

The Effect of China's National Essential Medicine Policy on Health Expenses: Evidence From a National Study

INQUIRY: The Journal of Health Care Organization, Provision, and Financing
Volume 55: 1–11
© The Author(s) 2018
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/0046958018787057
journals.sagepub.com/home/inq



Qian Li, PhD¹ , Fei Chen, PhD¹, Min Yang, MD², Liyong Lu, MSc¹, Jay Pan, PhD¹, Xiaosong Li, PhD¹, and Qun Meng, PhD²

Abstract

To increase use of medical service across the country, the Chinese government has tried to improve equity in health care access and reduce patients' medical expenses. For this purpose, the National Essential Medicine Policy (NEMP) was introduced in 2009 to mandate the distribution of medicines to health care facilities at a low cost and without profit. This study aims to evaluate the effect of the essential medicine policy on average per-visit expenses for outpatient and inpatient services. The annual national surveillance system data covering all the grassroots-level primary health care facilities (PHFs) in 2675 counties and 31 provinces in China during 2008 to 2012 were used in this study. The 4-level hierarchical random effects models were utilized to deal with possible dose-response effects of the policy and possible variations of such effects at the provincial, county, and facility levels. Our research findings suggest that the NEMP had positive effects in reducing both outpatient and inpatient expenses at grassroots level, and the policy effects tended to be greater as the exposure time increased. This study provides implications on reforming China's health system and its medicine cost control policies.

Keywords

essential drugs, cost control, primary health care, statistical models, China

What do we already know about the topic?

Current studies evaluating the impact of China's National Essential Medicines Policy (NEMP) are mainly based on sampled studies in several counties/provinces; therefore, the results may be biased and can hardly represent the overall China's situation.

How does your research contribute to the field?

We evaluate the effects of China's NEMP on health expenditures by using the annual national surveillance data covering all the primary health care facilities (PHFs) in China during 2008 to 2012; we also investigate the heterogeneity among regions and facilities.

What are your research's implications toward theory, practice, or policy?

This study provides implications on reforming China's health system and its drug cost control policies.

Introduction

Medicines play an important role in protecting, maintaining, and restoring human health.¹ The regular provision of appropriate medicines of assured quality, in adequate quantities, and at affordable prices is a global concern for both developing and developed countries.² Particularly in low- and middle-income countries, access to and use of essential medicines is more difficult than others.³ In 1975, the World Health Organization (WHO) put forward the Essential Medicines Policy (EMP) to promote equitable access to medicines and improve the health of the entire population. Since then, more than 150 countries, mostly developing ones, have established a national essential medicines list.⁴

Public concern over the climbing health care expenses in China has been increasing dramatically for the recent years,

¹West China School of Public Health, Sichuan University, Chengdu, China

²West China Research Centre for Rural Health Development, Sichuan University, Chengdu, China

³National Health and Family Planning Commission of the People's Republic of China, Beijing, China

Received 25 December 2017; revised 3 June 2018; revised manuscript accepted 3 June 2018

Corresponding Author:

Xiaosong Li, West China School of Public Health, Sichuan University, Chengdu, Sichuan, China.

Email: lixiaosong1101@126.com



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons

Attribution-NonCommercial 4.0 License (<http://www.creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

particularly as a result of excessive drug prescription in the health facilities.⁵ As a matter of fact, drug sales constitute the largest revenue source for China's health facilities in that hospitals derive substantial profits from drug sales and doctors have a pecuniary incentive to overprescribe expensive drugs.⁶ In 2008, drug cost accounted for 42.7% of China's total health expenditure,⁷ whereas the proportion was only 17% for the Organisation for Economic Co-operation and Development (OECD) countries.⁸ Moreover, empirical evidence has demonstrated that excessive drug prescription is common in rural China,^{9,10} and increasing high drug costs are primary contributors to medical impoverishment.¹¹ A study by Yip found that 11.6% of the rural poor households in China became impoverished due to outpatient (OP) expenses related to chronic conditions.¹² In April 2009, to address the financial hardship experienced by patients especially in rural settings, the Chinese government initiated a new wave of health system reform to reinvigorate the National Essential Medicine Policy (NEMP), aiming to curtail the escalating drug cost and increase the service utilization in primary health care facilities (PHFs).¹³ The NEMP focuses on every aspect of health system, including provincial-level pooled tendering and procurement, centralized drug distribution, mandate use, and "zero-markup" (ie, no-profit) policy for medicines on the new National Essential Drugs List at the grassroots level.⁷ The NEMP was first piloted in some areas and gradually scaled-up over the nation. By September 2011, China officially announced that NEMP had been scaled up in all government-run PHFs.¹⁴

Previous studies in China have shown that NEMP was associated with a change in the availability and rational use of essential medicines in PHFs.¹⁵⁻¹⁸ But empirical evidence remains limited in terms of the overall impact of the NEMP on medical expenses. Existing literature evaluating the policy impact on health expenses is mostly based on research in one or several counties/provinces. For example, a recent study by Zhou et al investigated 2 county hospitals in rural western China and found that the expense per visit was reduced by 11% for both OP and inpatient (IP) services.¹⁹ Another study examining township health institutions in eastern, central, and western China also revealed that OP and IP expenses per visit were reduced.²⁰ One study conducted by Chen and Dai with a larger sample size found a reduction of cost per prescription in 88 primary health institutions.²¹ Other studies conducted in Hubei, Shandong, and Beijing drew the same conclusions respectively.^{17,22,23} In addition, most study designs do not permit rigorous evaluation of the policy effect of NEMP due to methodological limitations. A recent study involving patients in Chongqing, Jiangsu, and Henan Province used the difference-in-difference (DID) method, a quasi-experimental approach to evaluate the effect of NEMP and identified a reduction in IP medication and health service expenditures as well.²⁴ Nevertheless, this study examined the short-term effect of the NEMP only, leaving the policy's long-term impact untouched.

The present study is a secondary analysis of annual national surveillance system data during 2008 to 2012 covering all the

public PHFs in 31 provinces of China's mainland. The objectives of this study are to identify the policy effects of NEMP in medical expenses, and further, the variation of such effects by regions and types of PHFs, and the possible dose-response effects of the policy. The remaining parts of the article are organized as follows: "Methods" section describes the data and variables and presents the methodology. "Results" section provides estimation results from the methods. "Discussion" and "Conclusions" sections discuss the findings and summarize the conclusions and policy implications.

