Research on the Structural Imbalance of Employee Medical Insurance Fund—Actuarial Analysis Based on A City Data

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Abstract. This paper mainly studies the structural imbalance of the employee medical insurance fund, finds out the possible causes of the imbalance and explores the feasible path to alleviate the structural imbalance of the fund. In order to delay the possibility of surplus deficit and time inflection point of employee medical insurance fund, reduce the payment pressure of employee medical insurance fund, promote the structure optimization and rational allocation of employee medical insurance fund to provide reference. Based on the principles of actuarial science, demography and statistics, this paper builds an actuarial model based on the income and expenditure policies of employee medical insurance fund in A City and historical data, and puts forward constructive suggestions through the sensitivity analysis of the model. The research finds that the income and expenditure scale of the pooling fund for employees' medical insurance in A City have an obvious growth trend in the future, and there will be a structural imbalance problem that the gap between the income and expenditure of the pooling fund for employees' medical insurance is increasing but the personal account is accumulating. The paper argues that reasonable adjustment of wage growth rate and control of per capita fund expenditure growth rate are feasible ways to optimize the allocation structure of employee medical insurance fund, but because of the rigidity of welfare, it is suggested to adopt asymptotic promotion strategy in the reform process.

Keywords: employee health insurance fund · structural imbalances · actuarial model · sensitivity analysis · welfare rigidity

1 Introduction

In 1998,《*Decision of The State Council on establishing the basic medical insurance system for urban workers*》proposed to establish a basic medical insurance system for urban employees that combines pooling funds and personal accounts (hereinafter referred to as "employee medical insurance"). This system has made important contributions to the development of China's medical security cause, especially in resisting the risks of serious and difficult diseases for employees. However, with the change of disease spectrum

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in China, the acceleration of aging rate and the improvement of personal health security demand, the basic medical insurance is facing huge expenditure pressure, and the risk of burnout of the employee medical insurance pooling fund has appeared in some areas. The reason lies in the structural imbalance of fund allocation in the block system design of "overall planning + individual accounts" of employee medical insurance, that is, there is not enough overall planning fund to solve immediate medical risks, while personal accounts accumulate too much. By the end of 2019, the number of insured employees in China had reached 329 million people. The accumulated balance of personal accounts in the employee medical insurance fund exceeds 827.6 billion yuan, accounting for more than 1/3 of the total accumulated balance of the fund and showing a trend of increasing growth. The huge personal account precipitation fund is difficult to effectively play the risk mutual guarantee function of medical insurance. In April 2021, 《*Guiding opinions of The general office of the State Council on establishing and improving the mutual aid guarantee mechanism of outpatient service of basic medical insurance for employees*》 proposed to reform individual accounts of employee medical insurance and establish and improve the mutual aid guarantee mechanism of outpatient service. As you can see, promoting the reform of individual accounts is an important direction to improve the employee medical insurance system. However, it is worth further studying how to adjust the structure of the overall fund and individual accounts, consider the stability and fairness of the system reform, and how to choose the feasible path of the reform more stably. For the above problems, the existing research results are mainly reflected in two aspects. On the one hand, the problems and causes of employee medical insurance are studied. Through empirical research, Lingli Xu found that the fund structural imbalance caused by the increasing personal account balance and the increasing cost of pooling fund was an important factor leading to the abnormal operation of medical insurance fund [1]. Yi Zeng pointed out from the perspective of equity of medical insurance fund that personal account resulted in unfair allocation of outpatient service and poor treatment for employees of different income classes in enjoying outpatient service, which was detrimental to the equity function of employee medical insurance fund [2]. Minglai Zhu pointed out that individual accounts in the employee medical insurance fund cannot play an effective role in restraining medical costs due to the lack of mutual-benefit sharing property, which affects the realization of the value of the employee medical insurance fund [3]. On the other hand, it is studied from the perspective of reform path. Guoen Liu believes that reasonable adjustment of the proportion of personal accounts in employee medical insurance funds is conducive to the control of medical costs and the balance between supply and demand of medical services [4]. Zhuxia Zhu proposed from the perspective of the balance of income and expenditure of the pooling fund that the payment pressure of employee medical insurance fund can be alleviated by increasing income and controlling expenditure [5].

