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Effect of critical illness insurance on the medical expenditures of rural patients in China: an interrupted time series study for universal health insurance coverage

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ABSTRACT

Objective The objective of this study is to determine if critical illness insurance (CII) promotes the universal health coverage to reduce out-of-pocket (OOP) medical expenditures and improve the effective reimbursement rate (ERR) in rural China.

Study design The 5-year monthly hospitalisation data, starting 2 years before the CII (ie, the 'intervention') began, were collected. Interrupted time series analysis models were used to evaluate the immediate and gradual effects of CII on OOP payment and ERR.

Setting The study was conducted in Xiantao County, Hubei Province, China.

Participants A total of 511 221 inpatients within 5 years were included in the analysis.

Results In 2016, 100 288 patients received in-patient services, among which 4137 benefited from CII. After the implementation of CII, OOP expenses increased 32.2% (95% CI 24.8% to 39.5%, p<0.001). Compared with the preintervention periods, the trend changes decline at a rate of 0.7% per month after the implementation of CII. Similarly, a significant decrease was observed in log ERR after the intervention started. The rate of level change is 16% change (95% CI −20.0% to −12.1%, p<0.001).

Conclusion CII did not decrease the OOP payments of rural inpatients in 2011–2016 periods. The limited extents of population coverage and financing resources can be attributed to these results. Therefore, the Chinese government must urgently raise the funds of CII and improve the CII policy reimbursement rate.

Strengths and limitations of this study

- This study determines the effect of critical illness insurance (CII) on the reduction of pocket medical expenditures in rural China.
- The study identifies the abovementioned effects by using interrupted time series analysis model with 5-year data.
- The study took Prais-Winsten regression to solve the autocorrelation.
- The study performed seasonal correction in accordance with periodic functions.
- The study was unable to identify a neighbouring county that did not implement CII with a similar level of economic status as a control group.

BACKGROUND

Since the publication of *The world health report 2010*, universal health coverage (UHC) has received increasing attention from researchers in relevant fields. UHC is defined as financing systems that are specifically designed to provide people access to necessary health services with sufficient quality. These services must ensure that the user will not encounter financial hardship.[1] In many low-income and middle-income countries, these conditions are not satisfied, and affordable and effective health services are not accessible to the entire population.

The lack of capacity to offer effective financial protection is the primary issue that hinders the achievement of UHC. In many countries, health financing relies on out-of-pocket (OOP) payments for services.[2] These costs prevent people from seeking or continuing care; those who seek care incur catastrophic financial burdens that push them to poverty.[3 4] People who lack health insurance coverage or another form of financial protection hardly access health services, especially in-patient care, or experience delay in doing so. Therefore, providing financial protection to patients is necessary.

The Chinese government conformed rapidly and launched a series of rural health reforms. The first step in China's reforms involves the expansion of the social health insurance coverage.[5] In 2003, China adopted the New Cooperative Medical Scheme (NCMS), a new health insurance system for rural areas where 80% of people do not have any kind of health insurance.[6] In 2011, the

NCMS expanded its coverage to include more counties, and 97% of the Chinese rural population was insured. This rate is higher compared with that in 2004, in which only 310 out of China's 2861 rural counties are covered by the scheme.[7 8] However, a high coverage of health insurance does not necessarily provide a guarantee of UHC. Literatures indicated that the NCMS has no effect on reducing the OOP payment[9 10] and even expands the gap of income-related inequity in rural China.[11]

In 30 August 2012, to further reduce the financial burden of rural patients, China established a supplementary insurance called critical illness insurance (CII), which aims to provide reimbursements of high medical expenses. In the early 1980s, CII is known as 'Dread Disease Insurance' in South Africa and began to flourish in USA, Canada and Australia.[12] In USA and the UK, CII provides a single lump sum payment to the insured individuals, which includes medical and non-medical costs, such as mortgages and credits.[13] In 2017, patients with critical illness get US$10 000 or US$20 000 as initial benefits from insurance companies in the USA.[14] Today, CII covers have a considerable market share in Asian insurance markets.[15]

Many researches on CII were performed. A series of studies found that the extra premiums under the CII policies are extremely high, and the possible costs of adverse selection are related to the use of genetic test.[16–18] Ozkok[19] used a Burr distribution to conduct the Bayesian modelling of the delay between the dates of diagnosis and settlement of claims in CII. Jindrová and VJRAiMMiAS used the same model to assess the event probability of CII.[20] Recent studies reported the existence of healthcare disparities within CII. For instance, rich people receive more benefits from this policy than their counterparts.[21] However, few studies evaluated the effect of CII, especially on health expenditures.

Unlike in other countries, the CII in China is an additional reimbursement for patients with higher payouts in NCMS. In other words, after claiming the CII via health insurance, all patients whose OOP payment still exceeds the premium, which is usually equal to the annual net income per capita of the rural residents, can obtain additional reimbursement.[22] The average reimbursement rate is approximately 50%–70%. The funding comes from NCMS, which means that roughly 5% of NCMS's total capital pool should be allotted to CII compensation. Given that the health system reform process aims to improve the UHC, policy-makers expect this scheme to reduce the OOP payments. The objective of the present study is to determine whether the CII relieves the individuals of the financial burden of healthcare by reducing such expenditures in rural China.

METHODS

Setting

Meng *et al*[23] reported that the lowest average in-patient reimbursement rates can be found in China's central region (41.2%). Households in the central region suffer from high rates of catastrophic health spending. The rates of catastrophic health expenditure of households with members who were hospitalised are also high.[24] In this study, we focus on the rural in-patient health expenditures in Xiantao County (XT), Hubei Province, which is one of the counties in the central region.