Methods

Data

National Health Resource and Medical Service Survey (NHRMSS) was an annual national survey conducted among all health facilities in 31 provinces of China's mainland as a surveillance for the health system reform from 2008 to 2012. The survey was conducted by the Center for Health Information and Statistics, National Health and Family Planning Commission of China. The survey instrument for PHFs to collect data at the end of each year includes questions on the number of staff, hospital beds, housing and infrastructure, quantity of large equipment, income and expenditure, assets and liabilities, medical service, and preventive primary public health service. Because direct variables indicating the exact date of the NEMP implementation at each facility were not available, we adopted the variable "income of essential medicines" in NHRMSS, which was collected at each year end, as a proxy variable to indicate whether the facility started implementing NEMP in that specific year. Before the implementation of the NEMP, the value of this variable should be zero because there are no such data categorized and reported. Therefore, if the value was not zero, it can be inferred that the facility implemented the NEMP during that year. This study used data from 34 506 primary hospitals (township hospitals [TSHs]), township center hospitals [TCHs], and community health centers [CHCs]) in 2675 counties of 31 provinces in China's mainland. Located in rural counties, the TS and TC provide basic health care primarily for the nation's rural population. In contrast, the CHC is situated in districts of cities and centers of some big counties and provides primary health care mainly for city dwellers living in the catchment areas. Context information, such as consumer price index (CPI), was obtained from the China Statistical Yearbook.

Variables

Six facility-level measures are (1) time exposed to policy of hospital in year (TETP) ranging from 0 to 4 years, (2) location (eastern, central, and western regions of China) and hospital type, (3) quantity of facility staff, (4) quantity of health professionals, (5) quantity of bed space in terms of bed-staff ratio, and (6) total assets. These variables could profile the basic

features of the facility in terms of staff, assets, and equipment. Dividing measures (4) and (5) by measure (3), we obtained 2 new variables: ratio of health professional over all staff and beds per staff, respectively, to measure relative quality of human resources and relative treatment bed space. In addition, dividing measure (6) by measure (3), and then logarithm transformed, we generated a new variable—total assets per staff—to reflect the relative capacity in medical tests or diagnosis.

Four outcome measures at the facility level are (1) OP expenses, ie, average OP expenses of care per visit; (2) IP expenses, average IP expenses of care per visit; (3) OP drug costs, average OP drug expenses per visit; and (4) IP drug costs, average IP drug expenses per visit. All four measures were adjusted by the nation's CPI in each year against that in 2012, and logarithm transformation was performed to address their skewed distributions.

Statistical Methods

Descriptive analysis. The descriptive method was used to analyze the raw data. PHFs resources were described by facility type, region, and NEMP exposure period. Besides, patient expenses in PHFs were classified by NEMP exposure period and year.

Four-level regression analysis. Our study aimed to identify the policy effects of NEMP in medical expenses, and further, the variation of such effects by regions and types of PHFs, and the possible dose-response effects of the policy. Specifically, the data we collected have 5 time points and a 4-level hierarchical structure, ie, time points are nested within primary health facilities, facilities within county, and counties within province, with obvious clustering effects among provinces, counties, and hospitals. Given the complex data structure, we fitted a 4-level regression model with random effects to identify the dose-response effects. Five consecutive 4-level models were constructed of the NEMP differentiating by region and facility type and adjusted for health resources of PHFs.

Following the definition of the software MLwiN for multilevel models, the letters i, j, k, and l denote the repeated measure in time (level 1), facility (level 2), county (level 3), and province (level 4), respectively. The following model estimates an overall linear effect with exposure time of policy measured by parameter β_1 and partitions the total variance in the outcome into 4 components for the 4 levels of sources: $\sigma_{w_0}^2$, $\sigma_{v_0}^2$, $\sigma_{u_0}^2$ and $\sigma_{e_0}^2$ for the random effects w_{0l} , v_{0kl} , u_{0jkl} and e_{0ijkl} among provinces, counties, facilities, and repeated measure in time, respectively.

$$\begin{aligned} y_{ijkl} &= \beta_{0ijkl} + \beta_1 (\text{exposure}_{-t})_{ijkl} \\ \beta_{0ijkl} &= \beta_0 + w_{0l} + v_{0kl} + u_{0jkl} + e_{0ijkl} \\ w_{0l} &\sim N(0, \sigma_{w_0}^2), v_{0kl} \sim N(0, \sigma_{v_0}^2), \\ u_{0jkl} &\sim N(0, \sigma_{u_0}^2), e_{0ijkl} \sim N(0, \sigma_{e_0}^2) \\ \text{cov}(w_{0l}, v_{0kl}, u_{0jkl}, e_{0ijkl}) &= 0 \\ \text{var}(y_{ijkl}) &= \sigma_{w_0}^2 + \sigma_{v_0}^2 + \sigma_{u_0}^2 + \sigma_{e_0}^2 \end{aligned} \quad (\text{M1})$$

In this model, the parameter β_1 is a unit of linear change in the dependent variable for each year's intervention period of the policy, the same interpretation of slope in any regression model. To separate the dose-response effects of the policy from those caused by the time change in a calendar year, by health care conditions, and by human resources of the facilities, we added some covariates in the fixed part of M2 with everything else in the model unchanged.

$$\begin{aligned} y_{ijkl} &= \beta_{0ijkl} + \beta_1 (\text{exposure}_{-t})_{ijkl} + \sum_{h=1}^4 \beta_{2h} (\text{year})_{hijkl} \\ &+ \sum \beta_{3f} (X_f)_{jkl} \\ \beta_{0ijkl} &= \beta_0 + w_{0l} + v_{0kl} + u_{0jkl} + e_{0ijkl}. \end{aligned} \quad (\text{M2})$$

The X denotes a set of covariates, such as the ratio of health professional over all staff, beds per staff, total assets per staff, and so on. The time differences in years, 2009 versus 2008, or 2010 versus 2008, for example, are estimated by a set of parameters β_{2h} that are independent from the dose-response effect of policy estimated by the parameter β_1 .