In conclusion, the majority of research has focused on introducing the reform experience of typical region, or from the perspective of the reform necessity of interview, investigation and study, or historical data validation, and from the perspectives of actuarial analysis and forecast the structure change of worker medical insurance fund trend and provide feasible reform path to solve the problem of structural imbalance of the study also relatively small. Therefore, the paper with A City as the research object, based on

the policy of income and expenses of fund of the city worker health and historical data, to build an actuarial model, from the aspect of fund operation structure and trend analysis of the potential risk to the worker medical insurance fund, and based on the model parameter and reasonable debugging, sensitivity analysis to optimize the configuration structure of medical insurance fund, the city worker to alleviate the structural imbalance of the fund to choose the feasible path of reform.

2 Research Design

2.1 Object of Study

This paper chooses A City as the research object for the following reasons:

2.1.1. *As a frontier city of China's reform and opening up, A City has a good foundation in terms of medical security level and medical insurance fund financing capacity.*
2.1.2. *City A, like other cities, faces the problem of insufficient mutual aid of employee medical insurance fund.*
2.1.3. *The proportion of employee medical insurance pooling fund transferring to personal account in A City is higher than that in most cities, and the structural imbalance between pooling fund and personal account is more prominent.*
2.1.4. *The population structure of City A is relatively young, but there are many high-income people. As the aging rate accelerates in the future and the demand of high-income people for high-quality medical services increases, the employee medical insurance fund will face great payment pressure. Therefore, the selection of A City as the research object is typical and representative of simulation analysis, and also has important reference significance to promote the reform of employee medical insurance system in developed areas.*

2.2 Data Sources

The data in this paper are from the primary data provided by the Medical Security Bureau of A City, including:

2.2.1. *Since 2000, the number of employees participating in medical insurance (including the number of on-the-job participants and the number of retired participants) and the age structure of the insured.*
2.2.2. *Data of income, expenditure and transfer ratio of employee medical insurance fund since 2014.*
2.2.3. *Data such as payment base and payment rate of employee medical insurance.*

It should be noted that the empirical research of this paper is carried out on the basis of effective cleaning, classification and quality control of original data. Due to the length of this paper, the process of data cleaning, classification and quality control is omitted below.

2.3 Actuarial Model Construction

Based on the principles of actuarial science, demography and statistics, an actuarial model of employee medical insurance fund in City A is established, which is composed of model factors such as total fund revenue, total fund expenditure and fund balance. Among them, the total fund income includes the overall fund income (current levied income, interest income, fiscal subsidy income and other income) and personal account income (current levied income, Interest income). Fund total depositions include as a whole fund depositions (on-the-job worker depositions, retired worker depositions, other depositions) and individual account depositions (on-the-job worker depositions, retired worker depositions). The fund balance is derived from total income minus total expenditures.

The exact algorithm process of this paper is as follows:

Firstly, the population structure prediction model is constructed to analyze the change of the number of employees (including the number of on-the-job employees, the number of retired employees, the number of deaths and so on). Secondly, the actuarial models of the income and expenditure of the employee medical insurance pooling fund and personal account are constructed to predict the internal structure change trend of the employee medical insurance fund. Thirdly, the total actuarial model of employee medical insurance fund is constructed to analyze the potential operation risks of the fund.

2.3.1 Demographic Prediction Models

Assuming that WP_t represents the number of active insured persons in year t, g_t represents the growth rate of active insured persons in year t relative to year $(t-1)$, RP_t represents the number of retired insured persons in year t, $P_{x,t}$ represents the number of insured persons in year t, $q_{x-1,x}$ represents the death rate of the population aged from $(x-1)$ to x, Then, the prediction model of the number of in-service insured persons and the number of retired insured persons in A City is as follows:

$$WP_t = WP_{(t-1)} * \left(1 + g_t\right)$$

$$RP_t = P_{55,t} + P_{56,t} + \ldots + P_{100,t} = \sum_{i=55}^{100} P_{i-(t-2019)+1,2019} * \tag{1}$$

$$\prod_{x=55-(t-2019)+1}^{i} \left(1 - q_{x-1,x}\right) \tag{2}$$

In Formula (1), the current number of insured persons is directly related to the number of insured persons and the growth rate of insured persons in the previous year. In Formula (2), the number of retirees insured in the current year is predicted by the functional relationship between the number of retirees insured in the current year (all employees in line with the retirement age range) and the population mortality rate, but the age benchmark should conform to the current situation of City A. For details, see parameter setting.