Hubei Province is located in central China and the middle reaches of Yangtze River. The gross domestic product (GDP) per capita of this province in 2016 was CNY55 665 (US$8383), which ranks 11th among the 32 provinces (municipalities and autonomous regions) in China. XT is a city in Southwest Hubei that has a total area of 2538 km^2. This county has jurisdiction in three streets and 15 towns. The total population of XT in 2016 was 1 563 500, and the GDP per capita is CNY56 065 (US$8438).

Intervention

The local government of Xiantao initiated a policy in May 2013 to improve the patients' financial access to medical care. The policy states that CII financing should allocate a certain percentage of funds from the NCMS. In 2013, NCMS financing included the contribution of individual rural residents (CNY60) and financial assistance of the government (CNY280) and the local government extracted CNY15 as the fund pool of CII.

We collected and compiled the local NCMS and CII policies from 2011 to 2016. Table 1 denotes the policy changes in XT which was discussed in methods. Table 2 presents the percentage of population enrolled in the CII programme. Before the CII implementation, the deductible amounts for medical institutions inside and outside the county set by NCMS are CNY200 and CNY500, respectively. Therefore, the reimbursement rate of hospitals inside and outside Xiantao increased in varying degrees. However, because the limited pool of funds does not provide sufficient support, the local government reduced the reimbursement rate of NCMS while implementing CII. The reimbursement rate of the NCMS of hospitals in the county decreased from 80% to 60% after May 2013. The deductible amount of CII in 2014 was CNY8000, which increased to CNY12 000 in 2016.

The rule of insurance reimbursement is to conduct NCMS before implementing CII. The government pays part of the reimbursement ratio prescribed by the policy, and the rest is paid by the patient. For example, consider a patient hospitalised in a county hospital in June 2013 with a total medical expense of CNY60 000. Assuming that all medical expenses are included in the benefit package, the NCMS can cover CNY35 880 ((60 000–200)×60%). This amount is higher than the deductible amount in 2013 (CNY8000). Therefore, the patient will be further insured by CII. The CII will cover CNY12 060 ((60 000–35880–8000)×50%), and the patient's OOP expenses will be CNY20 060 (60 000–35880–12060).

Table 1 Reimbursement policy for inpatient care in 2011–2016

Policy	2011	2012–2013 April	2013 May–2015 December	2016 January–2016 December
Insurance coverage	Only NCMS		NCMS+CII	
NCMS:				
Deductible (CN¥)				
In county*	200	200	200	500
Out county	500	500	800	1200
Policy reimbursement rate (%)				
In county†	75	80	60	70
Out county	50	60	50	50
CII:				
Deductible (CN¥)	Not available	Not available	80 000	12 000
Reimbursement rate (%)	Not available	Not available	CN¥8000–CN¥30 000: 50%	CN¥12 000–CN¥30 000: 55%
			CN¥ 30 000–CN¥50 000: 60%	CN¥ 30 000–CN¥100 000: 65%
			over CN¥50 000: 70%	over CN¥100 000: 70%

*The local medical institutions contained primary hospitals and secondary hospitals, and none tertiary hospital. For primary hospitals, local NCMS did not set deductible (means 0), so the deductible in county was the deductible for local secondary hospitals.
†The reimbursement rate of local primary hospitals was 90%, and did not changed for years. At the same time, the beneficiaries of CII that we are concerned about are basically not using services in primary medical institutions, so the ERR in county mentioned here is also the local secondary hospitals.
CII, critical illness insurance; ERR, effective reimbursement rate; NCMS, New Cooperative Medical Scheme.

Data source

This study is based on the standardised administrative medical claims database of NCMS in XT, which includes all detailed medical treatments and insurance information of the rural residents in the jurisdiction. We collected all relevant data involving in patients from May 2011 to May 2016.

The OOP spending and effective reimbursement rate (ERR) are used to evaluate the effect of CII on the patients' financial burden. The OOP expenditures comprise the expenses below the deductible amount, expenses above the deductible amount copaid by the patients, and the non-reimbursable amount beyond the NCMS benefit packages.[25] ERR is defined as the reimbursement amount divided by the total medical expenditure.[26] These definitions are consistently used by the National Health and Family Planning Commission in China. The primary outcomes are the average OOP payment and ERR per month of all CII patients, whereas the secondary ones are the average OOP payment and ERR of patients who sought health utilisation insides and outside XT. For example, the OOP spending inside the county refers to the average health expenditures paid by the patients when they avail in-patient services in county hospitals.

Statistical analysis

In this study, we used interrupted time series analysis (ITSA) models, which are the strongest quasi-experimental method, to estimate the postpolicy changes in the level and trend of each outcome measure.[27] After Gillings *et al*[28] introduced ITSA to the research on health

Table 2 The percentage of population enrolled in CII programme

Variables	2011	2012	2013	2014	2015	2016
Population	1 560 800	1 549 900	1 561 200	1 553 700	1 551 400	1 541 600
NCMS insured no (1)	1 145 104	1 196 530	1 217 000	1 223 088	1 132 475	1 099 935
Hospitalisation no (2)	60 489	87 536	74 502	87 614	100 792	100 288
CII insured no (3)	–	–	–	5308	4726	4137
CII insured percentage A (%) = (3)/(1)				0.434	0.417	0.376
CII insured percentage B (%) = (3)/(2)	–	–	–	6.058	4.689	4.125

CII, critical illness insurance; NCMS, New Cooperative Medical Scheme.

services, this approach has been widely used in assessing the effects of health services and policy interventions.[29] Segmented regression analysis a powerful statistical method for estimating the intervention effects in interrupted time series studies. This method uses baseline trends and levels to project future monthly outcomes with the assumption that these values reflect what would have happened without the policy (ie, the counterfactual). The basic model includes terms that estimate the baseline level for each outcome (intercept), baseline trend (slope), change in the level of the outcome measured immediately after policy implementation and change in postpolicy trend.

