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Forecasting health financing sustainability under the unified pool reform: evidence from China's Urban Employee Basic Medical Insurance

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Abstract

Objective The integration of the health insurance fund pool may threaten the sustainability of the fund by increasing its expenditures through the exacerbation of the moral hazard of participations. The purpose of this paper is to assess and predict the impact of the single pool reform of China's Urban Employee Basic Medical Insurance (UEBMI) on the expenditure and sustainability of the health insurance fund.

Methods In this paper, we consider the pilot implementation of the single pool reform in some provinces of China as a quasi-natural experiment, and develop a staggered DID model to assess the impact of the single pool reform on medical reimbursement expenditure. Based on the results, an actuarial model is developed to predict the impact on the accumulated balance of China's health insurance fund if the single pool reform is continued.

Results We found that the medical reimbursement expenditure would increase by 66.4% per insured person after the unified provincial-level pool reform. There is individual heterogeneity in the effects of the unified single pool reform on medical reimbursement expenditure, and the reimbursement expenditure of retired elderly has the largest increase. If the unified single pool reform is gradually promoted, the current and accumulated balance of the UEBMI pooling fund would have gaps in 2031 and 2042, respectively.

Conclusion We verified that a larger fund pool will bring unreasonable growth of fund expenditures, which will threaten the sustainable development of health insurance. To minimize the impact of the unified single pool reform on the sustainability of the health insurance fund, we suggest strengthening the monitoring of moral hazard behavior, promoting the delayed retirement system, and encouraging childbearing.

Keywords Unified single pool, Health insurance funds, Healthcare purchasing, Fund sustainability, Staggered DID, Actuarial model

Introduction

Although increasing the level of the health insurance fund pool can improve the fund's ability to withstand risks, its negative effects have not received enough attention [1]. The larger the fund pool, the more likely it is to induce moral hazard among regulators, health care organizations, and enrollees, leading to unreasonable growth in health care expenditures that threatens the sustainability of the health insurance fund [2]. The single pool arrangement, which set up horizontal integration of funds and a vertical chain of management, would trigger

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the conflict of interest between the upper and lower levels of government [3]. Due to the self-interest maximization considerations, the lower level governments would relax the supervision of healthcare purchasing [4]. In the absence of strong regulation of healthcare organizations, doctors will induce patients to overmedicate, resulting in higher healthcare expenditures [5].

China's Urban Employee Basic Medical Insurance (UEBMI) system started with pooling at the county level, and the health insurance fund was decentralized into a number of small pools. Due to the frequent movement of China's population between regions, there is a large disparity in the fund balance status of different regions. Places with a large inflow of people have larger balances, while places with a net outflow of people have smaller fund balances [6]. Therefore, the government is promoting the fund pool reform, which aims to unify the scattered fund pools managed by different cities into a single fund pool managed by the province to make the system more resilient to risks [7]. Now that municipal integration has been completed, provincial integration has become the focus of reform. However, we have found that the single pool reform has been accompanied by unanticipated increases in medical reimbursement expenditure.

Moral hazard may be the main reason for the increase in the cost of medical claims in the process of single pool reform [8, 9]. Centralized pool and third-party payment mechanisms lead to efficiency losses due to imperfect information [10]. An increase in moral hazard is associated with an increase in the size of the pool. When the pool is large, all members in the pool make little effort to avoid expected losses. The appropriate size of the pool should be determined on the basis of moral hazard [11]. Some balance should be struck between the gains from increasing the level of pooling and the losses from moral hazard [12].

Researchers have studied the effects of the unified single pool of health insurance on the behavior of governments, health care providers and enrollees. The unified single pool will distort the government's fund management behavior [9, 13]. In the reform, when the pooling level was raised from city to province, the dominance of the health insurance fund was transferred to the provincial government, and the municipal government was responsible for the collecting and disbursing the funds [14]. The separation of fund allocation power and fund management obligation might cause moral hazard of the government [10, 11]. Since there was no need to bear the bottom-line responsibility of the health insurance fund, the municipal government would relax supervision, leading to a substantial increase in the fund's health care purchasing [7, 15].

The unified single pool would also lead to a reduction in oversight of healthcare providers, which in turn would lead to increased demand and overmedication to maximize profits [16]. After pooling, the pursuit of more advanced medical services may lead enrollees who were previously outpatients in lower-quality medical facilities to higher-grade medical facilities for more expensive medical services [17–19]. These actions will lead to excessive spending on medical care, which will ultimately threaten fund balances and seriously affect the sustainability of health insurance [20, 21].

Most of the literature focuses on the impact of the health insurance fund pool reform on the behavior of the government, medical institutions and enrollees, but few scholars have conducted a scientific policy evaluation of the impact of upgrading the level of the health insurance fund pool on the reimbursement behavior of health insurance [4]. In addition, few studies have conducted systematic research from a macro perspective to examine the impact of changes in the health insurance consumption behavior on the sustainable operation of the fund [8, 22, 23]. Although scholars such as Dong demonstrated that the centralized management of funds led to an increase in health care expenditure [24], there is still a need to predict the impact on the fund balance.

Therefore, this paper aims to examine the impact of fund pool expansion on the sustainable development of the fund from both micro and macro perspectives. First, we utilized the provincial-level pooling reform of China's Urban Employee Basic Medical Insurance as a quasi-experiment, and built a staggered DID (difference-in-difference) model to assess the effects on healthcare purchasing. Then, an actuarial model of the fund was built to forecast the health fund's sustainability. The above study will provide inspiration for determining a reasonable fund pool size and answering the question of how to ensure the fund's sustainability while expanding the pool.

The highlights of the paper were as follows. Firstly, we utilized the staggered DID model to test the effects of the unified single pool reform on the healthcare expenditure which could avoid the endogeneity effectively. Secondly, we analyzed the reasons of the increase in healthcare expenditure combined with the official documents related to the pilot provinces. Thirdly, the healthcare expenditure of participants by different region, age, and gender was examined to predict the UEBMI funds sustainability more accurately.

