logarithm of the sample data, select $k-1$ real numbers to divide all samples into k intervals, determine the frequency n_i of each interval, use p_i to represent the probability that $\ln S_i$ falls into each interval, and use Pearson to construct statistics χ^2 according to the sample data information. See Table 1 for the observed values of samples for χ^2 calculation.

Table 1: χ^2 -fitting goodness test of lognormal distribution of per capita medical expenses

k	n_i	p_i	$(n_i - np_i)^2$	$\frac{(n_i - np_i)^2}{np_i}$
1	6	0.09304	0.94758	0.54866
2	8	0.22274	3.98666	0.96806
3	8	0.08229	5.67557	0.32635
4	7	0.04748	3.322	0.71209
5	3	0.24732	0.92556	0.55328
6	6	0.15199	2.66587	0.20939
7	5	0.22024	6.46453	1.25156
8	8	0.13003	0.89965	1.30075

The community rate calculated in this paper is mainly suitable for outpatient and health care expenses, and the serious illness and hospitalization expenses need to be calculated separately. At the same time, the community rate calculated in this paper only includes medical compensation fees, excluding risk reserve and management fees. It is not only feasible to embed the biometric data model into the actuarial model of medical insurance and apply it to the actuarial of social health insurance, but also improve the accuracy of the estimation of financing ratio in actuarial science, and also help to enhance the overall grasp of insurance losses or claims. The research results provide new ideas and methods for actuarial science of social health insurance in China.

6. Conclusions

Because the insurance period is too long, it also brings challenges to the assessment of relevant risks. At the same time, there is also a delay period in long-term health insurance, which is often longer than the period of disability. Its purpose is to observe the health status of the insured and facilitate underwriting claims. In this paper, the biometric data is used to establish a stochastic process model for this problem, and the related problems of long-term health insurance are studied. It is not only feasible to nest the biometric data model in the actuarial model of medical insurance and apply it to the actuarial calculation of social health insurance, but also to improve the accuracy of the estimation of financing ratio in actuarial calculation, and to enhance the overall grasp of insurance losses or claims.

References

[1] Zeng Yi, Zhou Yana, Yang Siqi, et al. Actuarial prediction of the financial operation of the basic medical insurance fund for urban workers under the background of aging-evaluation of the effect of the "comprehensive two-child" policy [J]. China Health Policy Research, 2019, 012(001):9-18.

[2] Qiu Chunjuan, Feng Bai, Chen Tao. Rationality analysis of actuarial assumptions on claims cost of fixed-payment inpatient medical insurance [J]. China Health Statistics, 2015, 32(1):3.

[3] Chen Kai. Discussion on the connotation and extension of health insurance actuarial-Comment on Health Insurance Actuarial [J]. China Education Journal, 2023(2):1.

[4] Tian Yong, Yin Jun, Xue Huiyuan. Design and evaluation of personal account reform scheme for urban workers'

medical insurance [J]. Economic Management, 2018, 40(9):16.
[5] Zhang Xinjie, Zhou Lvlin, Zeng Yi. Study on the impact of birth policy adjustment on the financial burden of medical insurance for urban and rural residents [J]. Financial Research, 2017(10):16.
[6] Yin Jun, Tian Yong, Xue Huiyuan. The impact of having two children in an all-round way and delaying retirement on the balance of income and expenditure of employee medical insurance pooling fund-based on the combined implementation of maternity insurance and employee medical insurance [J]. Statistics and Information Forum, 2019, 34 (5): 9.
[7] Zhao Zhengtang, Wu Jiangping. Promoting the reform of medical insurance system with financial support based on the principle of actuarial balance [J]. Financial Research, 2016(10):5.
[8] Yang Liangchu. It is feasible for retirees to pay medical insurance premiums in the medium and long term [J]. Economic Research Reference, 2016(30):3.
[9] Li Yaqing. Research on the dynamic adjustment mechanism of financial subsidies for basic medical insurance [J]. Journal of public management, 2017, 14(1):14.
[10] Sun Ling, Chi Jiayu. Urban workers' medical insurance system "systematic aging risk" calculation [J]. Statistics and decision, 2021(4):142-146.