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## Impact of New Cooperative Medical Scheme on the Trend of Catastrophic Health Expenditure in Rural Households with Hospitalized Members from 2003 to 2013

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-019442
Article Type:	Research
Date Submitted by the Author:	01-Sep-2017
Complete List of Authors:	Xie, Biao Huo, Minghe Wang, Zhiqiang; University of Queensland, School of Medicine Chen, Yongjie Fu, Rong Liu, Meina Meng, Qun
<b>Primary Subject Heading</b>:	Health services research
Secondary Subject Heading:	Health services research, Health policy, Health economics
Keywords:	CHE, NCMS, NHSS, rural households with hospitalized members

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## **Impact of New Cooperative Medical Scheme on the Trend of Catastrophic Health Expenditure in Rural Households with Hospitalized Members from 2003 to 2013**

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## Abstract

**Objective** To evaluate the trend of catastrophic health expenses (CHE) for inpatient care in relation to the commencement of New Cooperative Medical Scheme (NCMS) in rural China from 2003 to 2013 and the roles of NCMS in protecting affected households from CHE.

**Methods** We assessed 10-year trend of the incidence and severity of CHE in rural households with hospitalized members using the data from Chinese National Health Services Survey (NHSS). Generalized Estimating Equations (GEE) was used to estimate the odds ratio (OR) and 95% confidence interval (CI) for the association between incidence rates of CHE ( $R_{\text{CHE}}$ ) and NCMS reimbursement.

**Results** The incidence and severity of CHE after NCMS reimbursement both decreased and their changes increased rapidly from 2003 to 2013. After adjustment of the covariates, the  $R_{\text{CHE}}$  before reimbursement was significantly higher than that after reimbursement and the OR (95% CI) was 1.50(1.24-1.81), 1.79(1.69-1.90) and 2.94(2.77-3.11) in the year of 2003, 2008 and 2013, respectively.

**Conclusion** The incidence and severity of CHE both reduced after NCMS reimbursements in each year. Excluding some confounding factors,  $R_{\text{CHE}}$  was significantly associated with NCMS reimbursement. The NCMS partly protected the rural households with hospitalized members from CHE. However, the inequalities between different income groups still existed. The  $R_{\text{CHE}}$  in rural households with hospitalized members in three years were still rather high even though they were covered with NCMS. This study will provide suggestions for further reforms in China and guidance for other developing countries.

**Keywords** CHE; rural households with hospitalized members; NCMS; NHSS.

### Strengths and limitations of this study

- ▶ Most studies focused on a specific local area or the short-term effect of New Cooperative Medical System (NCMS) on catastrophic health expenses (CHE) in China. We assessed 10-year trend of the incidence and severity of CHE at national level using the data from the Chinese National Health Services Survey (NHSS).
- ▶ NCMS focused on inpatient care reimbursement. However, few previous studies had focused on rural households with hospitalized members. We assessed CHE in such affected rural households.
- ▶ Household income was transformed by Consumer Price Index (CPI). Three indicators were used to capture the catastrophe's incidence and intensity. Data was disaggregated by three geographic regions (east, central and west) and four household income levels. Generalized Estimating Equations (GEE) was used to estimate OR and 95% CI for the association between the catastrophe's incidence and NCMS reimbursement.
- ▶ The NCMS was at the start stage in 2003 and the coverage was very low in rural China. Therefore, the sample size in 2003 was small with only 338 households. Our estimates may not be adequate. We only focused on the rural households with hospitalized members covered by the NCMS. Thus, our findings should be interpreted cautiously.

## Introduction

The New Cooperative Medical System (NCMS) was introduced to rural China in 2003. It was designed to provide financial protection for its enrollees. In terms of the enrollment size, NCMS is by far the largest health insurance plan in the world.<sup>2</sup> Catastrophic health expenses (CHE) is defined as an out-of-pocket health expenditure which is larger than 40% of the household's capacity to pay (CTP).<sup>1</sup> CHE is an indicator reflecting the effectiveness of financial protection a health insurance could provide for its members. In 2008, 15.1% of the rural households and 35.0% of the rural households with hospitalized members faced CHE in China.<sup>3,4</sup> It was essential to evaluate the role of NCMS in preventing CHE among its members. There had been many studies measuring the impact of NCMS. However, most studies focused on a specific local area or the short-term effect of NCMS on CHE in China.<sup>3-10</sup> NCMS focused on inpatient care reimbursement. Among studies on the impact of NCMS on CHE, those focusing on affected rural households with hospitalized members were valuable. However, few previous studies had focused on such affected rural households.

We assessed 10-year trend of the incidence and severity of CHE in rural households with hospitalized members at national level using the data from the Chinese National Health Services Survey (NHSS). The trend of CHE for inpatient care in relation to the commencement of NCMS in rural China from 2003 to 2013 and the roles of NCMS in protecting affected households from CHE can provide evidence for NCMS in improving the financial protection for Chinese residents. As an exploratory attempt to study the impact of NCMS on CHE of rural households with hospitalized members, this study can provide some recommendations for the next phase of health reform for policy-makers.

## Method

### Data source and study population

Data used in this study was derived from the Chinese Third NHSS in 2003, the Fourth NHSS in 2008 and the Fifth NHSS in 2013. As the largest statewide health survey in China, the NHSS was organized by the Chinese government every 5 years since 1993. The NHSS was done with a robust multi-stage and stratified random cluster sampling method.<sup>11</sup> A total of 94 counties were selected from 2859 counties in 31 provinces, autonomous regions, and municipalities in China. In each county, five townships were selected within which two villages were selected. A total of 470 townships and 940 villages were included. In each village, 60 households were selected.<sup>12</sup> The institutional review board of the Chinese National Bureau of Statistics provided review and ethics approval of the survey. A district survey manager checked the questionnaires at the end of each day to avoid missing information or logic errors. 5% of the sampled households were randomly selected to be revisited to examine survey quality (95% was achieved).<sup>11</sup> According to a test conducted by the Health Statistical Center of the Ministry of Health of China, the survey data was representative of the age and structure of overall national population compared with the 2007 National Sampling Survey of Population Change.<sup>11</sup>

This study focused on the incidence and severity of CHE of rural households with hospitalized members covered by NCMS. Households which didn't join NCMS or didn't use inpatient services were not covered. This yielded a final sample of 6975 households which experienced inpatient care during the study period (180 in 2003, 2326 in 2008 and 4469 in 2013).

### The introduction of indicators

Out-of-pocket health expenditure payment (OOP) refers to the expenditure made by each household member after they receive health services without compensations from a third party. The poverty line is the average food expenditure of households of which food share is in the 45th to 55th percentile range. This poverty line multiplied

by the equalized household size (actual household size<sup>0.56</sup>) is household subsistence spending. CTP is generally defined as a non-subsistence spending. However, when food expenditure is lower than subsistence spending in some households, the non-food expenditure is used as non-subsistence spending in this particular situation.<sup>1</sup>

<sup>4</sup> The information on the questions in the questionnaire of NHSS employed to calculate indicators below were showed in Supplementary information.

#### (1) The incidence rates of CHE

There were various definitions of CHE, we employed the method recommended by World Health Organization (WHO) for calculating CHE in this study. An OOP is considered financially catastrophic when it is larger than 40% of the household's CTP.<sup>1</sup> Let  $R_{CHE}$  denotes the incidence rates of CHE, which can be calculated as

$$R_{CHE} = \frac{1}{N} \sum_{i=1}^N E_i \quad (1)$$

Where  $N$  represents the sample size.  $E_i = 1$  when  $^{OOP}/_{CTP} \geq 0.4$ ;  $E_i = 0$  when  $^{OOP}/_{CTP} < 0.4$ .

#### (2) The definitions and calculations of mean CHE gap ( $G_{CHE}$ ) and mean positive CHE gap ( $MPG_{CHE}$ )

The  $G_{CHE}$  describes how much of a household's health expenditure is in excess of the threshold of 40% of its CTP, which is estimated to reveal the average level of CHE severity for all studied households. The  $MPG_{CHE}$  refers to the average of the sum of the total excesses from all the catastrophic households in the sample.<sup>1</sup>  $G_{CHE}$  and  $MPG_{CHE}$  can be calculated as

$$G_{CHE} = \frac{1}{N} \sum_{i=1}^N O_i \quad (2)$$

$$MPG_{CHE} = \frac{\sum_{i=1}^N O_i}{\sum_{i=1}^N E_i} \quad (3)$$

Where  $O_i = ^{OOP}/_{CTP} - 0.4$  when  $^{OOP}/_{CTP} > 0.4$ ;  $O_i = 0$  when  $^{OOP}/_{CTP} \leq 0.4$ .

### Statistical analysis

Categorical variables and expenditure measures were described by numbers



1  
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3 (percentages) and means (standard deviation), respectively. Annual household income  
4 in 2008 and 2013 was transformed by Consumer Price Index (CPI) to the price level  
5 in 2003 with the transformation formula: real price = nominal price×(CPI of base  
6 year/CPI of object year).<sup>18</sup> Annual household income was classified as quartiles.  
7  
8 Three indicators above captured the catastrophe's incidence and intensity. We used  
9 stratification analysis to assess the 10-year trend of these indicators before and after  
10 NCMS reimbursement. The impact of NCMS in each year was reflected in the  
11 difference in CHE before and after reimbursement. The trend of difference from 2003  
12 to 2013 reflected overall change of the impact of NCMS. Data was disaggregated by  
13 three geographic regions (east, central and west) and four household income levels.  
14  
15 The  $R_{\text{CHE}}$  of each household had two records in each year, one before NCMS  
16 reimbursement and one after. We took it as a repeated measures analysis. Generalized  
17 Estimating Equations (GEE) was used to estimate OR and 95% CI for the association  
18 between the  $R_{\text{CHE}}$  and NCMS reimbursement. Covariates including age, gender,  
19 education of household head, household size, and one or more members older than 60  
20 years were adjusted. All of the analyses were performed using SAS 9.2 (SAS Institute  
21 Inc., Cary, NC, USA). A two-sided  $P < 0.05$  was established as the level of statistical  
22 significance for all tests.  
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## Result

### Characteristics of Households

Characteristics of all households enrolled in the study in 2003, 2008 and 2013 were shown in Table 1. The age of householders increased from 2003 to 2013, 49.38% of the householders were of age 60 or older in 2013. The proportion of households with one or more members younger than 5 years decreased from 17.78% in 2003 to 14.84% in 2013. The proportion of households with people of age 60 or older showed a 12.96% increase from 2003 to 2013. The proportion of householders with a junior high school or higher degree increased from 31.67% in 2003 to 40.17% in 2013. Annual household income of each year was divided into quartiles, with each quartile cutoffs shifting upward from 2003 to 2013.

**Table 1. Characteristics of all households enrolled in the study**

Characteristics	2003 (N=180)		2008 (N= 2326)		2013 (N= 4469)	
	n	%	n	%	n	%
<b>Household characteristics</b>						
Number of household members						
<5	128	71.11	1916	82.37	3971	88.86
≥5	52	28.89	410	17.63	498	11.14
One or more members older than 60 years						
No	104	57.78	1267	54.47	2003	44.82
Yes	76	42.22	1059	45.53	2466	55.18
One or more members younger than 5 years						
No	148	82.22	1948	83.75	3806	85.16
Yes	32	17.78	378	16.25	663	14.84
Time spent						

travelling to							
the nearest							
medical							
center							
≤15min	145	80.56	1701	73.13	3532	79.03	
>15min	35	19.44	625	26.87	937	20.97	
The number							
of							
observations							
in each region							
East	113	62.78	626	26.91	991	22.17	
Centre	14	7.78	759	32.63	1670	37.37	
West	53	29.44	941	40.46	1808	40.46	
Annual							
household							
income*							
Q 1	2643.33	1265.69	3956.52	1680.38	4785.49	2590.40	
Q 2	6914.23	1353.25	9062.74	1247.41	13003.64	2841.22	
Q 3	13505	2716.15	14699.42	2065.84	25958.15	5174.25	
Q 4	29194.35	10927.31	31665.48	20295.22	61082.23	44409.99	
<b>householders'</b>							
<b>characteristics</b>							
Gender							
Male	131	72.78	1796	77.21	3373	75.48	
Female	49	27.22	530	22.79	1096	24.52	
Age							
<60	120	66.67	1442	61.99	2262	50.62	
≥60	60	33.33	884	38.01	2207	49.38	
Marital status							
Unmarried	4	2.22	47	2.02	72	1.61	
Married	155	86.11	1953	83.96	3735	83.58	
Divorced	0	0	29	1.25	612	13.69	
Widow or							
others	21	11.67	297	12.77	50	1.12	
Education							
Illiterate	52	28.89	511	21.98	811	18.15	
Elementary							
school	71	39.44	917	39.44	1863	41.69	
Junior high							
school	48	26.67	722	31.05	1418	31.73	
Senior high							
school or	9	5.00	175	7.53	377	8.44	
above							
Employment							

Employed	126	70.00	1817	78.12	3222	72.10
Retired	12	6.67	60	2.58	157	3.51
Others	42	23.33	449	19.30	1090	24.39

\*Annual household income of each year was divided into four levels according to the quartile, the mean and standard deviation of each level were calculated.