Methodology

Reform structure

Since the establishment of China's Urban Employee Basic Medical Insurance (UEBMI) in 1998, China has formed a

fragmented health insurance system in urban areas. Fragmentation hindered the mutual aid function of health insurance, so the Chinese government began to promote the reform of fund pooling, raising the level of pooling from the municipal level to the provincial level.

In the process of provincial pooling reform, the centralization of fiscal power has been accompanied by the decentralization of administrative power. Centralization of fiscal power allow the provincial government to allocate health funds effectively, and diversify the risk of imbalances in municipal health funds. However, decentralization of administrative power created conditions for municipal governments to relax the supervision of health insurance funds. Due to the indulgence of health insurance fund expenditures by the municipal government, physician-induced demand and patient over-treatment have followed. Figure 1 shows the reform structure of provincial pooling arrangement in China.

Estimation method

China has endeavored to increase the pooling level to improve the mutual assistance capacity between cities. From 2000 to 2018, seven provinces successively implemented the unified single pool reform of UEBMI. Table 1 shows the provinces that have implemented pooling reform and the year of implementation. Given the differences in the timing of unified single pool reform across provinces, this paper used the staggered DID model to test the effects of the reform on medical reimbursement expenditure which was paid by the health fund [25]. In this paper, the provinces that implemented the unified single pool reform were defined as the treatment group, and the provinces that did not implement the unified single pool reform were defined as the control group. The model settings are as follows:

$$Y_{ict} = \beta_1 + \beta_2 \, Provpool_{ict} + X_{ict}^{'}\delta \, + \epsilon_{\,ict} \qquad (1)$$

Among them, the explained variable Y_{ict} is the patient's medical expenditures; the core explanatory variable $Provpool_{ict}$ indicates whether the province c where the individual i is located implements the unified single pool reform of UEBMI in period t. $Provpool_{ict}$=1 means that the province c where the individual i is located has implemented the unified single pool reform in period t, otherwise it is 0. $X_{ict}^{'}$ is the set of all control variables. Referring to related studies [4, 26], individual characteristic variables, health status variables and regional GDP per capita were selected as control variables in this paper. $\epsilon_{\,ict}$ is a random disturbance.

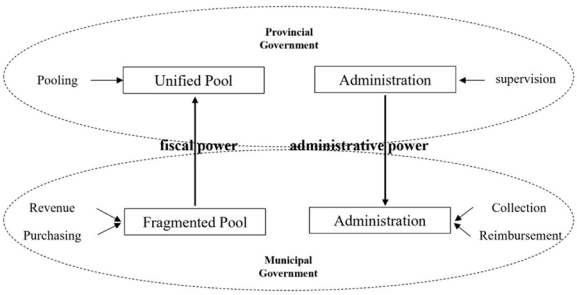

Fig. 1 Provincial pooling arrangement in china

Table 1 Implementation year of pilot provinces

Province	Pooling year
Shanghai	December 1, 2000
Beijing	April 1, 2001
Tianjin	November 1, 2001
Tibet	October 1, 2009
Chongqing	October 24, 2011
Hainan	January 01, 2012
Ningxia	January 1, 2017

Prediction approach

The UEBMI account in China is generally divided into two parts: the pooling account and the personal account. The pooling account implements the pay-as-you-go system, which is mainly used to pay for hospitalization and some outpatient medical expenditures. In general, the finance department bears the risk of making ends meet. The personal account implements a full accumulation system. It is mainly used to pay for medical expenditures that are not reimbursed by health insurance. If the balance in the personal account is insufficient, the individual will make up for it. Since the Chinese Ministry of Finance is only responsible for the security of the pooling fund account, and the unified single pool reform targets the pooling account fund, this paper mainly discusses the financial status of the pooling fund of UEBMI. Based on this, this article constructs actuarial models to quantitatively assess the impact of the unified single pool reform on the pooled fund. Specifically, we develop the model of pooling fund revenue, pooling fund expenditure, and pooling fund cumulative balance based on the practice of Feng [27] and Plamondon [28].

Actuarial modelling

(1) Population forecasting model. The construction of the population forecasting model takes full account of the quantity and structural characteristics of the population [29]. This paper divides the population into urban male population, urban female popula-

tion, rural male population and rural female population, and then uses the cohort element method combined with life table fitting, total fertility rate and other techniques to construct a population forecasting model with 2020 as the base period.

First, the urban population by age and gender in year t is the urban population by age and gender in year t-1 multiplied by the survival rate of the corresponding age group, multiplied by the net migration rate of the rural population by gender and age in year t. Then, the number of births in year t under different birth scenarios is added.

Assuming that the ratio of male to female births remains the same in 2020, the number of newborn children is obtained by multiplying the fertility rate by the number of women of childbearing age (15–49 years). The age- and gender-disaggregated urban population of each province in year t is obtained by multiplying the country's total age- and gender-disaggregated population in year t by the proportion of the population of the corresponding province in the national population. The specific expression is as follows:

$$N_{t,s} = N_{t,s}^{m} + N_{t,s}^{w} = N_{t}^{u} + N_{t}^{r} = \sum_{x=1}^{l} N_{t,x}^{u} \cdot (1 - R_d) + \sum_{x=15}^{49} N_{t,x,w}^{u} \cdot R_{b,x} + \sum_{x=0}^{l} N_{t,x}^{r} \cdot R_i \quad (2)$$

$$N_{t,s,g} = N_{t,s} \cdot R_g \quad (3)$$

In the two equations above, m is male, w is female. u stands for urban, and r for rural. x denotes age, l life expectancy. $N_{t,s}$ is the total urban population in year t, $N_{t,s,g}$ is the total urban population of province g in year t. $N_{t,s}^{m}$ is the urban male population in year t, $N_{t,s}^{w}$ is the urban female population in year t. N_{t}^{u} is the total urban population in year t, N_{t}^{r} is the number of people who migrated from rural areas to cities in year t. $N_{t,x}^{u}$ is the number of urban population aged x in year t, and R_d is the death rate. $N_{t,x,w}^{u}$ is the number of women of childbearing age in urban areas, $R_{b,x}$ is the fertility rate of women of childbearing age at age x. $N_{t,x}^{r}$ is the number of people aged x in rural areas in year t, and R_i is the net migration rate of the rural population to urban areas. R_g is the share of the population of province g in the total population.

