A study on the impact of healthcare reform policies on different patient behaviors in hospitals based on multiple regression analysis

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Abstract. To examine the impact of the government's healthcare reform—eliminating the 15% drug price markup—on hospital revenue structures and patient behavior across socioeconomic groups, a multiple regression model was applied to 2015–2018 Q2 patient data from a major hospital in Liaoning Province. Results revealed that the reform shifted hospital drug revenue from profit-driven to volume-driven models, with service revenue proportion rising. Rural patients saw a 12.5% reduction in drug costs, while elderly chronic disease patients experienced limited benefits due to a 14.1% increase in service fees. Insurance status showed no significant correlation with reform outcomes. The study confirms the reform's effectiveness in restructuring hospital income but highlights service cost burdens for elderly chronic patients. Policy recommendations include optimizing healthcare resource allocation by socioeconomic disparities and leveraging data to tailor insurance and institutional strategies.

Keywords: Healthcare Reform, Patient Behavior, Socioeconomic Groups, Multiple Regression Analysis.

1. Introduction

Global healthcare demand and aging populations have intensified challenges in China's healthcare system, including overprescription and rising burdens from "medication for treatment" practices [1] [2]. In August 2017, Liaoning Province launched a reform policy abolishing the 15% markup on all non-herbal drug prices in public hospitals while adjusting service fees, aiming to reduce patient expenses and enhance service quality [3]. This policy directly impacts hospital revenue structures and patient spending behaviors [4], necessitating a quantified analysis of its effects across socioeconomic groups.

Existing studies explore healthcare reforms' impacts on patient behavior and hospital finances. For instance, Qin et al. demonstrated that China's urban-rural healthcare integration policy increased rural patients' utilization of higher-tier hospitals [5]. Similarly, Gage et al. found relaxed U.S. Medicare telemedicine reimbursement policies raised follow-up visit rates among chronic disease patients [6]. Fang et al. highlighted how CHS-DRG payment reforms reduced hospital revenue elasticity, prompting adjustments in diagnosis processes and income structures [7]. While these studies address healthcare resource accessibility and financial impacts [8], they lack systematic analysis of socioeconomic group disparities from dual hospital-patient perspectives. Current reforms prioritize expanding insured populations without exceeding cost thresholds [9], yet research disproportionately focuses on disparities tied to ethnicity, hospital location, region, or teaching status [10], neglecting socioeconomic sensitivities to insurance design.

Therefore, this paper contains the following research objectives: (1) to assess the impact of healthcare reform policies on the revenue structure of hospital drugs and services, and to verify the income rebalancing effect after the mechanism of "medicine for medicine" is eliminated; (2) to

analyze the changes in prescription expenditures of patients in different socioeconomic groups, and to identify the groups benefited by the policies; (3) to reveal the correlation between the impacts of policies and the insurance status of patients, providing a basis for the formulation of differentiated policies.

2. Research data and methodology

2.1. Data description

This study uses outpatient data from Central Hospital of Dalian during 2015–2018, focusing on the second quarter (Q2: April–June) to mitigate holiday effects, align with reform timing, and ensure data reliability. Q1 was excluded due to low patient volumes during Chinese New Year (January/February). The 2017 reform began in mid-Q3 (August 26), making Q3–Q4 2017 a transition period. Incomplete data for Q4 2017 and Q1 2018 further justified selecting Q2 as the most robust dataset.

2.2. Description of the problem

The study analyzes a large general hospital ("Hospital D") and its three core Medical Centers (MCs), which accounted for 99.7% of outpatient revenue. Multidimensional panel data analysis evaluates the reform's impact on hospital revenue rebalancing, patient expenditure heterogeneity, and insurance-prescribing behavior linkages, providing empirical evidence for tailored healthcare policies.

2.2.1. Medical Centers

The first MC, in the downtown, offers the most comprehensive services and has the highest patient - visit volume (65%). The second MC, also in the city center, specializes in chronic diseases, cardiovascular diseases, and other serious illnesses, resulting in the highest average prescription cost among the three. The third MC, located in a rural area with a smaller population, has the fewest outpatient visits. Due to their different locations and specialties, these three MCs serve distinct patient groups. As Figure 1 shows, their patient age distributions vary: the second MC mainly serves the elderly, the first MC has more children, and the third MC's patients have an average age between the other two.