### **The incidence rates of CHE**

Table 2 showed the  $R_{\text{CHE}}$  among all the studied households. After NCMS reimbursement, the total  $R_{\text{CHE}}$  decreased rapidly, from 49.44% in 2003 to 34.88% in 2013. The change of the total  $R_{\text{CHE}}$  before and after reimbursement increased rapidly, from 9.45% in 2003 to 24.10% in 2013. A similar pattern was observed in different regions and different income levels. In addition, the poorest had the highest incidence and the change in the west region was bigger than those in other regions.

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**Table 2. Results of the incidence rates of CHE among all the studied households**

$R_{CHE}$	2003			2008			2013		
	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change
Total	58.89	49.44	9.45	54.90	41.75	13.15	58.98	34.88	24.10
East	58.41	50.44	7.97	58.79	46.49	12.30	63.47	39.56	23.91
Centre	85.71	85.71	0	49.54	38.47	11.07	57.13	35.51	21.62
West	52.83	37.74	15.09	56.64	41.23	15.41	58.24	31.75	26.49
Q1	71.11	71.11	0	78.65	60.67	17.98	86.25	58.75	27.50
Q2	60.47	48.84	11.63	59.32	44.30	15.02	73.61	43.13	30.48
Q3	60.87	45.65	15.22	50.93	39.22	11.71	54.79	29.16	25.63
Q4	43.48	32.61	10.87	37.23	27.88	9.35	32.86	18.39	14.47

### The Severity of CHE

The severity of CHE among all the studied households was shown in Table 3. After NCMS reimbursement, the total  $G_{CHE}$  exhibited a decreased trend, from 12.57% in 2003 to 8.15% in 2013. The change of the total  $G_{CHE}$  before and after reimbursement increased rapidly from 8.94% in 2003 to 33.50% in 2013. Different regions and different income levels had similar patterns. In addition, the highest  $G_{CHE}$  was observed in the poorest areas. A similar trend could be observed in  $MPG_{CHE}$ . The change of  $MPG_{CHE}$  was higher than that of  $G_{CHE}$  in each year.

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**Table 3. Results of the severity of CHE among all the studied households**

Indicators	2003			2008			2013		
	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change
<i>G<sub>CHE</sub></i>									
Total	21.51	12.57	8.94	23.23	10.08	13.15	41.65	8.15	33.50
East	19.54	13.56	5.98	28.54	12.54	16.00	56.92	10.51	46.41
Centre	25.12	25.12	0	20.28	8.74	11.54	38.00	8.29	29.71
West	24.73	7.15	17.58	22.09	9.52	12.57	36.64	6.72	29.92
Q1	26.37	21.66	4.71	42.80	16.32	26.48	86.46	15.96	70.50
Q2	28.51	12.94	15.57	22.77	10.17	12.60	57.13	9.57	47.56
Q3	18.70	9.06	9.64	17.38	8.57	8.81	28.70	6.02	22.68
Q4	13.01	6.85	6.16	13.56	6.55	7.01	13.90	4.05	9.85
<i>MPG<sub>CHE</sub></i>									
Total	36.52	25.43	11.09	42.32	24.14	18.18	70.61	23.35	47.26
East	33.46	26.88	6.58	48.54	26.97	21.57	89.67	26.58	63.09
Centre	29.31	29.31	0	40.94	22.73	18.21	66.53	23.33	43.20
West	46.82	18.95	27.87	39.00	23.09	15.91	62.91	21.16	41.75
Q1	37.07	30.46	6.61	54.41	26.90	27.51	100.24	27.17	73.07
Q2	47.15	26.50	20.65	38.38	22.96	15.42	77.61	22.19	55.42
Q3	30.72	19.84	10.88	34.12	21.86	12.26	52.38	20.65	31.73
Q4	29.93	21.01	8.92	36.42	23.48	12.94	42.32	22.03	20.29

### The influence of NCMS on the incidence rates of CHE

Table 4 showed the influence of NCMS on  $R_{CHE}$ . In the aggregate, the  $R_{CHE}$  before NCMS reimbursement was significantly higher than that after NCMS reimbursement and the OR (95% CI) was 1.46(1.23-1.74), 1.70(1.61-1.80) and 2.68(2.54-2.83) in 2003, 2008 and 2013, respectively. The OR changed rapidly. There was a 16.44% increase in the year 2008 compared to 2003 and a 57.65% increase in the year 2013 compared to 2008. After adjustment of the covariates, the OR (95% CI) was 1.50(1.24-1.81), 1.79(1.69-1.90) and 2.94(2.77-3.11) in 2003, 2008 and 2013, respectively. There was a 19.33% increase in the year 2008 compared to 2003 and a 64.25% increase in the year 2013 compared to 2008. A similar pattern was observed in different regions and at different income levels but there were several exceptions in central region and the lowest income groups of 2003 where the  $R_{CHE}$  before NCMS reimbursement was not significantly higher than that after NCMS reimbursements. Among these covariates, the protection factors of the CHE were the male gender of the householder, higher level of education of the householder and bigger household size. The risk factors of the CHE were having one or more members older than 60 and the older age of the householder (Supplementary information).

**Table 4. The influence of NCMS on the incidence rates of CHE**

	Year	Change	Crude		Adjusted	
			OR (95 % CI)	Increment (%)	OR (95 % CI)	Increment (%)
Total	2003	9.45	1.46(1.23-1.74)	-	1.50(1.24-1.81)	-
	2008	13.15	1.70(1.61-1.80)	16.44	1.79(1.69-1.90)	19.33
	2013	24.10	2.68(2.54-2.83)	57.65	2.94(2.77-3.11)	64.25
Area						
East	2003	7.97	1.38(1.13-1.69)	-	1.43(1.14-1.80)	-
	2008	12.30	1.64(1.48-1.82)	18.84	1.77(1.57-1.99)	23.78
	2013	23.91	2.66(2.37-2.97)	62.20	3.08(2.71-3.50)	74.01
Central	2003	0	1.00(1.00-1.00)	-	1.00(1.00-1.00)	-
	2008	11.07	1.57(1.43-1.72)	57	1.64(1.49-1.82)	64.00
	2013	21.62	2.42(2.23-2.63)	54.14	2.63(2.40-2.88)	60.37



1							
2							
3	West						
4		2003	15.09	1.85(1.24-2.75)	-	1.86(1.23-2.82)	-
5		2008	15.41	1.86(1.69-2.05)	0.54	1.96(1.77-2.16)	5.38
6		2013	26.49	3.00(2.74-3.28)	61.29	3.22(2.93-3.55)	64.29
7							
8	Income						
9	Q1						
10		2003	0	1.00(1.00-1.00)	-	1.00(1.00-1.00)	-
11		2008	17.98	2.39(2.03-2.81)	139.00	2.56(2.16-3.04)	156.00
12		2013	27.50	4.40(3.70-5.24)	84.10	4.65(3.89-5.55)	81.64
13							
14	Q2						
15		2003	11.63	1.60(1.08-2.37)	-	1.63(1.08-2.45)	-
16		2008	15.02	1.83(1.62-2.08)	14.38	1.90(1.67-2.16)	16.56
17		2013	30.48	3.68(3.19-4.25)	101.09	3.86(3.32-4.49)	103.16
18							
19	Q3						
20		2003	15.22	1.85(1.21-2.84)	-	1.89(1.23-1.92)	-
21		2008	11.71	1.61(1.44-1.80)	-12.97	1.63(1.46-1.83)	-13.76
22		2013	25.63	2.94(2.68-3.23)	82.61	3.04(2.76-3.35)	86.50
23							
24	Q4						
25		2003	10.87	1.59(1.08-2.34)	-	1.62(1.08-2.41)	-
26		2008	9.35	1.53(1.39-1.69)	-3.77	1.55(1.41-1.72)	-4.32
27		2013	14.47	2.17(1.94-2.43)	41.83	2.21(1.97-2.48)	42.58
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33	<b>Discussion</b>						
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35	According to Chinese NHSS in 1998 and 2003, rural residents' health expenditures						
36	grew at an annual rate of 11.48%, which was four times faster than their net income. <sup>18</sup>						
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38	High healthcare expenses in the absence of financial protection forced these rural						
39	households to fall into a difficult circumstance: "It's too difficult to see a doctor, and						
40	too expensive to seek health care!" <sup>18</sup> In 2003, 96% of rural households in China						
41	lacked medical insurance, and 38% of the sick didn't seek medical attention. <sup>11 18</sup> To						
42	address this issue, NCMS was introduced to Chinese rural areas in 2003. With great						
43	efforts of the government, NCMS had experienced rapid growth in coverage. By 2011,						
44	97.5% of the rural population had been covered by NCMS in China. <sup>3 17-18</sup> This had						
45	fuelled a significantly increased consumption of health services due to previously						
46	latent unmet demand. From 2003 to 2008, the inpatient hospital admission rate for						
47	rural residents almost doubled. <sup>2 4 18</sup> The $R_{CHE}$ of rural households with hospitalized						
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## Discussion

According to Chinese NHSS in 1998 and 2003, rural residents' health expenditures grew at an annual rate of 11.48%, which was four times faster than their net income.<sup>18</sup> High healthcare expenses in the absence of financial protection forced these rural households to fall into a difficult circumstance: "It's too difficult to see a doctor, and too expensive to seek health care!"<sup>18</sup> In 2003, 96% of rural households in China lacked medical insurance, and 38% of the sick didn't seek medical attention.<sup>11 18</sup> To address this issue, NCMS was introduced to Chinese rural areas in 2003. With great efforts of the government, NCMS had experienced rapid growth in coverage. By 2011, 97.5% of the rural population had been covered by NCMS in China.<sup>3 17-18</sup> This had fuelled a significantly increased consumption of health services due to previously latent unmet demand. From 2003 to 2008, the inpatient hospital admission rate for rural residents almost doubled.<sup>2 4 18</sup> The  $R_{CHE}$  of rural households with hospitalized

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3 members was much higher than other rural households.<sup>4</sup> It was meaningful to evaluate  
4 the effectiveness of NCMS to provide financial protection specifically for these rural  
5 households with hospitalized members.  
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9 In our study,  $R_{\text{CHE}}$  of these households before NCMS reimbursement were  
10 58.89%, 54.90% and 58.98% for 2003, 2008 and 2013, respectively (Table 2).  
11 Approximately 60% of the households would fall into CHE and be susceptible to  
12 disease-induced poverty if they were not covered with NCMS in three years. After  
13 NCMS reimbursement, the  $R_{\text{CHE}}$  decreased with different degrees, which were lowered  
14 to 49.44%, 41.75% and 34.88% for 2003, 2008 and 2013, respectively (Table 2). The  
15 total  $G_{\text{CHE}}$  and  $MPG_{\text{CHE}}$  also decreased after NCMS reimbursement (Table 3). The  
16 incidence and severity of CHE before NCMS reimbursement were higher than that  
17 after NCMS reimbursement in three years, which confirmed the effectiveness of  
18 NCMS to reduce CHE. Moreover, after adjustment of the covariates,  $R_{\text{CHE}}$  was  
19 significantly associated with NCMS reimbursement ( $P < 0.05$ ) (Table 4). To some  
20 extent, the NCMS protected the rural households with hospitalized members from  
21 CHE. Inpatient reimbursement rates in rural areas had a remarkable achievement,  
22 increasing 7.5 times from 5.8% in 2003 to 43.7% in 2011.<sup>3</sup> The financial protection in  
23 rural areas have been steadily improved. An apparent enhancement could be seen in  
24 this protective effect from 2003 to 2013, especially after the 2009 Health Care Reform.  
25 To further preventing CHE, NCMS should increase financing level to provide a better  
26 benefit package, such as lowering the deductibles and co-payments, and setting higher  
27 reimbursement rates and ceilings. Having one or more members older than 60 in a  
28 household, female gender and older age of the householder, lower level of education  
29 of the householder and smaller household size increased the risk of incurring CHE in  
30 our study (Supplementary information). This was consistent with the previous  
31 studies.<sup>4 19-22</sup> The NCMS should make preferential policies for these high-risk  
32 populations, such as providing special subsidies to them.  
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54 It was worth noting that the  $R_{\text{CHE}}$  in rural households with hospitalized members  
55 in three years were all more than 34% after NCMS reimbursement, which meant that  
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3 a number of households still faced CHE even though they were covered with NCMS  
4 (Table 2). Many studies had shown that CHE was very likely to occur in households  
5 with poor economic conditions.<sup>23-26</sup> The rural households with hospitalized members  
6 have heavy economic burdens and are likely to fall into such conditions. Thus, our  
7 study population tend to have higher proportion of CHE than previously reported in  
8 the whole rural households. Another reason for high proportion of CHE in these  
9 households is the limited numbers of drugs and treatments included in the scope of  
10 NCMS. Under the fee-for-service payment system in China, doctors had strong  
11 incentives to prescribe expensive drugs and examinations not included by NCMS.<sup>4</sup>  
12 The NCMS needs to increase financial investment to expand its catalogue of essential  
13 medicines, especially for medicines which could increase the profits of medical  
14 institutions and pharmaceutical factories. An effective monitoring system is needed to  
15 restrain oversupply of expensive medical services and ensures that first-line generic  
16 medicines are available and preferentially prescribed.  
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30 We observed that all three indicators declined with the increase of household  
31 income in our study (Table 2 and Table 3). Low-income households were more likely  
32 to incur CHE than other groups. One of the main reasons is their limited ability to pay  
33 for non-subsistence spending. These households are likely to fall into CHE, even as a  
34 result of low health expenditure. This phenomenon had also been experienced in  
35 many developing countries in Asia.<sup>19 26 28 29</sup> The inequalities of three indicators  
36 between different income groups still existed from 2003 to 2013 (Table 2 and Table 3).  
37 A higher share of resources from central governments should be allocated to areas  
38 with poor economic capacity. The current medical financial assistance scheme (MFA),  
39 which was a scheme designed to provide support to the poor households for their  
40 CHE, should be further promoted to play a more efficient role in preventing CHE.  
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50 The changes of  $R_{CHE}$  and OR before and after NCMS reimbursement in the west  
51 region were larger than the corresponding values in other regions in three years (Table  
52 2 and Table 4). A higher share of resources was allocated to west region. Inpatient  
53 reimbursement rates of east, central and west geographic regions in 2011 was 46.8%,  
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3 41.2% and 51.2%, respectively.<sup>3 29</sup> Almost all three indicators after NCMS  
4 reimbursement decreased rapidly from 2003 to 2008 but slowed down from 2008 to  
5 2013 (Table 2 and Table 3). This is due to the worst health situation in 2003 and the  
6 saturated health situation in 2008.<sup>13 15</sup>

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11 GEE is based on the quasi-likelihood function and generalized linear model. The  
12 advantage of GEE is to resolve the issues resulting from repeated measures that tend  
13 to be correlated.<sup>30</sup> The  $R_{\text{CHE}}$  of each household had two records, one before NCMS  
14 reimbursement and one after. We took it as a repeated measures analysis. We  
15 performed GEE with logit link including various covariates to estimate OR and 95%  
16 CI for the association between the  $R_{\text{CHE}}$  and NCMS reimbursement.