(2) Pooling fund revenue model. This paper first obtains the social average wage of each province from the China Labor Statistical Yearbook, which is used as the per capita contribution base for health insurance. The per capita contribution of health insurance in each province is obtained by multiplying the per capita contribution base by the contribution rate, and the revenue of the provincial health insurance fund is the per capita contribution multiplied by the number of insured workers. The total revenue of the national health insurance fund is obtained by summing up the revenue of the provincial health insurance funds. Finally, according to the ratio between the pooling account and the individual account, the total revenue of the pooling fund in year t is obtained. Therefore, the specific expression of the total revenue of the pooling fund is:

$$S_t = \sum S_{t,g} = \sum N_t \cdot Q_t \cdot R_g \cdot W_{t,g} \cdot R_t^1 \cdot R_t^2 = \sum \left(\sum_{a_t^m}^{b_t^m - 1} N_{t,x}^{m} \cdot Q_t^{m} + \sum_{a_t^w}^{b_t^w - 1} N_{t,x}^{w} \cdot Q_t^{w} \right) \cdot R_g \cdot W_{2020,g} \cdot \prod_{s=2020}^{t} (1 + k_s) \cdot \left(R_t^p + R_t^c \right) \cdot R_t^2 \quad (4)$$

In formula (4), S_t is the total revenue of the pooling fund, and $S_{t,g}$ is the revenue of the pooling fund of province g. N_t is the total number of employees in year t, $N_{t,x}^{m}$ is the number of male employees aged x in year t, and $N_{t,x}^{w}$ is the number of female employees aged x in year t. a_t^m is the initial enrollment age of males in year t, and a_t^w is the initial enrollment age of females in year t. b_t^m is the retirement age of men, and b_t^w is the retirement age of women. $W_{t,g}$ is the average wage of urban workers in province g in year t, $W_{2020,g}$ is the average wage of urban workers in province g in the base year 2020, and k_s is the average wage growth rate of urban workers in year s. R_t^1 is the contribution rate of UEBMI, R_t^p is the individual contribution rate of UEBMI, and R_t^c is the unit contribution rate of UEBMI. Q_t is the insurance participation rate of urban employees in year t, where Q_t^m is the insurance participation rate of male employees, and Q_t^w is the insurance participation rate of female employees. R_t^2 is the share of the fund allocated to the pooling fund account. The meaning of the other symbols is the same as the one above.

(3) Pooling fund expenditure model. The total expenditure of the pooling fund is the sum of the medical reimbursement expenditure of the insured persons in each province. First, this paper obtains the per capita medical reimbursement expenditure in each province

from the China Labor Statistical Yearbook. Considering that some provinces may implement the single pool reform in the future, and the per capita medical reimbursement expenditure will change accordingly, this paper simulates the future pooling fund expenditure based on the growth rate of reimbursement expenditure considering age and gender. The future per capita medical reimbursement expenditure in provinces that are expected to implement single pool reform is obtained by multiplying the base reimbursement expenditure in the province by the growth rate of reimbursement expenditure. The per capita medical reimbursement expenditure in year t is multiplied by the total number of enrollees in each province, and then summed up to obtain the total pool fund expenditure:

$$C_t = \sum C_{t,g} = \sum (N_t \cdot Q_t^1 + N_t' Q_t^2) \cdot R_g \cdot \bar{W}_{t,g} \cdot Q_t \cdot (1 + R_g^i)$$

$$= (\sum_{a_t^m}^{b_t^m - 1} N_{t,x}^{m,1} \cdot Q_t^{m,1} + \sum_{a_t^w}^{b_t^m - 1} N_{t,x}^{w,1} \cdot Q_t^{w,1} + \sum_{b_t^m}^{l} N_{t,x}^{m,2} \cdot Q_t^{m,2} + \sum_{b_t^m}^{l} N_{t,x}^{w,2} \cdot Q_t^{w,2}) \cdot R_g \cdot \bar{W}_{2020,g} \cdot \prod_{s=2020}^{t} (1 + k_s') \cdot Q_t \cdot (1 + R_g^i) \quad (5)$$

In formula (5),C_t is the total expenditure of the pooling fund. N_t is the total number of employees in year *t*. N_t' is the total number of retired employees in year *t*. Q_t^1 is the participation rate of employees, and Q_t^2 is the insurance participation rate of the retired. l is the life expectancy. $\bar{W}_{t,g}$ is the per capita medical reimbursement expenditure of urban employees in province g in year t, and $\bar{W}_{2020,g}$ is the average medical reimbursement expenditure in the base year 2020. k_s' is the growth rate of medical reimbursement expenditure over time in year *t*. R_g^i is the growth rate of per capita reimbursement expenditure caused by pooling arrangement reform (when $i=0$, it means that the unified single pool reform is not implemented; when $i=1$, it means that the unified single pool reform is implemented). The meanings of the other symbols are the same as those described above.