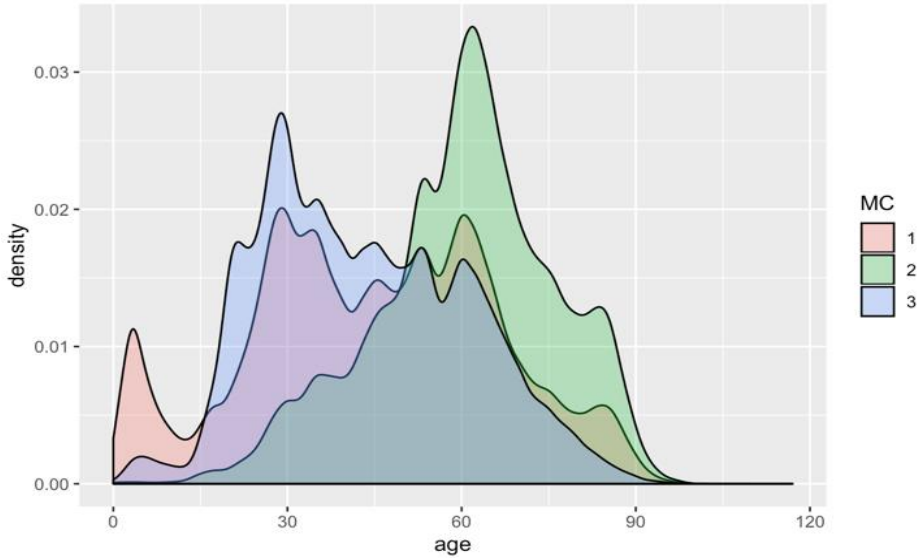

Figure 1. Age distribution by medical center

2.2.2. Flow of outpatient visits

The typical flow of a visit to Hospital D is that the patient first registers and schedules a departmental visit, the doctor diagnoses and examines the patient, and finally the patient pays for the medication. The first step of the process involves the patient's expenditure prior to receiving the

doctor's recommendation (registration fee), while the second step is based on the doctor's note or prescription (expenditure on medicines, tests, and services) and is known as the cost of prescription. Despite the reforms reducing drug prices, the average cost of over-the-counter drugs in the first step of the reform increased from $9 to $18, and the average prescription drug cost increased from $298 (Q2 2015) to $320 (Q2 2018). The analysis in this paper is based on prescription costs as it reflects physician and patient behavior and details the major revenues of Hospital D.

2.2.3. Price lists and prescription records

The hospital price lists for the second quarter of 2015-2018 correspond to price information for 3522, 3505, 3476, and 3440 items (drugs, services, and medical supplies), respectively. For convenience, all non-pharmaceutical items are referred to as "Services" in this paper. Hospitals update their price lists annually by removing obsolete or low-demand items, adding new items, and adjusting the unit prices of the remaining items. The net change in the unit price of any item after year t is defined as $\Delta P_{t,i} = p_{t+1,i}/p_{t,i}$. Where$p_{t,i}$ is the price of item i in year t.

During the second quarter of 2015-2018, the Patient's Outpatient Prescription Expense dataset had 2,793,483, 3,002,920, 3,161,806, and 3,437,855 records, respectively. Each record represents one prescription expenditure by a patient, and each prescription written by a physician may contain one or more such records. In this paper, the number of patient visits (N) is defined as the number of outpatient prescriptions, identified by a unique prescription ID. Characteristics of prescription and expenditure records include the patient's age group (< 20, 20-40, 40-60, and > 60), insurance status (yes/no), prescription type (drug/service), and MC (1, 2, 3).

2.3. Research methodology

This paper analyzes hospitals' per-revenue and per-patient expenditures on prescription drugs to understand the direct impact of price adjustments across socio-economic groups and the indirect impact on patients' prescription drug costs.

First, the study focuses on the hospital's revenue per prescription item by analyzing the distribution of items in the hospital's prescription drug price list and their revenue changes after the reform. In this paper, the items in year t are categorized into two main groups, drugs and services, and each item is further grouped according to the changes it undergoes: the group of items that are new in year t (added); the group of items that are carried over from last year's (t-1) list (co-existing) but may have their prices adjusted; and the group of items that will no longer be listed in the following year (t + 1) (deleted). Then for each item in the concurrent group, the paper compares the change in unit price$\Delta P_{2017,i}$ to the net change in hospital revenue after year t , i.e.,$\Delta R_{t,i} = (R_{t+1,i}/N_{t+1})/(R_{t,i}/N_t)$, where$R_{t,i}$ is the total revenue for item i in the second quarter of year t, andN_t is the total patient visits to the hospital in the second quarter of year t. The elimination of the drug markup regulates doctors' over-prescribing behavior, but the resulting increase in potential demand or the natural increase in patient visits can make the effect of price adjustment on revenue not directly visible. Therefore, this paper divides each program's revenue by the number of patient visits to reduce the impact of differences in the number of patient visits on changes in that revenue.