Segmented regression (with methods to account for autocorrelation) is the most commonly used modelling technique in ITSAs. When only one group is under study (ie, no comparison groups), the regression model is expressed as

$$Y_t = \beta_0 + \beta_1 \left(T\right) + \beta_2 \left(X_t\right) + \beta_3 \left(XT_t\right)$$

where Y_t is the outcome variable during a time period, which changes on a monthly basis between May 2011 and May 2016, T is the time since the start of the study (May 2011=1, June 2011=2, …, May 2016=61), and X_t is a dummy (indicator) variable that represents the intervention. Preintervention periods are denoted as 0; otherwise, the value is 1. In this study, the value of X_t before May 2013 is 0, whereas that after this period is 1. XT_t is an interaction term, which is 0 before May 2013, and then increases by 1 each month from May 2013 (1 = May 2013, 2 = June 2013, 3 = July 2013, …). β_0 represents the intercept or starting level of the outcome variable before CII, β_1 is the slope or trajectory of the outcome variable until the introduction of CII, β_2 is the level change following the intervention, and β_3 indicates the slope change following the intervention. XT_t is the interaction between time and intervention). The CI of the p value was 95%.

For time series data, seasonality is an issue need be concerned. If there is an uneven distribution of months before and after the intervention, such as a higher proportion of winter months, this could bias the results, especially in the analysis of short series. We confirmed the existence of seasonality through the timing chart and performed seasonal correction in accordance with the periodic functions used in similar research.[30]

Autocorrelation is another problem. Assumption of standard regression models is that observations are independent. This assumption is often violated in time series data because consecutive observations tend to be more similar to one another than those that are further apart, a phenomenon known as autocorrelation. Autocorrelation was assessed by examining the plot of residuals and the partial autocorrelation function and, where data are normally distributed, conducting tests such as Durbin-Watson (D-W) test. The D-W test suggested the existence of autocorrelations, which we corrected using the generalised least squares method (Prais-Winsten).[31] We adopted the Dickey-Fuller statistic to determine the stability, and the results showed that the data constitute a stationary time series. The results of the Kolmogorov-Smirnov test indicated that the distribution of OOP payments is non-normal. Therefore, the logarithm of this value was used. According to Beard *et al*[32] when the input and output time series have been log-transformed using a natural log-transformation and the data made stationary we can interpret the coefficients in terms of elasticity, that is, a change of 1% from the overall mean value in the input series leads to a β% change from the overall mean in the output series. Log transforming the ERR outcomes was taken for coherence across the research. Given the large reimbursement differences between the hospitals inside and outside the county, the trend of the medical expenditure costs in these two subgroups were further analysed to examine the effects of CII. The raw data and stata command are provided in online supplemental files 1 and 2, and the CHEERS checklist is added in online supplemental file 3).

Wagner *et al*[33] stated that the extreme values that do not fit in the series, which are referred to as wild data points, might occur in the time series. The result showed a decline in the OOP expenses in the county starting from January 2013, few months prior to the introduction of CII. The data points of the ERR in the same subgroup demonstrated a sharp increase after January 2013. The extreme change in both cases returned to relatively normal values after CII was introduced. The possible reason for this phenomenon is that the CII policy was issued at the beginning of the year, but the policy was implemented on May 2013. Therefore, the medical expenses incurred in the first 4months of 2013 were not included. The lag between the periods when CII was announced and implemented may suggest people to visit primary hospitals and delay expensive procedures until they have coverage. To illustrate this modification, we represented the excluded points as hollow points to establish a contrast against the solid ones.

Patient involvement

Patients or the public were not involved in the conceptualisation or execution of this research.

RESULTS

In 2014, 87614 patients received in-patient services, among which 5308 (6.058%) benefited from CII. This percentage decreased to 4.125% in 2016.

Figure 1 and table 3 show that after the implementation of CII, OOP expenses increased 32.2% (95% CI 24.8% to 39.5%, p<0.001). Compared with the preintervention periods, the trend changes decline at a rate of 0.7%/month after the implementation of CII (95% CI −1.1% to −0.2%, p<0.001). The OOP spending of patients who were hospitalised in the county shows the same trend (figure 2). There is significant change of ERR in the regression slope is observed after the intervention started. The rate of level change is 16% change (95% CI −20.0%