To examine whether the policy effects varied by province, by county, and by facility, we assumed random effects of the parameter β_1 in the following models:

$$\begin{aligned} y_{ijkl} &= \beta_{0ijkl} + \beta_{1jkl} (\text{exposure}_{-t})_{ijkl} + \\ &\sum_{h=1}^4 \beta_{2h} (\text{year})_{hijkl} + \sum \beta_{3f} (X_f)_{jkl} \\ \beta_{0ijkl} &= \beta_0 + w_{0l} + v_{0kl} + u_{0jkl} + e_{0ijkl} \\ \beta_{1jkl} &= \beta_1 + w_{1l} + v_{1kl} + u_{1jkl} \\ (w_{0k}, w_{1k}) &\sim MN(0, \Omega_w) (v_{0kl}, v_{1kl}) \sim \\ &MN(0, \Omega_v), (u_{0jkl}, u_{1jkl}) \sim MN(0, \Omega_u) \\ (e_{0ijkl}) &\sim N(0, \sigma_{e_0}^2) \\ \Omega_w &= \begin{pmatrix} \sigma_{w_0}^2 & \\ \sigma_{w_01} & \sigma_{w_1}^2 \end{pmatrix}, \Omega_v = \begin{pmatrix} \sigma_{v_0}^2 & \\ \sigma_{v_01} & \sigma_{v_1}^2 \end{pmatrix}, \\ \Omega_u &= \begin{pmatrix} \sigma_{u_0}^2 & \\ \sigma_{u_01} & \sigma_{u_1}^2 \end{pmatrix}. \end{aligned} \quad (\text{M3})$$

In M3, the terms $w_{0l}, v_{0kl}, u_{0jkl}$ are random effects of the overall mean, and the terms $w_{1l}, v_{1kl}, u_{1jkl}$ are random effects of the dose-response estimate at the level of province, county, and facility accordingly. By estimating and testing variance terms $\sigma_{w_1}^2$, $\sigma_{v_1}^2$, and $\sigma_{u_1}^2$ of the random effects $w_{1l}, v_{1kl}, u_{1jkl}$, respectively, we worked out the distribution of the dose-response random effects at different levels and identified the “best” or “worst” units (province or county or facility) in the policy implementation for further management. The latter task can be accomplished by estimating and ranking random effects w_{1l}, v_{1kl} , and u_{1jkl} , respectively.

Table 1. Primary Health Facility Resources by Facility Type, Region, and NEMP Exposure Period.

NEMP exposure period in year	Number of primary health care facilities	Ratio of health professional over all staff	Beds per staff	Log (total assets per staff)
Eastern region				
1	2438	0.76 (0.21)	0.79 (0.74)	10.8 (2.52)
2	2509	0.80 (0.13)	0.73 (0.58)	11.4 (1.24)
3	1927	0.81 (0.12)	0.78 (0.55)	11.5 (1.03)
4	2092	0.80 (0.13)	0.86 (0.67)	11.4 (0.93)
Central region				
1	2643	0.77 (0.18)	0.88 (0.70)	10.6 (2.14)
2	2806	0.79 (0.14)	0.88 (0.57)	11.0 (1.32)
3	2278	0.80 (0.13)	0.90 (1.13)	11.1 (1.08)
4	2175	0.80 (0.13)	0.90 (0.56)	11.2 (0.86)
Western region				
1	3193	0.74 (0.21)	0.94 (0.94)	10.2 (2.91)
2	3403	0.78 (0.15)	1.01 (0.68)	10.9 (1.61)
3	3531	0.78 (0.14)	1.08 (0.68)	11.1 (1.15)
4	3958	0.80 (0.13)	1.06 (0.65)	11.2 (0.95)
CHC				
1	750	0.67 (0.33)	0.39 (0.63)	9.15 (4.72)
2	573	0.80 (0.17)	0.46 (0.52)	11.1 (2.66)
3	530	0.81 (0.14)	0.54 (0.49)	11.4 (1.94)
4	497	0.82 (0.10)	0.51 (0.48)	11.4 (1.16)
TC				
1	2010	0.81 (0.14)	0.91 (0.57)	10.9 (2.00)
2	2293	0.83 (0.12)	0.95 (0.60)	11.2 (1.30)
3	2331	0.83 (0.11)	0.96 (0.54)	11.3 (1.04)
4	2343	0.83 (0.11)	0.99 (0.55)	11.4 (0.87)
TS				
1	5514	0.75 (0.19)	0.93 (0.89)	10.6 (2.29)
2	5852	0.78 (0.15)	0.91 (0.63)	11.0 (1.30)
3	4875	0.78 (0.14)	1.00 (0.95)	11.2 (1.02)
4	5385	0.79 (0.14)	1.00 (0.67)	11.2 (0.92)

Note. Standard deviations are shown in parentheses. NEMP = National Essential Medicine Policy; CHC = community health center; TC = town center hospital; TS = township hospital.

Model fitting and comparison. We used MLwiN 2.30 for all modeling analyses and SAS 9.3 for the descriptive analysis. Wald statistic was used to test the significance of both fixed effects estimated by β_s and random effects estimated by variances at different levels. To compare the goodness of fit between nested models, we used the -2LogLikelihood (-2LL) value. The smaller the -2LL , the better fitted the model. To select between fixed effects and random effects model, we used both Wald statistic and deviance chi-square tests derived from -2LL .

Results

Descriptive Results

Total of 32 953 PHFs were included in the assessment of the NEMP effects. Among them, there were 2350 (7.1%) urban city-based CHCs, 21 626 (65.6%) rural county-based township hospitals (TSHs), and 8977 (27.2%) town center hospitals

(TCs). The regional distribution of PHFs by eastern, central, and western China is of 27.2%, 30.0%, and 42.7%, respectively. Because the PHFs started implementing the NEMP in temporal sequence, 8274 (25.1%) of them had only 1 year exposure by 2012, and 8718 (26.5%), 7736 (23.5%), and 8225 (25.0%) of them had an exposure period of 2, 3, and 4 years, respectively.

The health care resources of the PHFs in terms of ratios of health professionals over staff, beds per staff, and total assets per staff were improved slowly as the time of NEMP exposure increased overall. Such trends stratified by geographic region and by type of PHFs are shown in Table 1. The average ratio of health professional was not significantly different between eastern, central, and western regions with the overall means being 0.79, 0.79, and 0.78, respectively. However, the ratio was significantly different by type of PHFs, with the highest in the town center hospitals with overall mean at 0.82, and 0.77 and 0.76 for township hospitals and CHCs, respectively. The number of beds per staff was the highest in western region ($M = 1.02$), lowest in

Table 2. Medical Expenses in Primary Health Facilities by NEMP Exposure Period and Year (Raw Data).

