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Short-term and long-term effects of Sanming healthcare system reform on drug-related expenditures for rural patients with cancer in public hospitals: an interrupted time series analysis using segmented regression model in China

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ABSTRACT

Objectives To assess the effects of 'Sanming model' on drug-related expenditures.

Design Interrupted time series analysis with two time points was conducted to analyse the effects of 'Sanming model' using segmented regression model.

Setting Two hundred and eighty public hospitals in Fujian province in China.

Participants A total of 777 171 inpatients and 792 743 outpatients with cancer who participated in New Rural Cooperative Medical Scheme (NRCMS) were included.

Interventions 'Sanming model' was issued by Sanming government in February 2013 and spread to other cities in Fujian province in January 2015.

Primary outcome measures Four drug-related expenditure variables.

Results Among inpatients, total drug expenditures and drug expenditures covered by NRCMS dropped instantly after the reform in all hospitals. Although there was insignificant change during the short-term reform period, the total drug expenditures and drug expenditures covered by NRCMS decreased at the rate of ¥20.3 (p=0.0099) and ¥18.8 (p=0.0341) per capita month-to-month during the long-term reform period in Sanming hospitals, respectively. Among outpatients, total drug expenditures and drug expenditures covered by NRCMS decreased at the rate of ¥20.8 (p=0.0335) and ¥18.4 (p=0.0242) per capita month-to-month during the short-term reform period in Sanming hospitals, respectively. However, the downward trend did not continue into the long term. The significant decreases in trend of drug expenditures uncovered by NRCMS were only observed after the reform in provincial hospitals. The ratio of drug expenditures to inpatient (outpatient) expenditures decreased after the reform in all hospitals.

Conclusions 'Sanming model' had long-term effect in reducing total drug expenditures, drug ratio and drug expenditures covered by NRCMS for rural inpatients with cancer and only short-term positive effect for outpatients. However, there was limited effect of 'Sanming model' on drug expenditures uncovered by NRCMS. 'Sanming model' still needs to accumulate experiences and improves the reform measures dynamically.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study was strengthened by using individual-level data rather than hospital-level data to analyse the effects of Sanming healthcare system reform.
⇒ Interrupted time series analysis which was the strongest quasi-experimental design was applied to assess the intervention effects of Sanming healthcare system reform.
⇒ The results of this study were based on medical data from 2011 to 2016 so that it may not comprehensively demonstrate the long-term effects of Sanming healthcare system reform.

INTRODUCTION

The proportion of government health investment to national health expenditures was less than 25% in China before 2009,[1] and the government continuously set medical service charges below actual costs. To survive financially, hospital managers linked physicians' compensation to the profits they generated. Driven by financial incentives, physicians prescribed expensive drugs or overprescribed unnecessary drugs to patients to make profits. The behaviours depended on drug mark-up policy which allowed a markup up to 15% on the wholesale prices of drugs. The physicians also made profits from unnecessary tests and longer hospital stays. These all led to continuous increase in medical expenditures and heavier disease economic burden for patients. The State Council of China put forward deepening healthcare system reform to improve accessibility and equity

of health service in 2009, focusing on five aspects: basic medical security system, essential medicine system, grassroots healthcare services system, equity of public health service and public hospitals reform.[2 3] Since then, local governments at all levels tried to reform the healthcare system under the guidelines. Of which, 'Sanming model' was considered as one of the most remarkable healthcare system reform.

Sanming was an inland city whose Gross Domestic Product ranks the sixth among nine cities in Fujian province. Sanming was in the predicament of population ageing while not rich yet for a long time. In 2011, the deficits of Urban Employee Medical Insurance pooling fund reached more than ¥200 million, which accounted for nearly 15% of the city's financial level. Sanming government tried to take steps to monitor a batch of drugs which were suspected of generating high kickbacks at all its 22 public hospitals in February 2012. The medical expenditures turned to decline after the monitor. For the first time, Urban Employee Medical Insurance pooling fund changed from deficits to balances by the end of 2012. This trial hinted that overprescribing drugs was the primary reason for deficits of medical insurance fund. Therefore, drug cost control became the key point of Sanming healthcare system reform.

Sanming government simultaneously issued systemic reform in the governance structure, payment system and physician compensation methods at all its 22 public hospitals in February 2013, which was known as 'Sanming model'.[4 5] In short, a hospital governance commission which consolidated various departments was developed. It took charge of the strategic planning, strategic purchasing and supervising the achievement of goals. The hospital directors had autonomy to run their hospitals and were paid annual compensation based on the achievement of goals which were aforehand set by the hospital governance commission. In terms of payment system, the Zero Mark-up Drug Policy (ZMDP) was developed to remove the previously allowed 15% profit margin on drugs. The Centralised Procurement of Medicine Policy (CPMP) was carried out to strengthen bargaining power of drug procurement leading group and reduce the purchasing prices of drugs. Furthermore, the 'two-invoice' system, one invoicing by pharmaceutical factory to primary distributor and the other invoicing by primary distributor to public hospitals, was innovatively put forward to streamline supply chains of drugs. The fees for physician services that required time and skills were increased which offset the loss in drug revenues. The physician compensation was more based on seniority, quantity of services, quality of care and achievement of the goals such as cost control instead of profits making from prescribing drugs and tests by them.[4 5]

The hospital-level public data from Sanming government (http://www.jksmpt.com/portal/home/hospital/runList.html) showed that Sanming healthcare system reform had success in reducing medical expenditures and controlling cost in short term. The Fujian provincial government announced to implement the 'Sanming model' throughout the whole province in 2015.[6] Many researchers and organisations studied the effects of Sanming healthcare system reform using statistical model. Fu *et al* found that 'Sanming model' reduced medical costs significantly without measurably sacrificing clinical quality and productive efficiency.[4] He *et al* reported that the pharmaceutical reform (ZMDP) in Sanming reduced drug expenditures in short term but failed to meet its goal of combating sharp growth of drug and total health expenditures.[7] Jiang *et al* provided evidence that the implementation of reference pricing policy was associated with substantial decreases in drug costs, while the ZMDP seemed not.[8] Meng *et al* found that the typical systemic reform had some positive effects on cost control, but the out-of-pocket (OOP) expenditures as a share of total expenditures was still high.[9] Hu *et al* confirmed that 'Sanming model' promoted the appropriate use of antibiotics in county-level hospitals.[10]