## 17 18 19 20 21 22 **Conclusion**

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24 The  $R_{\text{CHE}}$ ,  $G_{\text{CHE}}$  and  $MPG_{\text{CHE}}$  all decreased rapidly after NCMS reimbursement and their  
25 changes increased rapidly from 2003 to 2013. After adjustment of the covariates, the  
26  $R_{\text{CHE}}$  after NCMS reimbursement were significantly lower than that before NCMS  
27 reimbursements in each year. The NCMS partly protected the rural households with  
28 hospitalized members from CHE. The financial protection in rural areas had been  
29 steadily improved with the development of NCMS. However, the inequalities between  
30 different groups still existed. The  $R_{\text{CHE}}$  in rural households with hospitalized members  
31 in three years were all more than 34% after reimbursement, which meant that many  
32 households still faced CHE even though they were covered with NCMS. To further  
33 prevent CHE, NCMS should increase financing level to provide a better benefit  
34 package, make preferential policies for the high-risk populations, properly expand  
35 catalogue of essential medicines and increase reimbursement rates and establish  
36 effective supervision system. A high-quality health care in China will contribute to  
37 global health because of China's great population share in the world. Undoubtedly, the  
38 gain and loss during this reform will serve as reference for other countries, especially  
39 developing countries.

## 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 **Acknowledgment**

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3 The research is funded by National Natural Science Foundation of China [81273183  
4 to Liu MN].  
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9 **Contributors**

10 XB, W-ZQ and H-MH drafted the manuscript. C-YJ and FR performed data collection  
11 and statistical analyses. L-MN and MQ made a substantial contribution to the  
12 interpretation of the data and study design. All authors read and approved the final  
13 manuscript.  
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20 **Competing interests:** None declared.  
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24 **Ethics approval :** The institutional review board of the Chinese National Bureau of  
25 Statistics provided review and ethics approval of the survey.  
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30 **Data sharing statement:** Original data is available on request. It was stored on  
31 password-protected computers at the centre for health statistics information of  
32 Ministry of Health in Beijing, China.  
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### Supplementary data 1 The questions in the questionnaire of NHSS employed to calculate indicators

Food consumption expenditure in each household was measured by the question, “How much did your household spend in food consumption expenditure during the last one year?”

The question, “How much did your household spend in living expenditure during the last one year?” was chosen to measure the total living expenditure in each household.

Actual household size was measured by the question, “How many people have a long-term residence at your household?”

The question, “How much did your household spend in medical expenses (without compensations from a third party) during the last one year” was chosen to measure the out-of-pocket health expenditure payment in each household.

### Supplementary data 2

**Table 1 Determinants of catastrophic health expenditure.**

Determinant	$\beta$ (95%CI)	SE	Z	P
<b>Gender of householder</b> (male vs female)	-0.51(-0.62--0.40)	0.06	-8.94	<.0001
<b>Age of householder</b>	0.28(0.11-0.46)	0.09	3.12	0.0018
<b>Educational level of householder</b>				
Elementary school vs Illiterate	-0.35(-0.48--0.22)	0.07	-5.31	<.0001
Junior high school vs Illiterate	-0.49(-0.64--0.35)	0.07	-6.84	<.0001
Senior high school or above vs Illiterate	-0.90(-1.11--0.70)	0.11	-8.56	<.0001
<b>One or more members older than 60 years</b> (yes vs no)	0.39(0.21-0.56)	0.09	4.35	<.0001
<b>One or more members younger than 5 years</b> (yes vs no)	0.03(-0.11-0.17)	0.07	0.37	0.7104
<b>Number of household members</b>	-0.27(-0.31--0.24)	0.02	-14.3	<.0001
<b>Years</b>				
2008 vs 2003	-0.27(-0.59-0.06)	0.17	-1.62	0.1057
2013 vs 2003	-0.28(-0.60-0.04)	0.16	-1.71	0.0877

**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology\***  
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4,5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6-7
		(b) Describe any methods used to examine subgroups and interactions	6-7
		(c) Explain how missing data were addressed	5
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	

		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	5
		(e) Describe any sensitivity analyses	
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	5
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	14-15
		(b) Report category boundaries when continuous variables were categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-15
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	15-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	3
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	3 , 15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	3
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Impact of New Cooperative Medical Scheme on the Trend of Catastrophic Health Expenditure in Chinese Rural Households: results from nationally representative surveys from 2003 to 2013

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-019442.R1
Article Type:	Research
Date Submitted by the Author:	01-Dec-2017
Complete List of Authors:	Xie, Biao Huo, Minghe Wang, Zhiqiang; University of Queensland, School of Medicine Chen, Yongjie Fu, Rong Liu, Meina Meng, Qun
<b>Primary Subject Heading</b>:	Health services research
Secondary Subject Heading:	Health services research, Health policy, Health economics
Keywords:	CHE, rural households with hospitalized members, NCMS, NHSS

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1           **Impact of New Cooperative Medical Scheme on the Trend of**  
2           **Catastrophic Health Expenditure in Chinese Rural Households:**  
3           **results from nationally representative surveys from 2003 to 2013**

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## 29 Abstract

30 **Objective** To evaluate the trend of catastrophic health expenses (CHE) for inpatient  
31 care in relation to the commencement of New Cooperative Medical Scheme (NCMS)  
32 in rural China from 2003 to 2013 and the roles of NCMS in protecting affected  
33 households from CHE.

34 **Methods** We assessed 10-year trend of the incidence and severity of CHE in rural  
35 households with hospitalized members using the data from Chinese National Health  
36 Services Survey (NHSS). Generalized Estimating Equations (GEE) were used to  
37 estimate the odds ratio (OR) and 95% confidence interval (CI) for the association  
38 between incidence rates of CHE ( $R_{CHE}$ ) and NCMS reimbursement.

39 **Results** The incidence and severity of CHE after NCMS reimbursement both  
40 decreased and their changes increased rapidly from 2003 to 2013. After adjustment of  
41 the covariates, the  $R_{CHE}$  before reimbursement was significantly higher than that after  
42 reimbursement and the OR (95% CI) was 1.50(1.24-1.81), 1.79(1.69-1.90) and  
43 2.94(2.77-3.11) in the year of 2003, 2008 and 2013, respectively.

44 **Conclusion** The incidence and severity of CHE both reduced after NCMS  
45 reimbursements in each year. Excluding some confounding factors,  $R_{CHE}$  was  
46 significantly associated with NCMS reimbursement. The NCMS partly protected the  
47 rural households with hospitalized members from CHE. However, the inequalities  
48 between different income groups still existed. The  $R_{CHE}$  in rural households with  
49 hospitalized members were still rather high in 2003, 2008 and 2013 even though they  
50 were covered with NCMS. This study will provide suggestions for further reforms in  
51 China and guidance for other developing countries.

52  
53 **Keywords** CHE; rural households with hospitalized members; NCMS; NHSS.  
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60 **Strengths and limitations of this study**

- 61 ▶ Generalized Estimating Equations (GEE) were used to estimate OR and 95% CI
- 62 for the association between the catastrophe's incidence and NCMS
- 63 reimbursement.
- 64 ▶ We assessed 10-year trend of the incidence and severity of CHE at national level
- 65 using the data from the Chinese National Health Services Survey (NHSS).
- 66 ▶ Three indicators were used to capture the catastrophe's incidence and intensity.
- 67 ▶ The sample size in 2003 was small with only 180 households.

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3 894 90 **Introduction**

5  
6 91 The New Cooperative Medical System (NCMS) was introduced to rural China in  
7  
8 92 2003. It was designed to provide financial protection for its enrollees. In terms of the  
9  
10 93 enrollment size, NCMS is by far the largest health insurance plan in the world.<sup>1</sup>  
11  
12 94 Catastrophic health expenses (CHE) is defined as an out-of-pocket health expenditure  
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14 95 which is larger than 40% of the household's capacity to pay (CTP).<sup>2</sup> CHE is an  
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16 96 indicator reflecting the effectiveness of financial protection a health insurance could  
17  
18 97 provide for its members. In 2008, 15.1% of the rural households and 35.0% of the  
19  
20 98 rural households with hospitalized members faced CHE in China.<sup>3 4</sup> It was essential to  
21  
22 99 evaluate the role of NCMS in preventing CHE among its members. There had been  
23  
24 100 many studies measuring the impact of NCMS. However, most studies focused on a  
25  
26 101 specific local area or the short-term effect of NCMS on CHE in China.<sup>3-10</sup> NCMS  
27  
28 102 focused on inpatient care reimbursement. Among studies on the impact of NCMS on  
29  
30 103 CHE, those focusing on affected rural households with hospitalized members were  
31  
32 104 valuable. However, few previous studies had focused on such affected rural  
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34 105 households.

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36 106 We assessed 10-year trend of the incidence and severity of CHE in rural  
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38 107 households with hospitalized members at national level using the data from the  
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40 108 Chinese National Health Services Survey (NHSS). The trend of CHE for inpatient  
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42 109 care in relation to the commencement of NCMS in rural China from 2003 to 2013 and  
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44 110 the roles of NCMS in protecting affected households from CHE can provide evidence  
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46 111 for NCMS in improving the financial protection for Chinese residents. As an  
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48 112 exploratory attempt to study the impact of NCMS on CHE of rural households with  
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50 113 hospitalized members, this study can provide some recommendations for the next  
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52 114 phase of health reform for policy-makers.

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6 122 **Method**7  
8 123 **Data source and study population**

9 124 Data used in this study was derived from the Chinese third NHSS in 2003, the fourth

10 125 NHSS in 2008 and the fifth NHSS in 2013. As the largest statewide health survey in

11 126 China, the NHSS was organized by the Chinese government every 5 years since 1993.

12 127 All data in NHSS was collected using a structured questionnaire, whose validity and

13 128 reliability had been demonstrated.<sup>11 12</sup> The NHSS was done with a robust multi-stage14 129 and stratified random cluster sampling method.<sup>13</sup> A total of 94 counties were selected

15 130 from 2859 counties in 31 provinces, autonomous regions, and municipalities in China.

16 131 In each county, five townships were selected within which two villages were selected.

17 132 A total of 470 townships and 940 villages were included. In each village, 60

18 133 households were selected.<sup>14</sup> The institutional review board of the Chinese National

19 134 Bureau of Statistics provided review and ethics approval of the survey. A district

20 135 survey manager checked the questionnaires at the end of each day to avoid missing

21 136 information or logic errors. 5% of the sampled households were randomly selected to

22 137 be revisited to examine survey quality (95% was achieved).<sup>13</sup> According to a test

23 138 conducted by the Health Statistical Center of the Ministry of Health of China, the

24 139 survey data was representative of structure of overall national population compared

25 140 with the 2007 National Sampling Survey of Population Change.<sup>13</sup>

26 141 This study focused on the incidence and severity of CHE of rural households

27 142 with hospitalized members covered by NCMS. Households which didn't join NCMS

28 143 or didn't use inpatient services were not covered. This yielded a final sample of 6975

29 144 households which experienced inpatient care during the study period (180 in 2003,

30 145 2326 in 2008 and 4469 in 2013).

31 146 **The introduction of indicators**

32 147 Out-of-pocket health expenditure payment (OOP) refers to the expenditure made by

33 148 each household member after they receive health services without compensations

34 149 from a third party. The poverty line is the average food expenditure of households of

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3 150 which food share is in the 45th to 55th percentile range. This poverty line multiplied  
4 151 by the equalized household size (actual household size<sup>0.56</sup>) is household subsistence  
5  
6 152 spending. CTP is generally defined as a non-subsistence spending. However, when  
7  
8 153 food expenditure is lower than subsistence spending in some households, the  
9  
10 154 non-food expenditure is used as non-subsistence spending in this particular situation.<sup>1</sup>  
11 155 <sup>4</sup> The information on the questions in the questionnaire of NHSS employed to  
12  
13 156 calculate indicators below were showed in Supplementary information.