2.3.2 Actuarial Model of Fund Income and Expenditure for Employee Medical Insurance Pooling

Assuming that I_t represents the total income of the employee's medical insurance pooling fund in the year t, IP_t represents the contribution income of the employee's medical insurance pooling fund in the year t, II_t represents the interest income of the employee's medical insurance pooling fund in the year t, IU_t represents other income (such as financial subsidies) of the employee's medical insurance pooling fund in the year t, W_t represents the annual average wage of employees employed in urban units in the year t, f_t represents the rate of enterprise contribution in the year t, λ_t represents the proportion of enterprise contribution into the pooling fund of employee medical insurance fund in the year t, r_t represents the rate of return of employee medical insurance fund in the year t, AF_t represents the accumulated balance of employee medical insurance pooling fund in the year t. In addition, the assumption O_t worker health care as A whole fund expenditure, said the first t years $O_{(t)}$ is the first t year worker medical insurance fund expenditure per capita k_t said the t years relative to the $(t - 1)$ worker health care as a whole fund ginseng protect personnel to the per capita annual expenditure growth rate, then A City worker health insurance fund income and expenditure actuarial models are:

$$I_t = WP_t * W_t * f_t * \lambda_t + (AF_{t_0} + \sum_{i=t_0+1}^{t-1} AC_i) * r_{(t-1)} + IU_t \tag{3}$$

$$O_t = [WP_t + RP_t] * O(t-1) * k_t \tag{4}$$

Among them, the total income of the employee medical insurance pooling fund in the t year is composed of the contribution income, interest income and other income of the employee medical insurance pooling fund in the current year. The contribution income of the employees' medical insurance pooling fund in the current year is affected by many factors, such as the number of employees participating in the current year, the average annual wage of employees employed in urban units, the rate of enterprise contribution, and the proportion of employees' medical insurance fund enterprise contribution included in the pooling fund. In those days, the interest income of the fund of the worker's medical insurance plans as a whole is decided by the function relation between the accumulated balance of the fund of the worker's medical insurance and the yield of the fund of the worker's medical insurance. In this paper, the base year of the accumulated balance of the employee medical insurance pooling fund is 2019, and the current balance is derived from the difference between the total income and total expenditure of the pooling fund. In addition, the total expenditure of employees' medical insurance pooling fund in that year is mainly affected by the number of employees and retired participants, the per capita expenditure of employees' medical insurance pooling fund and its growth rate.

2.3.3 Actuarial Model of Individual Account Income and Expenditure for Employee Medical Insurance

Suppose that PAI_t represents the total income of the employee's individual medical insurance account in the t year, $PAIP_t$ represents the contribution income of the employee's

individual medical insurance account in the t year, $PAII_t$ represents the interest income of the employee's individual medical insurance account in the t year, α_t represents the proportion of the employee's medical insurance fund enterprise contribution transferred to the individual account in the t year, β_t represents the individual contribution rate of the employee in the t year, PAB_t represents the accumulated balance of the employee's personal medical insurance account in the t year, PAO_t represents the total expenditure of the employee's personal medical insurance account in the t year, and PAO (t) represents the t year per capita personal account expenditure for medical insurance of employees in year t, θ_t represents the growth rate of per capita annual expenditure of personal account for medical insurance of employees in year t relative to year (t − 1), then the actuarial models of personal account income and expenditure for medical insurance of employees in City A are as follows:

$$PAI_t = WP_t * W_t * f_t * \alpha_t + WP_t * W_t * \beta_t + \left(PAB_{t_0} + \sum_{i=t_0+1}^{t-1} PCB_i\right) * r_{(t-1)} \tag{5}$$

$$PAO_t = [WP_t + RP_t] * PAO(t-1) * \theta_t \tag{6}$$

Among them, the total income of the employee's personal medical insurance account in the t year is composed of the payment income and interest income of the employee's personal medical insurance account in the current year; The income from the employee's personal account for medical insurance in the current year is affected by the number of employees in the current year, the average annual wage of employees employed in urban units, the rate of enterprise contribution, the proportion of enterprise contribution of employee's medical insurance fund transferred into individual accounts, and the rate of individual contribution of on-the-job employees. The interest income of individual account of employee medical insurance in the current year is affected by factors such as accumulated balance and yield of individual account of employee medical insurance in the previous year. The base year of the balance of the employee's personal medical insurance account in this paper is 2019, and the balance of the current period is derived from the difference between the total income and total expenditure of the employee's personal medical insurance account in the current period. In addition, the total expenditure of employees' personal accounts for medical insurance in that year is mainly affected by the number of in-service and retired participants, the per capita expenditure of employees' personal accounts for medical insurance and its growth rate.