The existing studies about 'Sanming model' mainly evaluated the short-term achievements in Sanming hospitals using hospital-level data. The long-term achievements in Sanming hospitals and the achievements after the promotion of 'Sanming model' in hospitals of other cities in Fujian province remain unclear. The effect of 'Sanming model' on drug expenditures uncovered by medical insurance which reflected the burden of actual payment for patients were given less attention relative to total drug expenditures. Moreover, the performance achieved on reform may vary from disease to disease. Considering cancer caused high disease economic burden[11] and rural residents were more vulnerable to poverty due to illness, this study aimed to analyse the short-term and long-term effects of Sanming healthcare system reform on drug-related expenditures for rural patients with cancer in public hospitals. The findings will provide evidences for summing up the experiences of Sanming healthcare system reform and promoting the reform.

METHODS

Study design

The Sanming healthcare system reform was issued in February 2013 and extended to the whole Fujian province in January 2015. Therefore, this study was divided into three periods: January 2011—February 2013, March 2013—December 2014 and January 2015—December 2016. The whole province was under the same background of healthcare system except 'Sanming model' (online supplemental figure 1). The medical expenditures varied in different levels of hospitals, so the public hospitals were classified into 22 county or municipal hospitals in Sanming (group A), 232 county or municipal hospitals (group B) and 26 provincial hospitals (group C) in other eight cities of Fujian province.

Interrupted time series (ITS) analysis had been proved to be the strongest quasi-experimental design to estimate intervention effects.[12 13] In this study, ITS analysis

with two time points was used to analyse the short-term (March 2013—December 2014) and long-term (January 2015—December 2016) effects of 'Sanming model' on drug-related expenditures in group A and the short-term (January 2015—December 2016) effects in group B and group C. In addition to the time dimension, the differences among groups were also described in comparison.

Data source and study population

The data were extracted from medical records of rural patients with New Rural Cooperative Medical Scheme (NRCMS) who had a confirmed diagnosed of cancer and were treated in Fujian province between 1 January 2011 and 31 December 2016. Patient variables included gender, age, residential county, name of admitted hospital, hospital level (county, municipal or provincial hospital), low income or not, length of stay, surgery or not and drug-related expenditures. We excluded patients with illogical values (eg, reimbursement expenses ≥total expenditures) or missing values (eg, gender, age, expenditures), patients who visited medical institutions below the county level, private hospitals or hospitals outside Fujian province. This resulted in a total of 777 171 inpatients and 792 743 outpatients in 280 public hospitals (online supplemental figure 2).

Drug-related expenditure variables

Four drug-related expenditure variables were used to assess the effects of 'Sanming model' on drug cost control for rural patients with cancer, as follows: (1) Total drug expenditures: included drug expenditures covered and uncovered by NRCMS; (2) Ratio of drug expenditures to inpatient (outpatient) expenditures (hereinafter referred to as drug ratio): calculated as total drug expenditures divided by total inpatient (outpatient) expenditures. The drug ratio was an evaluation indicator which was required below 30% to stem physicians from profiting from overprescribing[14]; (3) Drug expenditures covered by NRCMS: expenditures of class A and class B drugs which were in the National Reimbursement Drug List (NRDL). Two classes of drugs could be reimbursed 100% and 70%–90% by NRCMS, respectively. The reimbursement ratio of class B drugs can be adjusted by provincial and municipal governments, but the adjustment cannot exceed the 15% set by the state; (4) Drug expenditures uncovered by NRCMS: expenditures of class C drugs which were out of the NRDL and they should be paid by OOP. The amount of all drug-related expenditures from 2011 to 2016 were converted to the price level in 2011 using the consumer price index.[15]

STATISTICAL ANALYSIS

The number (percentage) was calculated for categorical variable. The drug-related expenditures per capita in each month in three groups between January 2011 and December 2016 were calculated as dependent variable for ITS analysis. ITS analysis was conducted using segmented regression model which was specified as follows:

$$Y_t = \beta_0 + \beta_1 \times time_t + \beta_2 \times short\_term\ intervention_t + \beta_3 \times time\ after\ short\_term\ intervention_t + \beta_4 \times long\_term\ intervention_t + \beta_5 \times time\ after\ long\_term\ intervention_t + e_t$$

Here, Y_t is drug-related expenditure variable at time t; $time_t$ is a continuous variable counting the number of months at time t from the start of study; $short\_term\ intervention_t$ is an indicator for time t occurring before (0) or after (1) the healthcare system reform, which was implemented at month 27 in the series (March 2013); $time\ after\ short\_term\ intervention_t$ is a continuous variable counting the number of months at time t after the reform (0 before the reform and 1—46 after the reform); $long\_term\ intervention_t$ is an indicator for time t occurring before (0) or after (1) the long-term reform, which started at month 49 in the series (January 2015); $time\ after\ long\_term\ intervention_t$ is a continuous variable counting the number of months at time t after the long-term reform, coded 0 before January 2015 and 1—24 thereafter.

For parameters, β_0 estimates the baseline level of the outcome at time zero; β_1 estimates the baseline trend of the outcome before the reform; β_2 estimates the level change in the outcome immediately after the reform; β_3 estimates the trend change in the outcome after the reform; β_4 estimates the level change in the outcome immediately after the long-term reform; β_5 estimates the trend change in the outcome after the long-term reform. Thus $\beta_1 + \beta_3$ is the short-term reform slope while $\beta_1 + \beta_3 + \beta_5$ represents the long-term reform slope (online supplemental figure 1). e_t is an error term at time t.