14  
15 157 (1) The incidence rates of CHE

16 158 There were various definitions of CHE, we employed the method recommended by  
17  
18 159 World Health Organization (WHO) for calculating CHE in this study. An OOP is  
19  
20 160 considered financially catastrophic when it is larger than 40% of the household's  
21  
22 161 CTP.<sup>1</sup> Let  $R_{\text{CHE}}$  denotes the incidence rates of CHE, which can be calculated as

$$123 \quad 162 \quad R_{\text{CHE}} = \frac{1}{N} \sum_{i=1}^N E_i \quad (1)$$

24  
25  
26  
27 163 Where  $N$  represents the sample size.  $E_i = 1$  when  $\text{OOP}/\text{CTP} \geq 0.4$ ;  $E_i = 0$  when  
28  
29 164  $\text{OOP}/\text{CTP} < 0.4$ .

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31 165 (2) The definitions and calculations of mean CHE gap ( $G_{\text{CHE}}$ ) and mean positive CHE  
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33 166 gap ( $\text{MPG}_{\text{CHE}}$ )

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35 167 The  $G_{\text{CHE}}$  describes how much of a household's health expenditure is in excess of the  
36  
37 168 threshold of 40% of its CTP, which is estimated to reveal the average level of CHE  
38  
39 169 severity for all studied households. The  $\text{MPG}_{\text{CHE}}$  refers to the average of the sum of the  
40  
41 170 total excesses from all the catastrophic households in the sample.<sup>1</sup>  $G_{\text{CHE}}$  and  $\text{MPG}_{\text{CHE}}$   
42  
43 171 can be calculated as

$$44 \quad 45 \quad 172 \quad G_{\text{CHE}} = \frac{1}{N} \sum_{i=1}^N O_i \quad (2)$$

$$46 \quad 47 \quad 48 \quad 49 \quad 173 \quad \text{MPG}_{\text{CHE}} = \frac{\sum_{i=1}^N O_i}{\sum_{i=1}^N E_i} \quad (3)$$

50  
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52  
53 174 Where  $O_i = \text{OOP}/\text{CTP} - 0.4$  when  $\text{OOP}/\text{CTP} > 0.4$ ;  $O_i = 0$  when  $\text{OOP}/\text{CTP} \leq 0.4$ .

## 175 **The introduction of Generalized Estimating Equations (GEE)**

176 GEE is based on the quasi-likelihood function and generalized linear model. It can be  
177 used to resolve repeated measures issues.<sup>15-17</sup> GEE has the following advantages:

178 (1) More robust modeling. When connectivity function of GEE is correct, we can  
179 get stable parameter estimates even if the correlation matrix is chosen  
180 randomly;

181 (2) Flexibility. Dependent variable of GEE can follow any kind of exponential  
182 distribution. Various covariance structures can also be chosen.<sup>15-17</sup>

183 In this study, the  $R_{\text{CHE}}$  of each household had two records, one before NCMS  
184 reimbursement and one after. We took it as a repeated measures analysis. Dependent  
185 and independent variable is the prevalence status of CHE and reimbursement status  
186 of NCMS, respectively. We performed GEE with logit link to estimate OR and 95%  
187 CI for the association between the  $R_{\text{CHE}}$  and NCMS reimbursement.

### 188 **Statistical analysis**

189 Categorical variables and expenditure measures were described by numbers  
190 (percentages) and means (standard deviation), respectively. Annual household income  
191 in 2008 and 2013 was transformed by Consumer Price Index (CPI) to the price level  
192 in 2003 with the transformation formula: real price=nominal price  $\times$  (CPI of base  
193 year/CPI of object year).<sup>18</sup> Annual household income was classified as quartiles.  
194 Three indicators above captured the catastrophe's incidence and intensity. We used  
195 stratification analysis to assess the 10-year trend of these indicators before and after  
196 NCMS reimbursement. The impact of NCMS in each year was reflected in the  
197 difference in CHE before and after reimbursement. The trend of difference from 2003  
198 to 2013 reflected overall change of the impact of NCMS. Data was disaggregated by  
199 three geographic regions (east, central and west) and four household income levels.  
200 The  $R_{\text{CHE}}$  of each household had two records in each year, one before NCMS  
201 reimbursement and one after. We took it as a repeated measures analysis. GEE was  
202 used to estimate OR and 95% CI for the association between the  $R_{\text{CHE}}$  and NCMS

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4 203 reimbursement. Covariates including age, gender, education level, employment and  
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6 204 marital status of household head, household size, one or more members younger than  
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8 205 5 years and one or more members older than 60 years were adjusted. All of the  
9  
10 206 analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC, USA). A  
11  
12 207 two-sided  $P < 0.05$  was established as the level of statistical significance for all tests.

13 208

## 14 209 **Result**

### 15 210 **Characteristics of Households**

16 211 Characteristics of all households enrolled in the study in 2003, 2008 and 2013 were  
17  
18 212 shown in Table 1. The age of householders increased from 2003 to 2013, 49.38% of  
19  
20 213 the householders were of age 60 or older in 2013. The proportion of households with  
21  
22 214 one or more members younger than 5 years decreased from 17.78% in 2003 to 14.84%  
23  
24 215 in 2013. The proportion of households with people of age 60 or older showed a 12.96%  
25  
26 216 increase from 2003 to 2013. The proportion of householders with a junior high school  
27  
28 217 or higher degree increased from 31.67% in 2003 to 40.17% in 2013. Annual  
29  
30 218 household income of each year was divided into quartiles, with each quartile cutoffs  
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32 219 shifting upward from 2003 to 2013.

### 33 220 **The incidence rates of CHE**

34  
35 221 Table 2 showed the  $R_{CHE}$  among all the studied households. After NCMS  
36  
37 222 reimbursement, the total  $R_{CHE}$  decreased rapidly, from 49.44% in 2003 to 34.88% in  
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39 223 2013. The change of the total  $R_{CHE}$  before and after reimbursement increased rapidly,  
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41 224 from 9.45% in 2003 to 24.10% in 2013. A similar pattern was observed in different  
42  
43 225 regions and different income levels. In addition, the poorest had the highest incidence  
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45 226 and the change in the west region was bigger than those in other regions.

### 46 227 **The Severity of CHE**

47  
48 228 The severity of CHE among all the studied households was shown in Table 3. After  
49  
50 229 NCMS reimbursement, the total  $G_{CHE}$  exhibited a decreased trend, from 12.57% in  
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52 230 2003 to 8.15% in 2013. The change of the total  $G_{CHE}$  before and after reimbursement  
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54 231 increased rapidly from 8.94% in 2003 to 33.50% in 2013. Different regions and

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4 232 different income levels had similar patterns. In addition, the highest  $G_{CHE}$  was observed  
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6 233 in the poorest areas. A similar trend could be observed in  $MPG_{CHE}$ . The change of  
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8 234  $MPG_{CHE}$  was higher than that of  $G_{CHE}$  in each year.

### 9 235 **The influence of NCMS on the incidence rates of CHE**

10  
11 236 Table 4 showed the influence of NCMS on  $R_{CHE}$ . In the aggregate, the  $R_{CHE}$  before  
12  
13 237 NCMS reimbursement was significantly higher than that after NCMS reimbursement  
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15 238 and the OR (95% CI) was 1.46(1.23-1.74), 1.70(1.61-1.80) and 2.68(2.54-2.83) in  
16  
17 239 2003, 2008 and 2013, respectively. The OR changed rapidly. There was a 16.44%  
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19 240 increase in the year 2008 compared to 2003 and a 57.65% increase in the year 2013  
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21 241 compared to 2008. After adjustment of the covariates, the OR (95% CI) was  
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23 242 1.50(1.24-1.81), 1.79(1.69-1.90) and 2.94(2.77-3.11) in 2003, 2008 and 2013,  
24  
25 243 respectively. There was a 19.33% increase in the year 2008 compared to 2003 and a  
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27 244 64.25% increase in the year 2013 compared to 2008. A similar pattern was observed  
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29 245 in different regions and at different income levels but there were several exceptions in  
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31 246 central region and the lowest income groups of 2003 where the  $R_{CHE}$  before NCMS  
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33 247 reimbursement was not significantly higher than that after NCMS reimbursements.  
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35 248 Among these covariates, the protection factors of the CHE were the male gender of  
36  
37 249 the householder, higher level of education of the householder and bigger household  
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39 250 size. The risk factors of the CHE were having one or more members older than 60 and  
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41 251 the older age of the householder (Supplementary information).

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### 44 253 **Discussion**

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46 254 According to Chinese NHSS in 1998 and 2003, rural residents' health expenditures  
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48 255 grew at an annual rate of 11.48%, which was four times faster than their net income.<sup>18</sup>  
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50 256 High healthcare expenses in the absence of financial protection forced these rural  
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52 257 households to fall into a difficult circumstance: "It's too difficult to see a doctor, and  
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54 258 too expensive to seek health care!"<sup>18</sup> In 2003, 96% of rural households in China  
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56 259 lacked medical insurance, and 38% of the sick didn't seek medical attention.<sup>13 18</sup> To

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4 260 address this issue, NCMS was introduced to Chinese rural areas in 2003. With great  
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6 261 efforts of the government, NCMS had experienced rapid growth in coverage. By 2011,  
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8 262 97.5% of the rural population had been covered by NCMS in China.<sup>3 18 19</sup> This had  
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10 263 fueled a significantly increased consumption of health services due to previously  
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12 264 latent unmet demand. From 2003 to 2008, the inpatient hospital admission rate for  
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14 265 rural residents almost doubled.<sup>1 4 18</sup> The  $R_{\text{CHE}}$  of rural households with hospitalized  
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16 266 members was much higher than other rural households.<sup>4</sup> It was meaningful to evaluate  
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18 267 the effectiveness of NCMS to provide financial protection specifically for these rural  
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20 268 households with hospitalized members.

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22 269 In our study,  $R_{\text{CHE}}$  of these households before NCMS reimbursement were  
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24 270 58.89%, 54.90% and 58.98% for 2003, 2008 and 2013, respectively (Table 2).  
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26 271 Approximately 60% of the households would fall into CHE and be susceptible to  
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28 272 disease-induced poverty if they were not covered with NCMS in three years. After  
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30 273 NCMS reimbursement, the  $R_{\text{CHE}}$  decreased with different degrees, which were lowered  
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32 274 to 49.44%, 41.75% and 34.88% for 2003, 2008 and 2013, respectively (Table 2). The  
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34 275 total  $G_{\text{CHE}}$  and  $MPG_{\text{CHE}}$  also decreased after NCMS reimbursement (Table 3). The  
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36 276 incidence and severity of CHE before NCMS reimbursement were higher than that  
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38 277 after NCMS reimbursement in three years, which confirmed the effectiveness of  
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40 278 NCMS to reduce CHE. Moreover, after adjustment of the covariates,  $R_{\text{CHE}}$  was  
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42 279 significantly associated with NCMS reimbursement ( $P < 0.05$ ) (Table 4). To some  
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44 280 extent, the NCMS protected the rural households with hospitalized members from  
45  
46 281 CHE. Inpatient reimbursement rates in rural areas had a remarkable achievement,  
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48 282 increasing 7.5 times from 5.8% in 2003 to 43.7% in 2011.<sup>3</sup> The financial protection in  
49  
50 283 rural areas have been steadily improved. An apparent enhancement could be seen in  
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52 284 this protective effect from 2003 to 2013, especially after the 2009 Health Care Reform.  
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54 285 Having one or more members older than 60 in a household, female gender and older  
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56 286 age of the householder, lower level of education of the householder and smaller  
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58 287 household size increased the risk of incurring CHE in our study (Supplementary

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4 288 information). This was consistent with the previous studies.<sup>4 20-23</sup> The NCMS should  
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6 289 make preferential policies for these high-risk populations, such as providing special  
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8 290 subsidies, extending the depth and breadth of coverage and providing a better benefit  
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10 291 package to them. As with targeted poverty alleviation, targeted CHE alleviation  
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12 292 among these populations is needed.

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14 293 It was worth noting that the  $R_{\text{CHE}}$  in rural households with hospitalized members  
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16 294 in three years were all more than 34% after NCMS reimbursement, which meant that  
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18 295 a number of households still faced CHE even though they were covered with NCMS  
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20 296 (Table 2). Many studies had shown that CHE was very likely to occur in households  
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22 297 with poor economic conditions.<sup>24-27</sup> The rural households with hospitalized members  
23  
24 298 have heavy economic burdens and are likely to fall into such conditions. Thus, our  
25  
26 299 study population tend to have higher proportion of CHE than previously reported in  
27  
28 300 the whole rural households. Another reason for high proportion of CHE in these  
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30 301 households is the limited numbers of drugs and treatments included in the scope of  
31  
32 302 NCMS. Under the fee-for-service payment system in China, doctors had strong  
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34 303 incentives to prescribe expensive drugs and examinations not included by NCMS.<sup>4</sup>  
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36 304 The NCMS needs to increase financial investment to expand its catalogue of essential  
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38 305 medicines, especially for medicines which could increase the profits of medical  
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40 306 institutions and pharmaceutical factories. An effective monitoring system is needed to  
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42 307 restrain oversupply of expensive medical services and ensures that first-line generic  
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44 308 medicines are available and preferentially prescribed. Besides, NCMS should increase  
45  
46 309 financing level to provide a better benefit package, such as lowering the deductibles  
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48 310 and co-payments, and setting higher reimbursement rates and ceilings. Redesigning  
49  
50 311 cost sharing arrangements and provider payment methods and developing more  
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52 312 effective cost control mechanisms are also important.

