Evaluating Sustainability of Medical Insurance Scheme for Urban Employed Individuals in China*

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In the late 1990s, the Chinese government established the medical insurance scheme for urban employees and retirees. Given China's considerable size and diversity, the reform of the medical care system faces many challenges. It is important to analyse and evaluate the impact of the reform on individuals' health care benefits and on their financial burden due to medical expenses. This research investigates the sustainability of the urban medical insurance system. With co-operation from the Bureau of Labour and Social Security of Kunming of China, this article creates a static micro-simulation model for predicting and evaluating the medical insurance policies. The model investigates the balances of the social pool fund and personal savings accounts. In the model, administrative data over 2001–2005 were used as the micro-simulation base data sets. With 2006 as the commencement year, the model forecasts medical service expenses and medical insurance policy settings for five years until 2010. This research aims to advance the understanding and impact of health insurance reform in China, and to assist in future policy formulation and implementation.

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Introduction

In the last decade or so, China has begun to reform its health care system nationwide, due to pressures such as an ageing population and increasing demand on health services. From 1998 onwards, the medical insurance reform for urban employees and retirees has been extended to the whole country.¹ Under this medical insurance system, a social pool fund and personal savings accounts have been established. The social pool fund is mainly responsible for serious illnesses, while personal savings accounts

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¹ See Xu (2007).

are responsible for minor illnesses.² After more than a decade of carrying out this medical insurance scheme, significant achievements have been made in providing basic medical services for urban employees and retirees.

However, the reform of the medical system in a country of 1.3 billion people, admittedly, is a very difficult task, especially considering the chronic inefficiency of the State medical system that emphasised equality at the expense of efficiency in the planned economic period.³ In addition, the ageing population in China imposes a heavy burden on medical insurance. The reform of China's medical insurance system faces many challenges.⁴ Given China's considerable size and diversity, both geographically and demographically, further extension of pilot programmes and implementation to all citizens will still take a long time.

It is important to analyse and evaluate the impact of the reform on individuals' health care benefits—in particular, on their financial burden due to medical expenses. It is also quite essential for the Government to analyse the sustainability of the current medical insurance policies.⁵ Powerful policy analysis tools are urgently needed to support the medical insurance policy-makers. However, very few research studies have been found on the prediction and evaluation of the medical insurance policy.

This article focuses on the urban medical insurance system reform, involving both urban employees and retirees. Selecting one of the southwest capital cities in China, Kunming, this project creates a static micro-simulation model of the medical insurance system. Using micro-simulation techniques,⁶ this project answers the major research question: Is the current social medical insurance policy for urban employees sustainable in a short-term period, from 2006 to 2010? The key aims are to assess the distributional impacts of medical insurance policies and predict the medical expenses for urban employees and retirees. SAS (version 9.1.3) software was used to create such a model.

In the following sections, Kunming's basic medical insurance system for urban employees is introduced first. Then the data sources used in the model are uncovered, followed by describing the framework of the model. After creating a base file for the model, modelling medical behaviour of insured individuals will be discussed. Finally, the article goes to the discussions and conclusions.

Kunming's medical insurance scheme for urban employees

Kunming, capital of Yunnan Province, is located in the southwest of China, with a total population of 6.08 million at the end of 2005.⁷ Kunming commenced its medical insurance reform for urban employees and retirees in April 2001.

² See State Council (2004).

³ See Sun *et al.* (2009).

⁴ See, for example, Dong (2007), Ma (2008).

⁵ See Zhu (2009).

⁶ See, for example, Harding (1996), Harding and Gupta (2007).

⁷ See Kunming Municipal Government (2009).

There were about 1.08 million insured urban employees and retirees at the end of 2005. For insured individuals, the ratio of employees to retirees was about 2:1, which was lower than the relative ratio 2.67:1 for the national urban area of China.⁸ The annual average wage of urban employees in 2005 was 19,128 Yuan,⁹ which was slightly higher than the national counterpart of 18,405 Yuan.¹⁰ Concerning health status, the life expectancy of Kunming in 2005 was 74.3 years old, which was higher than the national counterpart of 72 years old.¹¹

Like other urban areas in China, the basic medical insurance funds in Kunming include the social pool fund and personal savings accounts.¹² Basically, the social pool fund is mainly responsible for hospitalisation expenses, whereas the personal savings accounts are responsible for outpatient treatment fees. From 2004 onwards, Kunming has been conducting the following medical insurance system for urban employees and retirees.¹³

Levy of the medical insurance fund

The medical insurance fund mainly comes from premiums contributed by both employers and employees under the medical insurance scheme. The premium paid by the employers is 10 per cent of the employees' total wage bill in the previous year, while that paid by the employees is 2 per cent of their wages. Retirees are exempted from paying premiums. The medical insurance premiums do not pay the tax; that is, the premiums are not included in personal wage or salary income, exempt from personal income tax. The contributions are distributed to the personal savings accounts and the social pool fund.

The personal savings accounts are managed by individuals themselves. In addition to the individual's contribution, 30 per cent of employer's contribution, on average, goes to the personal savings accounts. The percentage of the employer's premium which goes to personal savings accounts differs according to age: 1.5 per cent of the wage bill for participants under 35 years of age, 2 per cent of the wage bill for participants aged 35–49 years, and 2.5 per cent of the wage bill for participants aged 50 years and over. For retirees, 4.5 per cent of their pensions goes to their personal savings accounts. After paying for the personal savings accounts, the remaining employers' contributions go to the social pool fund, which is managed by the local governments.

Beneficiary of the medical insurance scheme

The personal savings accounts are for the payments of clinic services and medications listed in the medical insurance scheme. In addition, the personal savings accounts are responsible for medical expenses of hospitalisation services under the threshold

⁸ See Kunming Medical Insurance Centre (2007).

⁹ See *Yunnan Daily* (2007).

¹⁰ See National Bureau of Statistics of China (2006).

¹¹ See Jin (2006).

¹² See Yunnan Government (2006).

¹³ See Kunming Medical Insurance Association (2004).

payment,¹⁴ and a small proportion shared with the social pool fund for hospitalisation expenses. When the personal savings accounts are exhausted, the excess fees should be paid by individuals directly.