The segmented regression model was conducted in groups A, B and C, separately. In view of the cofounding effects of age, gender, economic condition, length of stay and therapy method on medical expenditures, the proportion of male, proportion of age ≥60 years, proportion of low income, proportion of length of stay ≥10 days and proportion of surgery at each month were adjusted in the multivariate analyses. Furthermore, Dickey-Fuller test was tested for seasonal fluctuations in the series of four drug-related expenditure variables and the results showed no seasonal fluctuations. If there was autocorrelation proved by Durbin-Watson test, segmented regression model with autoregressive integrated moving average method was used to estimate regression parameters. All analyses were conducted using SAS V.9.4 and two-sided statistical tests with $p<0.05$ were considered as statistically significant. P values for differences among groups were not reported because of the large sample size.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

Demographic characteristics

The average number of inpatients was far more than that of outpatients in each provincial hospital (12 452 vs 4347). The proportion of outpatients who visited county hospitals was higher than that of inpatients. Male patients were more than female patients. The proportion of patients with age ≥60 years were lower in provincial hospitals than that in county or municipal hospitals. The proportion of people whose household per capita income were below the local minimum living standard was higher among inpatients than outpatients. Of 777 171 inpatients, more than 40% of patients were hospitalised for more than 10 days and approximately 18% of patients had undergone surgery (table 1).

Group A: county or municipal hospitals in Sanming; group B: county or municipal in other eight cities of Fujian province; group C: provincial hospitals in Fuzhou or Xiamen.

Trend of drug-related expenditures

The drug-related expenditures in Sanming were lower than those in other eight cities of Fujian province in each period. The drug-related expenditures of three groups were all on the decline during the study period and the downward trends were more obvious in Sanming. The total drug expenditures of inpatients were higher than those of outpatients, but drug ratio of inpatients was lower than that of outpatients (figures 1 and 2).

The level and trend changes in four drug-related expenditure variables were examined numerically using segmented regression models among inpatients and outpatients, respectively. The adjusted numerical details were as follows:

INPATIENTS

In Sanming, the total drug expenditures and drug expenditures covered by NRCMS dropped instantly by ¥1202.0 and ¥618.2 per capita after the reform (March 2013), respectively. The growing rate increased dramatically by ¥64.9 and ¥58.7 per capita, respectively, resulting in insignificant change in these two variables during the short-term reform period (p=0.2071 and 0.8249, respectively). However, the total drug expenditures and drug expenditures covered by NRCMS decreased at the rate of ¥20.3 (p=0.0099) and ¥18.8 (p=0.0341) per capita month-to-month during the long-term reform period, respectively. The drug ratio decreased before and after the reform (p<0.0001, p=0.0001 and 0.0087, respectively), as well as significant abrupt drop of 0.0921 per capita immediately after the reform (table 2 and figure 1, group A).

In county or municipal hospitals in other eight cities of Fujian province, the total drug expenditures and drug expenditures covered by NRCMS increased before the reform. The total drug expenditures, drug ratio and drug expenditures covered by NRCMS sharply dropped ¥421.0, ¥0.0218 and ¥405.7 per capita immediately after the reform (January 2015) and decreased at the rate of ¥56.0, ¥0.0040 and ¥42.4 per capita month-to-month during the short-term reform period, respectively (table 2 and figure 1, group B). In provincial hospitals, significantly instant level change by –¥1077.0, ¥0.0270 and –¥1171.0 per capita in total drug expenditures, drug ratio and drug expenditures covered by NRCMS occurred right after the reform, respectively. The total drug expenditures and drug ratio decreased at the rate of ¥59.1 and ¥0.0028 per capita month-to-month during the short-term reform period, respectively (table 2 and figure 1, group C). There were statistical insignificant changes in trend of drug expenditures uncovered by NRCMS during the study period in three groups (table 2 and figure 1).

Group A: county or municipal hospitals in Sanming; group B: county or municipal in other eight cities of Fujian province; group C: provincial hospitals in Fuzhou and Xiamen.

β_0 : baseline level before the reform; β_1 : baseline trend before the reform; β_2 : level change immediately after the reform; β_3 : trend change after the reform; β_4 : level change immediately after the long-term reform; β_5 : trend change after the long-term reform; $\beta_1 + \beta_3$: short-term reform slope; $\beta_1 + \beta_3 + \beta_5$: long-term reform slope.

OUTPATIENTS

In Sanming, the total drug expenditures decreased at the rate of ¥20.8 (p=0.0335) per capita month-to-month during the short-term reform period. However, the downward trend did not continue into the long term (p=0.3093). Significant abrupt drop of 0.1199 per capita for drug ratio was noted immediately after the reform, but the ratio monthly increased at the rate of 0.0046 (p=0.0021) per capita during the short-term reform period. Subsequently, the growing rate dropped by 0.0067 (p=0.0007) per capita, resulting in insignificant change for ratio during the long-term reform period (p=0.0862). The drug expenditures covered by NRCMS decreased at the rate of ¥18.4 (p=0.0242) per capita month-to-month during the short-term reform period, but the downward trend did not continue into the long term (p=0.3150). There was statistical insignificant change in trend of drug expenditures uncovered by NRCMS after the reform (table 3 and figure 2, group A).

In county or municipal hospitals in other eight cities of Fujian province, the total drug expenditures, drug expenditures covered and uncovered by NRCMS decreased before March 2013, while there were statistical insignificant changes in trend of these expenditures after the reform (p=0.2609, 0.2874 and 0.2662, respectively). The drug ratio decreased at the rate of 0.0032 (p<0.0001) per capita month-to-month during the short-term reform period (table 3 and figure 2, group B). In provincial hospitals, four drug-related expenditures had already decreased before the reform and the downward trend continued after the reform (p<0.0001, p<0.0001,

Table 1 Demographic characteristics and drug-related expenditure variables of patients with malignant tumour, n (%)