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54 313 We observed that all three indicators declined with the increase of household  
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56 314 income in our study (Table 2 and Table 3). Low-income households were more likely  
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58 315 to incur CHE than other groups. One of the main reasons is their limited ability to pay



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4 316 for non-subsistence spending. These households are likely to fall into CHE, even as a  
5  
6 317 result of low health expenditure. This phenomenon had also been experienced in  
7  
8 318 many developing countries in Asia.<sup>20 27-29</sup> The inequalities of three indicators between  
9  
10 319 different income groups still existed from 2003 to 2013 (Table 2 and Table 3). A  
11  
12 320 higher share of resources from central governments should be allocated to areas with  
13  
14 321 poor economic capacity. The current medical financial assistance scheme (MFA),  
15  
16 322 which was a scheme designed to provide support to the poor households for their  
17  
18 323 CHE, should be further promoted to play a more efficient role in preventing CHE.

19 324 The changes of  $R_{CHE}$  and OR before and after NCMS reimbursement in the west  
20  
21 325 region were larger than the corresponding values in other regions in three years (Table  
22  
23 326 2 and Table 4). A higher share of resources was allocated to west region. Inpatient  
24  
25 327 reimbursement rates of east, central and west geographic regions in 2011 was 46.8%,  
26  
27 328 41.2% and 51.2%, respectively.<sup>3 29</sup> Almost all three indicators after NCMS  
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29 329 reimbursement decreased rapidly from 2003 to 2008 but slowed down from 2008 to  
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31 330 2013 (Table 2 and Table 3). This is due to the worst health situation in 2003 and the  
32  
33 331 saturated health situation in 2008.<sup>30 31</sup>

34 332 With the establishment of basic medical and health system and the improvement  
35  
36 333 of residents' health consciousness, the demand for medical and health services has  
37  
38 334 increased rapidly. Two-week prevalence rate of residents increased from 18.9% in  
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40 335 2008 to 24.1% in 2013, prevalence rate of chronic diseases increased from 24.1% in  
41  
42 336 2008 to 33.1% in 2013 and the rate of resident hospitalization increased by 150% in  
43  
44 337 the last 10 years.<sup>33</sup> Accordingly, medical expenditures have also increased rapidly.<sup>32 33</sup>  
45  
46 338 The financial protection of the NCMS in rural areas faces great challenges. To further  
47  
48 339 prevent CHE, the NCMS should keep in step with the process of improvement of  
49  
50 340 rural medical and health service system and adjust corresponding policies timely.

51 341

## 52 342 **Conclusion**

53  
54 343 The  $R_{CHE}$ ,  $G_{CHE}$  and  $MPG_{CHE}$  all decreased rapidly after NCMS reimbursement and their



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4 344 changes increased rapidly from 2003 to 2013. After adjustment of the covariates, the  
5 345  $R_{\text{CHE}}$  after NCMS reimbursement were significantly lower than that before NCMS  
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7 346 reimbursements in each year. The NCMS partly protected the rural households with  
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9 347 hospitalized members from CHE. The financial protection in rural areas had been  
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11 348 steadily improved with the development of NCMS. However, the inequalities between  
12  
13 349 different groups still existed. The  $R_{\text{CHE}}$  in rural households with hospitalized members  
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15 350 in three years were all more than 34% after reimbursement, which meant that many  
16  
17 351 households still faced CHE even though they were covered with NCMS. To further  
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19 352 prevent CHE, NCMS should increase financing level to provide a better benefit  
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21 353 package, make preferential policies for the high-risk populations, properly expand  
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23 354 catalogue of essential medicines and increase reimbursement rates and establish  
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25 355 effective supervision system. A high-quality health care in China will contribute to  
26  
27 356 global health because of China's great population share in the world. Undoubtedly, the  
28  
29 357 gain and loss during this reform will serve as reference for other countries, especially  
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31 358 developing countries.

32 359

### 33 360 **Acknowledgment**

34  
35 361 The research is funded by National Natural Science Foundation of China [81273183  
36  
37 362 to Liu MN].

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### 40 364 **Contributors**

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43 365 XB, W-ZQ and H-MH drafted the manuscript. C-YJ and FR performed data collection  
44  
45 366 and statistical analyses. L-MN and MQ made a substantial contribution to the  
46  
47 367 interpretation of the data and study design. All authors read and approved the final  
48  
49 368 manuscript.

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52 370 **Competing interests:** None declared.

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4 372 **Ethics approval:** The institutional review board of the Chinese National Bureau of  
5 373 Statistics provided review and ethics approval of the survey.  
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9 375 **Data sharing statement:** Original data is available on request. It was stored on  
10 376 password-protected computers at the centre for health statistics information of  
11 377 Ministry of Health in Beijing, China.  
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465 **Table 1. Characteristics of all households enrolled in the study**

Characteristics	2003 (N=180)		2008 (N= 2326)		2013 (N= 4469)	
	n	%	n	%	n	%
<b>Household characteristics</b>						
Number of household members						
<5	128	71.11	1916	82.37	3971	88.86
≥5	52	28.89	410	17.63	498	11.14
One or more members older than 60 years						
No	104	57.78	1267	54.47	2003	44.82
Yes	76	42.22	1059	45.53	2466	55.18
One or more members younger than 5 years						
No	148	82.22	1948	83.75	3806	85.16
Yes	32	17.78	378	16.25	663	14.84
Time spent travelling to the nearest medical center						
≤15min	145	80.56	1701	73.13	3532	79.03
>15min	35	19.44	625	26.87	937	20.97
The number of observations in each region						
East	113	62.78	626	26.91	991	22.17

Centre	14	7.78	759	32.63	1670	37.37
West	53	29.44	941	40.46	1808	40.46
Annual household income*						
Q 1	2643.33	1265.69	3956.52	1680.38	4785.49	2590.40
Q 2	6914.23	1353.25	9062.74	1247.41	13003.64	2841.22
Q 3	13505	2716.15	14699.42	2065.84	25958.15	5174.25
Q 4	29194.35	10927.31	31665.48	20295.22	61082.23	44409.99
<b>householders' characteristics</b>						
Gender						
Male	131	72.78	1796	77.21	3373	75.48
Female	49	27.22	530	22.79	1096	24.52
Age						
<60	120	66.67	1442	61.99	2262	50.62
≥60	60	33.33	884	38.01	2207	49.38
Marital status						
Unmarried	4	2.22	47	2.02	72	1.61
Married	155	86.11	1953	83.96	3735	83.58
Divorced	0	0	29	1.25	612	13.69
Widow or others	21	11.67	297	12.77	50	1.12
Education						
Illiterate	52	28.89	511	21.98	811	18.15
Elementary school	71	39.44	917	39.44	1863	41.69
Junior high school	48	26.67	722	31.05	1418	31.73
Senior high school or above	9	5.00	175	7.53	377	8.44
Employment						
Employed	126	70.00	1817	78.12	3222	72.10
Retired	12	6.67	60	2.58	157	3.51
Others	42	23.33	449	19.30	1090	24.39

466 \*Annual household income of each year was divided into four levels according to the quartile, the  
 467 mean and standard deviation of each level were calculated.

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**Table 2. Results of the incidence rates of CHE among all the studied households (%)**

$R_{CHE}$	2003			2008			2013		
	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change
Total	58.89	49.44	9.45	54.90	41.75	13.15	58.98	34.88	24.10
East	58.41	50.44	7.97	58.79	46.49	12.30	63.47	39.56	23.91
Centre	85.71	85.71	0	49.54	38.47	11.07	57.13	35.51	21.62
West	52.83	37.74	15.09	56.64	41.23	15.41	58.24	31.75	26.49
Q1	71.11	71.11	0	78.65	60.67	17.98	86.25	58.75	27.50
Q2	60.47	48.84	11.63	59.32	44.30	15.02	73.61	43.13	30.48
Q3	60.87	45.65	15.22	50.93	39.22	11.71	54.79	29.16	25.63
Q4	43.48	32.61	10.87	37.23	27.88	9.35	32.86	18.39	14.47

**Table 3. Results of the severity of CHE among all the studied households (%)**

Indicators	2003			2008			2013		
	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change
<i>G<sub>CHE</sub></i>									
Total	21.51	12.57	8.94	23.23	10.08	13.15	41.65	8.15	33.50
East	19.54	13.56	5.98	28.54	12.54	16.00	56.92	10.51	46.41
Centre	25.12	25.12	0	20.28	8.74	11.54	38.00	8.29	29.71
West	24.73	7.15	17.58	22.09	9.52	12.57	36.64	6.72	29.92
Q1	26.37	21.66	4.71	42.80	16.32	26.48	86.46	15.96	70.50
Q2	28.51	12.94	15.57	22.77	10.17	12.60	57.13	9.57	47.56
Q3	18.70	9.06	9.64	17.38	8.57	8.81	28.70	6.02	22.68
Q4	13.01	6.85	6.16	13.56	6.55	7.01	13.90	4.05	9.85
<i>MPG<sub>CHE</sub></i>									
Total	36.52	25.43	11.09	42.32	24.14	18.18	70.61	23.35	47.26
East	33.46	26.88	6.58	48.54	26.97	21.57	89.67	26.58	63.09
Centre	29.31	29.31	0	40.94	22.73	18.21	66.53	23.33	43.20
West	46.82	18.95	27.87	39.00	23.09	15.91	62.91	21.16	41.75
Q1	37.07	30.46	6.61	54.41	26.90	27.51	100.24	27.17	73.07
Q2	47.15	26.50	20.65	38.38	22.96	15.42	77.61	22.19	55.42
Q3	30.72	19.84	10.88	34.12	21.86	12.26	52.38	20.65	31.73
Q4	29.93	21.01	8.92	36.42	23.48	12.94	42.32	22.03	20.29



**Table 4. The influence of NCMS on the incidence rates of CHE**

	Year	Change (%)	Crude		Adjusted	
			OR (95 % CI)	Increment (%)	OR (95 % CI)	Increment (%)
<b>Total</b>						
	2003	9.45	1.46(1.23-1.74)	-	1.50(1.24-1.81)	-
	2008	13.15	1.70(1.61-1.80)	16.44	1.79(1.69-1.90)	19.33
	2013	24.10	2.68(2.54-2.83)	57.65	2.94(2.77-3.11)	64.25
<b>Area</b>						
<b>East</b>						
	2003	7.97	1.38(1.13-1.69)	-	1.43(1.14-1.80)	-
	2008	12.30	1.64(1.48-1.82)	18.84	1.77(1.57-1.99)	23.78
	2013	23.91	2.66(2.37-2.97)	62.20	3.08(2.71-3.50)	74.01
<b>Central</b>						
	2003	0	1.00(1.00-1.00)	-	1.00(1.00-1.00)	-
	2008	11.07	1.57(1.43-1.72)	57	1.64(1.49-1.82)	64.00
	2013	21.62	2.42(2.23-2.63)	54.14	2.63(2.40-2.88)	60.37
<b>West</b>						
	2003	15.09	1.85(1.24-2.75)	-	1.86(1.23-2.82)	-
	2008	15.41	1.86(1.69-2.05)	0.54	1.96(1.77-2.16)	5.38
	2013	26.49	3.00(2.74-3.28)	61.29	3.22(2.93-3.55)	64.29
<b>Income</b>						
<b>Q1</b>						
	2003	0	1.00(1.00-1.00)	-	1.00(1.00-1.00)	-
	2008	17.98	2.39(2.03-2.81)	139.00	2.56(2.16-3.04)	156.00
	2013	27.50	4.40(3.70-5.24)	84.10	4.65(3.89-5.55)	81.64
<b>Q2</b>						
	2003	11.63	1.60(1.08-2.37)	-	1.63(1.08-2.45)	-
	2008	15.02	1.83(1.62-2.08)	14.38	1.90(1.67-2.16)	16.56
	2013	30.48	3.68(3.19-4.25)	101.09	3.86(3.32-4.49)	103.16
<b>Q3</b>						
	2003	15.22	1.85(1.21-2.84)	-	1.89(1.23-1.92)	-
	2008	11.71	1.61(1.44-1.80)	-12.97	1.63(1.46-1.83)	-13.76
	2013	25.63	2.94(2.68-3.23)	82.61	3.04(2.76-3.35)	86.50
<b>Q4</b>						
	2003	10.87	1.59(1.08-2.34)	-	1.62(1.08-2.41)	-
	2008	9.35	1.53(1.39-1.69)	-3.77	1.55(1.41-1.72)	-4.32
	2013	14.47	2.17(1.94-2.43)	41.83	2.21(1.97-2.48)	42.58

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For peer review only

### Supplementary data 1 The questions in the questionnaire of NHSS employed to calculate indicators

Food consumption expenditure in each household was measured by the question, “How much did your household spend in food consumption expenditure during the last one year?”