	Calendar year	Label	NEMP exposure period in year					
			0	1	2	3	4	
Average outpatient expenses (¥)	2008	N	32 948	0	0	0	0	
		M (SD)	44.7 (30.9)	—	—	—	—	
	2009	N	24 728	8225	0	0	0	
		M (SD)	41.8 (39.0)	40.1 (54.2)	—	—	—	
	2010	N	16 992	7736	8225	0	0	
		M (SD)	46.9 (40.6)	44.5 (29.9)	43.5 (32.8)	—	—	
	2011	N	8274	8718	7736	8225	0	
		M (SD)	48.6 (49.5)	48.2 (36.7)	46.7 (30.5)	45.6 (34.5)	—	
	2012	N	0	8274	8718	7736	8225	
		M (SD)	—	48.7 (46.7)	48.0 (33.7)	47.7 (28.1)	46.2 (28.4)	
	Average inpatient expenses (¥)	2008	N	28 855	0	0	0	0
			M (SD)	938.7 (1589.5)	—	—	—	—
2009		N	21 473	7779	0	0	0	
		M (SD)	983.1 (1597.6)	899.4 (811.3)	—	—	—	
2010		N	14 541	7282	7797	0	0	
		M (SD)	1105.6 (1570.5)	1114.2 (1711.5)	1033.0 (877.8)	—	—	
2011		N	6523	7818	7189	7676	0	
		M (SD)	1170.7 (2117.7)	1163.3 (1608.5)	1184.7 (1761.9)	1091.0 (907.8)	—	
2012		N	0	6679	7801	7171	7691	
		M (SD)	—	1174.9 (2189.9)	1190.9 (2198.3)	1194.8 (2123.4)	1085.2 (834.1)	
Average medicine costs per outpatient (¥)		2008	N	32 948	0	0	0	0
			M (SD)	28.8 (222)	—	—	—	—
	2009	N	24 728	8225	0	0	0	
		M (SD)	27.5 (28.0)	26.1 (41.7)	—	—	—	
	2010	N	16 992	7736	8225	0	0	
		M (SD)	30.7 (28.9)	28.9 (21.3)	27.8 (23.8)	—	—	
	2011	N	8247	8718	7736	8225	0	
		M (SD)	26.5 (31.7)	28.4 (24.4)	27.8 (21.0)	27.1 (23.9)	—	
	2012	N	0	8274	8718	7736	8225	
		M (SD)	—	30.8 (34.3)	29.1 (24.3)	28.9 (19.7)	27.7 (20.8)	
	Average medicine costs per inpatient (¥)	2008	N	28 062	0	0	0	0
			M (SD)	531.8 (901.1)	—	—	—	—
2009		N	21 050	7725	0	0	0	
		M (SD)	573.7 (842.5)	524.3 (514.4)	—	—	—	
2010		N	14 369	7248	7770	0	0	
		M (SD)	647.6 (873.8)	631.5 (855.4)	593.4 (540.9)	—	—	
2011		N	5813	7779	7151	7650	0	
		M (SD)	631.4 (891.8)	607.8 (809.2)	618.0 (761.0)	572.5 (495.1)	—	
2012		N	0	6528	7708	7106	7622	
		M (SD)	—	653.2 (940.8)	627.7 (982.9)	629.9 (862.6)	576.1 (445.1)	

Note. NEMP = National Essential Medicine Policy.

eastern region ($M = 0.79$), and middle in central region ($M = 0.89$). The city-based CHCs had the fewest beds per staff with the mean being 0.47 in contrast to the rural county-based TS and TCH that had the same mean of 0.96. The facility assets per staff were higher in the eastern region, followed by the central, and the lowest in the western region with means in logarithm scale being 11.3, 11.0, and 10.9, respectively. TCHs ($M = 11.2$) and TSs ($M = 11.0$) had higher asset ratios than CHCs ($M = 10.6$).

Change of Medical Expenses by Exposure Period

Medical expenses in PHFs by NEMP exposure period and year. The 4 medical expense indicators for the NEMP changes, stratified by the calendar year and by exposure period in year to the policy, are summarized in Table 2.

For the average OP expenses, a clear pattern showed that from 2008 to 2012, the OP expenses were increased regardless of the NEMP exposure period. For PHFs with 1-year policy exposure, the OP expenses raised from average 40.1

Table 3. Estimated Dose-Response Effects of NEMP Differentiated by Region by Facility Type and Adjusted for Health Resources of Primary Health Care Facilities.

Effects	Outpatient expenses in logarithm	Inpatient expenses in logarithm	Medicine costs (outpatient) in logarithm	Medicine costs (inpatient) in logarithm
	Estimation (SE) (P)	Estimation (SE) (P)	Estimation (SE) (P)	Estimation (SE) (P)
NEMP linear effect	-0.033 (0.010) (.008)	-0.024 (0.009) (<.001)	0.064 (0.012) (<.001)	-0.052 (0.011) (<.001)
NEMP quadratic effect	-0.001 (0.002) (.410)	-0.007 (0.001) (<.001)	-0.018 (0.002) (<.001)	-0.007 (0.002) (<.001)
Year effect	0.064 (0.0016) (<.001)	0.101 (0.002) (<.001)	0.004 (0.002) (.045)	0.081 (0.002) (<.001)
Township vs CHC	-0.067 (0.016) (<.001)	-0.414 (0.018) (<.001)	0.042 (0.017) (.013)	-0.245 (0.020) (<.001)
Town center vs CHC	0.046 (0.016) (.004)	-0.245 (0.019) (<.001)	0.080 (0.018) (<.001)	-0.167 (0.020) (<.001)
Central vs Eastern	-0.343 (0.102) (<.001)	-0.493 (0.176) (.005)	-0.416 (0.139) (.002)	-0.386 (0.199) (.054)
Western vs Eastern	-0.648 (0.092) (<.001)	-0.785 (0.159) (<.001)	-0.636 (0.125) (<.001)	-0.660 (0.180) (<.001)
NEMP × Township vs CHC	-0.018 (0.007) (.010)	0.029 (0.007) (<.001)	-0.023 (0.007) (<.001)	0.027 (0.008) (<.001)
NEMP × Town Center vs CHC	-0.028 (0.007) (<.001)	0.017 (0.007) (.015)	-0.039 (0.008) (<.001)	0.016 (0.009) (.074)
NEMP × Central vs Eastern	0.029 (0.006) (<.001)	-0.001 (0.006) (.867)	0.039 (0.008) (<.001)	0.022 (0.008) (.005)
NEMP × Western vs Eastern	0.073 (0.006) (<.001)	-0.001 (0.006) (.868)	0.088 (0.007) (<.001)	0.027 (0.007) (<.001)
Ratio of health professional over all staff	0.651 (0.013) (<.001)	0.148 (0.014) (<.001)	0.540 (0.015) (<.001)	0.114 (0.016) (<.001)
Beds per staff	0.055 (0.004) (<.001)	-0.012 (0.004) (.002)	0.050 (0.004) (<.001)	-0.016 (0.005) (<.001)
Log (total assets per staff)	0.141 (0.001) (<.001)	0.033 (0.002) (<.001)	0.125 (0.001) (<.001)	0.036 (0.002) (<.001)

Note. NEMP = National Essential Medicine Policy; CHC = community health center.