Second, this paper examines the interaction of health care reform and other variables (MC, age, insurance status, and prescription type) on patients' average cost per prescription. Differences in the three MC locations and the focus of the prescribing department also led to differences in their patients' age and expenditures. Therefore, to reflect the impact of this reform on patients from different socioeconomic groups (rural/urban and age groups), this paper uses the following multiple regressions to estimate patient expenditures per prescription:

$$C_{j,m} = \beta_0 + \beta_1 I_{j,m} + \beta_2 Age_{j,m} + \beta_3 Ref_{j,m} + \beta_4 Medi_{j,m} + \beta_5 Age_{j,m} * Ref_{j,m} + \beta_6 Age_{j,m} * Medi_{j,m} + \beta_7 Ref_{j,m} * Medi_{j,m} + \beta_8 Age_{j,m} * Ref_{j,m} * Medi_{j,m} + \varepsilon_{j,m} \quad (1)$$

Where, for prescription j with m in MC,$C_{j,m}$ is the corresponding average expenditure;$I_{j,m}$ equals 1 to indicate that the patient is insured and 0 otherwise;$Age_{j,m}$ refers to patients in the (<20, 20-40,

40-60, or > 60) age group;$Ref_{j,m}$ equals 1 if the reform is carried out and 0 otherwise; and$Medi_{j,m}$ equals 1 if the type of prescription is a medication and 0 otherwise. In this paper, we use the 2015-2017 data as the control group (pre-reform) and the 2018 data as the treatment group (post-reform). Insurance status is used as a control variable because patient price sensitivity is not affected by this variable.

3. Results and analysis

3.1. Analysis of patient expenditure data

Table 1 lists the hospital's patient visits (N) for the second quarter of 2015-2018, broken down by insurance status, prescription type, MC, and age group. The total number of patient visits is increasing over the study period, with a year-over-year increase of approximately 4%. The total number of patient visits for the second quarter of 2018 was 620,815.

Prescription types can contain both drug and service items and may be both insured and non-insured, with patients being able to transfer between the two MCs. Therefore, the total sample size for each category may not equal the total number of patient visits.

While more than 50 percent of patients are uninsured, the percentage of patients with insurance has continued to grow over the four-year period. in 2015, only 36.8 percent of visits were insured, while in 2018, the percentage reached 46.4 percent. The paper also observes that during this period, patients were more heavily represented in service (non-drug) programs and in the 20-40 and 40-60 age groups.

In Figure 2, total patient spending on prescriptions from 2015 through the second quarter of 2018 is further illustrated. Although total patient spending has shown growth over the years, the growth rate has been declining, particularly for prescription drug spending after the 2017 reforms - in 2016, the growth rate for both drug and service spending was around 10%; in 2017, the drug spending rate declined to 3.54%, and in 2018, there was virtually no increase in prescription drug spending (0.69%), which reflects the reforms' drug impact from the price reductions.

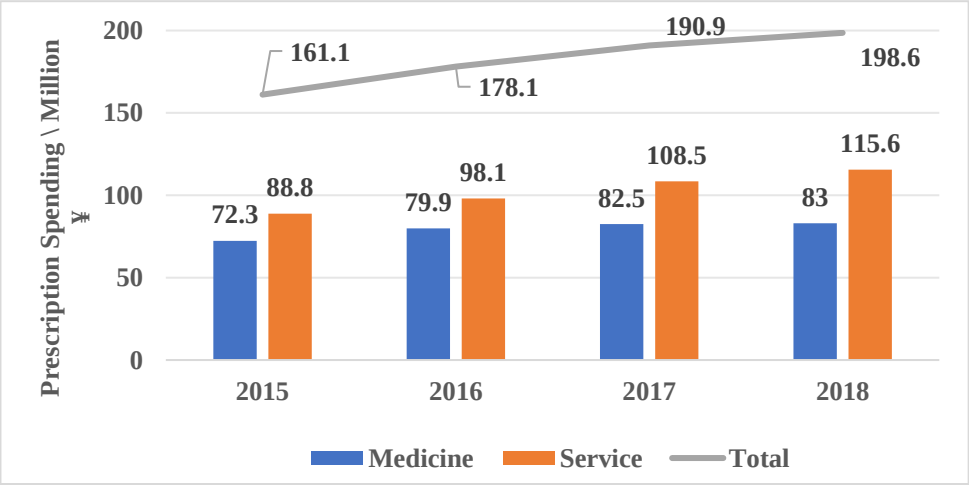

Figure 2. Patient Expenditures

In addition, drug expenditures accounted for 41.81% of total expenditures in 2018 and 44.87% in 2015. Compared to the ratio of the number of prescriptions between medicines and services reported in Table 1, it can be seen that the reforms of 2017 reduced the use of medicines, while the decrease in the price of medicines stimulated the willingness of patients to buy more medicines, thus boosting the sale of medicines in hospitals.