(4) Pooling fund cumulative balance model. The cumulative balance model of the pooling fund is obtained from the sum of the cumulative balance of previous years and the current balance. The cumulative balance is obtained by multiplying the current balance over the years by the regular interest rate, and the current balance is obtained by multiplying the current balance by the one-year interest rate:

$$Y_t = Y_{t-1} \cdot (1 + r_f) + (S_t - C_t) \cdot (1 + r_p) = Y_{2020} \cdot \prod_{s=2021}^{t} \left(1 + r_f^s\right) + (S_t - C_t) \cdot (1 + r_p) \quad (6)$$

In formula (6), Y_t is the cumulative balance of the pooling fund for urban employees in year *t*. r_f is the one-year deposit rate, $r_f^s$is the one-year deposit rate in year s, and r_p is the one-year demand deposit rate. The current balance of the pooling fund is obtained by subtracting the current expenditure from the current revenue.

Parameter setting

(1) Number of participants in UEBMI. Firstly, the size and structure of the urban population are forecasted. Based on the urban population by gender and age in the 2020 census data, the population by gender and age in 2020–2050 is recursively calculated year by year through the fertility rate and death rate. Based on the Chinese fertility rate of 1.3 in 2020, the total fertility rate in 2020 is set to be 1.3. The age-specific mortality data are taken from the China Population Statistical Yearbook. Assume that the population structure, fertility rate and mortality rate remain unchanged for some time.

Second, calculate the insurance participation rate of the urban population by age and gender. It is assumed that age 16 is the initial enrollment age and that males retire at 60 and females at 50. The number of insured workers by age and gender in year t equals the number of insured workers by age and gender in year t-1 multiplied by the corresponding probability of survival plus the urban employed population at age 16. The number of insured workers by age and gender in year t in province g equals the number of enrolled workers by age and gender in year t multiplied by R_g.

(2) Per capita contribution base. According to the Decision of the State Council on Establishing the UEBMI, the basic health insurance premiums are paid jointly by units and individuals, of which 6% is paid by the unit and 2% by the individual, for a total of 8%. In this paper, the provincial average wage is

used as the base for both individual and company contributions [30].

(3) Per capita reimbursement expenditure. Per capita reimbursement expenditure in each province is taken from the China Labor Statistical Yearbook. As some provinces have implemented the unified single pool reform before 2020, their per capita reimbursement expenditure will change. This paper uses CFPS micro data to calculate the increase in per capita reimbursement expenditure after pooling. According to the empirical results, the implementation of provincial pooling led to an increase of 928.558 CNY in per capita medical reimbursement expenditure, a growth rate of 66.4%. Therefore, this paper assumes that after the implementation of the unified single pool reform, the per capita reimbursement expenditure will increase by 66.4%. In addition, the paper considers the influence of population, wages, GDP, and inflation on reimbursement expenditure.

(4) Other parameters. First, the growth rate of health insurance contributions and reimbursements. It is assumed that the health insurance payment base and reimbursement will align with the economic growth rate (GDP) and the consumer price index (CPI), which is the sum of the GDP and CPI growth rates. This article assumes that the CPI is stable at 2% per year and that the GDP growth rate is reduced every five years according to the country's current economic status of transition from high-speed development to medium-low-speed and high-quality development. We report the growth rates of GDP, CPI, and reimbursement expenditure, as detailed in Appendix 1.

Second, the interest income from the health insurance fund balance. According to the Renminbi Deposit Benchmark Interest Rate Adjustment Table for Financial Institutions in 2020 published by the People's Bank of China, this paper sets the one-year deposit interest rate for the accumulated balance of the health insurance fund at 2.15%, and the demand deposit interest rate for the current balance of the health insurance fund at 0.35%.

Third, the pooling fund transfer ratio. According to the 2020 National Medical Security Development Statistical Bulletin, the total revenue of the UEBMI in 2020 is 1.5732 billion CNY, of which 914.5 billion CNY is allocated to the pooling fund, accounting for about 58%. Therefore, this paper assumes that the proportion of the revenue of UEBMI allocated to the pooling fund is 58% and remains unchanged.

Results

Data description

The data in this paper are mainly from the China Family Panel Studies (CFPS), the China Statistical Yearbook, and documents from the official websites of regional governments, health insurance bureaus, and human resources bureaus. The micro data in this paper are mainly from the 2016 and 2018 CFPS databases. The macro data, such as the economic development status of each region, are mainly from the China Statistical Yearbook. The pooling arrangement reform information is mainly obtained by manually collecting official documents published on the official websites of provincial governments, health insurance bureaus, and human resources and social security bureaus in each province, which contain information on the implementation time of provincial coordination and fund supervision measures.

The explained variable is total health expenditure (*Texp*), where total health expenditure can be divided into reimbursements (*Reim*) and out-of-pocket expenditure (*Opck*) according to the payment channel. The explanatory variable is whether or not the united single pool reform was implemented (*Provpool*). First, the year of policy release is obtained from the date of the document issued by each region on the implementation of the united single pool reform. Second, we match the release date of the document with the year of the questionnaire survey. If the release date is earlier than the year of the questionnaire survey, the variable is "1", indicating that the united single pool reform has been implemented in the region; otherwise, it will be "0", which means that the united single pool reform has not been implemented in the region. Individual characteristics, health status, and regional GDP per capita (*ReGDP*) were selected as control variables. Individual characteristics include age (*Age*), gender (*Gender*), education (*Edu*), household income per capita (*Income*), marital status (*Marital*), and retirement status (*Retire*). Health status variables include chronic disease status (*Chronic*) and self-rated health (*Health*).

In this paper, respondents enrolled in UEBMI are selected as research subjects, and the entire sample is screened and processed. After eliminating the samples with missing information, this paper finally obtains 2-period panel data with a total of 9060 observations. The descriptive results of the relevant variables are presented in Table 2.