2.3.4 Total Actuarial Model of Employee Health Insurance Fund

Integrate the above actuarial model of employee medical insurance pooling fund and personal account income and expenditure, namely, merge Eqs. (3) and (5), (4) and (6) respectively, and obtain the actuarial model of total income and total expenditure of employee medical insurance fund in A City. The difference between the two is the summative actuarial model of employee medical insurance fund in A City.

2.4 Parameter Setting

2.4.1 Average Wage Growth Rate of Employees

Since the average wage growth rate of urban workers in China is basically the same as the GDP growth rate, the average wage growth rate of on-the-job workers in City A is set to be consistent with the GDP growth rate of City A in 2019, so the monthly average wage growth rate of on-the-job workers in City A is set to be 7.2%.

2.4.2 Rate of Return of Health Insurance Fund

According to the regulations of The State Council on the deposit interest of medical insurance fund, the rate of return of medical insurance fund in City A is set at 2%.

2.4.3 Personal Accounts Are Included in the Proportion

Set the income of employee medical insurance fund in A City and charge it into personal account with 5% of basic payment data every month. The reason is that, according to the policy of A City, only the first gear medical insurance enrollee have personal accounts, and the proportion of enterprise payment into the pooling fund and personal account is 50%.

2.4.4 Rules for Other Parameters

It is assumed that the maximum living age of employees in City A is 100 years old, and the mortality rate is consistent with the data of the seventh national census. The minimum age of employed insured persons is 16, regardless of gender, which is the same age structure as the economically active population in urban areas during the seventh National Census. The average retirement age of employees is set at 55 (the current retirement policy is 60 for men and 50 for women). In the future, the population development trend of City A generally conforms to the UN prediction standard, and the prediction time is set as 2019–2050. During the forecast period, the income of employee medical insurance fund in A City mainly comes from payment income and interest income, while fiscal subsidy and other income are 0. During the forecast period, the effect of inflation on the income and expenditure of employee medical insurance fund is not considered. During the forecast period, non-quantitative indexes such as medical behavior and settlement mode have little influence on the income and expenditure of employee medical insurance fund.

3 Analysis of Empirical Results

3.1 Actuarial Results of Employee Medical Insurance Pooling Fund and Personal Account

Based on the above actuarial model, an actuarial prediction analysis is made on the income and expenditure of the employee medical insurance pooling fund in A City. The results show that the income and expenditure scale of the insurance pooling fund for future employees in A City have an obvious growth trend. Specifically, the revenue of

the pooling fund will be 13.9 billion yuan in 2019 and 15.4 billion yuan in 2020, and will increase to 30.3 billion yuan in 2050. The expenditure of the pooling fund will increase from 4.1 billion yuan in 2019 and 4.7 billion yuan in 2020 to 354.6 billion yuan in 2050. If the state prediction is deduced by adjusting the variables set by the actuarial model, with the increase of years, the scale of coordinated fund expenditure will become larger and larger, while the scale of current and accumulated balance will continue to decrease. Starting from 2033, the current balance of the pooling fund will be smaller than the scale of the pooling fund expenditure. In 2047, there will be a deficit gap in which the expenditure is greater than the income. In 2050, the deficit gap will reach 54.3 billion yuan, indicating that according to the current policy design, the pooling fund for employees' medical insurance in A City will have structural operation risks in the future.

Actuarial results of personal account receipts and expenditures show that the income, expenditure and balance scale of personal account of employee medical insurance in A City all show a rising trend, and the current balance and accumulated balance scale of personal account will become larger and larger during the forecast period. Main reason is that A 5% of the City according to the monthly payment base plan into personal accounts, transfer rate is too high, weaken the fund of medical risk in all aid support capability, to promote the efficiency of fund using, indicates that A City worker medical insurance fund allocation are structural imbalances, and the problems with the increase of years will be more and more obvious.

3.1.1 Actuarial Results of Total Income and Expenditure and Internal Structure Trend of Employee Medical Insurance Fund

According to the growth rate of all kinds of indicators and variables set during the forecast, the overall income and expenditure of employee medical insurance fund in A City can maintain basically stable operation in a long period of time. Table 1 shows the overall income and expenditure of employee medical insurance fund in A City. Specifically, the total income and total expenditure of fund in A City are 37.1 billion yuan and 8.6 billion yuan respectively in 2019, and will reach 297.3 billion yuan and 134.4 billion yuan respectively in 2040. The sum balance of fund in the current period is in a relatively healthy state. However, if the trend continues, starting from 2043, the total expenditure of the employee medical insurance fund in A City will be greater than the current summary balance, indicating that after 2043, the expenditure growth of the employee medical insurance fund in A City will accelerate, and the fund management will face payment pressure.