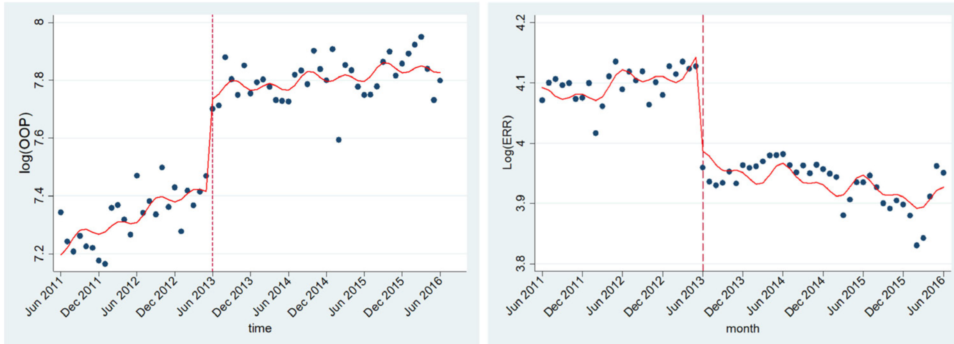

Figure 1 Segmented regression model showing OOP and ERR, May 2011–May 2016. ERR, effective reimbursement rate; OOP, out of pocket.

to −12.1%, p<0.001). The ERRs in the two subgroups decline after the implementation of the CII, but the ERR of the patients who sought healthcare in the county is more obvious at the time of intervention with 9.3% change (95% CI −14.2% to −4.4%, p<0.001). Figure 2 also shows that the trend changes of ERR of the patients hospitalised in the county declines after the announcement of CII. The adjusted R squared of segmented regression model of log OOP was 0.935, which shows the fitness of this model was acceptable. The adjusted R squared, autocorrelation and partial autocorrelation plots of the model are presented in online supplemental file 4.

The financing and use of CII funds in XT in 2014 and 2015 denote that the expenses exceed the amount raised in 2014 (CII funds=255.2 million, CII expenses=292.1 million). In 2015, the CII funds and expenses decrease.

DISCUSSION

The CII was designed to reduced OOP expenses and increase the ERR. Not only did it not do this, it may have had the opposite effect: a 32% increase in the OOP and a 16% reduction in the ERR. For the decline of ERR, local insurance policy probably should take primary responsibility. The increased ERR before the implementation of CII is due to the government's increasing investment on NCMS. The budget of the government for NCMS from May 2011 to May 2013 increased from CNY200 to CNY280,[34] which might attribute to the lower deductible amount and higher policy reimbursement rate. As a result, the ERR during this period increased. However, CII does not raise funds separately, but withdraws funds from the existing pool of NCMS total funds. The implementation of CII poses overspending risks towards NCMS funds. In 2014, CII used funds excessively and overpaid roughly ¥40 million. In consideration of the overspending risk, the local government lowered the policy reimbursement rate of NCMS after May 2013, thereby resulting in a significant reduction in the ERR of all local patients after the implementation of CII. The purpose of basic health insurance is to protect all patients from the financial risks of diseases. CII aims to protect the economic risks of expensive treatments and vulnerable people and therefore should not crowd out the funds of NCMS to avoid decreasing the benefits of the patients, especially fragile ones.

The decreased ERR directly engage with the increase in OOP. For CII patients, lower reimbursement rate means they would get less benefit from insurance, and they had to pay more by themselves. Besides, this phenomenon can be attributed to two another reasons. First is the small number of rural patients who benefited from CII, which implies that the new insurance only reduces parts of the financial burden of the patients and does not affect the average OOP payments of all rural patients. The second reason is the limited average beneficiary of

Table 3 Interrupted time series analysis of outcome variables

Outcome variables	β_2, level change after CII, (95% CI)	β_3, trend/slope change after CII, (95% CI)
Log (out-of-pocket payments)	0.322*** (0.248 to 0.395)	−0.007** (−0.011 to to 0.002)
In county	0.170** (0.056 to 0.283)	0.004 (−0.004 to 0.104)
Out county	−0.037 (−0.270 to 0.196)	−0.019* (−0.033 to to 0.004)
Log (effective reimbursement rate)	−0.161*** (−0.200 to to 0.121)	−0.004** (−0.007 to to 0.001)
In county	−0.093*** (−0.142 to to 0.044)	−0.005** (−0.008 to to 0.002)
Out county	0.018 (−0.031 to 0.066)	−0.001 (−0.004 to 0.002)

% changes results are multiplied by 100.
*P<0.05, **p<0.01, ***p<0.001.
CII, critical illness insurance.