CNY (US\$6.1) per OP visit in 2009 to 48.7 CNY in 2012. For those with 2 years' policy exposure, the OP expenses raised from 43.5 CNY in 2010 to 48.0 CNY in 2012. However, within each calendar year, the mean statistics presented a declining trend as the policy exposure time increased. For instance, in 2010, the average OP expense was 46.9 CNY among those that had not yet implemented the NEMP and was down to 44.5 after 1-year exposure and further down to 43.5 CNY after 2 years' exposure.

Similar upward patterns over calendar years and decreasing trends over the increased policy exposure years can be found in the average IP expenses, average OP drug costs, and average IP drug costs.

Estimated dose-response effects of NEMP differentiated by region and facility type and adjusted for health resources of PHFs. Considering that the observed trends in raw data may have been confounded with differences in medical care resources of PHFs, effects of regions, and effects of time in calendar year, further modeling analyses adjusted for those effects with estimates of policy effects in a dose-response form are presented in Table 3. For all outcome measures in Table 2, we observed large standard deviations that were close to or even larger than their means, which suggested skewed distributions of those measures. The natural logarithm translation of them was performed for the modeling analysis.

The results in Table 3 presented statistical evidences in association with the NEMP effects. They showed that for the reference facilities (CHCs in eastern region), OP expenses,

IP expenses, and IP drug costs declined as the NEMP exposure time increased. Using "T" to indicate the policy exposure time, their mean declining rate on the original scale was estimated as $e^{-(0.033 \times T + 0.001 \times T \times T)}$, $e^{-(0.024 \times T + 0.007 \times T \times T)}$, and $e^{-(0.052 \times T + 0.007 \times T \times T)}$, respectively. In a different pattern, OP drug costs showed linear increase and then declined in acceleration as the NEMP exposure time increased. The overall change was at the rate $e^{(0.064 \times T - 0.002 \times T \times T)}$.

Results in Table 3 also showed that in most cases, the NEMP effects in terms of linear change were differentiated significantly among type of facilities and by regions. Further description of differentiated effects is presented in the following session.

The accelerated nonlinear change in quadratic term did not show significantly differentiated effects by type of facilities and by region in our analysis; hence, no interactive effects were presented here.

Model estimated change trends of outcome measures and total change of medical care costs in response to NEMP exposure year by PHF type and by region. Based on the model estimated in Table 3, predicted change curves in each of the 4 outcome measures as a quadratic function of the NEMP exposure year were calculated by PHF type and by region, respectively (Figure 1). The estimated mean change values from 0 exposure to 4 years' exposure to the NEMP are presented in Table 4, and by type of facilities and by region, for each outcome measure, respectively. In Table 4, the value -0.85 in the OP

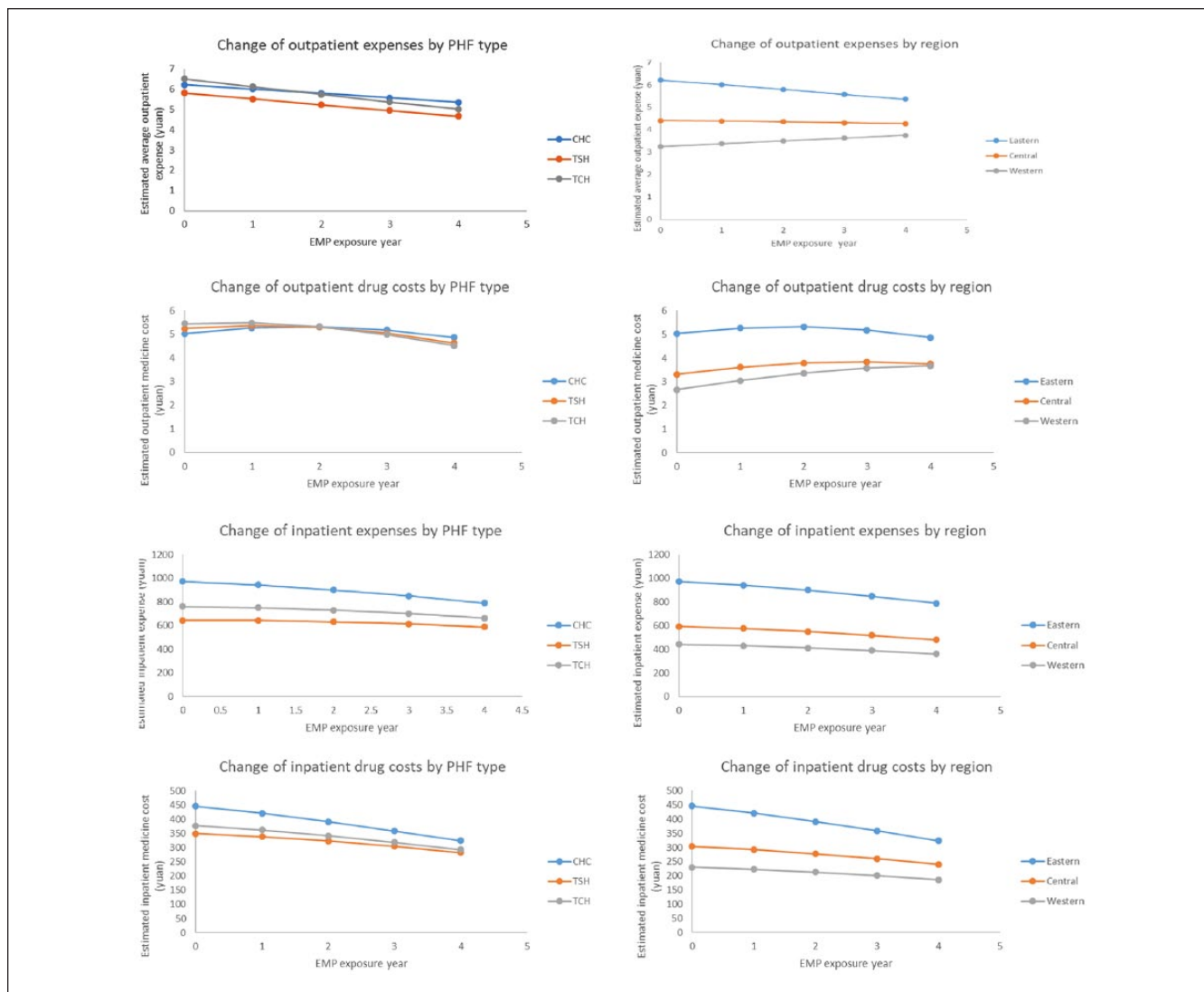


Figure 1. Model estimated change trends of outcome measures in response to National Essential Medicine Policy exposure year by PHF type and by region.