The effects of unified pooling reform on healthcare expenditures

Benchmark regression

Based on the above data and methodology, this part conducted an empirical study of the relationship

Table 2 Descriptive statistics results

Variable	Obs.	Mean	Std. Dev	Min	Max
Texp	9060	3331.352	8727.510	0	60,000
Opck	9060	1795.663	4422.441	0	30,000
Reim	9060	1553.228	5038.280	0	35,200
Provpool	9060	0.193	0.395	0	1
Age	9060	46.321	16.329	16	98
Gender	9060	0.566	0.496	0	1
Marital	9060	0.812	0.391	0	1
Retire	9060	0.312	0.463	0	1
Edu	9060	4.020	1.432	1	8
Health	9060	3.011	1.066	1	5
Chronic	9060	0.170	0.376	0	1
Income	9060	3.345	0.785	1	4
ReGDP	9060	68940.190	32160.200	27,643	140211.2

between the unified single pool reform of UEBMI and enrollees' medical expenditure. Table 3 explicitly reports the effects of the unified single pool reform on total medical expenditure, reimbursement expenditure, and out-of-pocket expenditure. Regardless of whether the control variables are added, the regression coefficients of *Provpool* on reimbursement expenditure are significant at the 5% significance level, indicating that unified single pool reform has a significant positive effect on reimbursement expenditure. The regression coefficients in column (6) show that the reimbursement expenditure increases by approximately 453.183 CNY after pooling. The empirical results indicate that the provincial pooling reform has a significant positive impact only on reimbursement expenditure, while its effect on out-of-pocket expenditure and total medical expenditure is not significant.

In provincial pooling reform, the reimbursement ratio did not change. With a fixed reimbursement ratio, the increase in reimbursement expenditure without a corresponding increase in out-of-pocket expenditure suggests that the rise in reimbursement expenditure is not justified. This phenomenon can be attributed to the relaxation of oversight by municipal governments following the reform, creating opportunities conducive to collusion between patients and doctors.

Robustness test

In this paper, four methods were selected for robustness testing. The first is to replace the explained variables. Replace the reimbursement expenditure with the reimbursement expenditure share and compare whether there is a difference between the two. Second, use a panel fixed effects model. Adjust the unbalanced panel data to balanced panel data and add time-fixed effects to control for the effect that time trends have on medical expenditure and estimate the net effect of the unified single pool reform as accurately as possible. Third, the propensity score matching (PSM) method is combined with the staggered DID model. PSM can effectively control for inter-individual differences and avoid endogeneity bias in the results [31]. Finally, the placebo test. Referring to Dreber et al. [32], we randomly generated a dummy variable as a policy variable for two-way fixed effects regression. Table 4 shows the results of the robustness tests. The above robustness test results show that the regression results for reimbursement expenditure in Table 3 are robust.

Table 3 Benchmark regression results for medical expenditure

Variables	Texp		Opck		Reim	
	(1)	(2)	(3)	(4)	(5)	(6)
Provpool	973.994*** (231.897)	510.904 (357.263)	-59.336 (117.621)	91.288 (182.062)	1000.620*** (133.588)9	453.183** (209.937)
Age		50.134*** (9.718)		27.842*** (4.952)		33.814*** (5.711)
Gender		-35.345 (172.959)		-195.963** (88.140)		120.911*** (101.635)
Marital		-101.485 (221.601)		-115.841 (112.928)		-90.741 (130.219)
Retire		1598.461*** (314.205)		573.596*** (160.119)		869.363*** (184.635)
Edu		97.133 (72.558)		18.159 (36.976)		85.739** (42.637)
Health		1213.507*** (86.830)		750.903*** (44.248)		524.275*** (51.023)
Chronic		5359.065*** (241.355)		2261.977*** (122.995)		2683.010*** (141.826)
Income		97.219 (115.829)		28.955 (59.026)		98.607 (68.064)
ReGDP		0.000 (0.004)		-0.006** (0.002)		0.004* (0.003)
constant	3142.896*** (102.005)	-4775.051*** (694.259)	1807.144*** (51.738)	-1914.726*** (353.796)	1359.621*** (58.762)	-3385.310*** (407.966)
Observations	9060	9060	9060	9060	9060	9060
R^2	0.002	0.163	0.000	0.153	0.006	0.131

***, **, *indicate significance at 1%, 5%, and 10%, respectively

Table 4 Robustness test

Variables	Reim			
	Replacing the explained variable	Panel fixed effects model	PSM-DID	placebo test
	(1)	(2)	(3)	(4)
Provpool	0.028** (0.014)	937.430*** (332.139)	928.558*** (332.259)	-96.657 (97.770)
constant	-0.217*** (0.027)	-3477.713*** (651.586)	-3445.995*** (652.652)	-10,313 (1380.776)
Control Variables	Yes	Yes	Yes	Yes
Time-fixed effects	No	Yes	Yes	Yes
Observations	9060	4672	4664	9060
R^2	0.109	0.129	0.130	0.134

***, **, *indicate significance at 1%, 5%, and 10%, respectively

Comparative analysis of individual heterogeneity

Age is an important factor influencing participants' medical expenditure. Does the unified single pool arrangement lead to significant differences in the medical reimbursement expenditure of participants of different ages? The following figure illustrates the changes in medical reimbursement expenditure for participants aged 16–98 in the pooling and non-pooling groups.

Figures 2, 3 and 4 show that medical expenditure increases as participants get older. Comparatively, the pooling group's medical expenditure grows significantly faster than the non-pooling group's, with the gap gradually widening. Regarding gender, the reimbursement expenditure for male participants increases significantly after age 60. The reimbursement expenditure for the pooling group is significantly higher than that for the non-pooling group. The reimbursement expenditure for female participants starts to increase mainly after age 50. The reimbursement expenditure for the pooling group is significantly higher than that for the non-pooling group.

We also divide enrollees into four groups according to gender and whether they are retired: male employees, female employees, male retirees, and female retirees. Using the PSM-DID model to run panel fixed effects regressions, the effects of the unified single pool reform on the medical reimbursement expenditure of the different groups were examined.