The question, “How much did your household spend in living expenditure during the last one year?” was chosen to measure the total living expenditure in each household.

Actual household size was measured by the question, “How many people have a long-term residence at your household?”

The question, “How much did your household spend in medical expenses (without compensations from a third party) during the last one year” was chosen to measure the out-of-pocket health expenditure payment in each household.

### Supplementary data 2

**Table 1 Determinants of catastrophic health expenditure.**

Determinant	$\beta$ (95%CI)	SE	Z	P
<b>Gender of householder</b> (male vs female)	-0.51(-0.62--0.40)	0.06	-8.94	<.0001
<b>Age of householder</b>	0.28(0.11-0.46)	0.09	3.12	0.0018
<b>Educational level of householder</b>				
Elementary school vs Illiterate	-0.35(-0.48--0.22)	0.07	-5.31	<.0001
Junior high school vs Illiterate	-0.49(-0.64--0.35)	0.07	-6.84	<.0001
Senior high school or above vs Illiterate	-0.90(-1.11--0.70)	0.11	-8.56	<.0001
<b>One or more members older than 60 years</b> (yes vs no)	0.39(0.21-0.56)	0.09	4.35	<.0001
<b>One or more members younger than 5 years</b> (yes vs no)	0.03(-0.11-0.17)	0.07	0.37	0.7104
<b>Number of household members</b>	-0.27(-0.31--0.24)	0.02	-14.3	<.0001
<b>Employment</b> (employed vs others)	-0.81(-0.97--0.65)	0.08	-7.58	<.0001
<b>Marital status</b> (married vs others)	-0.63(-0.78--0.48)	0.08	-7.24	<.0001

**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology\***  
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	5
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5,7
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	

		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	5
		(e) Describe any sensitivity analyses	
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	8
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(b) Report category boundaries when continuous variables were categorized	19
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	10-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	3
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Impact of New Cooperative Medical Scheme on the Trend of Catastrophic Health Expenditure in Chinese Rural Households: results from nationally representative surveys from 2003 to 2013

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-019442.R2
Article Type:	Research
Date Submitted by the Author:	19-Dec-2017
Complete List of Authors:	Xie, Biao Huo, Minghe Wang, Zhiqiang; University of Queensland, School of Medicine Chen, Yongjie Fu, Rong Liu, Meina Meng, Qun
<b>Primary Subject Heading</b>:	Health services research
Secondary Subject Heading:	Health services research, Health policy, Health economics
Keywords:	CHE, rural households with hospitalized members, NCMS, NHSS

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1           **Impact of New Cooperative Medical Scheme on the Trend of**  
2           **Catastrophic Health Expenditure in Chinese Rural Households:**  
3           **results from nationally representative surveys from 2003 to 2013**

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## 29 Abstract

30 **Objective** To evaluate the trend of catastrophic health expenses (CHE) for inpatient  
31 care in relation to the commencement of New Cooperative Medical Scheme (NCMS)  
32 in rural China from 2003 to 2013 and the roles of NCMS in protecting affected  
33 households from CHE.

34 **Methods** We assessed 10-year trend of the incidence and severity of CHE in rural  
35 households with hospitalized members using the data from Chinese National Health  
36 Services Survey (NHSS). Generalized Estimating Equations (GEE) were used to  
37 estimate the odds ratio (OR) and 95% confidence interval (CI) for the association  
38 between incidence rates of CHE ( $R_{CHE}$ ) and NCMS reimbursement.

39 **Results** The incidence and severity of CHE after NCMS reimbursement both  
40 decreased and their changes increased rapidly from 2003 to 2013. After adjustment of  
41 the covariates, the  $R_{CHE}$  before reimbursement was significantly higher than that after  
42 reimbursement and the OR (95% CI) was 1.50(1.24-1.81), 1.79(1.69-1.90) and  
43 2.94(2.77-3.11) in the year of 2003, 2008 and 2013, respectively.

44 **Conclusion** The incidence and severity of CHE both reduced after NCMS  
45 reimbursements in each year. Excluding some confounding factors,  $R_{CHE}$  was  
46 significantly associated with NCMS reimbursement. The NCMS partly protected the  
47 rural households with hospitalized members from CHE. However, the inequalities  
48 between different income groups still existed. The  $R_{CHE}$  in rural households with  
49 hospitalized members were still rather high in 2003, 2008 and 2013 even though they  
50 were covered with NCMS. This study will provide suggestions for further reforms in  
51 China and guidance for other developing countries.

52  
53 **Keywords** CHE; rural households with hospitalized members; NCMS; NHSS.  
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60 **Strengths and limitations of this study**

- 61 ▶ Generalized Estimating Equations (GEE) were used to estimate OR and 95% CI
- 62 for the association between the catastrophe's incidence and NCMS
- 63 reimbursement.
- 64 ▶ We assessed 10-year trend of the incidence and severity of CHE at national level
- 65 using the data from the Chinese National Health Services Survey (NHSS).
- 66 ▶ Three indicators were used to capture the catastrophe's incidence and intensity.
- 67 ▶ The sample size in 2003 was small with only 180 households.

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3 894 90 **Introduction**

5  
6 91 The New Cooperative Medical System (NCMS) was introduced to rural China in  
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8 92 2003. It was designed to provide financial protection for its enrollees. In terms of the  
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10 93 enrollment size, NCMS is by far the largest health insurance plan in the world.<sup>1</sup>  
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12 94 Catastrophic health expenses (CHE) is defined as an out-of-pocket health expenditure  
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14 95 which is larger than 40% of the household's capacity to pay (CTP).<sup>2</sup> CHE is an  
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16 96 indicator reflecting the effectiveness of financial protection a health insurance could  
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18 97 provide for its members. In 2008, 15.1% of the rural households and 35.0% of the  
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20 98 rural households with hospitalized members faced CHE in China.<sup>3 4</sup> It was essential to  
21  
22 99 evaluate the role of NCMS in preventing CHE among its members. There had been  
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24 100 many studies measuring the impact of NCMS. However, most studies focused on a  
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26 101 specific local area or the short-term effect of NCMS on CHE in China.<sup>3-10</sup> NCMS  
27  
28 102 focused on inpatient care reimbursement. Among studies on the impact of NCMS on  
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30 103 CHE, those focusing on affected rural households with hospitalized members were  
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32 104 valuable. However, few previous studies had focused on such affected rural  
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34 105 households.

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36 106 We assessed 10-year trend of the incidence and severity of CHE in rural  
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38 107 households with hospitalized members at national level using the data from the  
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40 108 Chinese National Health Services Survey (NHSS). The trend of CHE for inpatient  
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42 109 care in relation to the commencement of NCMS in rural China from 2003 to 2013 and  
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44 110 the roles of NCMS in protecting affected households from CHE can provide evidence  
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46 111 for NCMS in improving the financial protection for Chinese residents. As an  
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48 112 exploratory attempt to study the impact of NCMS on CHE of rural households with  
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50 113 hospitalized members, this study can provide some recommendations for the next  
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52 114 phase of health reform for policy-makers.

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6 122 **Method**7  
8 123 **Data source and study population**

9 124 Data used in this study was derived from the Chinese third NHSS in 2003, the fourth

10 125 NHSS in 2008 and the fifth NHSS in 2013. As the largest statewide health survey in

11 126 China, the NHSS was organized by the Chinese government every 5 years since 1993.

12 127 All data in NHSS was collected using a structured questionnaire, whose validity and

13 128 reliability had been demonstrated.<sup>11 12</sup> The NHSS was done with a robust multi-stage14 129 and stratified random cluster sampling method.<sup>13</sup> A total of 94 counties were selected

15 130 from 2859 counties in 31 provinces, autonomous regions, and municipalities in China.

16 131 In each county, five townships were selected within which two villages were selected.

17 132 A total of 470 townships and 940 villages were included. In each village, 60

18 133 households were selected.<sup>14</sup> The institutional review board of the Chinese National

19 134 Bureau of Statistics provided review and ethics approval of the survey. A district

20 135 survey manager checked the questionnaires at the end of each day to avoid missing

21 136 information or logic errors. 5% of the sampled households were randomly selected to

22 137 be revisited to examine survey quality (95% was achieved).<sup>13</sup> According to a test

23 138 conducted by the Health Statistical Center of the Ministry of Health of China, the

24 139 survey data was representative of structure of overall national population compared

25 140 with the 2007 National Sampling Survey of Population Change.<sup>13</sup>

26 141 This study focused on the incidence and severity of CHE of rural households

27 142 with hospitalized members covered by NCMS. Households which didn't join NCMS

28 143 or didn't use inpatient services were not covered. This yielded a final sample of 6975

29 144 households which experienced inpatient care during the study period (180 in 2003,

30 145 2326 in 2008 and 4469 in 2013).

31 146 **The introduction of indicators**

32 147 Out-of-pocket health expenditure payment (OOP) refers to the expenditure made by

33 148 each household member after they receive health services without compensations

34 149 from a third party. The poverty line is the average food expenditure of households of

150 which food share is in the 45th to 55th percentile range. The detailed definition of  
 151 poverty line used in the study was showed in Supplementary information. This  
 152 poverty line multiplied by the equalized household size (actual household size<sup>0.56</sup>) is  
 153 household subsistence spending. CTP is generally defined as a non-subsistence  
 154 spending. However, when food expenditure is lower than subsistence spending in  
 155 some households, the non-food expenditure is used as non-subsistence spending in  
 156 this particular situation.<sup>1 4</sup> The information on the questions in the questionnaire of  
 157 NHSS employed to calculate indicators below were showed in Supplementary  
 158 information.

### 159 (1) The incidence rates of CHE

160 There were various definitions of CHE, we employed the method recommended by  
 161 World Health Organization (WHO) for calculating CHE in this study. An OOP is  
 162 considered financially catastrophic when it is larger than 40% of the household's  
 163 CTP.<sup>1</sup> Let  $R_{CHE}$  denotes the incidence rates of CHE, which can be calculated as

$$164 \quad R_{CHE} = \frac{1}{N} \sum_{i=1}^N E_i \quad (1)$$

165 Where  $N$  represents the sample size.  $E_i = 1$  when  $^{OOP}/_{CTP} \geq 0.4$ ;  $E_i = 0$  when  
 166  $^{OOP}/_{CTP} < 0.4$ .

### 167 (2) The definitions and calculations of mean CHE gap ( $G_{CHE}$ ) and mean positive CHE 168 gap ( $MPG_{CHE}$ )

169 The  $G_{CHE}$  describes how much of a household's health expenditure is in excess of the  
 170 threshold of 40% of its CTP, which is estimated to reveal the average level of CHE  
 171 severity for all studied households. The  $MPG_{CHE}$  refers to the average of the sum of the  
 172 total excesses from all the catastrophic households in the sample.<sup>1</sup>  $G_{CHE}$  and  $MPG_{CHE}$   
 173 can be calculated as

$$174 \quad G_{CHE} = \frac{1}{N} \sum_{i=1}^N O_i \quad (2)$$

$$175 \quad MPG_{CHE} = \frac{\sum_{i=1}^N O_i}{\sum_{i=1}^N E_i} \quad (3)$$

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3 176 Where  $O_i = \text{OOP}/\text{CTP} - 0.4$  when  $\text{OOP}/\text{CTP} > 0.4$ ;  $O_i = 0$  when  $\text{OOP}/\text{CTP} \leq 0.4$ .

### 177 **The introduction of Generalized Estimating Equations (GEE)**

178 GEE is based on the quasi-likelihood function and generalized linear model. It can be  
179 used to resolve repeated measures issues.<sup>15-17</sup> GEE has the following advantages:

180 (1) More robust modeling. When connectivity function of GEE is correct, we can  
181 get stable parameter estimates even if the correlation matrix is chosen  
182 randomly;

183 (2) Flexibility. Dependent variable of GEE can follow any kind of exponential  
184 distribution. Various covariance structures can also be chosen.<sup>15-17</sup>

185 In this study, the  $R_{\text{CHE}}$  of each household had two records, one before NCMS  
186 reimbursement and one after. We took it as a repeated measures analysis. Dependent  
187 and independent variable is the prevalence status of CHE and reimbursement status  
188 of NCMS, respectively. We performed GEE with logit link to estimate OR and 95%  
189 CI for the association between the  $R_{\text{CHE}}$  and NCMS reimbursement.

### 190 **Statistical analysis**

191 Categorical variables and expenditure measures were described by numbers  
192 (percentages) and means (standard deviation), respectively. Annual household income  
193 in 2008 and 2013 was transformed by Consumer Price Index (CPI) to the price level  
194 in 2003 with the transformation formula: real price = nominal price  $\times$  (CPI of base  
195 year/CPI of object year).<sup>18</sup> Annual household income was classified as quartiles.  
196 Three indicators above captured the catastrophe's incidence and intensity. We used  
197 stratification analysis to assess the 10-year trend of these indicators before and after  
198 NCMS reimbursement. The impact of NCMS in each year was reflected in the  
199 difference in CHE before and after reimbursement. The trend of difference from 2003  
200 to 2013 reflected overall change of the impact of NCMS. Data was disaggregated by  
201 three geographic regions (east, central and west) and four household income levels.  
202 The  $R_{\text{CHE}}$  of each household had two records in each year, one before NCMS  
203 reimbursement and one after. We took it as a repeated measures analysis. GEE was

204 used to estimate OR and 95% CI for the association between the  $R_{\text{CHE}}$  and NCMS  
205 reimbursement. Covariates including age, gender, education level, employment and  
206 marital status of household head, household size, one or more members younger than  
207 5 years and one or more members older than 60 years were adjusted. All of the  
208 analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC, USA). A  
209 two-sided  $P < 0.05$  was established as the level of statistical significance for all tests.