Variables		Inpatients			Outpatients		
		Group A	Group B	Group C	Group A	Group B	Group C
Hospital characteristics							
No		22	232	26	22	232	26
Hospital level	County	18 (81.8)	172 (74.1)	0 (0.0)	18 (81.8)	172 (74.1)	0 (0.0)
	Municipal	4 (18.2)	60 (25.9)	0 (0.0)	4 (18.2)	60 (25.9)	0 (0.0)
	Provincial	0 (0.0)	0 (0.0)	26 (100.0)	0 (0.0)	0 (0.0)	26 (100.0)
Patient characteristics							
No		37 871	415 548	323 752	68 313	611 400	113 030
Average no per hospital		1721	1791	12 452	3105	2635	4347
Hospital level	County	19 126 (50.5)	169 905 (40.9)	0 (0.0)	48 673 (71.2)	339 392 (55.5)	0 (0.0)
	Municipal	18 745 (49.5)	245 643 (59.1)	0 (0.0)	19 640 (28.8)	272 008 (44.5)	0 (0.0)
	Provincial	0 (0.0)	0 (0.0)	323 752 (100.0)	0 (0.0)	0 (0.0)	113 030 (100.0)
Gender, male		19 036 (50.3)	233 383 (56.2)	177 409 (54.8)	28 858 (42.2)	317 814 (52.0)	53 470 (47.3)
Age, years	<18	280 (0.7)	4486 (1.1)	6422 (2.0)	1057 (1.5)	5125 (0.8)	4428 (3.9)
	18–44	6126 (16.2)	63 975 (15.4)	64 392 (19.9)	11 220 (16.4)	84 622 (13.8)	21 775 (19.3)
	45–59	14 609 (38.6)	164 445 (39.6)	147 203 (45.5)	30 748 (45.0)	256 687 (42.0)	50 927 (45.1)
	≥60	16 856 (44.5)	182 642 (44.0)	105 735 (32.7)	25 288 (37.0)	264 966 (43.3)	35 900 (31.8)
Low income		2284 (6.0)	21 569 (5.2)	10 410 (3.2)	1719 (2.5)	7784 (1.3)	1130 (1.0)
Length of stay, ≥10 days		15 286 (40.4)	171 101 (41.2)	139 493 (43.1)	—	—	—
Surgery		7015 (18.5)	71 609 (17.2)	63 372 (19.6)	—	—	—

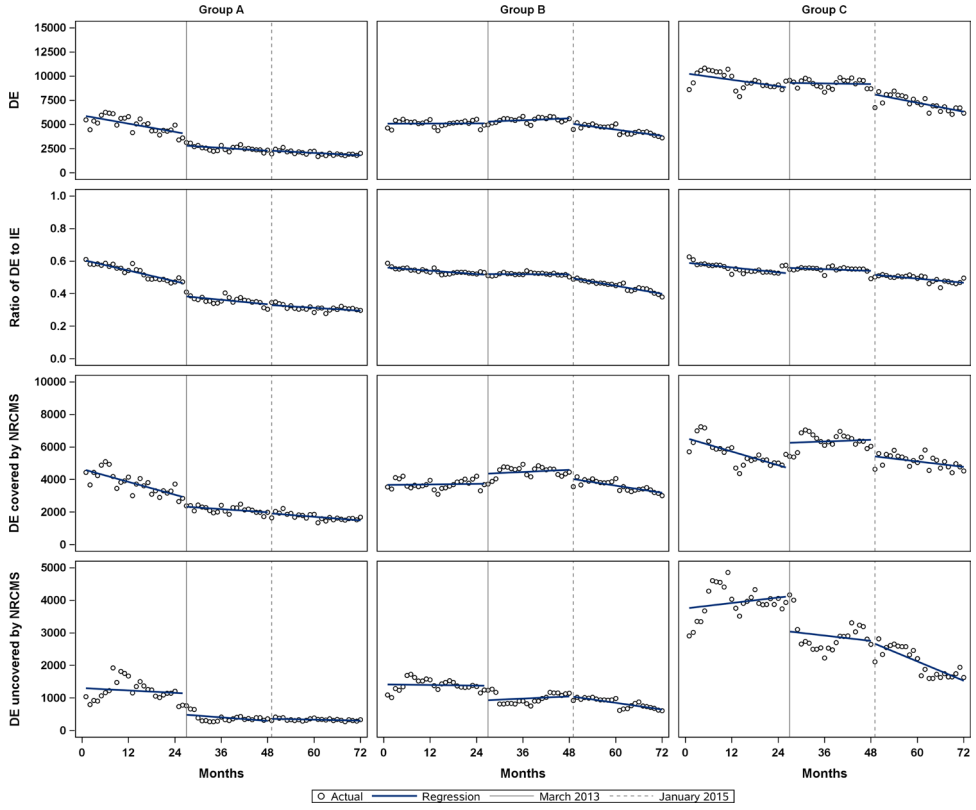

Figure 1 Trend in four drug-related expenditure variables per capita for inpatients. The unit of DE, DE covered by NRCMS and DE uncovered by NRCMS is the Yuan. Group A: county or municipal hospitals in Sanming; Group B: county or municipal in other eight cities of Fujian province; Group C: provincial hospitals in Fuzhou and Xiamen. DE, drug expenditures; IE, inpatient expenditures; NRCMS, New Rural Cooperative Medical Scheme.

p=0.0287 and p<0.0001, respectively) (table 3 and figure 2, group C).

DISCUSSION

A new round of healthcare system reform was put forward in 2009 to ease the disease economic burden of patients and improve the efficiency of public hospitals in China.[16] Among dozens of pilot public hospital reforms, 'Sanming model' got more attention because of its short-term positive effect.[17] A series of measures were innovatively put forward by 'Sanming model' to control the drug cost, so this study focused on the short-term and long-term effects of 'Sanming model' on drug-related expenditures. The data from medical records of patients with cancer who participated in NRCMS shown that total drug expenditures and drug expenditures covered by NRCMS decreased during the long-term reform period among inpatients and only short-term decrease was observed among outpatients in Sanming hospitals. The drug expenditures uncovered by NRCMS only decreased during the short-term reform period among outpatients in provincial hospitals. The drug ratio decreased after the reform in all hospitals.

The age-standardised incidence rate and age-standardised mortality rate of cancer in China were above the global average level, resulting in a heavy economic burden.[18] To increase reimbursement coverage, National Medical Insurance Administration has been updating the NRDL to include a wider variety of drugs.[19] Although the government had increased investment on healthcare every year in the past decades,[1] the monthly medical insurance fund in each hospital was still unable to meet the growing demand for healthcare. The policy makers and hospital administrators expected to control the spending of medical insurance fund. Sanming government innovatively carried out ZMDP, CPMP, 'two-invoice' system and reformed the annual compensation for hospital directors and physicians to control drug cost. This study found that inpatient total drug expenditures dropped instantly ¥1202, ¥421 and ¥1077 per capita right after the reform in three groups, respectively. This was a significant drop comparing with per capita monthly disposable income of ¥735 for rural residents.[20] The positive effects lasted from short-term to long-term reform period in Sanming hospitals. The results implied that 'Sanming model' solved the problem of deficits of medical insurance fund to a certain extent and the policy effects tended to be continuity. However, the trend of drug expenditures uncovered by NRCMS which were paid by OOP had little change before and after the reform in this study. Because inpatients with cancer were generally severe cases, more effective or imported drugs which were out of the NRDL had to be used.[21] By using limited medical insurance fund, the reform could not cover these expenditures.