The actuarial results of the internal structure trend show that although the income of the pooling fund and the income of the personal account of employees in A City are both growing, the growth rate of the income of the personal account is faster than that of the pooling fund. In addition, the proportion of personal account expenditure and overall fund expenditure in total fund expenditure changes in the opposite trend, showing that the scale of overall fund expenditure is greater than the scale of personal account expenditure, and there is a trend of intensification. Therefore, from the overall structure and trend of the fund, the employee medical insurance fund in A City will also face sustainability challenges.

Table 1. Forecast of overall income and expenditure of employee medical insurance fund in A City

Year	Total Income of Employee Medical Insurance Fund in A City (100 Million Yuan)	Total Expenditure of Employee Medical Insurance Fund in A City (100 Million Yuan)	Balance of Current Medical Insurance Fund (100 Million Yuan)
2019	371	86	285
2020	410	97	312
2025	673	180	492
2030	1104	343	761
2035	1812	672	1140
2040	2973	1344	1629
2045	4879	2739	2141
2050	8008	5666	2343

3.2 Sensitivity Analysis Results

In order to test the reliability and sensitivity of the above actuarial model, this part analyzes the sensitivity of the actuarial model from the perspectives of average wage growth rate and fund per capita expenditure growth rate respectively.

First, the sum balance of employee medical insurance fund in A city under different average wage growth rates was simulated. Assuming that other parameters remain unchanged, the wage growth rate will be raised or lowered to 3.5%, 4.5%, 5.5%, 6.5% and 7.2% respectively. As shown in Fig. 1, the overall sum balance of medical insurance fund in City A shows A trend of first rise and then decline. However, under the influence of different wage growth rates, the trend change range of sum balance of fund is different. For example, when the wage growth rate is 3.5%, A city will have A surplus deficit of medical insurance fund in 2041, and the deficit will reach 306.3 billion yuan in 2050. At a wage growth rate of 4.5%, there would be a $9.5 billion surplus in 2044. When the wage growth rate is 5.5%, there will be fund surplus deficit in 2048, and the deficit will be 86.4 billion yuan in 2050. But when wage growth stays at 6.5% or 7.2%, the surplus of employee medical insurance fund in A city is less likely to be in deficit before 2050.

Further, the summary balance of employee medical insurance fund in A City is simulated under different per capita expenditure growth rates of the fund. It is assumed that the growth rate of per capita expenditure of the fund is adjusted up or down to 11%, 13%, 15% and 17% respectively, except for the growth rate of per capita expenditure of the fund. As shown in Fig. 2, when the per capita expenditure growth rate of the fund is 17%, the summary balance of the medical insurance fund for employees in A City will be in deficit in 2044, and the deficit will reach 367.7 billion yuan in 2050. But if the fund per capita expenditure growth rate is controlled respectively at the levels of 15%, 13% and 11%, the possibility of deficit problems in the employee medical insurance fund of A City decreases successively before 2050.

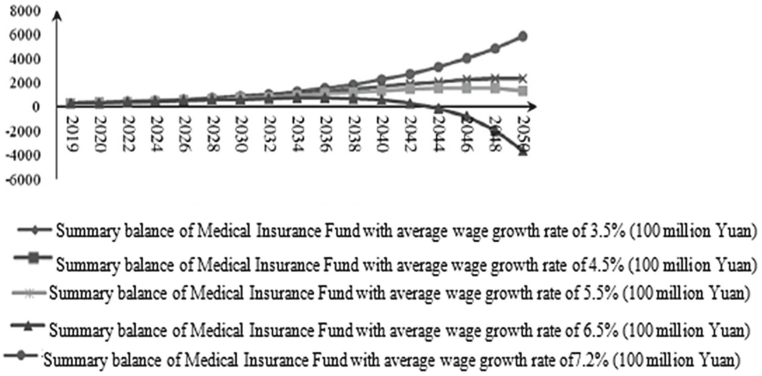

Fig. 1. Summary balance of employee medical insurance fund in A City under different average wage growth rates