Note. PHF = primary health care facilities; CHC = community health center; TSH = township hospital; EMP = Essential Medicines Policy; TCH = .

Table 4. Model Estimated Total Change of Medical Care Costs Due to National Essential Medicine Policy Effects by PHF Type and by Region.

Medicine expenses (CNY)	Average outpatient all expenses	Average outpatient medicine costs	Average inpatient all expenses	Average inpatient medicine costs
PHF type				
Community health centers (Ref)	-0.85	-0.16	-182.65	-122.22
Town center hospital	-1.49	-0.93	-99.45	-85.30
Township hospital	-1.15	-0.61	-56.51	-66.73
Region				
Eastern (Ref)	-0.85	-0.16	-182.65	-122.22
Central	-0.14	+0.44	-112.53	-62.82
Western	+0.50	+1.00	-81.87	-44.07

Note. PHF = primary health care facilities.

Table 5. Estimated Variation With Distribution Limits of the Linear Change Rate of National Essential Medicine Policy Effects Among Counties and Among Primary Health Facilities.

Outcome measures	County, N = 2697		Primary health care facilities, N = 32 953	
	Estimation variance (SE)	95% lower to upper limit of change rate	Estimation variance (SE)	95% lower to upper limit of change rate
Outpatient expenses in logarithm	0.0958 (.0036) ^{***}	e ^{-0.639} -e ^{0.574}	0.008 (.0004) ^{***}	e ^{-0.208} -e ^{0.142}
Inpatient expenses in logarithm	0.0467 (.0022) ^{***}	e ^{-0.448} -e ^{0.399}	0.0449 (.0029) ^{***}	e ^{-0.439} -e ^{0.391}
Medicine costs (outpatient) in logarithm	0.1367 (.005) ^{***}	e ^{-0.661} -e ^{0.789}	0.0067 (.0005) ^{**}	e ^{-0.096} -e ^{0.224}
Medicine costs (inpatient) in logarithm	0.0605 (.0029) ^{***}	e ^{-0.534} -e ^{0.430}	0.0781 (.0037) ^{***}	e ^{-0.599} -e ^{0.496}

^{**}*P* < .001, ^{***}*P* < .0001.

all expenses for CHCs suggested a reduction of 0.85 CNY in average over the whole NEMP exposure period among all CHCs in this outcome. In general, reduction in service expenses and medication costs was observed over the policy implementation period, except for an increase of 0.50 CNY in the OP expenses and of 1.00 CNY in the OP medication costs in western region, and of 0.44 CNY in the OP medication costs in the central region. Such trends of increasing expenses/costs can be seen clearly in Figure 1.

In addition, much more reduction in expenses and costs was estimated in the 2 IP measures than that in the 2 OP measures.

Among facilities, the city-based CHCs performed differently from TCHs and TSs in rural counties. For the 2 OP measures, CHCs showed slower reduction than TCHs and TSs, whereas for the 2 IP measures, CHCs showed faster reduction than the latter two. The declining patterns in the 4 measures were similar between TCHs and TSs (Figure 1).

In different regions, the average OP expenses and the average OP drug costs have shown a downward trend for the eastern region and an upward trend for its western counterpart. For the central region, the average OP expenses decreased, but its average OP drug costs showed a slow non-linear upward trend. All regions demonstrated a downward trend in the 2 IP outcome measures, with more reduction in expenses and costs in the eastern region than that in the other two.

Estimated variation with distribution limits of the linear change rate of NEMP effects among counties and primary health facilities. In Table 5, we presented model estimated random effects of linear change of NEMP with regard to variance of random effects at the county and PHF levels, respectively, for the 4 outcome measures. They were all statistically significant, suggesting large variations in the NEMP mean effects across counties and among PHFs. Based on the NEMP overall effects presented in Table 3 and the estimated variance of NEMP random effects at the county and PHF levels as shown in Table 5, we calculated the 95% lower and upper limits of the linear change rates distribution of each outcome for the county and PHF levels, respectively. The

results clearly showed that although the OP expenses were declined by an average rate of e^{-0.033}, such rate can be as low as e^{-0.639} for some counties and as high as e^{0.574} for some other. Among the PHFs, the lowest rate can be e^{-0.208}, and the highest e^{0.142}. The distribution of this outcome at both levels leaned toward the negative value or declining side, echoing the overall declining trends. Similar trends and variation in distributions were demonstrated in the IP expenses and IP drug costs.

For the OP drug costs, the average linear change rate, in the logarithm scale as shown in Table 3, was estimated at 0.064 of increase rate (*P* < .001), with significantly large variations among counties with the change rate distribution of 95% limits being e^{-0.661}-e^{0.789}, and among PHFs being e^{-0.096}-e^{0.224}.

We did not include the random effects of the quadratic change in this analysis because the mean effects of such term in all 4 outcomes showed a trend of accelerated decline with negative parameter estimates for both OP expenses and OP drug costs being insignificant. The linear random effects already represent the main change in the trends.

Discussion

Overall Policy Effect

We evaluated the average impact of the NEMP using the comprehensive administrative data covering all the grass-roots facilities in China during 2008-2012 and tried to identify the heterogeneous policy impact by region and by facility type. Our findings suggest that all 4 outcome measures of health expenses, ie, OP expenses, OP drug costs, IP expenses, IP drug costs declined as the NEMP exposure time increased, in a quadratic or dose-response relationship. However, the NEMP effect on OP drug costs is estimated positive while the NEMP quadratic effect on this outcome is estimated negative, with a small reduction during the study period. This phenomenon indicates a nonlinear change trend of the NEMP effects. One possible explanation is that the policy was imperfect when initiated and that it took some time for it to take effect.