Table 1. Characterization of Hospital D 2015-2018 Q2 data

	2015 (Q2)	2016 (Q2)	2017 (Q2)	2018 (Q2)
Number of visits (N)	544,227	581,095	598,173	620,815
Insurance status	544,397	581,304	598,345	620,989
have	36.8%	37.5%	41.2%	46.4%
not have	63.2%	62.5%	58.8%	53.6%
Type of prescription	626,035	667,112	686,004	714,538
medicaments	43.0%	42.3%	42.1%	44.1%
service	57.0%	57.7%	57.9%	55.9%
MC	544,622	581,517	598,556	621,239
one-part	66.6%	65.2%	64.5%	63.0%
second-part	7.8%	8.0%	8.4%	9.1%
three-part	25.5%	26.6%	26.9%	27.7%
four-part	0.2%	0.2%	0.2%	0.1%
Age groups	544,185	581,095	598,173	620,815
<20	8.56%	8.57%	8.86%	8.59%
20-40	32.77%	32.77%	31.50%	29.70%
40-60	33.88%	33.15%	33.30%	33.58%
>60	24.79%	25.50%	26.34%	28.13%

3.2. Price analysis of medicines and services

3.2.1. Price-driven demand and replacement strategies on the price list

Figure 3 lists how drugs and services were updated each year on the price list during the study period of this paper. Based on the price list of drugs or services from the i program for the year $t \in \{2015,2016,2017\}$, this paper plots prescription revenues $R_{t,i}$ versus unit prices $P_{t,i}$, with two-axis logarithmic transformations to base 10 for all 3 groups (increasing, decreasing, and coexisting), and captures the trend for each group using kernel smoothing. Based on the graphs for drugs (Figures 3a-3c), it can be seen that low unit prices (ranging from 0.1 to 10 RMB) are usually associated with high sales, implying that patient demand for low-priced drugs is price-driven. But the service item trends are different (Figures 3d-3f). Through the three groups of trends in the service image, it was found that the coexisting items (green) usually have lower unit prices and higher revenues, while the other two groups of items that characteristic is not obvious. However, we found an overall increase in revenues for drugs and a more pronounced trend of higher sales for lower unit price items during 2017-2018 year, and significantly fewer items were eliminated (blue) than coexisting (green) and new items (red). At the same time, the upward trend in images during 2017-2018 year slowed down significantly at higher unit prices, probably because doctors are not over-prescribing expensive prescription drugs after the reform. This phenomenon suggests that substitution of services in the price list does not depend on the reform, whereas substitution of medicines is affected by the reform - low-volume and high-cost medicines are more likely to be dropped in the reform.