The social pool fund covers different types of medical expenses, involving a large part of inpatient service expenses beyond the threshold payment, fees for clinic emergency services, and expenses incurred in treatments for chronic diseases and special clinic check-ups. The expenses that exceed the threshold are covered mainly by the social pool fund, of which the individual shares a small part of the bill (10 per cent on average). The maximum annual medical expense (ceiling) covered by the social pool fund per person is about four times the average annual wage of employees, which has been 49,000 Yuan from 2004 onwards.

When an insured individual is admitted to a hospital for a second time in a calendar year, the individual's threshold payment falls to 30 per cent of the initial threshold. When an individual has three times or more of hospitalisation services in a year, from the third time of hospitalisation onwards, the individual does not need to pay the threshold any more.

Complementary medical insurance funds

If the incurred expenses of hospitalisation exceed the maximum coverage of the social pool fund, the insured patient may get a benefit from a large sum fund—the serious illness fund. Participants submit 0.1 per cent of the previous annual average wage or pension per person annually, while employers submit 0.6 per cent, to join this serious illness fund. The amount of hospitalisation expenses beyond the coverage of the social pool fund are covered by the serious illness fund and the individual jointly, in which the individual contributes 10 per cent of the expenses.

The other medical supplement fund is the Government official fund for government officials and civil servants, which is financed by the local governments. The Government official fund provides a supplement to government officials for their medical expenses.

The above medical insurance scheme is for urban employees and retirees only and does not include their children or partners. A medical insurance scheme has been established for urban residents without work at the end of 2007.¹⁵ The social medical insurance scheme is for basic medical services. For unusually heavy or light medical utilisation and expenses (e.g. a catastrophe), there are specific security funds provided by the central government and the local governments.

Data sources and framework of the model

Data sources used in the model

The main data used in the model are administrative medical records of medical insurance participants of Kunming over the period of 2001–2005. The data sets

¹⁴ A certain amount of money should be paid by patients in order to trigger the social pool fund.

¹⁵ See Zhu (2009).

basically include five kinds of medical insurance records, which are described briefly as follows:

- basic individual data sets, which provide individuals' demographic information;
- individual status alteration data sets, which provide information of individual status alteration (e.g. newly registered participant, quit insurance scheme, retired);
- medical insurance premium data sets, which record the amount of premiums contributed by individuals and their employers to the medical insurance scheme;
- medical expense data sets of hospitalisation, which provide medical expenditure records in both hospitalisation and special disease services; and
- medical expense records of ordinary clinic services, which provide the medical expenditure records in both general clinic services and medication in pharmacies.

These five kinds of data sets are interlinked through their unique personal identifiers and together formed the whole medical insurance data sources. In these five kinds of data sources, the first three provide the demographic information of medical insurance participants, individual status alteration and insurance premium contribution records, while the last two give information on medical expenses.

After the initial analysis of the raw data, the basic information for medical insurance participants and their medical expense records were created for the period of 2001–2005. There were 793,987 personal records at the end of 2005 under the administration of the Kunming Municipal Government.

Framework of the simulation model

The main method used in this research is micro-simulation. A micro-simulation model differs from other types of models in that it operates on individual units rather than on aggregate information.¹⁶ Unlike modelling based on a typical or median case, micro-simulation models provide a much richer source for research by enabling the exploration of heterogeneity and diversity within the simulated population.¹⁷

Micro-simulation has proven to be a particularly useful tool for policy analysis in many areas of policy. Apart from making a major contribution to the development of tax and transfer policies, micro-simulation models in recent years have become more common in the research and policy areas of health and aged care.¹⁸ The models involve pharmaceutical subsidies,¹⁹ human resource issues in health,²⁰ medical services and medical insurance schemes,²¹ dental health services,²² and primary and aged care.²³

¹⁶ See Harding and Gupta (2007).

¹⁷ See Brown and Harding (2002).

¹⁸ See Gupta and Harding (2007).

¹⁹ See Walker (2000), Harding *et al.* (2004).

²⁰ See Gupta and Basu (2007).

²¹ See Lymer *et al.* (2006), Xiong and Ma (2007).

²² See Spielauer (2007).

²³ See, for example, Pearson *et al.* (2009), Lymer *et al.* (2008), Schofield *et al.* (2009), Tanton *et al.* (2009).

Figure 1. Flow chart of medical services simulation.

Note: Pool funds include: Social pool fund; Serious illness fund; Government official fund.

The following discusses the framework of the model created in this research, with the construction of the base file coming first. The initial base file was constructed for 2005, with 2006 being the first simulation year. On the basis of the base file for the year 2005, the medical services behaviour of insured individuals under the medical insurance scheme was modelled, with 2006 as the first out-year. The modelling framework is divided into three parts, as shown in Figure 1.

The first part (I) simulates the collection and allocation of the medical insurance premiums. After collecting the insurance premiums and depositing money into the social pool fund and the personal savings accounts, the social insurance system is ready to benefit the insured individuals. The second part (II) predicts each individual's medical service usage in occurred medical expenses. These expenses are mainly classified into two categories: clinical services and hospitalisation services. After simulating the medical service usage of insured individuals for a financial year, the model goes to the third part. The third part (III) of the model is for adjustment and preparation of the data set for the next year's simulation, and for the aggregation of results after completing the simulation. This part is responsible for simulating the events of death and new entries to the medical insurance scheme, as well as adjusting insured individuals' annual income. After finishing the simulation, the model produces the output and aggregates the results.

Construction of medical insurance micro data sets

Medical insurance participants' micro records in 2005

The starting point for the construction of the medical insurance micro data sets (or base file) is the basic information of medical insurance scheme participants at the end of 2005. The insurance status of individuals altered in 2005 included new scheme entry, scheme quit, retired and re-employed. The new scheme entry accounted for a large part, while the proportion of scheme quit was very low. For simplification, when constructing the basic individual data set at the end of 2005, the records of individuals who quit the scheme need to be removed. Eliminating the records of individuals who quit the scheme, a data set containing 790,186 individual records was obtained. This data set did not contain the records of individuals who died in 2005. However, when estimating the population of insurance participants and analysing medical expenses in 2005, it is important to consider the individuals who died in that year.