After the implementation of the NEMP, the bidding prices for essential drugs were capped by the government through provincial-level pooled tendering and procurement, and thus ideally the drug cost could be contained to some extent. Moreover, the “zero-markup” policy abolished the previous mark-up of at least 15% on all drugs, resulting in reduced drug expenses.²⁵ In the present study, we found that the drug cost for both OP and IP visits decreased for overall impact, which is consistent with other research findings.^{21,24} However, the decrease of drug expense may not necessarily result in the decrease of total medical expenses because it is possible that the provider may turn to unnecessary high margin tests or examinations in response to the profit loss due to the elimination of drug revenue.⁷ Our findings have demonstrated an overall trend of decreased medical expense by the implementation of NEMP for both OP and IP services.

The NEMP aims to increase affordability and availability of essential drugs at grassroots level.^{2,26} Our findings indicate that the NEMP is having its intended impact on drug cost on the whole. However, price controls and procurement procedures have adversely affected the supply of certain drugs.²⁷ This may be attributed to the fact that pharmaceutical manufacturers may cease the production of some essential drugs in response to the profit loss caused by governmental setting of “ceiling” prices. Strategies such as reasonable drug pricing and subsidies for pharmaceutical manufactures should be formulated to secure the supply of essential drugs.

Variation by Region and Facility Type

Compared with its eastern counterpart, PHFs in the western and central region generally had much less medical expenses and less drug costs for both OP and IP services. Region analysis showed smaller reduction in IP expenses and drug costs but slightly upward trend in OP expenses and drug cost than that of eastern region. Among 3 types of facilities, CHCs had more reduction in IP expenses and drug costs than TCHs which had more reduction than TSHs.

Several factors may account for the large variation among regions. First, compared with the eastern region, western and central regions are relatively underprivileged in social-economic development and health resources. As the NEMP effects are strongly associated with the allocation of health resources, ie, lower resources and less NEMP effects, so that the OP and IP expenses, and OP drug costs in the central and western region are lower than that in the eastern region in the beginning but ended up with less policy effects in central and western regions than that of the eastern region. Some studies reported similar results to our research. Song²² found that the average prescription charge decreased by 6.78% after the NEMP implementation in Shandong, an eastern province of China. Zhou et al¹⁹ showed that the total expense per visit reduced by 19.02 CNY (US\$3.12) for OP services and 399.6 CNY (US\$65.60) for IP services and that the expense per visit was reduced by 11% for both OP and IP services in the

western region. Further research should be conducted to find more evidence to explain the variation among regions.

Compared with CHS, township hospitals (TSs) had lower OP and IP expenses, and lower IP drug costs, but higher OP drug costs in general, while town center hospitals (TCHs) had higher OP expenses and drug costs, and lower IP expenses and drug costs. However, as the NEMP exposure time increased, TSs and TCHs showed significantly faster declining in the OP expenses and drug costs, but less such declining in IP expenses and drug costs.

The NEMP has some effects in reducing drug costs for all 3 types of PHFs. The difference in the effects of NEMP may be caused by the disparities in policies and in the patients treated at different PHFs; the specific reasons, however, should be identified from further research. It is true that the initiation of the NEMP in the country since 2009 has been followed by a series of governmental documents and regulations. However, such official documents for this reform provide only guiding principles that encourage local adaptation and piloting.⁷ In fact, each province has their own essential drugs lists and strategies to compensate PHFs and health providers for income loss due to the “zero mark-up” policy, and these lists and strategies vary by provinces and between urban and rural areas largely because of unbalanced social-economic development among areas and regions across the country. Therefore, to maximize the effects of NEMP, specific promoting measures should be formulated according to the unique characteristics of each type of primary health facilities.

Dose-Response Relationship

While initiated in 2009 and implemented in all public PHFs in 2011, the exact date when NEMP was implemented at each specific PHFs varied. Results of this study demonstrated that the NEMP was piloted in 2009 to cover about 27% of facilities, up to 53% in 2010 and 75% in 2011, and finally scaled up to all facilities in 2012. The 4 health expenses measures decreased as the NEMP exposure time increased, in a quadratic or dose-response relationship. This indicated that the NEMP had a positive effect in reducing both OP and IP expenses and the policy effects tended to be greater as the exposure time increased. The reason underlying this phenomenon may be the policy adaptation with elapsing time, suggesting that longer time may allow the policy to adapt itself to local and realistic conditions, and to generate more effects in curbing drug costs as a result.²⁸

Justification of Analytical Methods

Great heterogeneity exists within provinces in China due to the unbalanced social-economic development, which cannot be overlooked when choosing the appropriate analytical model. Given the 4-level hierarchical structure of the data, obvious clustering effects exist among provinces, counties,

and hospitals. To tackle the complexity of the data, we used a 4-level hierarchical random effects models to assess the policy effects. Recently, a quasi-experimental approach, the DID, has been commonly used in policy evaluation.^{29,30} Although DID is effective in evaluating the interventions with observations from 2 time points and assumes independence in data or no clustering effects, it did not suit our data in the present study. More detailed discussion on methodological issues can be found in another paper by our team.³¹

Limitations

This study has several limitations, which should be noted in the interpretation of our findings. First, the data were collected from the health administrative system, which might contain reporting errors and missing information at some time points. Lack of facility-level and county-level contextual factors in the data made it impossible to separate the effect due to policy intervention from that due to area contextual and micro-level factors. In addition, because direct variables indicating the exact date of the NEMP implementation at facility level were not available, we had to adopt the variable “income of essential medicines” in NHRMSS as a proxy variable to indicate whether the facility implemented NEMP in that year. Although each facility may start the implementation of the NEMP at any time of the year, the calculation of policy exposure time is only a proximate value based on year-end information, which may have resulted in estimation bias.

Second, adding the control variables such as ratio of health professional over all staff, beds per staff, and total assets per staff may suffer from endogenous problem because these variables may have interaction effects with the NEMP and could result in biased estimates. However, our empirical strategy cannot fully resolve the endogenous problem. In our future research, data from supply capacity shocks might be utilized to help through an instrumental variables (IV) approach.

Given that the NEMP was initiated in the context of comprehensive health system reform in China along with other interventions being simultaneously introduced as part of the wider reform, the changes observed in this study cannot be entirely attributed to the NEMP. For example, the expanding coverage of health insurance may have an impact on service uptake and thus increase the total health expenditures. However, all of the observed changes in drug costs are probably attributable to the NEMP.

Despite these limitations, our findings are consistent with those of other evaluations of the NEMP,^{19,21,24} and this study is strengthened by a large amount of national data with an appropriate analytic method to assess the policy impact of the NEMP on medical expenses.