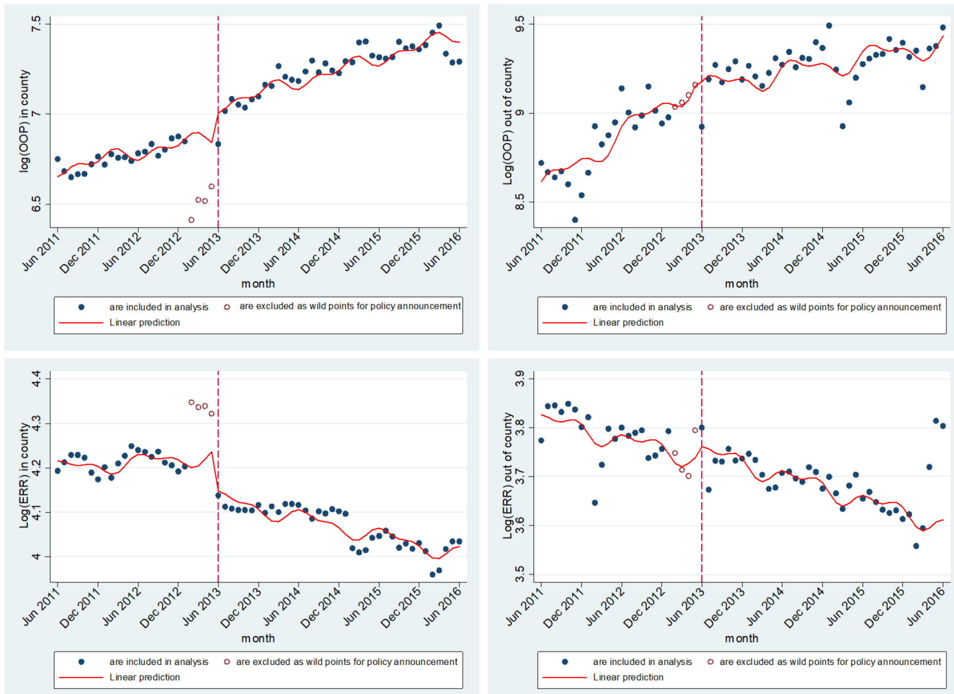

Figure 2 Segmented regression model showing OOP and ERR in and out of county, May 2011–May 2016. ERR, effective reimbursement rate; OOP, out of pocket.

the patients insured with CII. Nearly 10% of the total medical expenditure are paid by CII for the patients. The excessive deductible amount and limited reimbursement rate restrict the benefits of CII. In Xiantao, there were only 55% reimbursement ratio for medical expenditure during CNY12 000–CNY30 000. Only the patients who pay more than CNY100 000 can enjoy a 70% reimbursement rate. However, few patients reach this high level. The results clearly illustrate the drawback of CII when the OOP expenses rapidly increase.

These results are consistent with the findings of other studies. In a recent commentary, Yip and Hsiao claimed that the financial protection function of the current Chinese health system remains insufficient. According to the global health expenditure database of the WHO, the OOP payments in China account for 32% of the total health expenditure in 2014, which is higher than the level (15%–20%) recommended by the WHO.[35] Empirical evidences show that the high level of OOP payments in China results in severe health expenditure and medical impoverishment of the poor and disadvantaged.[36]

The trend of OOP payments inside and outside XT shows several differences. For patients who were hospitalised in county hospitals, the CII dramatically increases the OOP expenses at the intervention moment, which can be ascribed to the low policy reimbursement rate of NCMS. The average OOP expenses do not meet the deductible amount, and the economic burden reduction is dependent on the role of basic health insurance. Once the NCMS reimbursement rate decreases, the OOP spending increases. However, because hospitals outside the county have better and more expensive medical technology than county hospitals, the OOP expenditures of the patients who availed healthcare outside XT is relatively high[37 38] (almost over CNY10 000), and they are highly likely to benefit from CII. The increased reimbursement rate of CII neutralises the role of NCMS in reducing the reimbursement ratio, and thus slightly changes the trend of OOP payments. As a result, people who seek medical care outside the county benefit more from CII than patients in the county.

To expand the population coverage of CII and decrease the households' direct payments or co-payments for services, the government must improve the CII policy. The deductible amount should be settled not only in consideration of local medical expense distribution and disease characteristics, but also of the local average income. As presented in the annual government work report, the unified CII deductible line will be reduced, and the reimbursement rate will increase from 50% to 60%.[39] The funds of CII, however, should be increased separately. The highest government announced that it will increase the per capita financial subsidy by CNY30 and allot half of this amount to CII.

Strengths and limitations

This study has several limitations. First, we are unable to find a neighbouring county who does not implement CII with a similar level of economic status as a control group. Finding such country will eliminate the mixed effects of other external influences. However, because this policy is implemented throughout the province, no suitable control group is identified. Meanwhile, the implementation pattern of CII among the provinces is quite different,

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and thus is not suitable as a control group. Second, because CII is an annual reimbursement, the amount is reimbursed once in the second half of the year in most cases. For the convenience of calculation, we disperse this amount in accordance with the proportion of medical expenses to each month, thereby disregarding the instantaneous effect of CII reimbursement. Lastly, because of the limitation of sample selection, the results of this study can only represent the regions with comparable sample GDP levels. The findings cannot reflect the results of economically developed eastern regions.

CONCLUSION

This study provides new evidence that CII did not effectively improve the UHC process in 2011–2016. The policy had limited extent of population and health service coverages and did not effectively decrease the OOP payments of inpatients. CII even decreased the ERR by spending the basic medical insurance fund pool. The results suggested that the Chinese government must urgently raise the funds of CII and improve the policy reimbursement rate.