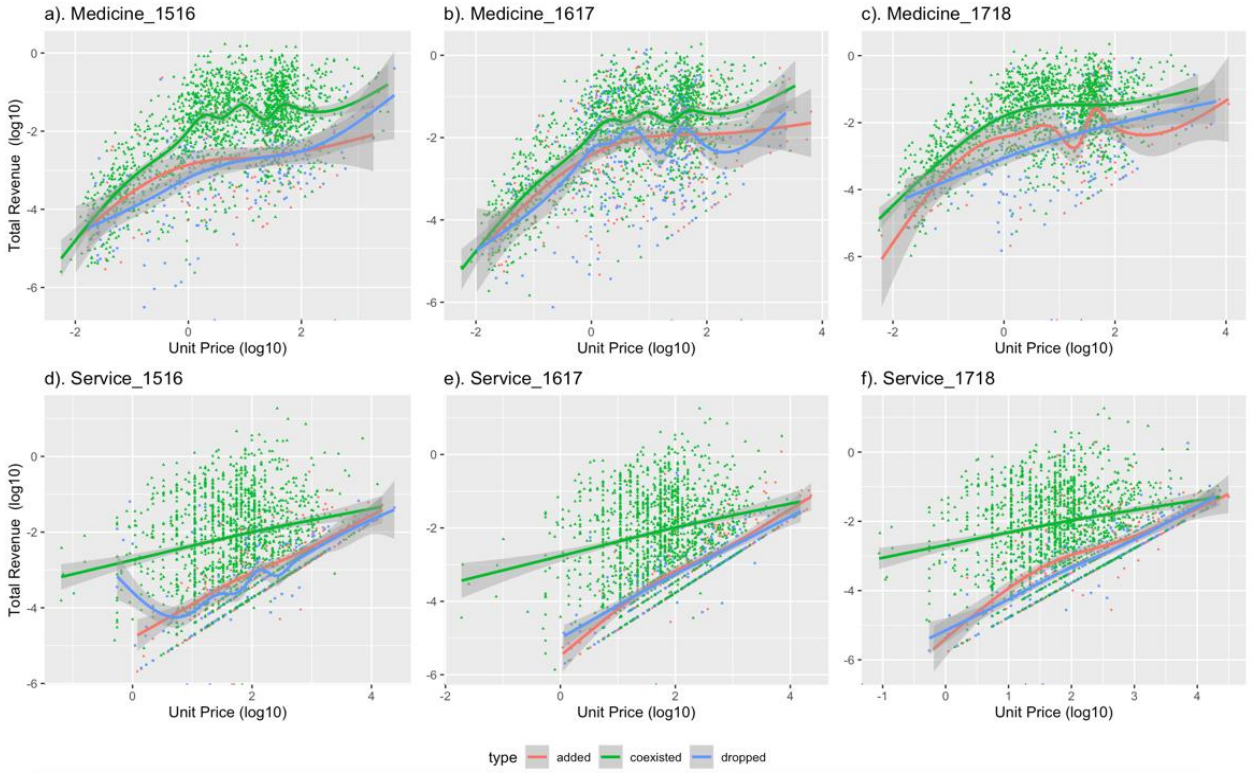

Figure 3. Total revenue and unit price of drugs/services

3.2.2. Price adjustment -- rebalancing of rates of change in income

Under the 2017 reform, which eliminated the 15% drug price markup, unit prices for all non-herbal medicines were expected to decrease. Figure 4 depicts the price adjustment of medicines by plotting the price change$\Delta P_{2017,i}$ of medicinesi against the unit price$P_{2017,i}$ during the 2017 reform (on a logarithmic scale with a base of 10). The color of the dot ($R'_{2017,i} = R_{2017,i}/N_{2017}$) reflects the flat revenue of the drugi in 2017.The graph reveals that high-priced drugs (CNY 10–1000) generally experienced price reductions, while many low-priced drugs (CNY 0.01–10) saw price increases—a trend diverging from prior assumptions and prompting further investigation into pricing strategies.

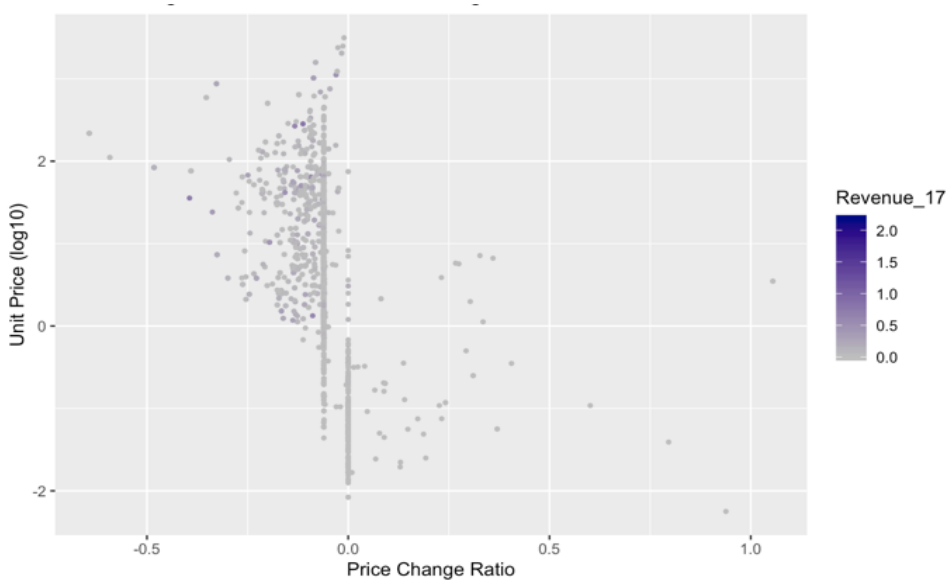

Figure 4. Prices of drugs and price changes

In Figures 5a and 5b, information related to drugs and services in the price lists over the four-year period 15-18 can be seen to illustrate the price adjustments for itemi after the 2017 reform ($\Delta P_{2017,i}$), relative to the change in net revenues for itemi after year t ($\Delta R_{t,i}$), wheret = 2015 (red), 2016 (green),