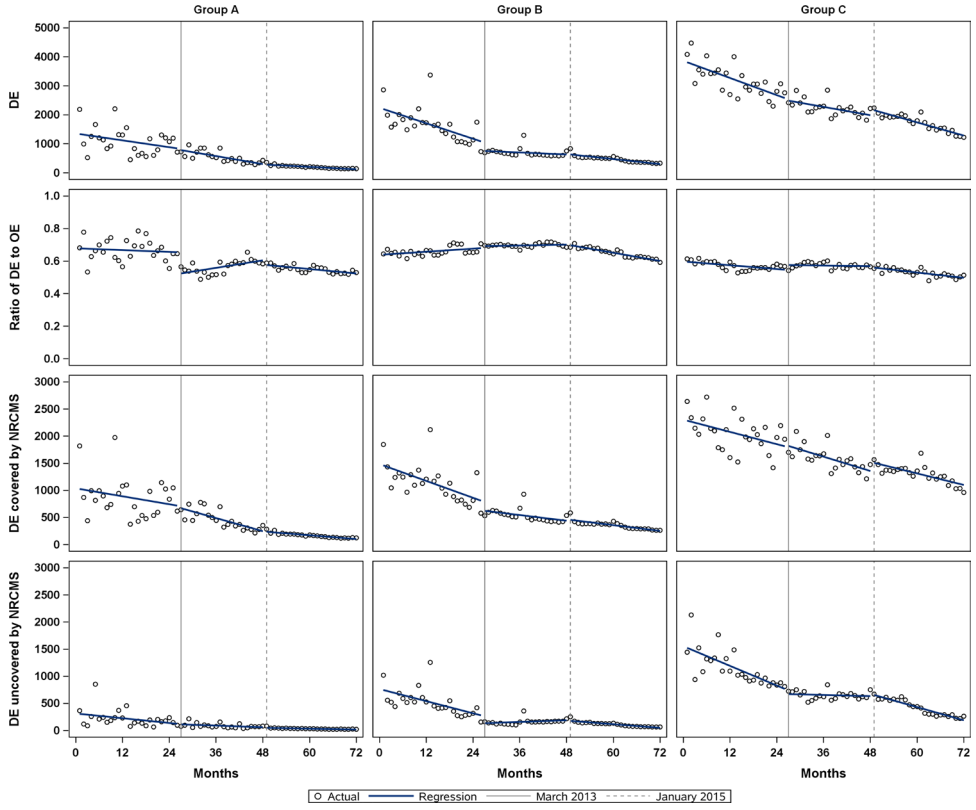

Figure 2 Trend in four drug-related expenditure variables per capita for outpatients. The unit of DE, DE covered by NRCMS and DE uncovered by NRCMS is the Yuan. Group A: county or municipal hospitals in Sanming; Group B: county or municipal in other eight cities of Fujian province; Group C: provincial hospitals in Fuzhou and Xiamen. DE, drug expenditures; OE, outpatient expenditures; NRCMS, New Rural Cooperative Medical Scheme.

With the improvement of NRCMS, it can gradually cover outpatient care.[22] However, the outpatients must be diagnosed as special diseases, for example, cancer, in hospitals at county level and above. The related disease diagnosis certificate, medical records of more than 3 months and discharge summary must be registered at healthcare centre. Medical institutions are designated, and outpatient care had higher deductible and lower reimbursement ceiling for compensation than inpatient care.[23] For cancer, only the expenditures of chemotherapy and radiotherapy can be covered by medical insurance. Despite these limitations, the NRCMS can still lower the economic burden of eligible outpatients to some extent.[24] Compared with inpatients, outpatients with cancer tended to visit lower level hospitals and the proportion of patients with low income was lower. Although 'Sanming model' did not cause abrupt drop in outpatient drug expenditures right after the reform, these expenditures reduced in the short-term reform period in Sanming hospitals and provincial hospitals. Unfortunately, the positive effects did not continue in long-term reform period and the short-term effect was not found in county or municipal hospitals in other eight cities. These results might attribute to the fact that drug expenditures had already decreased before the reform and cost related to drug production, transportation and management limited the continued decline in drug expenditures. Unlike inpatients, drug expenditures uncovered by NRCMS of outpatients reduced after the reform in provincial hospitals. It could be explained by the fact that the drug expenditures uncovered by NRCMS were high before the reform, while it was required that the proportion of drug expenditures uncovered by NRCMS should be controlled within 15% in public hospitals above county level.[25] In addition, the NRDL was updated with cheap and effective drugs,[26] resulting in outpatients were more likely to use the drugs listed in the NRDL to reduce economic burden.

To control the drug expenditures, the physicians and hospital managers were paid based on whether or not drug ratio falls below 30%.[14] The China Health Statistical Yearbook revealed that the drug ratio of inpatients (outpatients) decreased from 43.4% (52.3%) in 2010 to 27.9% (46.7%) in 2016 in public hospitals.[1] In this study, the drug ratio of patients with cancer also decreased after the Sanming healthcare system reform and it dropped to nearly 30% for inpatients in Sanming hospitals. However, the drug ratio was still obviously higher than national average level. Meanwhile the drug ratio of outpatients was even higher than 55%. The reason for such a high ratio was that NRCMS only covered the chemotherapy and radiotherapy for outpatients with cancer and the outpatient treatment was mainly medication.