210

## 211 **Result**

### 212 **Characteristics of Households**

213 Characteristics of all households enrolled in the study in 2003, 2008 and 2013 were  
214 shown in Table 1. The age of householders increased from 2003 to 2013, 49.38% of  
215 the householders were of age 60 or older in 2013. The proportion of households with  
216 one or more members younger than 5 years decreased from 17.78% in 2003 to 14.84%  
217 in 2013. The proportion of households with people of age 60 or older showed a 12.96%  
218 increase from 2003 to 2013. The proportion of householders with a junior high school  
219 or higher degree increased from 31.67% in 2003 to 40.17% in 2013. Annual  
220 household income of each year was divided into quartiles, with each quartile cutoffs  
221 shifting upward from 2003 to 2013.

### 222 **The incidence rates of CHE**

223 Table 2 showed the  $R_{\text{CHE}}$  among all the studied households. After NCMS  
224 reimbursement, the total  $R_{\text{CHE}}$  decreased rapidly, from 49.44% in 2003 to 34.88% in  
225 2013. The change of the total  $R_{\text{CHE}}$  before and after reimbursement increased rapidly,  
226 from 9.45% in 2003 to 24.10% in 2013. A similar pattern was observed in different  
227 regions and different income levels. In addition, the poorest had the highest incidence  
228 and the change in the west region was bigger than those in other regions.

### 229 **The Severity of CHE**

230 The severity of CHE among all the studied households was shown in Table 3. After  
231 NCMS reimbursement, the total  $G_{\text{CHE}}$  exhibited a decreased trend, from 12.57% in  
232 2003 to 8.15% in 2013. The change of the total  $G_{\text{CHE}}$  before and after reimbursement

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4 233 increased rapidly from 8.94% in 2003 to 33.50% in 2013. Different regions and  
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6 234 different income levels had similar patterns. In addition, the highest  $G_{CHE}$  was observed  
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8 235 in the poorest areas. A similar trend could be observed in  $MPG_{CHE}$ . The change of  
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10 236  $MPG_{CHE}$  was higher than that of  $G_{CHE}$  in each year.

### 11 237 **The influence of NCMS on the incidence rates of CHE**

12  
13 238 Table 4 showed the influence of NCMS on  $R_{CHE}$ . In the aggregate, the  $R_{CHE}$  before  
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15 239 NCMS reimbursement was significantly higher than that after NCMS reimbursement  
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17 240 and the OR (95% CI) was 1.46(1.23-1.74), 1.70(1.61-1.80) and 2.68(2.54-2.83) in  
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19 241 2003, 2008 and 2013, respectively. The OR changed rapidly. There was a 16.44%  
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21 242 increase in the year 2008 compared to 2003 and a 57.65% increase in the year 2013  
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23 243 compared to 2008. After adjustment of the covariates, the OR (95% CI) was  
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25 244 1.50(1.24-1.81), 1.79(1.69-1.90) and 2.94(2.77-3.11) in 2003, 2008 and 2013,  
26  
27 245 respectively. There was a 19.33% increase in the year 2008 compared to 2003 and a  
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29 246 64.25% increase in the year 2013 compared to 2008. A similar pattern was observed  
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31 247 in different regions and at different income levels but there were several exceptions in  
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33 248 central region and the lowest income groups of 2003 where the  $R_{CHE}$  before NCMS  
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35 249 reimbursement was not significantly higher than that after NCMS reimbursements.  
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37 250 Among these covariates, the protection factors of the CHE were the male gender of  
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39 251 the householder, higher level of education of the householder and bigger household  
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41 252 size. The risk factors of the CHE were having one or more members older than 60 and  
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43 253 the older age of the householder (Supplementary information).

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### 45 255 **Discussion**

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47 256 According to Chinese NHSS in 1998 and 2003, rural residents' health expenditures  
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49 257 grew at an annual rate of 11.48%, which was four times faster than their net income.<sup>18</sup>  
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51 258 High healthcare expenses in the absence of financial protection forced these rural  
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53 259 households to fall into a difficult circumstance: "It's too difficult to see a doctor, and  
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55 260 too expensive to seek health care!"<sup>18</sup> In 2003, 96% of rural households in China

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4 261 lacked medical insurance, and 38% of the sick didn't seek medical attention.<sup>13 18</sup> To  
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6 262 address this issue, NCMS was introduced to Chinese rural areas in 2003. With great  
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8 263 efforts of the government, NCMS had experienced rapid growth in coverage. By 2011,  
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10 264 97.5% of the rural population had been covered by NCMS in China.<sup>3 18 19</sup> This had  
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12 265 fueled a significantly increased consumption of health services due to previously  
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14 266 latent unmet demand. From 2003 to 2008, the inpatient hospital admission rate for  
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16 267 rural residents almost doubled.<sup>1 4 18</sup> The  $R_{\text{CHE}}$  of rural households with hospitalized  
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18 268 members was much higher than other rural households.<sup>4</sup> It was meaningful to evaluate  
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20 269 the effectiveness of NCMS to provide financial protection specifically for these rural  
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22 270 households with hospitalized members.

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24 271 In our study,  $R_{\text{CHE}}$  of these households before NCMS reimbursement were 58.89%,  
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26 272 54.90% and 58.98% for 2003, 2008 and 2013, respectively (Table 2). Approximately  
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28 273 60% of the households would fall into CHE and be susceptible to disease-induced  
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30 274 poverty if they were not covered with NCMS in three years. After NCMS  
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32 275 reimbursement, the  $R_{\text{CHE}}$  decreased with different degrees, which were lowered to  
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34 276 49.44%, 41.75% and 34.88% for 2003, 2008 and 2013, respectively (Table 2). The  
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36 277 total  $G_{\text{CHE}}$  and  $MPG_{\text{CHE}}$  also decreased after NCMS reimbursement (Table 3). The  
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38 278 incidence and severity of CHE before NCMS reimbursement were higher than that  
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40 279 after NCMS reimbursement in three years, which confirmed the effectiveness of  
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42 280 NCMS to reduce CHE. Moreover, after adjustment of the covariates,  $R_{\text{CHE}}$  was  
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44 281 significantly associated with NCMS reimbursement ( $P < 0.05$ ) (Table 4). To some  
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46 282 extent, the NCMS protected the rural households with hospitalized members from  
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48 283 CHE. Inpatient reimbursement rates in rural areas had a remarkable achievement,  
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50 284 increasing 7.5 times from 5.8% in 2003 to 43.7% in 2011.<sup>3</sup> The financial protection in  
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52 285 rural areas have been steadily improved. An apparent enhancement could be seen in  
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54 286 this protective effect from 2003 to 2013, especially after the 2009 Health Care Reform.  
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56 287 Having one or more members older than 60 in a household, female gender and older



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3 288 age of the householder, lower level of education of the householder and smaller  
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5 289 household size increased the risk of incurring CHE in our study (Supplementary  
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7 290 information). This was consistent with the previous studies.<sup>4,20-23</sup> The NCMS should  
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9 291 make preferential policies for these high-risk populations, such as providing special  
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11 292 subsidies and an extra benefit package to them. As with targeted poverty alleviation,  
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13 293 targeted policies should be designed to achieve targeted CHE alleviation among these  
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15 294 households.

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17 295 It was worth noting that the  $R_{CHE}$  in rural households with hospitalized members  
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19 296 in three years were all more than 34% after NCMS reimbursement, which meant that  
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21 297 a number of households still faced CHE even though they were covered with NCMS  
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23 298 (Table 2). Many studies had shown that CHE was very likely to occur in households  
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25 299 with poor economic conditions.<sup>24-27</sup> The rural households with hospitalized members  
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27 300 have heavy economic burdens and are likely to fall into such conditions. Thus, our  
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29 301 study population tend to have higher proportion of CHE than previously reported in  
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31 302 the whole rural households. Another reason for high proportion of CHE in these  
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33 303 households is the limited numbers of drugs and treatments included in the scope of  
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35 304 NCMS. Under the fee-for-service payment system in China, doctors had strong  
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37 305 incentives to prescribe expensive drugs and examinations not included by NCMS.<sup>4</sup>  
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39 306 The NCMS needs to increase financial investment to expand its catalogue of essential  
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41 307 medicines, especially for medicines which could increase the profits of medical  
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43 308 institutions and pharmaceutical factories. An effective monitoring system is needed to  
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45 309 restrain oversupply of expensive medical services and ensures that first-line generic  
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47 310 medicines are available and preferentially prescribed.

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49 311 We observed that all three indicators declined with the increase of household  
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51 312 income in our study (Table 2 and Table 3). Low-income households were more likely  
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53 313 to incur CHE than other groups. One of the main reasons is their limited ability to pay  
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55 314 for non-subsistence spending. These households are likely to fall into CHE, even as a  
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57 315 result of low health expenditure. This phenomenon had also been experienced in

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4 316 many developing countries in Asia.<sup>20 27-29</sup> The inequalities of three indicators between  
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6 317 different income groups still existed from 2003 to 2013 (Table 2 and Table 3). Equity  
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8 318 needs to be considered in the upgrade of NCMS. A higher share of resources should  
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10 319 be allocated to areas with poor economic capacity, especially for low-income  
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12 320 households, known as ‘Dibaohu’ in China. The current medical financial assistance  
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14 321 scheme (MFA), which was a scheme designed to provide support to the poor  
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16 322 households for their CHE, should be further promoted to play a more efficient role in  
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18 323 preventing CHE.

19 324 The changes of  $R_{CHE}$  and OR before and after NCMS reimbursement in the west  
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21 325 region were larger than the corresponding values in other regions in three years (Table  
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23 326 2 and Table 4). A higher share of resources was allocated to west region. Inpatient  
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25 327 reimbursement rates of east, central and west geographic regions in 2011 was 46.8%,  
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27 328 41.2% and 51.2%, respectively.<sup>3 29</sup> Almost all three indicators after NCMS  
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29 329 reimbursement decreased rapidly from 2003 to 2008 but slowed down from 2008 to  
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31 330 2013 (Table 2 and Table 3). This is due to the worst health situation in 2003 and the  
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33 331 saturated health situation in 2008.<sup>30 31</sup>

34 332 With the establishment of basic medical and health system and the improvement  
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36 333 of residents’ health consciousness, the demand for medical and health services has  
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38 334 increased rapidly. Two-week prevalence rate of residents increased from 18.9% in  
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40 335 2008 to 24.1% in 2013, prevalence rate of chronic diseases increased from 24.1% in  
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42 336 2008 to 33.1% in 2013 and the rate of resident hospitalization increased by 150% in  
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44 337 the last 10 years.<sup>32</sup> Accordingly, medical expenditures have also increased rapidly.<sup>32 33</sup>  
45  
46 338 The financial protection of the NCMS in rural areas faces great challenges. To further  
47  
48 339 prevent CHE, NCMS should increase financing level to lower the deductibles and  
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50 340 co-payments, and set higher reimbursement rates and ceilings. A more effective cost  
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52 341 control mechanism is also important.

53 342 There are several strengths in this study. First, to control the validity and  
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55 343 reliability of statistical analysis, GEE, in view of its advantages, was used to estimate

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4 344 OR and 95% CI for the association between the catastrophe's incidence and NCMS  
5 345 reimbursement. Second, most studies focused on a specific local area or the  
6 346 short-term effect of NCMS on CHE in China. We assessed 10-year trend of the  
7 347 incidence and severity of CHE at national level using the data from NHSS. Third,  
8 348 three indicators were used to capture the catastrophe's incidence and intensity and  
9 349 data was disaggregated by three geographic regions and four household income levels.  
10  
11 350 There are also some limitations in this study. First, the NCMS was at the start stage in  
12 351 2003 and the coverage was very low in rural China. Therefore, the sample size in  
13 352 2003 was small with only 338 households. However, the impact of NCMS in 2003,  
14 353 2008 and 2013 was reflected in the difference in CHE before and after reimbursement  
15 354 and all the analysis was independently conducted in each year. In addition, we  
16 355 focused the overall trend of results from 2003 to 2013 and the sample size in 2003 had  
17 356 little influence on this trend. Second, we only focused on the rural households with  
18 357 hospitalized members covered by the NCMS in this study. This limited the  
19 358 generalizability of the results considering that our results were specific to these  
20 359 households. Our findings should be interpreted cautiously. The inclusion of data from  
21 360 other countries should contribute to the ability to generalize the results of future  
22 361 studies.