and 2017 (blue). Prior to the 2017 reform, hospitals seldom adjusted the drugs and services unit prices, so att=2015 and 2016, this paper uses the pseudo x-coordinate$\Delta P_{2017,i}$. The paper further uses smoothed curves to capture individual trends at colored points, as well as a black dashed baseline with an intercept of 0 and a slope of 1. The baseline represents the constant rate of change, i.e., a one unit increase in unit price results in a one unit increase in net income. In addition, to minimize the effect of outliers, this paper will focus primarily on the top 500 programs with the highest total revenues across all drug and service programs. The study finds that compared to the pre-reform period (red and green curves), the reform rebalances the rate of change for drugs to be closer to the baseline. That is, if a drug/service had a large net revenue change ratio before the reform, the magnitude of its unit price change in the reform is likely to leverage that point closer to the baseline, and vice versa.

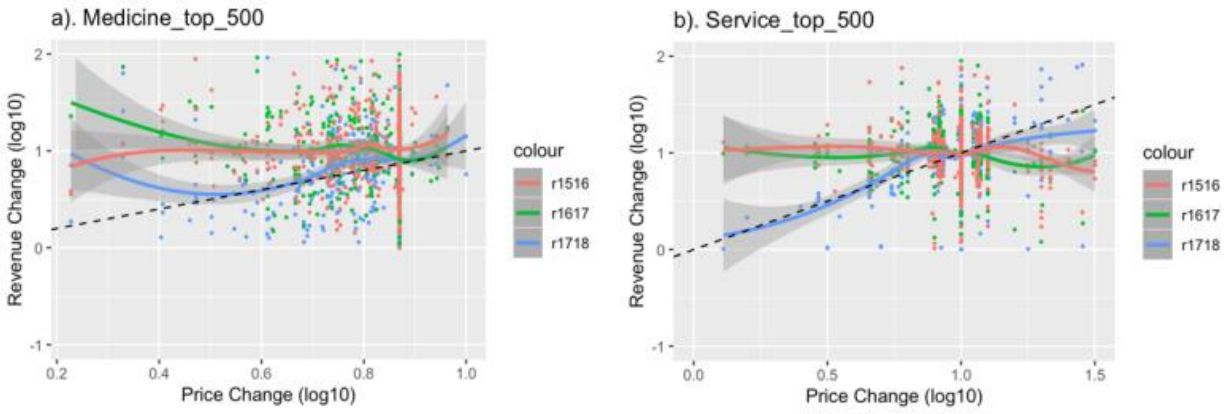

Figure 5. Changes in drug and service ratios

3.3. Expenditures on drugs and services for different socioeconomic groups

As shown in Figure 6, this section analyzes the change in average patient spending per prescription over the study period for each of the four variables. It was found that the average drug cost was higher than the cost of services, but the average cost decreased significantly after the reform, whereas service expenditures remained at the same level, but their growth changed (Figure 6a). At the same time, according to Figures 6b-6d, average costs were higher for the elderly and for patients who had insurance, lived in an urban area (MC1), or had a serious illness (MC 2). Notably, regardless of patients' insurance status, their average expenditures declined at a similar rate after the reform (Figure 6b).