After adding the death records onto the individual information data set, the number of individual records at the end of 2005 totalled 793,987. This figure was very close to the target population of 794,130 at the end of 2005, which was reported by the Bureau of Labour and Social Security of Kunming.²⁴

Death record data set for 2001–2005

According to the initial individual records, in addition to the total number of deaths, the death rates by gender across age groups were calculated. Table 1 illustrates the age group death rate of male participants. Because of incomplete death information in 2001, due to the first year commencement of the scheme, the death rates by gender across age group in 2001 were quite different from the other four years. In forecasting personal medical behaviour and medical insurance policies over the period of 2006–2010, the average death rates over 2002–2005 were used to project death events.

Medical expenses for 2001–2005

After completing the construction of the 2005 basic individual information data set, extra personal information (like individual income) was added to this data set, and a personal savings account was set up for each insured participant. The average monthly income for each participant was added annually, then the information on medical expenses was added to each individual's basic information records over 2001–2005. The total medical expenses for individuals are covered jointly by the personal saving accounts or patients themselves, the social pool fund, the serious illness fund, and the government fund for officials.

It is calculated that, on average, the personal saving accounts of employees could cover all the medical service costs shared by individuals with some balances. However, for retirees, especially for retirees aged 65 years and over, the balances of their

²⁴ See Kunming Medical Insurance Centre (2006).

Table 1 Age group death rates of males (2001–2005)

Year	Number					Rates				
	≤34	35–49	50–64	≥65	Total number	≤34	35–49	50–64	≥65	Total rate
2001	4	16	47	127	194	0.0804	0.2543	0.8673	4.3571	0.9899
2002	35	99	374	1,095	1,603	0.5003	1.0766	4.4636	23.1903	5.4724
2003	43	152	525	1,653	2,373	0.5057	1.3631	5.0157	27.3214	6.5605
2004	66	178	612	1,808	2,664	0.6881	1.4875	5.2957	27.7599	6.7226
2005	60	195	761	1,725	2,741	0.5678	1.5188	6.1504	23.6195	6.3623
Average death rate over 2002–2005 (0.1%)						0.5655	1.3615	5.2314	25.4728	6.2795

personal savings accounts were negative. Regarding retirees, the older the individuals, the bigger the gap to cover the medical treatment fees which are supposed to be paid by their personal saving accounts.

Simulation of medical insurance participants for 2006–2010

Death events

The simulation of medical services of insurance participants started in 2006, with a time sequence of one year as a simulation unit until 2010. This section discusses the simulation of the medical insurance participants. Simulation of deaths is the first event modelled for each forecasting year. At the beginning of the modelling in 2006, by deleting the records with a death index in the data set of the basic individual information at the end of 2005, death simulation was completed for the year 2006. Because information on death was already included in the data set in 2005, the model just eliminated these death records at the beginning of the simulation in 2006.

For modelling death events for the following years' 2007–2010, the method of complete random sampling was used to randomly select individual records according to death rates by gender across age groups (as Table 1 illustrated). The model then removed the selected records allocated as representing deaths in the forecasting year.

For the number of simulations, Table 2 illustrates two simulations for males' death events in 2007 according to the death rates in Table 1. The percentage of simulated deaths are very close in two simulations; the difference of each age group is less than 0.05 per cent. The simulated average age of each age group was also examined. The difference of each average age in two simulations was less than 0.001. The same results occurred for modelling females' deaths.

The model pertains to employees and retirees in a big city, Kunming: it has a very large population insured in the medical insurance scheme (around 800,000), so this is a large-scale study. In modelling, the seeds for random numbers were fixed. The main concerns focused on the aggregated results for examining the sustainability of medical insurance scheme. In addition, the simulation follows some created rules, such as

Table 2 Comparison of two death simulations of males (2007)

Age group (years)	Total number	Simulation one		Simulation two		Absolute difference of %
		Number of death	% to the total number	Number of death	% to the total number	
≤34	109,857	60	0.0546	65	0.0592	0.0046
35–49	132,055	164	0.1242	166	0.1257	0.0015
50–64	130,578	742	0.5682	697	0.5338	0.0345
≥65	78,586	2013	2.5615	2008	2.5552	0.0064

the target population requirements and monthly income criteria. So as illustrated in modelling death events, using the other seeds, the results may vary a little, but the answers would not have changed.

New scheme entry events

After handling death events, the model then simulated new participants into the scheme. Because of low proportion and for modelling convenience, the individuals joining and then leaving the scheme for a short-time period were not considered in the model. This part is for new entry insurance participants in each forecasting year, with the number of total insured individuals considered first. According to the trends of actual numbers of the participants over the period of 2001–2005 (diamond dots in Figure 2), the population figures for each year between 2006 and 2010 was estimated (squire dots in Figure 2) by fitting an exponential curve.

After determining the total population of insured individuals for each forecasting year, the next step was to determine the number of participants in each age group. The insured population by age group over the period of 2006–2010 was estimated by fitting curves similar to those for deriving the estimated total number of participants. The percentage of retirees in the total population in 2006 was estimated to be 33.34 per cent, which is very close to the actual figure of 33.4 per cent reported by the Bureau of Labour and Social Security of Kunming.⁸

The model then randomly selected new participants from the population base file in the previous year for each subsequent year between 2006 and 2010, according to the target population requirements. The date of entry scheme for each new individual was set in June of the forecasting year, and their personal saving accounts were set to 0. Their monthly income and medical expense records in the previous year are the same as those individuals who were randomly picked from the base population file. By combining the new entry, individuals with the existing population under the medical insurance scheme in the previous year, the basic individual information data set was created and updated for the forecasting year (say 2006).

Adjust income and set funds

Both the social pool fund and the personal saving accounts are collected with the premiums based on the individual's income, and it has direct effects on the results

Figure 2. Estimation of number of participants over the period of 2001–2010.