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REFERENCES

1 Organization WH. *World health report, 2010: health systems financing the path to universal coverage: World Health organization*, 2010.
2 van Doorslaer E, O'Donnell O, Rannan-Eliya RP, *et al*. Effect of payments for health care on poverty estimates in 11 countries in Asia: an analysis of household survey data. *Lancet* 2006;368:1357–64.
3 Xu K, Evans DB, Carrin G, *et al*. Protecting households from catastrophic health spending. *Health Aff* 2007;26:972–83.
4 Carrin G, Evans D, Xu K. Designing health financing policy towards universal coverage: SciELO public health 2007.
5 Meng Q, Fang H, Liu X, *et al*. Consolidating the social health insurance schemes in China: towards an equitable and efficient health system. *Lancet* 2015;386:1484–92.
6 Wagstaff A, Lindelow M, Jun G, Gao J, *et al*. Extending health insurance to the rural population: an impact evaluation of China's new cooperative medical scheme. *J Health Econ* 2009;28:1–19.
7 Lei X, Lin W. The new cooperative medical scheme in rural China: does more coverage mean more service and better health? *Health Econ* 2009;18 Suppl 2:S25–46.
8 You X, Kobayashi Y. The new cooperative medical scheme in China. *Health Policy* 2009;91:1–9.
9 Wagstaff A, Lindelow M, Jun G. Extending health insurance to the rural population: an impact evaluation of China’s new cooperative medical scheme: The World Bank 2007.
10 Cheng L, Liu H, Zhang Y, *et al*. The impact of health insurance on health outcomes and spending of the elderly: evidence from China's new cooperative medical scheme. *Health Econ* 2015;24:672–91.
11 Ma J, Xu J, Zhang Z, *et al*. New cooperative medical scheme decreased financial burden but expanded the gap of income-related inequity: evidence from three provinces in rural China. *Int J Equity Health* 2016;15:72.
12 Gatzert N, Maegebier A. Critical illness Insurances: challenges and opportunities for insurers. *Risk Management and Insurance Review* 2015;18:255–72.
13 Cummins JD, Venard B. *International insurance markets: between global dynamics and local Contingencies—An introduction*. Springer US, 2007.
14 Company MLI. *What are accident and critical illness insurance?* 200 Park Avenue, New York, NY 10166: Metropolitan Life Insurance Company, 2017[Available from:. https://www.d47.org/cms/lib/IL01904560/Centricity/Domain/512/Accident_Critical%20Illness%20FAQ.pdf. (accessed November 18th, 2018).
15 Re G. Dread Disease-Studie Der gen re für 2000 bis 2004 – Wie Alles Anfing, 2007. Available: http://www.genre.com/sharedfile/pdf/Themen15_Droste-de.pdf [Accessed 08/30/2012].
16 Macdonald AS, Waters HR, Wekwete CT. The genetics of breast and ovarian cancer II: a model of critical illness insurance. *Scand Actuar J* 2003;2003:28–50.
17 Gutiérrez C, Macdonald AS. Adult polycystic kidney disease and critical illness insurance. *North American Actuarial Journal* 2003;7:93–115.
18 Macdonald AJSAJ. Huntington’s disease, critical illness insurance and life insurance 2004;2004:279–313.
19 Ozkok E, Streftaris G, Waters HR, *et al*. Bayesian modelling of the time delay between diagnosis and settlement for critical illness insurance using a Burr generalised-linear-type model. *Insurance: Mathematics and Economics* 2012;50:266–79.
20 Jindrová P, VJRAiMMiAS P. Bayesian probability models for critical illness insurance 2014:218–21.
21 Jiang J, Chen S, Xin Y, *et al*. Does the critical illness insurance reduce patients’ financial burden and benefit the poor more: a comprehensive evaluation in rural area of China. *J Med Econ* 2019;22:455–63.
22 Government C. Guiding opinions on carrying out critical disease insurance work for urban and rural residents, 2012. Available: http://www.gov.cn/gzdt/2012-08/31/content_2214223.htm
23 Meng Q, Xu L, Zhang Y, Qun M, Ling X, Yaoguang Z, *et al*. Trends in access to health services and financial protection in China between 2003 and 2011: a cross-sectional study. *Lancet* 2012;379:805–14.
24 Li Y, Wu Q, Xu L, *et al*. Factors affecting catastrophic health expenditure and impoverishment from medical expenses in China: policy implications of universal health insurance. *Bull World Health Organ* 2012;90:664–71.

25 Xiang L, Pan Y, Hou S, *et al*. The impact of the new cooperative medical scheme on financial burden of tuberculosis patients: evidence from six counties in China. *Infect Dis Poverty* 2016;5:8.
26 Yi H, Zhang L, Singer K, *et al*. Health insurance and catastrophic illness: a report on the new cooperative medical system in rural China. *Health Econ* 2009;18 Suppl 2:S119–27.
27 Petrou P. An interrupted time-series analysis to assess impact of introduction of co-payment on emergency room visits in Cyprus. *Appl Health Econ Health Policy* 2015;13:515–23.
28 Gillings D, Makuc D, Siegel E. Analysis of interrupted time series mortality trends: an example to evaluate regionalized perinatal care. *Am J Public Health* 1981;71:38–46.
29 Zhang F, Wagner AK, Soumerai SB, *et al*. Methods for estimating confidence intervals in interrupted time series analyses of health interventions. *J Clin Epidemiol* 2009;62:143–8.
30 Bhaskaran K, Gasparrini A, Hajat S. Time series regression studies in environmental epidemiology 2013;42:1187–95.
31 Cliff A, Ord K. Testing for spatial autocorrelation among regression residuals. *Geogr Anal* 1972;4:267–84.
32 Beard E, Marsden J, Brown J. Understanding and using time series analyses in addiction research 2019;114:1866–84.
33 Wagner AK, Soumerai SB, Zhang F. Segmented regression analysis of interrupted time series studies in medication use research 2002;27:299–309.
34 County HaFPCoX. NCMS fundraising standard 2011.
35 WHO. *Draft global health sector strategy on viral hepatitis, 2016–2021–the first of its kind*, 2015.
36 Yip WC-M, Hsiao WC, Chen W, *et al*. Early appraisal of China's huge and complex health-care reforms. *Lancet* 2012;379:833–42.
37 Hou Z, Van de Poel E, Van Doorslaer E, *et al*. Effects of NCMS on access to care and financial protection in China. *Health Econ* 2014;23:917–34.
38 Ye C, Duan S, Wu Y, *et al*. A preliminary analysis of the effect of the new rural cooperative medical scheme on inpatient care at a County Hospital. *BMC Health Serv Res* 2013;13:519.
39 The annual government work report of 2019, 2019. Available: http://www.gov.cn/zhuanti/2019qglh/2019lhzfgzbg/index.htm