Comparing the results in Table 5, it can be seen that the reimbursement expenditure of male employees increases by about 90.061 after the provincial pooling, but the result is not significant. The regression coefficient *Provpool* for female employees is about 886.257 and is significant at the 1% significance level. The coefficients for male retirees and female retirees are 1,909.457

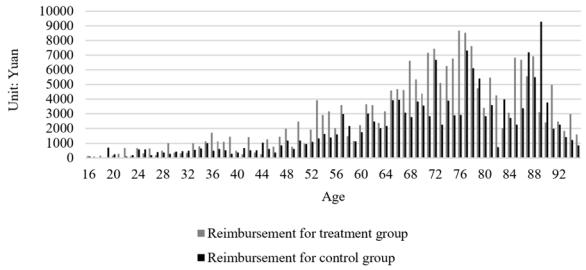

Fig. 2 Comparison of reimbursement expenditure between the pooling and non-pooling groups

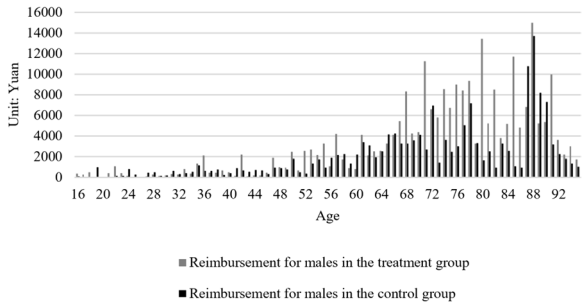

Fig. 3 Comparison of reimbursement expenditure for male between the pooling and non-pooling groups

CNY and 2,178.322 CNY respectively, and both are significant at the 1% level.

Table 6 shows the growth of medical reimbursement expenditure in the sub-samples after pooling. The pooled growth ratio is obtained by dividing the pooled net effect by the average reimbursement cost of the non-pooled group. After the provincial pooling, the per capita reimbursement expenditure of the insured person increased by about 0.664. As the increase in the reimbursement

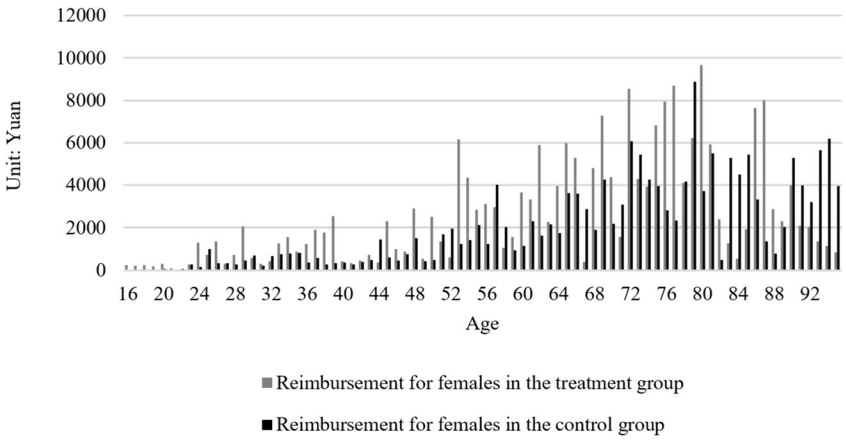

Fig. 4 Comparison of reimbursement expenditure for females between the pooling and non-pooling groups

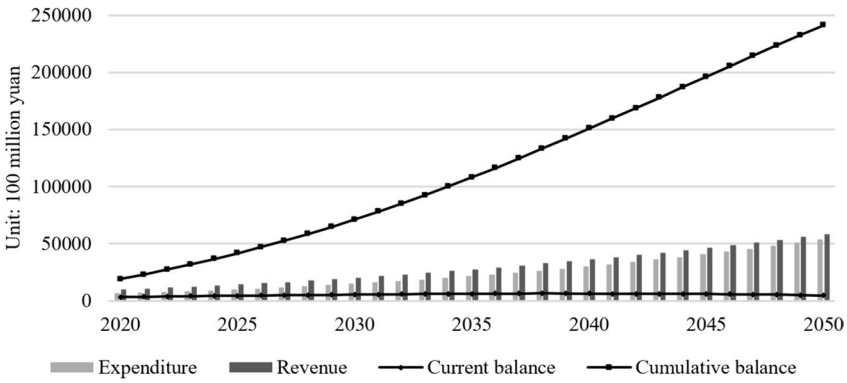

Fig. 5 The trend of UEBMI fund under scenario 1

Table 5 The effects on medical reimbursement expenditure by gender and retirement status

Variables	Reim				
	Total sample	On-the-job employees		Retirees	
		Male	Female	Male	Female
Provpool	928.558*** (332.259)	90.061 (218.872)	886.257*** (231.0192)	1909.457*** (732.050)	2178.322*** (808.921)
contant	-3445.995*** (652.652)	-614.129 (507.082)	-655.150 (625.075)	-7265.025*** (1862.656)	-3722.41* (1967.296)
Control Variables	Yes	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	4664	1908	1261	789	706
R2	0.130	0.046	0.051	0.141	0.112

***, **, *indicate significance at 1%, 5%, and 10%, respectively

expenditure for male employees is not significant, the net effect growth ratio for male employees is 0. The net effect growth ratio for female employees is 1.422. The net effect growth ratio for male and female retired employees is 0.660 and 0.756, respectively.