'Sanming model' was successfully implemented in Sanming and the whole Fujian province and had achieved

Table 2 Parameter estimate (p value) in segmented regression model for inpatients, per capita

Parameter	Total DE		Ratio of DE to IE		DE covered by NRCMS		DE uncovered by NRCMS	
	Crude	Adjusted*	Crude	Adjusted*	Crude	Adjusted*	Crude	Adjusted*
Group A								
β_0	**5952.0 (<0.0001)**	793.1 (0.4554)	**0.6094 (<0.0001)**	**0.4946 (<0.0001)**	**4647.0 (<0.0001)**	276.1 (0.7754)	**1319.0 (<0.0001)**	528.6 (0.3553)
β_1	**−71.8 (<0.0001)**	**−77.3 (<0.0001)**	**−0.0057 (<0.0001)**	**−0.0068 (<0.0001)**	**−65.8 (<0.0001)**	**−61.3 (<0.0001)**	−15.0 (0.2049)	−10.4 (0.3425)
β_2	**−1,253.0 (<0.0001)**	**−1,202.0 (<0.0001)**	**−0.0712 (<0.0001)**	**−0.0921 (<0.0001)**	**−600.0 (0.0009)**	**−618.2 (0.0014)**	−145.7 (0.3700)	−174.6 (0.2123)
β_3	**46.9 (0.0067)**	**64.9 (<0.0001)**	**0.0027 (0.0094)**	**0.0047 (<0.0001)**	**49.8 (0.0002)**	**58.7 (0.0004)**	−8.6 (0.6832)	−13.5 (0.4801)
β_4	13.5 (0.9538)	−78.1 (0.6015)	0.0085 (0.5114)	−0.0062 (0.4308)	−44.3 (0.8000)	−74.9 (0.6833)	−5.1 (0.9747)	159.8 (0.2704)
β_5	4.2 (0.8115)	−7.9 (0.5119)	0.0011 (0.2909)	0.0010 (0.1169)	−2.8 (0.8313)	−16.3 (0.3071)	27.2 (0.2206)	19.9 (0.3149)
$\beta_1+\beta_3$	−25.0 (0.0635)	−12.4 (0.2071)	**−0.0029 (0.0003)**	**−0.0021 (0.0001)**	−16.0 (0.1121)	−2.6 (0.8249)	−23.6 (0.0857)	−24.0 (0.0540)
$\beta_1+\beta_3+\beta_5$	−20.8 (0.0783)	**−20.3 (0.0099)**	**−0.0018 (0.0117)**	**−0.0011 (0.0087)**	**−18.8 (0.0345)**	**−18.8 (0.0341)**	3.6 (0.7827)	−4.1 (0.7249)
Group B								
β_0	**5055.0 (<0.0001)**	586.7 (0.7011)	**0.5635 (<0.0001)**	**0.7322 (<0.0001)**	**3623.0 (<0.0001)**	118.7 (0.9368)	**1324.0 (<0.0001)**	557.3 (0.4994)
β_1	3.0 (0.7597)	**28.0 (0.0250)**	**−0.0017 (<0.0001)**	**−0.0019 (<0.0001)**	7.3 (0.4863)	33.1 (0.0714)	−3.2 (0.7465)	0.0 (0.9964)
β_2	119.1 (0.5678)	−63.7 (0.7020)	−0.0014 (0.8535)	0.0009 (0.8923)	421.5 (0.0514)	−70.8 (0.6935)	−71.4 (0.5305)	−148.8 (0.1269)
β_3	16.9 (0.2932)	35.6 (0.0751)	**0.0017 (0.0075)**	**0.0015 (0.0200)**	13.2 (0.4526)	33.7 (0.2870)	−0.6 (0.9748)	0.9 (0.9523)
β_4	**−604.4 (0.0053)**	**−421.0 (0.0231)**	**−0.0181 (0.0246)**	**−0.0218 (0.0023)**	**−657.8 (0.0031)**	**−405.7 (0.0428)**	−170.6 (0.1358)	18.8 (0.8591)
β_5	**−72.2 (<0.0001)**	**−119.5 (<0.0001)**	**−0.0044 (<0.0001)**	**−0.0036 (<0.0001)**	**−55.8 (0.0034)**	**−109.1 (0.0012)**	−6.6 (0.7272)	−19.0 (0.2020)
$\beta_1+\beta_3$	19.8 (0.1093)	**63.6 (<0.0001)**	0.0001 (0.9029)	−0.0005 (0.3258)	20.5 (0.1180)	**66.7 (0.0012)**	−3.8 (0.7397)	0.8 (0.9280)
$\beta_1+\beta_3+\beta_5$	**−52.3 (<0.0001)**	**−56.0 (<0.0001)**	**−0.0044 (<0.0001)**	**−0.0040 (<0.0001)**	**−35.4 (0.0035)**	**−42.4 (0.0308)**	−10.4 (0.3419)	−18.2 (0.0591)
Group C								
β_0	**10 065.0 (<0.0001)**	**12 530.0 (<0.0001)**	**0.5908 (<0.0001)**	**0.9779 (<0.0001)**	**6245.0 (<0.0001)**	**6206.0 (0.0110)**	**3424.0 (<0.0001)**	**5990.0 (0.0001)**
β_1	−41.1 (0.0827)	−13.7 (0.5344)	**−0.0023 (0.0004)**	**−0.0026 (<0.0001)**	−42.0 (0.0506)	−12.6 (0.6389)	13.9 (0.6345)	18.5 (0.4896)
β_2	211.1 (0.6490)	58.3 (0.8810)	0.0232 (0.0812)	0.0130 (0.2214)	635.2 (0.1078)	120.6 (0.7648)	153.3 (0.6110)	90.5 (0.7358)
β_3	47.8 (0.2306)	36.1 (0.2491)	0.0016 (0.1338)	**0.0019 (0.0343)**	**82.9 (0.0254)**	83.0 (0.0572)	−71.2 (0.1828)	−74.4 (0.1157)
β_4	**−1,344.0 (0.0052)**	**−1,077.0 (0.0106)**	−0.0175 (0.1901)	**−0.0270 (0.0182)**	**−1,279.0 (0.0017)**	**−1,171.0 (0.0074)**	−438.1 (0.1479)	−238.2 (0.3958)
β_5	−75.0 (0.0754)	**−81.5 (0.0309)**	−0.0015 (0.1780)	−0.0020 (0.0509)	−67.3 (0.0816)	−77.6 (0.1171)	34.9 (0.5287)	26.0 (0.6068)
$\beta_1+\beta_3$	6.7 (0.8173)	22.4 (0.4076)	−0.0007 (0.3564)	−0.0007 (0.3249)	40.9 (0.1129)	**70.4 (0.0325)**	−57.3 (0.0891)	−55.9 (0.0747)
$\beta_1+\beta_3+\beta_5$	**−68.3 (0.0109)**	**−59.1 (0.0253)**	**−0.0022 (0.0023)**	**−0.0028 (0.0002)**	−26.5 (0.2640)	−7.2 (0.8134)	−22.5 (0.4787)	−29.9 (0.3105)

The boldface values indicated that the trend or change was statistically significant.
*Adjusted for proportion of male, proportion of age ≥60 years, proportion of low income, proportion of length of stay ≥10 days and proportion of surgery.
DE, drug expenditures; IE, inpatient expenditures; NRCMS, New Rural Cooperative Medical Scheme.