Conclusions

Although the NEMP tended to produce the expected effects on health expenditures, large variations of such effects existed between western and eastern regions of China, between rural

and urban facilities, and between the time periods before and after implementation of the policy. The effects of the policy were particularly limited in western and urban areas. The variations in the essential medicine policy effects among the regions and PHF types indicate that policy makers should formulate relevant policies corresponding to local and realistic factors when implementing the policy. The original purpose of the essential medicine policy is to promote equitable access to medicines and improve the health of the entire population; it is possible, however, that the distribution of medical resources could impact the effects of the essential medicine policy. To address this inadequacy, further research is needed to identify poorly performed counties or even PHFs for in-depth examination on contextual and micro-level factors.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Qian Li  <https://orcid.org/0000-0001-9041-575X>

References

1. World Health Organization. *Guidelines for Developing National Drug Policies*. 1988. World Health Organization, Geneva, Switzerland.
2. Quick JD, Hogerzeil HV, Velasquez G, Rago L. Twenty-five years of essential medicines. *Bull World Health Organ*. 2002;80(11):913-914.
3. Bigdeli M, Javadi D, Hoebert J, Laing R, Ranson K. Health policy and systems research in access to medicines: a prioritized agenda for low- and middle-income countries. *Health Res Policy Syst*. 2013;11:37
4. Hogerzeil HV. The concept of essential medicines: lessons for rich countries. *BMJ*. 2004;329(7475):1169-1172.
5. Hu S, Tang S, Liu Y, Zhao Y, Escobar ML, Ferranti DD. Reform of how health care is paid for in China: challenges and opportunities. *Lancet*. 2008;372(9652):1846-1853.
6. Dennis RD, Sun J, Tang S, Chen W, Wagner AK. Availability and use of essential medicines in China: manufacturing, supply, and prescribing in Shandong and Gansu provinces. *BMC Health Serv Res*. 2010;10(1):211.
7. Hu S. *Financing, Pricing and Utilization of Pharmaceuticals in China: The Road to Reform*. The World Bank; 2010. Washington DC, the United States.
8. Seiter A, Wang H, Zhang S. *A Generic Drug Policy as a Cornerstone to Essential Medicines in China*. The World Bank; 2010. Washington DC, the United States.
9. Dong L, Yan H, Wang D. Antibiotic prescribing patterns in village health clinics across 10 provinces of Western China. *J Antimicrob Chemother*. 2008;62(2):410-415.
10. Zhan SK, Tang SL, Guo YD, Bloom G. Drug prescribing in rural health facilities in China: implications for service quality and cost. *Trop Doct*. 1998;28(1):42-48.

11. Wagstaff A, van Doorslaer E. Catastrophe and impoverishment in paying for health care: with applications to Vietnam 1993-1998. *Health Econ.* 2003;12(11):921-934.
12. Yip W, Hsiao WC. Non-evidence-based policy: how effective is China's new cooperative medical scheme in reducing medical impoverishment? *Soc Sci Med.* 2009;68(2):201-209.
13. China. *Implementation Plan for the Recent Priorities of the Health Care System Reform (2009-2011)*. The State Council; 2009. Beijing, China.
14. China. *China National Essential Medicines Policy Has Been Established*. http://www.gov.cn/jrzq/2011-09/01/content_1938132.htm. Published 2011. Accessed December 14, 2017.
15. Gong Y, Yang C, Yin X, et al. The effect of essential medicines programme on rational use of medicines in China. *Health Policy Plan.* 2016;31(1):21-27.
16. Yang L, Huang C, Liu C. Distribution of essential medicines to primary care institutions in Hubei of China: effects of centralized procurement arrangements. *BMC Health Serv Res.* 2017;17(1):727.
17. Yang L, Liu C, Ferrier JA, Zhou W, Zhang X. The impact of the National Essential Medicines Policy on prescribing behaviours in primary care facilities in Hubei province of China. *Health Policy Plan.* 2013;28(7):750-760.
18. Fang Y, Wagner AK, Yang S, Jiang M, Zhang F, Ross-Degnan D. Access to affordable medicines after health reform: evidence from two cross-sectional surveys in Shaanxi Province, Western China. *Lancet Glob Health.* 2013;1(4):e227-e237.
19. Zhou Z, Su Y, Campbell B, et al. The financial impact of the "zero-markup policy for essential drugs" on patients in county hospitals in western rural China. *PLoS One.* 2015;10(3):e0121630.
20. Wang HTY, Liu Y, Yang L, Zhang X. Effect evaluation of national essential medicine system in China: based on survey data from Shandong, Hubei and Sichuan. *Chin J Health Policy.* 2012(5):30-34.
21. Chen YBB, Dai T. Effect on implementing essential medicine system at primary healthcare institutions in Anhui Province. *Chin J Health Policy.* 2013;6:34-35.
22. Song YBY. Impact evaluation of essential medicine system on prescription charges in township hospitals of Shandong province. *Chin Health Serv Manag.* 2012(8):586-587.
23. Shi YLW. Effect evaluation and consideration of essential drug system in Beijing Xicheng District around 6 years before and after the implementation of the system. *Chin Pharmacy.* 2013;24:300-302.
24. Zhang X, Wu Q, Liu G, et al. The effect of the National Essential Medicines Policy on health expenditures and service delivery in Chinese township health centres: evidence from a longitudinal study. *BMJ Open.* 2014;4(12):e006471.
25. Yu X, Li C, Shi YH, Yu M. Pharmaceutical supply chain in China: current issues and implications for health system reform. *Health Policy.* 2010;97(1):8-15.
26. World Health Organization. *How to Develop and Implement a National Drug Policy*. 2002. World Health Organization, Geneva, Switzerland.
27. Li Y, Ying C, Sufang G, Brant P, Bin L, Hipgrave D. Evaluation, in three provinces, of the introduction and impact of China's National Essential Medicines Scheme. *Bull World Health Organ.* 2013;91(3):184-194.
28. Matsiko CW. *From Policy to Practice: Making Health Policies in Developing Countries Work*. 2009. Kampala, Uganda.
29. Mdege ND, Man MS, Taylor Nee Brown CA, Torgerson DJ. Systematic review of stepped wedge cluster randomized trials shows that design is particularly used to evaluate interventions during routine implementation. *J Clin Epidemiol.* 2011;64(9):936-948.
30. Ren Y, Yang M, Li Q, et al. Assessing dose-response effects of national essential medicine policy in China: comparison of two methods for handling data with a stepped wedge-like design and hierarchical structure. *BMJ Open.* 2017;7(2):e013247.
31. Brown CA, Lilford RJ. The stepped wedge trial design: a systematic review. *BMC Med Res Methodol.* 2006;6:54