year	month	OOP	ERR	time	nterventioı	xt
2011	5	1544.817	58.63928	1	0	0
2011	6	1396.885	60.36961	2	0	0
2011	7	1349.261	60.71383	3	0	0
2011	8	1425.052	60.11541	4	0	0
2011	9	1372.456	60.35386	5	0	0
2011	10	1365.596	58.7725	6	0	0
2011	11	1307.231	58.89231	7	0	0
2011	12	1292.836	60.35043	8	0	0
2012	1	1569.692	55.52166	9	0	0
2012	2	1584.169	58.05543	10	0	0
2012	3	1506.81	61.01936	11	0	0
2012	4	1429.943	62.52118	12	0	0
2012	5	1754.145	59.71966	13	0	0
2012	6	1541.717	61.49196	14	0	0
2012	7	1605.915	60.56224	15	0	0
2012	8	1533.578	61.49648	16	0	0
2012	9	1803.733	58.22301	17	0	0
2012	10	1575.2	60.42082	18	0	0
2012	11	1685.357	59.14202	19	0	0
2012	12	1446.143	62.05317	20	0	0
2013	1	1665.689	61.21668	21	0	0
2013	2	1583.141	62.51318	22	0	0
2013	3	1659.822	61.75949	23	0	0
2013	4	1752.533	62.03109	24	0	0
2013	5	2210.115	52.4374	25	1	1
2013	6	2238.231	51.2183	26	1	2
2013	7	2644.167	50.916	27	1	3
2013	8	2450.281	51.13	28	1	4
2013	9	2319.746	52.09092	29	1	5
2013	10	2569.247	51.07366	30	1	6
2013	11	2332.467	52.64627	31	1	7
2013	12	2425.21	52.41083	32	1	8
2014	1	2447.505	52.53722	33	1	9
2014	2	2388.819	52.96115	34	1	10
2014	3	2280.418	53.50403	35	1	11
2014	4	2273.124	53.53717	36	1	12
2014	5	2266.075	53.62383	37	1	13
2014	6	2488.314	52.63817	38	1	14
2014	7	2526.236	52.01699	39	1	15
2014	8	2410.118	52.60144	40	1	16
2014	9	2703.455	51.9241	41	1	17
2014	10	2537.06	52.6854	42	1	18
2014	11	2440.584	52.30497	43	1	19
2014	12	2720.107	51.916	44	1	20
2015	1	1986.393	51.61688	45	1	21
2015	2	2575.068	48.43857	46	1	22
2015	3	2528.166	49.72584	47	1	23
2015	4	2387.17	51.16444	48	1	24
2015	5	2320.347	51.17683	49	1	25
2015	6	2321.891	51.7535	50	1	26
2015	7	2390.296	50.758	51	1	27
2015	8	2603.536	49.43456	52	1	28
2015	9	2695.564	48.989	53	1	29

2015	10	2480.678	49.64898	54	1	30
2015	11	2586.276	49.31366	55	1	31
2015	12	2677.126	48.42763	56	1	32
2016	1	2760.2	46.09883	57	1	33
2016	2	2835.096	46.65154	58	1	34
2016	3	2540.965	49.98213	59	1	35
2016	4	2279.974	52.5497	60	1	36
2016	5	2439.469	51.98215	61	1	37

```
***************************************************************************
* This file provides the Stata code used for the analysis of the raw dataset
* used in the paper:
* Interrupted time series regression for the evaluation of critical illness insurance(CII)
* interventions: CII policy
* BMJ OPEN, 2020
* Junnan Jiang, Shanquan Chen, Lu Li, Li Xiang
***************************************************************************
****************
insheet using "raw data.csv", comma

/* This dataset includes the following variables
year
month
time = elapsed time since the start of the study
OOP =   Out-of- pocket spending paid by patients (the outcome)
ERR   = Effective reimbursement rate, the reimbursement amount divided by the total medical expenditure(the outcome)
intervention = coded 0 before the intervention and 1 after the intervention
xt =a continuous variable counting the number of months after the intervention at time t, coded 0 before the cap and (time—20) after the cap.
/*

/*Adjust for seasonality
gen degrees=(time/12)*360
fourier degrees, n(2)
prais logoop intervention cos* sin* time xt
predict res, r
twoway (scatter res time)(lowess res time),yline(0)
tsset time
ac res
pac res, yw

predict pred, nooffset
twoway (scatter logoop time) (line pred time, lcolor(red)) xline(25)

egen avg_cos_1 = mean(cos_1)
egen avg_sin_1 = mean(sin_1)
egen avg_cos_2 = mean(cos_2)
egen avg_sin_2 = mean(sin_2)

drop cos* sin*

rename avg_cos_1 cos_1
```

```
rename avg_sin_1 sin_1
rename avg_cos_2 cos_2
rename avg_sin_2 sin_2

predict pred2, nooffset

twoway (scatter logoop time) (line pred time, lcolor(red)) (line pred2 time, lcolor(red) lpattern(dash)), xline(25)
```

CHEERS checklist—Items to include when reporting economic evaluations of health interventions

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as “cost-effectiveness analysis”, and describe the interventions compared.	Page 1, line 1-2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Page 1, line 12-29
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study.	Page 4
		Present the study question and its relevance for health policy or practice decisions.	Page 5, line 21-23
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Not mentioned
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Page 5-6
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	Page 7
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Page 6,line 11-24
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Page 7, line7-8
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	Not mentioned
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	Page 7, line 9-15
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	Not mentioned
	11b	*Synthesis-based estimates:* Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	Not suitable

Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	Not mentioned
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Page 7,line 21-29
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Not suitable
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Page 6,line 4-5
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	Page 8, line 3-12
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Not mentioned
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	Page 8, line 22-29
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	Page 9, line 12-14
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator	Page 9, line 15-25

		groups. If applicable, report incremental cost-effectiveness ratios.	
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	Page 9, line 15-25
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	Not suitable
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Page 9, line 27-29
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	Page 10-12
Others			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	Page 2, line 18-21
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	Page 2, line 23

Figure A1: Autocorrelation plots of the deviance residuals

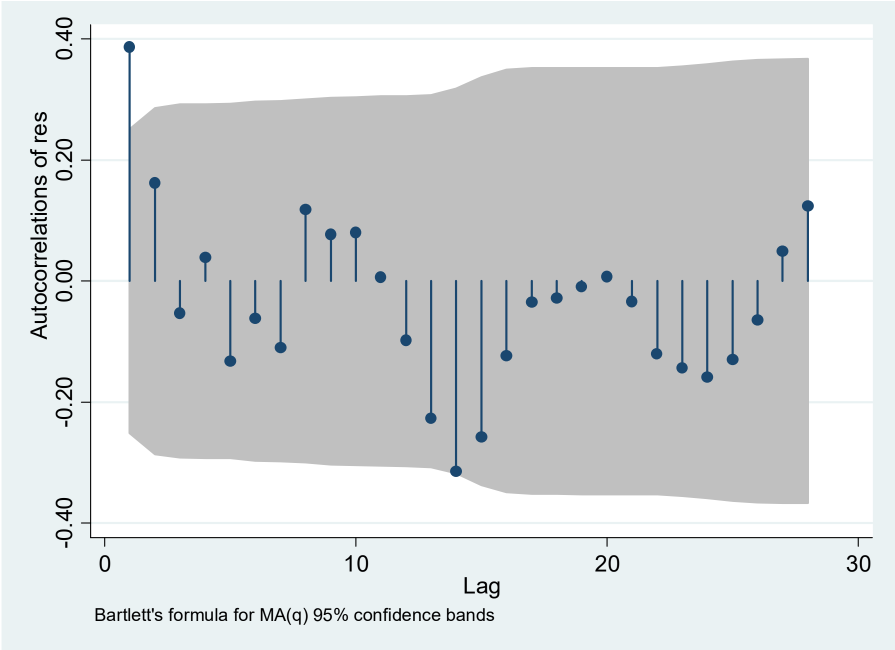

Figure A2: Partial autocorrelation plots of the deviance residuals

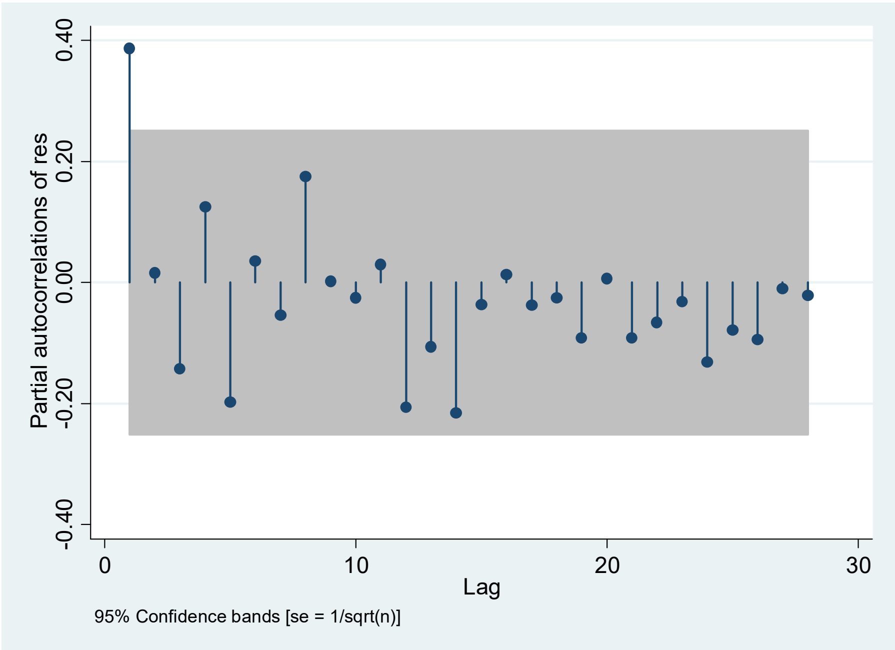

Table 1 Baseline effects and adjusted R squared of Interrupted time series analysis

Outcome variables	β_0, starting level, (95% CI)	β_1, Trend/slope change before CII, (95% CI)	Adjusted R^2
Log(Out-of-pocket payments)	7.212(7.153,7.270)***	0.009(0.005,0.014)***	0.935
In county	6.688(6.609,6.768)***	0.008(0.001,0.141)*	0.984
Out county	8.550(8.388,8.712)***		0.961
Log(Effective reimbursement rate)	4.067(4.033,4.102)***	0.002(0.001,0.005)*	0.984
In county	4.196(4.162,4.230)***	0.001(-0.002,0.004)	0.997
Out county	3.820(3.787,3.854)***	-0.003(-0.006,-0.001)*	0.841

Note:*means the p<0.05, ** means p<0.01, ***means p<0.001.