Table 3 Parameter estimate (p value) in segmented regression model for outpatients, per capita

Parameter	Total DE		Ratio of DE to OE		DE covered by NRCMS		DE uncovered by NRCMS	
	Crude	Adjusted*	Crude	Adjusted*	Crude	Adjusted*	Crude	Adjusted*
Group A								
β_0	**1352.0 (<0.0001)**	**1884.0 (<0.0001)**	**0.6790 (<0.0001)**	**0.5175 (<0.0001)**	**1036.0 (<0.0001)**	**1602.0 (<0.0001)**	**315.8 (<0.0001)**	**282.4 (0.0388)**
β_1	**−19.6 (0.0092)**	**−17.9 (0.0363)**	−0.0009 (0.4468)	**−0.0032 (0.0137)**	−12.3 (0.0511)	−11.0 (0.1183)	**−7.3 (0.0046)**	**−6.9 (0.0246)**
β_2	−36.0 (0.8253)	−100.3 (0.5578)	**−0.1356 (<0.0001)**	**−0.1199 (<0.0001)**	−26.1 (0.8502)	−80.6 (0.5717)	−9.9 (0.8589)	−19.7 (0.7462)
β_3	−3.3 (0.7845)	−2.9 (0.8259)	**0.0048 (0.0166)**	**0.0078 (0.0002)**	−8.0 (0.4306)	−7.3 (0.5002)	4.7 (0.2501)	4.5 (0.3376)
β_4	−14.3 (0.9307)	−8.7 (0.9576)	−0.0264 (0.3282)	−0.0227 (0.3569)	−6.3 (0.9627)	−5.5 (0.9681)	−7.8 (0.8899)	−3.3 (0.9555)
β_5	15.7 (0.2117)	12.5 (0.3254)	**−0.0061 (0.0037)**	**−0.0067 (0.0007)**	14.3 (0.1729)	11.6 (0.2743)	1.2 (0.7833)	0.9 (0.8387)
$\beta_1+\beta_3$	**−22.8 (0.0175)**	**−20.8 (0.0335)**	**0.0039 (0.0142)**	**0.0046 (0.0021)**	**−20.2 (0.0131)**	**−18.4 (0.0242)**	−2.6 (0.4204)	−2.4 (0.4859)
$\beta_1+\beta_3+\beta_5$	−7.1 (0.3899)	−8.3 (0.3093)	−0.0023 (0.0939)	−0.0021 (0.0862)	−5.7 (0.4164)	−6.8 (0.3150)	−1.4 (0.6150)	−1.5 (0.6120)
Group B								
β_0	**2248.0 (<0.0001)**	**4624.0 (<0.0001)**	**0.6375 (<0.0001)**	**0.4754 (<0.0001)**	**1485.0 (<0.0001)**	**2770.0 (<0.0001)**	**762.2 (<0.0001)**	**1854.0 (<0.0001)**
β_1	**−44.6 (<0.0001)**	**−28.9 (0.0028)**	**0.0017 (0.0037)**	**0.0019 (0.0008)**	**−25.9 (<0.0001)**	**−17.7 (0.0033)**	**−18.7 (<0.0001)**	**−11.3 (0.005)**
β_2	−325.5 (0.0604)	−305.3 (0.0594)	0.0093 (0.4374)	0.0091 (0.3206)	−178.7 (0.0927)	−172.7 (0.0854)	**−146.8 (0.0431)**	−132.6 (0.0497)
β_3	**38.5 (0.0029)**	18.6 (0.1612)	−0.0012 (0.2144)	−0.0009 (0.2367)	**17.3 (0.0268)**	6.7 (0.4173)	**21.2 (0.0001)**	**12.0 (0.0327)**
β_4	18.1 (0.9165)	13.1 (0.9348)	0.0008 (0.9461)	−0.0013 (0.8892)	20.0 (0.8508)	12.4 (0.9005)	−1.9 (0.9795)	0.7 (0.9922)
β_5	−8.4 (0.5247)	−0.5 (0.967)	**−0.0048 (<0.0001)**	**−0.0041 (<0.0001)**	−0.1 (0.9954)	4.6 (0.5515)	−8.3 (0.1327)	−5.1 (0.3248)
$\beta_1+\beta_3$	−6.1 (0.5395)	−10.3 (0.2795)	0.0005 (0.4617)	0.001 (0.0745)	−8.6 (0.1575)	−11.0 (0.066)	2.6 (0.5328)	0.7 (0.8633)
$\beta_1+\beta_3+\beta_5$	−14.4 (0.0992)	−10.8 (0.2609)	**−0.0042 (<0.0001)**	**−0.0032 (<0.0001)**	−8.7 (0.1062)	−6.4 (0.2874)	−5.7 (0.1158)	−4.5 (0.2662)
Group C								
β_0	**3856.0 (<0.0001)**	**1889.0 (0.0096)**	**0.5976 (<0.0001)**	**0.4949 (<0.0001)**	**2307.0 (<0.0001)**	1323.0 (0.054)	**1560.0 (<0.0001)**	**1532.0 (0.0003)**
β_1	**−49.1 (<0.0001)**	**−40.5 (<0.0001)**	**−0.0019 (0.0002)**	**−0.0013 (0.0100)**	**−18.9 (0.0009)**	**−13.5 (0.0226)**	**−30.6 (<0.0001)**	**−28.8 (<0.0001)**
β_2	−53.9 (0.6494)	−135.6 (0.2762)	**0.0282 (0.0104)**	0.0147 (0.2110)	26.0 (0.8318)	−10.5 (0.9377)	−90.7 (0.1349)	−97.3 (0.1683)
β_3	**24.3 (0.0055)**	**24.1 (0.0036)**	0.0015 (0.0513)	0.0013 (0.1116)	−3.2 (0.7241)	−1.8 (0.8471)	**28.6 (<0.0001)**	**30.8 (<0.0001)**
β_4	221.2 (0.0688)	**245.3 (0.0229)**	−0.0059 (0.5856)	−0.0027 (0.7990)	167.4 (0.1786)	179.6 (0.141)	49.5 (0.4177)	59.8 (0.3193)
β_5	−13.3 (0.1371)	**−19.6 (0.0221)**	**−0.0023 (0.0059)**	**−0.0030 (0.0006)**	4.4 (0.6419)	0.0 (0.9964)	**−18.8 (<0.0001)**	**−21.7 (<0.0001)**
$\beta_1+\beta_3$	**−24.8 (0.0005)**	**−16.4 (0.0160)**	−0.0004 (0.5603)	−0.0001 (0.9274)	**−22.1 (0.0025)**	**−15.3 (0.0462)**	−2.0 (0.5638)	2.0 (0.5915)
$\beta_1+\beta_3+\beta_5$	**−38.2 (<0.0001)**	**−36.0 (<0.0001)**	**−0.0027 (<0.0001)**	**−0.0031 (<0.0001)**	**−17.7 (0.0054)**	**−15.2 (0.0287)**	**−20.8 (<0.0001)**	**−19.7 (<0.0001)**