Table 3 Estimated average wage and pension for the period of 2002–2010

Year	Average wage of employees			Average pension of retirees				
	Actual	Estimated	Adjusted	Actual	Curve fit	Line fit	Estimated	Adjusted
2002	850	844		674	673	668	670	
2003	960	963		692	686	693	690	
2004	1,068	1,081		703	707	719	713	
2005	1,209	1,200		755	741	744	743	
2006	1,422*	1,318	1,422	821*	796	769	782	821
2007		1,437	1,550		882	795	839	881
2008		1,555	1,678		1,020	820	920	966
2009		1,674	1,806		1,240	846	1,043	1,095
2010		1,792	1,933		1,590	871	1,231	1,292
Fitting R^2		0.9957			0.9695	0.8887		

Notes: The actual incomes for 2002–2005 were used to estimate the incomes for 2006–2010; *the actual incomes for 2006 were used as a test to adjust the obtained estimation.

of the medical insurance policy simulation. So, after creating the basic individual information data set for the forecasting year, the incomes of different age groups were adjusted. Prior to doing this, certain criteria were created for the income adjustments to follow. Table 3 gives the estimated average wages and pensions for the forecasting years of 2006–2010, based on the figures from 2002–2005.

Table 4 Monthly income adjustment parameters

<i>Sex</i>	<i>Group</i>	<i>Income</i>	<i>Rate1</i>	<i>Rate2</i>	<i>Rate3</i>	<i>Rate4</i>	<i>Rate5</i>	<i>Rate6</i>	<i>Rate7</i>	<i>Rate8</i>
1	1	1	0.12266	0.14138	0.21787	0.47927	1.04961	1.73501	3.31952	4.66841
1	1	2	0.08690	0.11716	0.20500	0.42003	0.87130	1.47540	3.00536	4.31932
1	1	3	−0.00323	0.06362	0.13608	0.39481	0.81915	1.47868	2.85378	4.02337
1	1	4	−0.18203	−0.03832	0.03729	0.22041	0.49273	0.95651	2.01142	3.10143
:	:	:	:	:	:	:	:	:	:	:
2	5	8	−0.60547	−0.41587	−0.00792	0.03741	0.06543	0.11838	0.17226	0.27425
2	5	9	−0.68014	−0.47035	−0.16917	0.02955	0.05355	0.10269	0.13050	0.18214
Relative frequency			0–0.10	0.10–0.25	0.25–0.50	0.50–0.75	0.75–0.90	0.90–0.95	0.95–0.99	0.99–1.00

For employees, the estimated average wages were the results of fitting a straight line. For retirees, two fittings were carried out because of instability in the actual figures—one fitted an exponential curve and the other fitted a straight line. The estimated average pensions were the weighted results of curve fitting (weight 0.5) and line fitting (weight 0.5), which aims to avoid estimations that are too large or too small. The actual figures in 2006⁸ were treated as a test to revise the estimated incomes for the period of 2006–2010. The adjusted average estimations of wages and pensions form the criteria when making adjustments for individuals' incomes for each forecasting year (Table 3).

When predicting the individuals' income, the income increase parameters (or adjustment parameters) of the participants were obtained using the income information from 2002 to 2005 (Table 4, the detailed process refers to Appendix A).

With the parameters of monthly income rates of increase in Table 4, each individual's monthly income in 2006–2010 can be projected. For example, for a male in age group 1 (employee aged less than 35 years), if his monthly wage fell into the lowest section (Income='1'), then his monthly wage in the coming year would have an increase rate of 0.12266 with a chance of 10 per cent. Such income adjustment was carried out once a year in the model.

After calculating the adjustment of income for each individual, the average monthly wages and pensions were compared with the estimated figures (Table 3) as the criteria to see if further adjustments were needed. After completing the adjustment of an individual's monthly income, the personal savings accounts and three different kinds of funds are allocated according to the medical insurance scheme rules. Table 5 gives the comparison of the different types of total funds, including total personal saving accounts, between the projections and the reported actual totals in 2006.⁸ The projections for the social pool fund, serious illness fund and the total fund of personal saving accounts are very good, with their relative errors less than 1 per cent. For the government official fund, no reported figure was available in 2006.

Forecasting medical expenses

Four medical service items in the model

After simulating the population of insurance participants for the forecasting year and setting up the different types of funds, the model predicts medical expenses.

Table 5 Comparison between projected and reported funds in 2006 (million Yuan)

<i>Item</i>	<i>Social pool fund</i>	<i>Serious illness fund</i>	<i>Government official fund</i>	<i>Personal savings account</i>
Projected	685.4504	81.2833	23.4272	583.4117
Actual	683.5709	81.9657	—	583.3401
Difference (million)	1.8795	−0.6824	—	0.0716
Relative error (%)	0.2750	−0.8325	—	0.0123

Note: Relative error = (Projected—Actual)/Actual × 100%.

Predicting medical expenses is one of the essential and very important parts in the simulation of insurance participants' medical behaviour. This aspect of the simulation is also very complicated and difficult, because of several medical service items needing to be included in the model. The different kinds of medical service items have different payment modes. Four types of medical services were considered in predicting individual's medical service usage, that is, ordinary clinic services and pharmacy medication, chronic disease services, special check-ups in clinical and hospitalisation services. While hospitalisation services include items of admitted to hospital, special disease clinic treatment, clinic emergency and hospital transform. The following describes how each of these four parts of medical services is projected respectively for the period of 2006–2010.

Clinic treatment and medication in pharmacies

The payment for both clinic treatment and medication in pharmacies is from personal saving accounts or patients' pockets. Such medical services are simulated annually. Categorical factors considered in the model include gender, age group, levels of medical expenses and increase of medical rates. Two steps are carried out in the simulation. The first step is to identify individuals who do not have such medical treatments in the forecasting year. The second step is to project the medical expenses for those who have such medical treatments.

For the first step, the proportion of individuals without medical treatments for each forecasting year between 2006 and 2010 was estimated by hyperbola curve fitting, using the actual information from 2002–2005. It is estimated that there are about 16.22 per cent of individuals (population 134,571) without medical expenses in clinics and pharmacies in 2006.