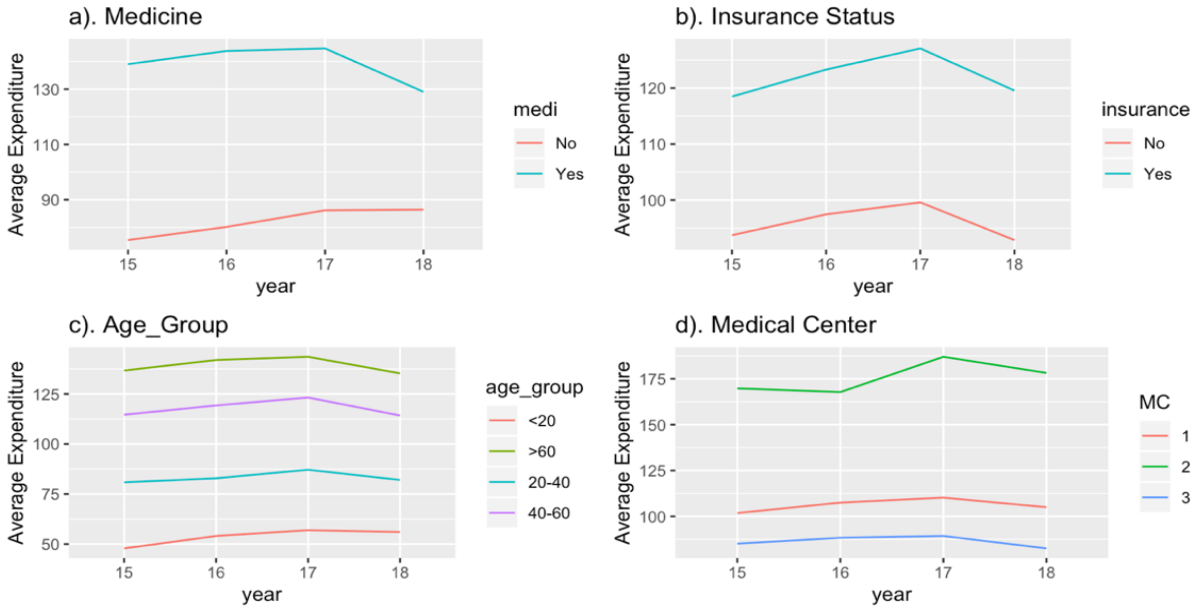

Figure 6. Interaction diagram of variables

Table 2 also reports the impact of the 2017 reform and other factors on average patient spending per prescription in the three MCs based on regression results. In this paper, pre-reform (years 15, 16, and 17), age group "<20," prescription type "service," and insurance status "no" are used as the base group. And the results contain the interaction relationships of both two variables and three variables. Having previously accounted for the fact that MC1 reflects the impact on urban patients, MC3 represents the impact on rural patients, and MC2 describes the pattern for elderly and chronically ill patients, the analysis revealed a different pattern of 2017 reform effects among the three MCs. Figure 7 illustrates the projected expenditures per prescription for patients in different socioeconomic groups, where "*" is a standard deviation confidence interval.

Table 2. Result analysis table

	MC1	MC2	MC3
(Intercept)	39.61 (0.89) ***	105.46 (24.14) ***	46.29 (1.3) ***
Insurance	4.28 (0.42) ***	22.07 (3.34) ***	14 (0.44) ***
Age 20-40	59.48 (1.12) ***	12.95 (24.46)	26.19 (1.49) ***
Age 40-60	23.69 (1.04) ***	2.68 (25.22)	6.99 (1.39) ***
Age > 60	51.23 (1.05) ***	46.18 (24.51).	25.3 (1.41) ***
Reform	4.55 (1.77) **	-39.74 (46.51)	0.05 (2.34)
Medicine (Medi)	29.1 (1.33) ***	29.33 (70.11)	13.12 (2.03) ***
Interaction (2 variables)			
Age 20-40: Reform	1.88 (2.07)	0.15 (48.55)	-0.34 (2.51)
Age 40-60: Reform	-0.28 (2.06)	66.81 (47.16)	-2.42 (2.54)
Age > 60: Reform	-1.72 (2.15)	68.89 (46.98)	-3.02 (2.69)
Age 20-40: Medi	27.01 (1.57) ***	49.48 (71.28)	27.57 (2.15) ***
Age 40-60: Medi	30.83 (1.56) ***	35.99 (70.42)	45.68 (2.19) ***
Age >60: Medi	51.24 (1.61) ***	65.13 (70.31)	67.97 (2.3) ***
Reform: Medi	-0.64 (2.64)	-29.26 (128.27)	-9.72 (3.68) **
Interaction (3 variables)			
Age 20-40: Reform: Medi	-22.18 (3.16) ***	-25.48 (128.64)	-12.11 (4.19) **
Age 40-60: Reform: Medi	-16.98 (3.13) ***	58.89 (130.45)	-2.28 (3.96)
Age > 60: Reform: Medi	-23.1 (3.09) ***	-32.66 (128.84)	-9.63 (3.99) *
*Signif. codes: '***' <0.001 '**' <0.01 '*' <0.05 '.' <0.1*			

Regression results (Table 2 and Figure 7) showed that this reform overall reduced average patient drug expenditures by 4% to 50% (MC1, -9.2%; MC2, -11.6% and MC3, -12.5%), but increased average costs by 6% for patients who were minors (<20 years old) in MC1. At the same time, expenditures for services increased by 1% to 23% for most patients (MC1, 7.2%; MC2, 14.1% and MC3, 0.2%), with the exception of patients over 40 years of age in MC3 (2% decrease) or under 40 years of age in MC2 (32% to 36% decrease).