Group A: county or municipal hospitals in Sanming; group B: county or municipal in other eight cities of Fujian province; group C: provincial hospitals in Fuzhou and Xiamen.
β_0: baseline level before the reform; β_1 : baseline trend before the reform; β_2 : level change immediately after the reform; β_3 : trend change after the reform; β_4 : level change immediately after the long-term reform; β_5 : trend change after the long-term reform; $\beta_1 + \beta_3$: short-term reform slope; $\beta_1 + \beta_3 + \beta_5$: long-term reform slope.
The boldface values indicated that the trend or change was statistically significant.
*Adjusted for proportion of male, proportion of age ≥60 years and proportion of low income.
DE, drug expenditures; OE, outpatient expenditures; NRCMS, New Rural Cooperative Medical Scheme.

some success. It was the only local reform model which could attract the attention, study, discussion and recommendation of national leaders, departments at all levels, research institutions. The Chinese President Jinping Xi endorsed the demonstrable progress in reforming the public hospital system in Sanming and Fujian province. The State Council had successively issued policies to promote 'Sanming model' in nationwide since 2016.[27–29] The extent of promotion was from some pilot provinces to further promotion to in-depth promotion. It was also required to follow-up and evaluate the progress of local promotion, timely notify the work lag and supervise the rectification. Because the success of 'Sanming model' was the result of favourable timing, geographical and human conditions, it is hard to replicate in nationwide completely. Drug cost control is only the entry point of Sanming healthcare system reform, while its top-level design is a coordinated reform of healthcare, medical insurance and medicines. The reform involves too many interests of departments and the coordination among departments is too difficult. Some beneficiaries are unwilling to change current situation. The solutions to successful in-depth promotion may be to integrate healthcare, medical insurance and medicine management into one department at the national level, through the internal coordination of department to achieve unity of power, responsibility and interests.

Certainly, some problems had also been encountered in the process of reform. To reduce the drug ratio, physicians sometimes did not prescribe expensive drugs which listed in the NRDL to patients and asked them to buy drugs by OOP in drugstore. Physicians sometimes also prescribe other medical services resulting in no change or increase the total medical expenditures. The drug expenditures decreased according to the hospital data, but the economic burden of patients might not reduce and might even increase.[30 31] Furthermore, the outpatient treatment for patients with cancer was mainly chemotherapy and radiotherapy which was easy to exceed the 30% limit for drug ratio. Patients eligible for outpatient treatment may be advised to be hospitalised, resulting in the waste of medical resources. Therefore, drug ratio was not an appropriate indicator to evaluate the rationality of prescribing for antitumour treatment. In 2018, National Medical Insurance Administration and Health Commission jointly issued a policy stating that the expenditures of antitumour drugs are not included in the calculation of drug ratio.[32] In the same year, Sanming was chosen as the first pilot city to implement 'Chinese diagnosis-related groups payment' to reduce OOP payments while lowering medical expenditures.[33 34] The CPMP emphasised to obtain the lowest price and pay less attention to drugs quality. This resulted in price wars among manufacturers and some commercial bids were even below cost. Consequently, fewer manufacturers registered production and some firms effectively left the market. In some regions, some drugs in the NRDL were not easily procured due to sole source manufacturers, lack of supplier and non-acceptance of the tendering price,[35] which caused patients to buy these drugs by OOP in drugstore. Thus, the system of multisource suppliers is needed to ensure rational competition and choice.

Several issues should be considered in the interpretation of current findings. First, because ITS design can obtain robust estimation results in the absence of effective control, the differences among three groups were just described rather than inferred from more complicated segmented regression model. Second, long-term positive effects among outpatients were not found, but the achievements of 'Sanming model' should still be recognised, as the cost of production, transportation and management for drugs should be considered. Third, although 'Sanming model' had made some progress, the expenditures outside the hospitals were difficult to measure which might increase after the reform. Fourth, the results of this study were based on medical data from 2011 to 2016 so that it may not comprehensively demonstrate the long-term effects of reform. Last, the effects of reform could not be evaluated comprehensively by single index of drug expenditures. We plan to further investigate the effects of Sanming healthcare system reform on different types of medical expenditures using updated data.

CONCLUSIONS

This study demonstrated that Sanming healthcare system reform had long-term effect in reducing total drug expenditures, drug ratio and drug expenditures covered by NRCMS for rural inpatients with cancer and only short-term positive effect for outpatients. However, there was limited effect of 'Sanming model' on drug expenditures uncovered by NRCMS. 'Sanming model' still needs to accumulate experiences and improves the reform measures dynamically.

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