Discussions

Fund sustainability forecasting

Scenario 1: no expansion of pilot provinces

At present, only seven provinces and cities, Shanghai, Beijing, Tianjin, Tibet, Chongqing, Hainan, and Ningxia, have implemented single pool reform. Keeping the

Table 6 Growth ratio of medical reimbursement expenditure by gender and retirement status

	Reim				
	Total sample	On-the-job employees		Retirees	
		Male	Female	Male	Female
Mean	1567.400	730.546	813.728	3272.409	3269.734
Pooling group mean	1398.396	706.625	623.369	2893.089	2882.648
Non-pooling group mean	2408.953	846.629	1667.035	5326.293	5588.416
Net effect	928.558	0	886.257	1909.457	2178.322
Net effect growth ratio	0.664	0	1.422	0.660	0.756
Observations	4664	1908	1261	789	706

provinces that have implemented the single pool reform unchanged, this paper simulates the revenue, expenditure and balance of the UEBMI fund.

Figure 5 shows the changing trend of the UEBMI fund in the next 30 years under such circumstances. If only the seven provinces and cities implement the pooling arrangement policy, the revenue and expenditure of the pooling fund will show an upward trend. In the next 30 years, there will be a slight balance in the current revenue, and the accumulated balance will continue to increase. There will be no deficits in the current and accumulated balance before 2050. The reason for this phenomenon may be that the promotion of the pooling arrangement level has improved the fund's risk prevention capability and mutual assistance capability, and can efficiently realize the transfer of funds between different regions and different risk groups in the same province [30].

Table 7 shows the forecasting results of the UEBMI fund in some years, assuming that the provinces implementing the single pool reform remain unchanged. It is worth noting that the current balance of the fund shows an "inverted U-shape" and will peak at 637.5327 billion CNY in 2040. Under the dual pressure of slowing population growth and further aging, the current balance will decline year by year after 2040. Therefore, although the current operating conditions of the fund are relatively optimistic, it is foreseeable that the fund balance will deteriorate in the further future. Other supportive policies will need to be implemented to maintain balance and sustainable development.

Table 7 The forcasting results of UEBMI fund under scenario 1

Year	Expenditure	Revenue	Current balance	Cumulative balance
2020	6452.998	9851.573	3398.574	19003.99
2025	9989.22	14406.69	4417.472	41626.68
2030	14925.8	20319.07	5393.271	71301.59
2035	21563.61	27684.54	6120.928	108114.2
2040	30189.25	36564.57	6375.327	150986.1
2045	40690.57	46578.05	5887.481	196255.7
2050	53587.88	58293.16	4705.282	241565.4

Scenario 2: expansion of pilot provinces

The Social Insurance Law clarifies the objective of promoting unified provincial single pool arrangement of UEBMI, and it is the trend for more provinces to implement unified single pool reform. Considering the different development status of each province and city, different provinces may have different times to promote unified single pool reform. Therefore, this article will design a simulated reform plan (as shown in Table 8; Fig. 6). Except for the provinces that have been implemented before 2020, the rest of the provinces will implement unified single pool reform in order every five years in the eastern, central and western regions. The simulation results of the fund revenue, expenditure and balance are as follows.

Figure 7 shows the financial operation of the pooling fund in scenario 2. Overall, the pooling fund's revenue and expenditure are increasing. In the early period, revenue is higher than expenditure, and the current revenue and expenditure are slightly balanced, but in the later period, the growth rate of expenditure gradually exceeds that of revenue, and the current balance of the pooling fund starts to show a gap in 2031, and the gap increases year by year. The current balance turns from positive to negative. As a result, the cumulative balance of the pooling fund starts to show an exponential downward trend in 2042 after a slow initial growth.

Table 9 shows the turning point and values of the UEBMI fund under scenario two. In the next 30 years, the current balance and the accumulated balance of the pooling fund will have gaps for the first time in 2031 and

Table 8 Forecasting the plan of expansion of pilot provinces

Provinces	Implementation Year of Forecasting
Hebei, Shandong, Jiangsu, Zhejiang, Fujian, Guangdong	2025
Shanxi, Henan, Hubei, Anhui, Hunan, Jiangxi	2030
Heilongjiang, Jilin, Liaolin, Inner Mongolia, Xinjiang, Gansu, Qinghai, Ningxia, Shaanxi, Sichuan, Yunnan, Guangxi	2035

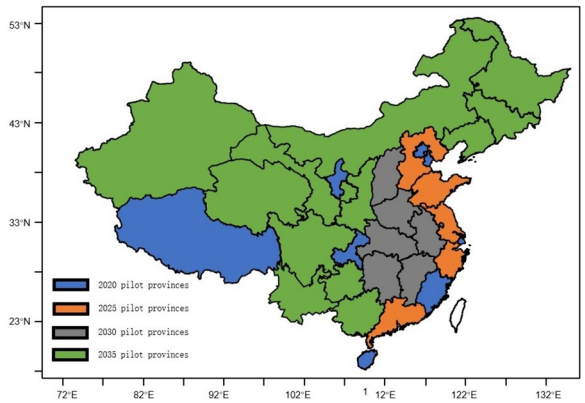

Fig. 6 The map of pilot provinces

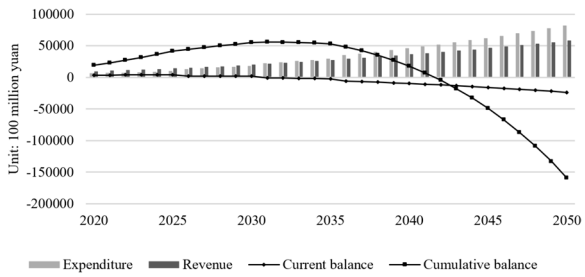

Fig. 7 The trend of UEBMI fund under scenario 2

2042, respectively. By 2050, the expenditure will increase to 82,094.98 billion CNY, which is about 1.41 times the revenue of the pooling fund, and the balance of the fund will further deteriorate.

Comparing the prediction results of the two scenarios, it can be seen that if no more provinces implementing provincial-level pooling reform are added, the cumulative balance will increase year by year, and the long-term sustainable development of the fund can be realized. If the provincial-level pooling reform policy continues to be implemented in the remaining provinces, the payment risk of the health insurance fund will be exacerbated.