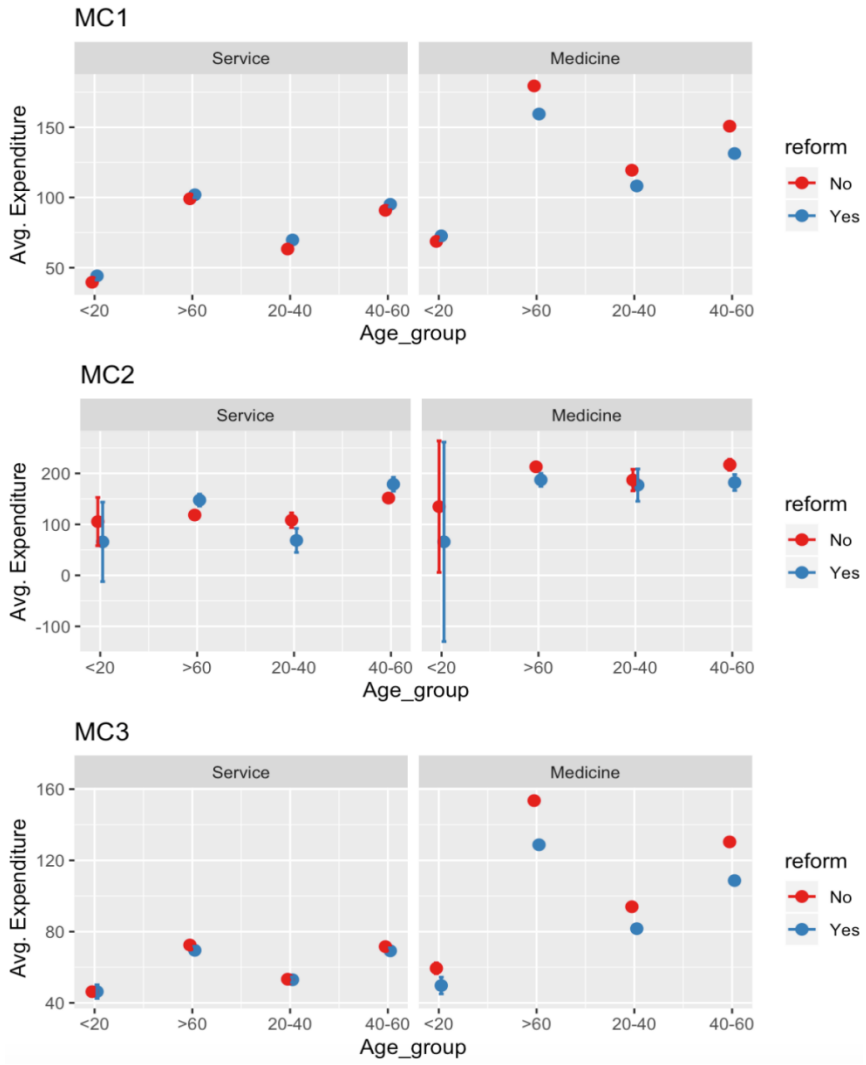

Figure 7. Projected expenditures by prescription in different patients

The study found that the reduced profitability of pharmaceuticals after the reforms prompted hospitals to seek more revenue from services. However, the average cost of medicines to patients has decreased and the cost of services has increased after the reforms, but the proportion of drug prescriptions has increased compared to service prescriptions. This means that hospitals' drug revenues have shifted from profit-driven to volume-driven. However, overall drug revenues are still growing after the reform and pharmaceuticals remain the main financial source for hospitals, as the decrease in drug prices has led to an increase in volume.

4. Conclusion

The study reveals the dual impact of the 2017 healthcare reform policy on hospitals and patients through multiple regression analysis. Firstly, at the hospital level, the policy has successfully reshaped the revenue structure, with drug revenue shifting from high profit and low sales volume to low profit and high sales volume, and service revenue becoming an important supplement, which verifies the policy's effectiveness in breaking the "medicines for doctors" mechanism. From the patient level, rural patients became the biggest beneficiaries due to the increase in the use of low-cost drugs and service cost control, while elderly patients with chronic diseases benefited only limitedly due to the increase in service prices. At the same time, insurance status does not affect the effectiveness of the policy, demonstrating the universality of the health-care reform.

Despite the results of this study, there is still room for further improvement. In the future, data from more hospitals can be included, especially using non-reformed hospitals as a control, to further

analyze the impact of geographic differences and hospital size on the effects of the policy, and to assess the long-term mechanism of the policy's effect on the total healthcare expenditure, in order to achieve a fair distribution of healthcare resources and efficiency improvement.

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