After getting the target number of individuals with zero expenses for each forecasting year, the next mission is to select individuals randomly from all records of individuals and set them to have no such medical expenses. Whether an individual has zero expenses or not in the forecasting year is highly connected with the previous year's expenses of that individual. As the actual data indicated that among the individuals who had no expenses in 2004, about half of them also had zero expenses in 2005.

After finishing selecting individuals with zero expenses, the model goes to the second step—forecasting the medical expenses for non-zero clinic individuals. This is done by using the empirical increase rates of medical expenses in clinical services as shown in

Table 6 Medical expenses increase rates for clinical services and pharmaceutical medication

<i>Sex</i>	<i>Group</i>	<i>Cost</i>	<i>Rate1</i>	<i>Rate2</i>	<i>Rate3</i>	<i>Rate4</i>	<i>Rate5</i>	<i>Rate6</i>	<i>Rate7</i>
1	1	1	0.06589	16.60188	47.71548	95.43158	163.87904	277.31424	539.38778
1	1	2	−0.37050	6.76185	16.78486	31.32959	48.99126	71.97331	134.95649
1	1	3	−0.33942	3.55881	8.08568	14.61235	22.21332	32.55702	58.37946
1	1	4	−0.47770	1.48758	3.55289	6.60375	10.32175	15.66591	29.20982
:	:	:	:	:	:	:	:	:	:
2	5	13	−0.74277	−0.36311	−0.05337	0.29175	0.59092	0.99288	1.79346
2	5	14	−0.83037	−0.58731	−0.39835	−0.16696	0.02399	0.20833	0.52567
Relative frequencies			0–0.25	0.25–0.50	0.50–0.75	0.75–0.90	0.90–0.95	0.95–0.99	0.99–1.00

Table 6. The construction of these increase rate parameters is similar to the construction of the individual monthly income parameters (Table 4).²⁵

In Table 6, the first two columns indicate gender and age group (five groups) respectively. The third column represents 14 categories of medical expenses from lowest to highest by percentiles. Similar to the construction of adjustment parameters for monthly income, the fourteen categories are Minimum–P1 (the first percentile of medical cost, similar for the others), P1–P5, P5–P10, P10–P25, P25–P40, P40–P50, P50–P60, P60–P70, P70–P80, P80–P85, P85–P90, P90–P95, P95–P99, P99–Maximum. Rate 1—Rate 7 in the first row gives the different rates of increase in medical expenses, with their relative frequencies in the last row. When projecting medical expenses, with the year 2006 as an example, the medical expenses for each individual by gender, age group and medical expenses in 2005 is considered first. Then a uniform random number is assigned to each individual, on which the individual's expenses in 2006 will be projected. For example, suppose a male under 35 years of age had medical expenses in 2005 in the lowest category, then his increase rate of clinical medical expenses in 2006 would be 0.06589, with a chance of 25 per cent. Hence his medical expenses in 2006 are estimated to be his medical expenses in 2005 multiplied by $(1 + 0.06589)$.

Chronic disease clinical services

The medical expenses of this kind of medical treatment are covered by the social pool fund, up to 2000 Yuan annually. In the simulation, the first step is to confirm individuals with chronic diseases by gender across age group, then project their annual medical expenses. In simulating chronic disease services, the model isolates the costs for items which are not on the list of the medical insurance scheme. This part of costs is covered totally by individual payment.

To determine individuals with chronic disease, using the trends in the proportion of individuals with chronic diseases to the total population in 2002–2005, proportion and number of individuals with chronic diseases in 2006–2010 were estimated. It is estimated that, in 2006, 31,418 medical insurance participants (about 3.79 per cent of

²⁵ See Appendix A.

the total population) will have chronic diseases, of which 23,734 patients will keep having chronic diseases in the following year. On average, 80.41 per cent of chronic disease patients will keep having chronic diseases in the next year. So when determining the individuals with chronic diseases, this factor should be considered as well as gender and age group.

Medical expenses of chronic disease patients were projected for the period of 2006–2010 by using the annual empirical increase rates of medical expenses. In the same way as with clinical services and pharmaceutical medication, the empirical rates of increase of medical expenses for chronic diseases were established. In creating those empirical rates, the impact factors include gender, age group and categories of previous medical expenses from the lowest to the highest. The medical expenses were projected by assigning a uniform random number to each individual who has chronic diseases.

Special clinical check-ups

The social pool fund covers 70 per cent of the medical expenses for the clinical special check-up service, while patients contribute the remaining 30 per cent of the bill. The first step in predicting the medical expenses is to identify individuals who have clinic special check-ups. By analysing the population who had the clinical special check-ups in 2002–2005, the percentage of this kind of patients in the total population was estimated for 2006–2010. It is estimated that 27,707 individuals (or 3.34 per cent of the total population) had special clinical check-ups in 2006. When forecasting the medical expenses for the clinical special check-up, individuals, according to their gender and age group, were randomly selected by the estimated proportion of such patients to the total population.

Unlike the characteristics of chronic diseases, based on the analysis of the actual data in 2002–2005, it was found that a special clinical check-up has *no continuity* to medical service usage in the following year. So the predictive factors considered in determining the patients who would have special clinical check-ups for the forecast year only included gender and age group.

The medical expenses associated with special check-ups were predicted by using created cost distribution parameters. These parameters were constructed by using the actual information for 2002–2005. With the created average increase rates and the mean expenses in the previous year, the mean of expenses in forecasting year could be projected for each category of medical expenses until 2010.

Hospitalisation services

For hospitalisation services, the social pool fund and the serious illness fund share a large part in meeting the medical expenses. Figure 3 illustrates the payment mode for hospitalisation services. The total cost for an inpatient is split into four tiers. The first tier includes total self-payment, self-payment under the medical insurance scheme, and the threshold to trigger the social pool fund. The next tier is the social pool fund area, immediately followed by the third tier—the serious illness fund area. When medical

Figure 3. Payment modes for hospitalisation services.

expenses exceed the ceiling of the serious illness fund, which is very rare, the excess medical bill is paid by patients themselves.