Table 9 The forcasting results of UEBMI fund under scenario 2

Year	Expenditure	Revenue	Current balance	cumulative balance
2020	6452.998	9851.573	3398.574	19003.99
2025	9989.22	14406.69	4417.472	41626.68
2026	13426.82	15405.12	1978.303	44339.39
2030	18521.03	20319.07	1798.041	55339.56
2031	22319.02	21621.35	-697.667	55608.24
2035	29929.77	27684.54	-2245.24	53032.11
2036	35363.41	29348.85	-6014.56	47927.57
2041	49164.51	38331.52	-10,833	7201.254
2042	52230.07	40297.7	-11932.4	-4640.89
2050	82094.98	58293.16	-23801.8	-158,952

Conclusion

Based on the dual perspective of micro and macro, this paper uses the staggered DID model to examine the effects of unified single pool reform of UEBMI on reimbursement expenses, and an actuarial model to predict the effects on fund sustainability. We found that: (1) the medical reimbursement expenditure increases significantly by about 66.4% after the unified provincial single pool reform. The above conclusions still hold after the robustness tests of replacing the explained variable, using the panel fixed effects model and the placebo test. (2) there is individual heterogeneity in the effects of the unified single pool reform on medical reimbursement expenditure, and the reimbursement expenditure of retired elderly has the largest increase. (3) If the unified single pool reform is gradually promoted, the current balance and cumulative balance of pooling funds will have gaps in 2031 and 2042, respectively, which will put great pressure on the expenditure of the UEBMI fund.

The results indicated that moral hazard was the key factor in the negative impact of provincial pooling reform on the sustainability of health insurance. Under the reform of fiscal centralization and administrative decentralization, municipal governments were not responsible for covering health insurance fund deficits but were still required to collect for fund and reimburse from fund. This structure led municipal governments to relax fund supervision, further inducing moral hazard among doctors and patients. Therefore, the separation of fiscal power and administrative power triggered moral hazard among municipal governments, doctors, and patients, increasing the burden on fund expenditures ultimately.

Based on the findings of this paper, several policy implications can be drawn: first, strengthen regulation to limit moral hazard behavior among regulators, physicians, and enrollees. After the implementation of the unified single pool reform, the moral hazard of participations leads to a sharp increase in medical reimbursement expenditure. Therefore, the moral hazard should be reduced by establishing incentive and constraint mechanisms. Second, the delayed retirement system should be implemented as soon as possible to reduce the sharp increase in medical reimbursement expenditure after retirement. We find that in provinces with provincial pooling reform, the medical reimbursement expenditures of retired workers grow more compared to those employed in the workforce. Third, encouraging childbearing expands the population base. The younger the age structure of the population, the smaller the impact of the unified single pool reform on the sustainability of the health insurance fund. Therefore, expanding the contributing population base by encouraging childbearing can be an effective way to offset the negative impact of the unified single pool reform.

The research values of this paper are as follows: first, it confirms that a larger fund pool will instead lead to moral hazard and unreasonable growth in fund expenditures; second, it combines micro-individual behavior with the macro situation of fund operation to predict the impact of pooling on the sustainability of the fund; third, it provides clear policy insights for optimizing the unified single pool reform based on the sustainable development of the fund.

There are some limitations in this paper. Firstly, the provincial pooling reform of UEBMI might have effects on the revenues. Due to data limitations, the study did not consider the effects of the reform on fund revenues, which is our future research focus. Secondly, the study set the fertility rate at a fixed value and did not consider the effects of fertility fluctuations on medical expenditures. Thirdly, the fund forecasting results might be affected by the results of the DID model's estimation of reimbursement expenditure. Finally, the pooling reform not only significantly impacts the income and expenditure of the health insurance fund but also changes the risk-bearing capacity of the funds in different cities within the pooling region. Thus, we should not overlook its positive role in risk diversification by focusing solely on its negative impact on fund expenditures, which is also a direction worth further exploration in the future.

Appendix 1

year	GDP	CPI	GDP + CPI	Medical reimbursement expenditure
2021	6.02	2	0.0802	1.0802
2022	6.02	2	0.0802	1.0802
2023	6.02	2	0.0802	1.0802
2024	6.02	2	0.0802	1.0802
2025	6.02	2	0.0802	1.0802
2026	5.52	2	0.0752	1.0752
2027	5.52	2	0.0752	1.0752
2028	5.52	2	0.0752	1.0752
2029	5.52	2	0.0752	1.0752
2030	5.52	2	0.0752	1.0752
2031	5.05	2	0.0705	1.0705
2032	5.05	2	0.0705	1.0705
2033	5.05	2	0.0705	1.0705
2034	5.05	2	0.0705	1.0705
2035	5.05	2	0.0705	1.0705
2036	4.56	2	0.0656	1.0656
2037	4.56	2	0.0656	1.0656
2038	4.56	2	0.0656	1.0656
2039	4.56	2	0.0656	1.0656
2040	4.56	2	0.0656	1.0656
2041	4.16	2	0.0616	1.0616
2042	4.16	2	0.0616	1.0616
2043	4.16	2	0.0616	1.0616
2044	4.16	2	0.0616	1.0616
2045	4.16	2	0.0616	1.0616
2046	4.02	2	0.0602	1.0602
2047	4.02	2	0.0602	1.0602
2048	4.02	2	0.0602	1.0602
2049	4.02	2	0.0602	1.0602
2050	4.02	2	0.0602	1.0602

Abbreviations

UEBMI	Urban Employee Basic Medical Insurance
CFPS	China Family Panel Studies
PSM	The propensity score matching method
DID	Difference-in-difference

Authors' contributions

JW: Designed the research, collected and analyzed data, and drafted and edited the article. HY and XP: Contributed to research design, assisted in data interpretation, and provided substantial content review.

Declarations

Competing interests

The authors declare no competing interests.

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