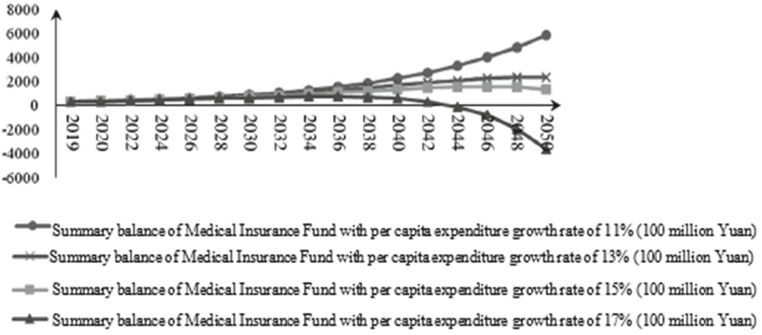

Fig. 2. Summary balance of employee medical insurance fund in A City under different per capita expenditure growth rates

It shows that the actuarial model has good reliability and sensitivity, and another feasible way to alleviate the structural imbalance of the fund is to reasonably control the growth rate of per capita expenditure of the employee medical insurance fund.

4 Research Conclusions and Policy Recommendations

4.1 Main Conclusion

The income and expenditure scale of the insurance pooling fund for future employees in A City have an obvious growth trend, and the balance between the current period and the accumulated balance shrinking, as a whole fund income gap and the gap is gradually expanding, but the worker medical insurance personal accounts of balance of payments and are in the rising trend, the balance amount in the forecast period income growth is higher than the growth and the gap is bigger, A City worker medical insurance fund allocation of existing structural imbalances, and with the increase of years, the problem will be more and more obvious.

4.2 Policy Suggestion

Based on the empirical analysis results of City A, the following two policy implications and suggestions can be obtained on how to alleviate the structural imbalance of employee medical insurance fund:

First, the key elements of the smooth operation of the employee medical insurance fund should be controlled, and the allocation structure of the employee medical insurance fund should be optimized through reasonable adjustment of sensitive indicators such as the growth rate of employee salary and the growth rate of fund per capita expenditure. According to the actuarial model and sensitivity analysis of City A, if the sensitive index is adjusted to a reasonable range or range, the possibility of deficit and time inflection point of the summary balance of employee medical insurance fund can be delayed, and the payment pressure of employee medical insurance fund can be reduced. At the same time, the pilot reforms being carried out in many places in China also show that we can reasonably adjust the growth rate of employee wages, the growth rate of fund per capita expenditure and other sensitive indicators and can optimize the configuration structure and running state of employee medical insurance fund.

Secondly, the reform process of employee medical insurance fund should consider the factors of employee rights and social welfare rigidity, and it is suggested to adopt asymptotic promotion strategy. Since the reform of individual medical insurance accounts directly involves the welfare rights and interests of employees, the reform concept needs to follow the principle of welfare rigidity, that is, the social welfare that employees enjoy is only allowed to have increasing flexibility, but not allowed to decline. As a result, the worker medical insurance personal accounts specific reforms before landing, the local health departments to do a good job in publicity and strategies to mitigate type prior to pilot and simulation run, in the process of simulation of pilot should be as widely as possible to consider all kinds of influence factors, and through the survey and the interview form to worker groups such as the subjective wishes and expectations, Obtain the understanding and recognition of the reform of the majority of workers, smoothly achieve the reform goal of the replacement of rights and interests of the individual accounts of the employees' medical insurance, and promote the structure optimization and rational allocation of the employees' medical insurance fund.

References

1. Xu LL (2011) The sharing effect of social pooling payment on residents' lifetime medical expenditure-an empirical study on urban workers' basic medical insurance policy. World Econ Rev 2:68–86
2. Zeng Y (2012) A study on the equity of individual accounts of basic medical insurance for urban workers in China. J Shanghai Univ Financ Econ 1:77–84
3. Zhu ML, Li T, Liu Y (2018) A study on the operating efficiency of urban employees' personal medical accounts. Insurance Res 3:91–105

4. Liu GE, Tang TT, Lei Z (2009) The impact of individual medical insurance accounts on medical expenses: panel analysis based on medical insurance data in Zhenjiang. China Health Econ 2:9–12
5. Zhu ZX, Yang YS, Wang TY (2013) A study on the balance of income and expenditure of medical insurance pooling fund for urban workers-an empirical analysis based on the data of C City. Public Manag Rev 1:20–37