### 362 363 **Conclusion**

364 The  $R_{CHE}$ ,  $G_{CHE}$  and  $MPG_{CHE}$  all decreased rapidly after NCMS reimbursement and their  
365 changes increased rapidly from 2003 to 2013. After adjustment of the covariates, the  
366  $R_{CHE}$  after NCMS reimbursement were significantly lower than that before NCMS  
367 reimbursements in each year. The NCMS partly protected the rural households with  
368 hospitalized members from CHE. The financial protection in rural areas had been  
369 steadily improved with the development of NCMS. However, the inequalities between  
370 different groups still existed. The  $R_{CHE}$  in rural households with hospitalized members

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3 371 in three years were all more than 34% after reimbursement, which meant that many  
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5 372 households still faced CHE even though they were covered with NCMS. To further  
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7 373 prevent CHE, NCMS should increase financing level to provide a better benefit  
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9 374 package and increase reimbursement rates, make preferential policies for the high-risk  
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11 375 populations and low-income households, properly expand catalogue of essential  
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13 376 medicines and establish effective supervision system. A high-quality health care in  
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15 377 China will contribute to global health because of China's great population share in the  
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17 378 world. Undoubtedly, the gain and loss during this reform will serve as reference for  
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19 379 other countries, especially developing countries.

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### 22 381 **Acknowledgment**

23  
24 382 The authors would like to thank all the participants in this study.

25  
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### 27 384 **Contributors**

28  
29 385 XB, W-ZQ and H-MH drafted the manuscript. C-YJ and FR performed data collection  
30  
31 386 and statistical analyses. L-MN and MQ made a substantial contribution to the  
32  
33 387 interpretation of the data and study design. All authors read and approved the final  
34  
35 388 manuscript.

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39 390 **Funding:** The research is funded by National Natural Science Foundation of China  
40  
41 391 [81273183 to Liu MN].

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44 393 **Competing interests:** None declared.

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48 395 **Ethics approval:** The institutional review board of the Chinese National Bureau of  
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50 396 Statistics provided review and ethics approval of the survey.

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54 398 **Data sharing statement:** Original data is available on request. It was stored on

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4 399 password-protected computers at the center for health statistics information of  
5 400 Ministry of Health in Beijing, China.

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**Table 1. Characteristics of all households enrolled in the study**

Characteristics	2003 (N=180)		2008 (N= 2326)		2013 (N= 4469)	
	n	%	n	%	n	%
<b>Household characteristics</b>						
Number of household members						
<5	128	71.11	1916	82.37	3971	88.86
≥5	52	28.89	410	17.63	498	11.14
One or more members older than 60 years						
No	104	57.78	1267	54.47	2003	44.82
Yes	76	42.22	1059	45.53	2466	55.18
One or more members younger than 5 years						
No	148	82.22	1948	83.75	3806	85.16
Yes	32	17.78	378	16.25	663	14.84
Time spent travelling to the nearest medical center						
≤15min	145	80.56	1701	73.13	3532	79.03
>15min	35	19.44	625	26.87	937	20.97
The number						



of						
observations						
in each region						
East	113	62.78	626	26.91	991	22.17
Centre	14	7.78	759	32.63	1670	37.37
West	53	29.44	941	40.46	1808	40.46
Annual						
household						
income*						
Q 1	2643.33	1265.69	3956.52	1680.38	4785.49	2590.40
Q 2	6914.23	1353.25	9062.74	1247.41	13003.64	2841.22
Q 3	13505	2716.15	14699.42	2065.84	25958.15	5174.25
Q 4	29194.35	10927.31	31665.48	20295.22	61082.23	44409.99
<b>householders'</b>						
<b>characteristics</b>						
Gender						
Male	131	72.78	1796	77.21	3373	75.48
Female	49	27.22	530	22.79	1096	24.52
Age						
<60	120	66.67	1442	61.99	2262	50.62
≥60	60	33.33	884	38.01	2207	49.38
Marital status						
Unmarried	4	2.22	47	2.02	72	1.61
Married	155	86.11	1953	83.96	3735	83.58
Divorced	0	0	29	1.25	612	13.69
Widow or						
others	21	11.67	297	12.77	50	1.12
Education						
Illiterate	52	28.89	511	21.98	811	18.15
Elementary						
school	71	39.44	917	39.44	1863	41.69
Junior high						
school	48	26.67	722	31.05	1418	31.73
Senior high						
school or	9	5.00	175	7.53	377	8.44
above						
Employment						
Employed	126	70.00	1817	78.12	3222	72.10
Retired	12	6.67	60	2.58	157	3.51
Others	42	23.33	449	19.30	1090	24.39

498 \*Annual household income of each year was divided into four levels according to the quartile, the  
 499 mean and standard deviation of each level were calculated.

**Table 2. Results of the incidence rates of CHE among all the studied households (%)**

$R_{CHE}$	2003			2008			2013		
	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change
Total	58.89	49.44	9.45	54.90	41.75	13.15	58.98	34.88	24.10
East	58.41	50.44	7.97	58.79	46.49	12.30	63.47	39.56	23.91
Centre	85.71	85.71	0	49.54	38.47	11.07	57.13	35.51	21.62
West	52.83	37.74	15.09	56.64	41.23	15.41	58.24	31.75	26.49
Q1	71.11	71.11	0	78.65	60.67	17.98	86.25	58.75	27.50
Q2	60.47	48.84	11.63	59.32	44.30	15.02	73.61	43.13	30.48
Q3	60.87	45.65	15.22	50.93	39.22	11.71	54.79	29.16	25.63
Q4	43.48	32.61	10.87	37.23	27.88	9.35	32.86	18.39	14.47

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**Table 3. Results of the severity of CHE among all the studied households (%)**

Indicators	2003			2008			2013		
	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change	Before reimbursement	After reimbursement	Change
<i>G<sub>CHE</sub></i>									
Total	21.51	12.57	8.94	23.23	10.08	13.15	41.65	8.15	33.50
East	19.54	13.56	5.98	28.54	12.54	16.00	56.92	10.51	46.41
Centre	25.12	25.12	0	20.28	8.74	11.54	38.00	8.29	29.71
West	24.73	7.15	17.58	22.09	9.52	12.57	36.64	6.72	29.92
Q1	26.37	21.66	4.71	42.80	16.32	26.48	86.46	15.96	70.50
Q2	28.51	12.94	15.57	22.77	10.17	12.60	57.13	9.57	47.56
Q3	18.70	9.06	9.64	17.38	8.57	8.81	28.70	6.02	22.68
Q4	13.01	6.85	6.16	13.56	6.55	7.01	13.90	4.05	9.85
<i>MPG<sub>CHE</sub></i>									
Total	36.52	25.43	11.09	42.32	24.14	18.18	70.61	23.35	47.26
East	33.46	26.88	6.58	48.54	26.97	21.57	89.67	26.58	63.09
Centre	29.31	29.31	0	40.94	22.73	18.21	66.53	23.33	43.20
West	46.82	18.95	27.87	39.00	23.09	15.91	62.91	21.16	41.75
Q1	37.07	30.46	6.61	54.41	26.90	27.51	100.24	27.17	73.07
Q2	47.15	26.50	20.65	38.38	22.96	15.42	77.61	22.19	55.42
Q3	30.72	19.84	10.88	34.12	21.86	12.26	52.38	20.65	31.73
Q4	29.93	21.01	8.92	36.42	23.48	12.94	42.32	22.03	20.29

**Table 4. The influence of NCMS on the incidence rates of CHE**

	Year	Change (%)	Crude		Adjusted	
			OR (95 % CI)	Increment (%)	OR (95 % CI)	Increment (%)
<b>Total</b>						
	2003	9.45	1.46(1.23-1.74)	-	1.50(1.24-1.81)	-
	2008	13.15	1.70(1.61-1.80)	16.44	1.79(1.69-1.90)	19.33
	2013	24.10	2.68(2.54-2.83)	57.65	2.94(2.77-3.11)	64.25
<b>Area</b>						
<b>East</b>						
	2003	7.97	1.38(1.13-1.69)	-	1.43(1.14-1.80)	-
	2008	12.30	1.64(1.48-1.82)	18.84	1.77(1.57-1.99)	23.78
	2013	23.91	2.66(2.37-2.97)	62.20	3.08(2.71-3.50)	74.01
<b>Central</b>						
	2003	0	1.00(1.00-1.00)	-	1.00(1.00-1.00)	-
	2008	11.07	1.57(1.43-1.72)	57	1.64(1.49-1.82)	64.00
	2013	21.62	2.42(2.23-2.63)	54.14	2.63(2.40-2.88)	60.37
<b>West</b>						
	2003	15.09	1.85(1.24-2.75)	-	1.86(1.23-2.82)	-
	2008	15.41	1.86(1.69-2.05)	0.54	1.96(1.77-2.16)	5.38
	2013	26.49	3.00(2.74-3.28)	61.29	3.22(2.93-3.55)	64.29
<b>Income</b>						
<b>Q1</b>						
	2003	0	1.00(1.00-1.00)	-	1.00(1.00-1.00)	-
	2008	17.98	2.39(2.03-2.81)	139.00	2.56(2.16-3.04)	156.00
	2013	27.50	4.40(3.70-5.24)	84.10	4.65(3.89-5.55)	81.64
<b>Q2</b>						
	2003	11.63	1.60(1.08-2.37)	-	1.63(1.08-2.45)	-
	2008	15.02	1.83(1.62-2.08)	14.38	1.90(1.67-2.16)	16.56
	2013	30.48	3.68(3.19-4.25)	101.09	3.86(3.32-4.49)	103.16
<b>Q3</b>						
	2003	15.22	1.85(1.21-2.84)	-	1.89(1.23-1.92)	-
	2008	11.71	1.61(1.44-1.80)	-12.97	1.63(1.46-1.83)	-13.76
	2013	25.63	2.94(2.68-3.23)	82.61	3.04(2.76-3.35)	86.50
<b>Q4</b>						
	2003	10.87	1.59(1.08-2.34)	-	1.62(1.08-2.41)	-
	2008	9.35	1.53(1.39-1.69)	-3.77	1.55(1.41-1.72)	-4.32
	2013	14.47	2.17(1.94-2.43)	41.83	2.21(1.97-2.48)	42.58

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### Supplementary data 1 The questions in the questionnaire of NHSS employed to calculate indicators

Food consumption expenditure in each household was measured by the question, “How much did your household spend in food consumption expenditure during the last one year?”

The question, “How much did your household spend in living expenditure during the last one year?” was chosen to measure the total living expenditure in each household.

Actual household size was measured by the question, “How many people have a long-term residence at your household?”

The question, “How much did your household spend in medical expenses (without compensations from a third party) during the last one year” was chosen to measure the out-of-pocket health expenditure payment in each household.

### Supplementary data 2

**Table 1 Determinants of catastrophic health expenditure.**

Determinant	$\beta$ (95%CI)	SE	Z	P
<b>Gender of householder</b> (male vs female)	-0.51(-0.62--0.40)	0.06	-8.94	<.0001
<b>Age of householder</b>	0.28(0.11-0.46)	0.09	3.12	0.0018
<b>Educational level of householder</b>				
Elementary school vs Illiterate	-0.35(-0.48--0.22)	0.07	-5.31	<.0001
Junior high school vs Illiterate	-0.49(-0.64--0.35)	0.07	-6.84	<.0001
Senior high school or above vs Illiterate	-0.90(-1.11--0.70)	0.11	-8.56	<.0001
<b>One or more members older than 60 years</b>	0.39(0.21-0.56)	0.09	4.35	<.0001
(yes vs no)				
<b>One or more members younger than 5 years</b>	0.03(-0.11-0.17)	0.07	0.37	0.7104
(yes vs no)				
<b>Number of household members</b>	-0.27(-0.31--0.24)	0.02	-14.3	<.0001
<b>Employment</b> (employed vs others)	-0.81(-0.97--0.65)	0.08	-7.58	<.0001
<b>Marital status</b> (married vs others)	-0.63(-0.78--0.48)	0.08	-7.24	<.0001

### Supplementary data 3 The definition of poverty line

The poverty line is defined as the average food expenditure of the household whose food expenditure share of total household expenditure is within the 45th and 55th percentile of the total sample.<sup>1</sup> Considering the economy scale of household consumption, the household equivalence scale is used rather than actual household

size. The equivalence scale is:

$$eqsize_h = hhsiz_e_h^\beta$$

where  $hhsiz_e_h$  is the household size.  $\beta$  equals 0.56.

The poverty line can be calculated as follows:

1. Generate the food expenditure share ( $foodexp_h$ ) for each household by dividing the household's food expenditure by its total expenditure

$$foodexp_h = \frac{food_h}{exp_h}$$

2. Generate the equivalent household size for each household as

$$eqsize_h = hhsiz_e_h^{0.56}$$

3. Divide each household food expenditure by the equivalent household size to get equivalized food expenditures ( $eqfood_h$ )

$$eqfood_h = \frac{food_h}{eqsize_h}$$

4. Identify the food expenditure shares of total household expenditure that are at the 45<sup>th</sup> and 55<sup>th</sup> percentile across the whole sample, name these two variables as  $food45$  and  $food55$ . If the survey includes a household weighting variable, the percentile calculation should consider the weight.
5. Calculate the weighted average of food expenditure in the 45<sup>th</sup> to 55<sup>th</sup> percentile range. This is exactly the poverty line ( $pl$ )

$$pl = \frac{\sum w_h * eqfood_h}{\sum w_h} \text{ where } food45 < foodexp_h < food55$$

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**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology\***  
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	5
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5,7
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	



		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	5
		(e) Describe any sensitivity analyses	
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	8
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(b) Report category boundaries when continuous variables were categorized	19
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	10-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	3
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).