If an individual should be admitted to a hospital a second time in a financial year, then the threshold for the hospital will reduce to 30 per cent of the regular threshold. If an individual should be admitted to a hospital a third time or more, then from the third time of hospitalisation services onward, the patient does not need to pay the threshold any more. Consistent with these insurance payment rules, hospitalisation services are predicted three times separately in the model—corresponding to the first, the second, and the third or more times admitted to hospital. The detailed predicting process refers to Appendix B.

Simulation results

Selected results of medical expenses

After simulating medical service usage and medical expenses of the urban medical insurance participants, the results were then aggregated. This section provides the selected results for medical expenses for the forecasting years of 2006–2010.

Table 7 gives the percentage of the different kinds of medical expenses to total annual expenditure. As a comparison, the corresponding data in 2002–2005 are also provided. The ratio of medical expenses of clinical services (including medications in pharmacies) to total medical expenses displays a slightly increased trend, while the

Table 7 Estimated percentage of different kind of medical services to total expenses and average individual cost (Yuan)

<i>Year</i>	<i>Insured population</i>	<i>Clinic services</i>	<i>Chronic disease</i>	<i>Special check-up</i>	<i>Hospital admission</i>	<i>Total</i>	<i>Average cost per person</i>	<i>Increase rate per person (%)</i>
2002	506,258	30.66	8.45	0.37	60.52	100.00	656	—
2003	630,108	29.06	6.94	0.51	63.49	100.00	1,169	78.29
2004	716,828	29.53	6.06	0.58	63.83	100.00	1,348	15.23
2005	793,987	29.43	7.24	0.57	62.76	100.00	1,454	7.88
2006	829,518	28.93	7.36	0.58	63.12	100.00	1,545	6.26
2007	858,925	29.39	7.23	0.59	62.79	100.00	1,632	5.62
2008	883,852	30.52	7.15	0.61	61.72	100.00	1,699	4.16
2009	905,486	31.71	7.13	0.63	60.53	100.00	1,753	3.13
2010	924,596	32.62	7.06	0.66	59.66	100.00	1,819	3.81

Note: Increase rate per person in the last column means growth rate compared with the year before.

percentages of medical costs of both chronic diseases and clinical special check-ups have remained stable as a share of total expenditures, at around 7.10 and 0.60 per cent of the total cost respectively. In contrast to clinical services, the cost of hospitalisation services as a proportion of total expenses has a slight downward trend in 2010 compared with 2005, from 62.76 per cent down to 59.66 per cent.

Table 7 also provides the average individual cost and the increase rate per person. It is estimated that the amount of annual medical services demanded by each individual would be about 1,819 Yuan in 2010. For the increase rate per person, in the first couple of years after commencing the medical insurance scheme, the annual increase in every individual medical cost was quite high. After the first three years, the annual rates of increase per person became more stable—around 3.1–6.3 per cent—and showed a slight slowing trend. Following the trend over the period of 2002–2005, the average increase rate per person has fallen over the period of projection. It might also be due to the government setting a cap for controlling the total payment of medical services, curbing the unreasonable medical expenses. The average medical cost per person in Kunming is estimated to increase 4.6 per cent annually over 2006–2010.

When considering the medical cost distributions, on average, for employees and retirees separately, completely different pictures emerge (Figure 4, where the inpatient services were split into three items corresponding to the first, the second or the third time or more admissions to a hospital).

For employees, more than half of their medical service costs (54.1 per cent) come from clinical services and medications. The second largest medical cost is estimated to occur in hospitalisation services, which is around 42.8 per cent of the total cost. The remaining 3.1 per cent of the medical cost comes from chronic disease treatment and clinical special check-ups. For retirees, more than three quarters (77.3 per cent) of their medical costs come from hospitalisation treatments. Only around 10 per cent of retirees' medical costs come from the general clinical services and medication. The medical cost for chronic diseases accounts for around 11 per cent of the total medical expenses, which is quadruple that of employees. The average percentage of

Figure 4. Estimated percentage distribution of spending on medical services, on average, over 2005–2010.

clinical special check-ups for retirees over 2006–2010 (0.60 per cent) is not much different from that of employees (0.64 per cent).

Balances of the personal savings accounts and self-payments

For the payments of medical expenses for the year 2006–2010, the balances of the personal saving accounts and the three kinds of pool funds (the social pool fund, the serious illness fund and the Government official fund) are aggregated.

After the medical cost subsidies from the above three pool funds, which together cover annually around 48–51 per cent of the total incurred medical costs over the period of 2006–2010, the remaining medical expenses are paid by personal saving accounts or individuals themselves. For personal saving accounts, the amounts of the balances are estimated to increase annually, with the estimated accumulative balance of 1938.08 million Yuan by 2010. The average balance of personal saving accounts per person is estimated to be 1,846 Yuan by 2010.

Although the average cumulative balance of the personal savings account could be as high as 1,840 Yuan in 2010, by differentiating employment status and income levels, the balances give a totally different story. Figure 5 estimates the deficit distributions in using personal saving accounts in 2010, and the results are presented for employees and retirees, respectively.

In Figure 5, the insured population was categorised into five quintile groups according to an individual's annual income, from the lowest 20 per cent to the highest 20 per cent. For both employees and retirees, the lower the income, the more

Figure 5. Deficit estimations of personal savings accounts by income quintiles in 2010.

possibility there is of negative balances in personal saving accounts in a financial year. For employees, for almost one quarter of employees in the lowest income quintile, their medical expenses are projected to exceed the funds residing in their personal saving accounts. This figure is nearly four times that in the highest quintile income group, which is less than 6 per cent. The corresponding percentage gap for retirees, which is from 21.31 per cent in the lowest quintile to 13.84 per cent in the highest quintile, is smaller than that for employees. The proportion of retirees with their accounts going into deficit is 3 percentage points higher than employees. In addition, the average deficit amount for retirees is 74.14 per cent higher than that for employees.

Forecasting the current medical insurance policy

As previously stated, under the social medical insurance scheme in Kunming, three different kinds of medical pool funds have been established. The social pool fund is for the basic medical insurance, largely subsidising hospitalisation services. The serious illness fund is a supplementary fund for serious diseases, right after the social pool fund. And, finally, the government official fund compensates the medical costs for government officials. Among these three funds, the first two funds are vital for the medical insurance scheme. Figure 6 presents the percentage of balances of the three different kinds of pool funds; the actual results for the period of 2001–2005 are also presented. The forecasting results show that the percentage of balances of the serious

Figure 6. Forecast percentage of balances of different kinds of pool funds (base case).

Notes: SPF—Social pool fund; SIF—Serious illness fund; GOF—Government official fund.

illness fund shows a downward trend as of 2009. In the meantime, the government official fund and the social pool fund keep relatively high percentages of balances, respectively.

Forecasting results for a policy scenario

The forecasting results under the current policy settings showed a financial risk for the serious illness fund as of 2009 (Figure 6). The serious illness fund is estimated to have a negative balance at the end of 2010. This phenomenon can be explained as: if the maximum payments of the social pool fund and serious illness fund remain unchanged, but medical expenses keep increasing annually, this would result in pressure on the social pool fund being transferred to the serious illness fund.

Based on the above forecasting results and analysis, the modelling adjusted the payment policy settings on the medical expenses. Maximum payment by the social pool fund was adjusted. The principle of this adjustment is to raise the maximum payment of the social pool fund by 2.5 per cent annually from 2008 until 2010.

After such adjustment of the maximum payment by the social pool fund, both the social pool fund and the serious illness fund would maintain reasonable percentages of balances on average (Figure 7). At the same time, such an adjustment has not had much impact on the proportion of balance of the government official fund. Furthermore, such maximum payment adjustment has very few effects on the payment distributions of personal saving accounts.

Figure 7. Forecast percentage of balances of different kinds of pool funds (scenario one).
Notes: SPF—Social pool fund; SIF—Serious illness fund; GOF—Government official fund.

Conclusions and discussions

This article discussed the modelling of the medical insurance scheme for urban employees and retirees in China. Based on the forecasting results of the medical expenses and medical insurance payments of 2006–2010, the balances of the personal saving accounts for each individual were obtained. This helped to estimate the distributional impacts of the medical insurance system on participants and to explore the benefits or burdens under the medical insurance scheme. By analysing the balances of the social pool fund, the serious illness fund and the government official fund at the end of each forecast year, the assistance capacity and sustainable development of these pool funds was examined. Except for the base case of the medical insurance scheme, the model simulated one scenario changing the medical insurance policy settings. The main findings in the model are summarised briefly as below.

Medical cost distribution

It is estimated that the average medical cost per person in Kunming increases 4.6 per cent annually over 2006–2010. When considering the four different kinds of medical services, the ratio of medical expenses of clinical services and pharmaceutical medication to the total medical expenses displays a slightly increased trend over the period of 2006–2010. In contrast to the clinical services, the cost proportion of hospitalisation services to the total expenses has a slight downward trend in 2010 compared with 2005, from 62.76 per cent down to 59.66 per cent.

When considering the medical cost distributions for employees and retirees separately, completely different pictures emerge. For employees, more than half of their medical service costs (54.1 per cent) come from clinical services and medications. The second largest medical cost is estimated to occur in hospitalisation services, which is around 42.8 per cent of the total cost. For retirees, more than three quarters (77.3 per cent) of their medical costs come from hospitalisation treatments. Only around 10 per cent of retirees' medical costs come from the general clinical services and medications. This is to suggest that when retirees are admitted to hospital, the proportion of medical expenses covered by the social pool fund and the serious illness fund for retirees should be further increased.

Payments for medical costs and balances of personal saving accounts

The social pool fund, the serious illness fund and the government official fund together cover annually around 48–51 per cent of the total incurred medical costs over the period of 2006–2010. The remaining costs are paid by personal savings accounts or individuals themselves.

The amounts of balances of the personal savings accounts are estimated to increase annually, with the estimated accumulative balance of 1938.08 million Yuan by 2010, giving the average balance per person of 1,846 Yuan. Although the average cumulative balance of a personal saving account could be as high as 1,846 Yuan in 2010, by differentiating employment status and income levels, the balances give a totally different story.

From the viewpoint of an individual's annual income, for both employees and retirees, the lower the income, the more possibility there is of negative balances in the personal saving accounts. For employees, the percentage of deficit in the lowest quintile income group is estimated to be nearly four times that in the highest quintile income group. The corresponding percentage gap for retirees, which is from 21.31 per cent in the lowest quintile to 13.84 per cent in the top quintile, is smaller than that for employees. The proportion of retirees with their accounts going into deficit is 3 percentage points higher than employees. In addition, the average deficit amount for retirees is 74.14 per cent higher than that for employees. This indicates that the government should pay more attention on medical services of lower income earners, especially for retirees with lower pensions. Effective actions should be taken to ease the burden of their medical expenses, such as compensating for the percentage of their income allocated to their personal saving accounts.

Balances of three funds

The forecasting results showed that, if the maximum payments of the social pool fund and the serious illness fund were unchanged, the social pool fund would have an increasing percentage of balance, but not the serious illness fund. Because of the continuing increase of total medical expenses annually, unchanged maximum payments means that the extra burden of medical expenditure will shift from the social pool fund to the serious illness fund. Under the current payment policy, the serious illness fund was estimated to have a financial risk as of 2009, and the situation

could be even worse by 2010. That is to say, the key finding is that the social pool fund looks like it is sustainable over the period of 2006–2010, but the serious illness fund does not appear financially sustainable over this period. Given this, and to illustrate the policy simulation capacity of the model, another policy scenario was run—adjusting the maximum payment by the social pool fund to see what might happen after such a change. The results of the scenario indicated that both the social pool fund and serious illness fund would maintain reasonable high percentages of balances on average. At the same time, such a change does not have much impact on the balance of the government official fund. Essentially, what they seem to mean by this is whether or not the scheme will collect enough revenue to pay for expenditures under it. The model suggests that adjusting the maximum payment by the social pool fund is necessary.

In summary, this article aims to advance the modelling techniques in a new area. The medical insurance policy in specific areas, such as Kunming, not only has similar properties to other urban areas in China, but also has its own characteristics. In the implementation process of the medical insurance system, policy settings have varied with time. The policies associated with the medical insurance scheme are continuously responding to different problems, which need to be considered in the research.

This research is also expected to make an academic contribution by advancing methods in micro-simulation. In this research, there were challenging issues surrounding complex and large data sources. In addition, many sophisticated and detailed variables were dealt with. Most importantly, the model techniques are more advanced in aspects of: creating annual death rates by gender across age groups; predicting the total number and construction of insurance participants by fitting exponential curves; establishing rational parameters for individual income adjustments, and for different kinds of medical services items.

This article analysed and evaluated the sustainability and the distributional impact of the medical insurance policy settings. The results outlined above are useful for improving the medical insurance system and make it more sustainable in the future in aspects of: taking care of different types of medical expenses by differentiating sub-groups; setting a maximum cap on out-of-pocket expenses, especially for retirees; considering the relative trends between medical services demand increase and economic development; adjusting the maximum payment of the different types of medical insurance funds.

Furthermore, in terms of economic policy, the results obtained in this article are useful in making economic and social development strategies. It may help to control the total balances of medical insurance premiums, government subsidises and medical payments. It also helps in maintaining the appropriate proportions among personal saving accounts and different types of medical insurance funds.

In the model, administrative data over 2001–2005 were used in forecasting the medical insurance system for five years until 2010. In the process of constructing the model, relative figures in 2006 were used for validation and parameter adjustment. Except for the base case of the medical insurance scheme, the model simulated one scenario which raised the maximum payment of the social pool fund by 2.5 per cent annually from 2008 until 2010. Actually, the Kunming government decided in March

2010 that the annual maximum payment by the social pool fund would be raised from 49,000 Yuan to 59,000 Yuan.²⁶

Based on this static micro-simulation model, more work could be done to analyse the impact of the urban medical insurance system on urban employees and employers, such as the distribution of personal saving accounts and the medical services burden for different age groups within the population. Furthermore, after combining the other information about the medical services needs of urban residents, the results from this model provided valuable preparation to subsequently estimate the medical expenses of all urban residents.

There are some limitations to the model that need to be improved in further research. The model did not include dependents and children in the simulation, as the medical insurance scheme is only designed for employees and retirees. Further research might consider family as a whole for medical insurance simulation. For simplification reasons, records were eliminated for persons who quit the scheme, when constructing the base file for the simulation. Although their number is limited, the short-term periods of membership might be an important source of surplus for the scheme, as individuals pay premiums but do not get the benefits. This should be considered in further research.

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Appendix A

Creating income adjustment parameters

In creating income adjustment parameters, it is assumed that an individual's monthly income remains unchanged during the course of each forecasting year. Under this assumption, monthly income is the same for 12 months in one year (say 2006), and adjusting monthly income in 2007 is compared with the previous year of 2006. The adjustment parameters were constructed by the following three steps:

- First, by categories of gender across age groups, the incomes were split into ten sections. The actual data analysis of 2002–2005 shows that the higher the income, the more variation occurs, so more classes should be used to catch the variation. As a result, the individual monthly incomes in each year of 2002–2004 were split into nine classes according to income percentile. So the individual income was categorised into $2 \times 5 \times 9 = 90$ groups.
- Second, for each of the above 90 income groups, increase rates of individual income were calculated for 2002–2003, 2003–2004 and 2004–2005. These rates of increase for each income group were further divided into eight segments from the lowest to the highest. So, $90 \times 8 = 720$ income cells were obtained. By the actual calculation, the rates of increase in those income cells for three different years of 2002–2003, 2003–2004 and 2004–2005 showed consistent trends.
- Third, in each income cell, the average rates of increase of the three years in a row were calculated. Such calculations were reasonable because the income cells stood for the same percentiles and had consistent trends. The results are illustrated in Table 4, where the first column indicates gender, the second column indicates five age groups, and the third column indicates nine income sections in percentile. Rate 1–Rate 8 at the first row means the different rates of increase, with the relative interval of frequency at the last row.

Appendix B

Predicting hospitalisation three times

First time admitted to a hospital in a financial year

For simulating patients who were admitted to a hospital for the first time in a year, a certain number of insured participants were randomly selected, according to hospitalisation rates, and admitted to different levels of hospitals. Then certain amounts of medical expenses were imputed to them. The inpatients pay a threshold fee (trigger criteria) before triggering the social pool fund.

The analysis of hospitalisation data in 2002–2005 showed that the hospitalisation rate was highly connected with whether an individual was admitted to a hospital in the previous year or not. Individuals who were admitted to hospitals in the previous year are three times more likely to be admitted to a hospital than other individuals. So, when constructing the hospitalisation parameters, whether an individual was admitted to a hospital in the previous year or not is considered, as well as the individual's gender and age group.

The hospitalisation rates for each forecasting year of 2006–2010 were estimated, on which a number of individuals were selected randomly as inpatients. For example, a male under 35 years old who was not admitted to a hospital in 2005 would have a chance of 0.028283 of being admitted to a hospital in 2006.

The percentage of hospitalisation expenses shared by patients varies with the level of the hospital. The hospital level distribution of inpatients was constructed through the actual data sets in 2002–2005. For example, for male inpatients who are aged less than 35 years in 2006, they would have a chance of 0.151465 of being admitted to a small hospital, a chance of 0.334527 to a medium hospital and a chance of 0.514008 to a large hospital.

After allocating inpatients to different levels of hospitals, the model is ready to project the medical expenses. The medical expenses distributions for the forecasting years were established by analysing the data of 2002–2005. The impact factors include hospital levels, gender, age group and the section of medical expenses from the lowest to the highest (14 categories). Combined together, all of these four factors made a total number of cells of 420. The calculated average hospitalisation expenses and the increase rates of medical expenses were taken to be the forecasting increase rates. Then the hospitalisation expenses were projected for each admitted inpatient.

Second time or three times more admitted to a hospital in a year

Similar to the first time hospitalisation service, forecasting medical behaviour for the second time, or three times or more hospitalisation service in a year was carried out. The only difference is that for patients admitted to hospital a second time in a year, pay only 30 per cent of the trigger criteria for the admitted hospital before they trigger the social pool fund. While individuals admitted to the hospital three times or more in a year do not need to pay for the trigger criteria any more.