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Evaluating the effect of health insurance reform on health equity and financial protection for elderly in low- and middle-income countries: evidences from China

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Abstract

Background To achieve Universal Health Coverage (UHC), China have implemented health system reform to expend health coverage and improve health equity. Scholars have explored the implementing effect of this health reform, but gaps remained in health care received by elderly. This study aims to assess the effect of implementing health insurance payment reform on health care received by elderly, as well as to evaluate its effect on cost sharing to identify whether improve financial protection of elderly under this reform.

Methods We identified hospitalization of 46,714 elderly with cerebral infarction from 2013 to 2023. To examine the determinant role played by DRGs payment reform in healthcare for elderly and their financial protection, this study employs the OLS linear regression model for analysis. In the robustness checks, we validated the baseline results through several methods, including excluding the data from the initial implementation of the reform (2021), reducing the impact of the pandemic, and exploring the group effects of different demographic characteristics.

Results The findings proposed that implementing DRGs payment reduces drug expenses but increases treatment expense of chronic disease for elderly in China. This exacerbates healthcare costs for elderly patients and seems to be contrary to the original purpose of health care reform. Additionally, the implementation of DRGs payment reduced the spending of medical insurance fund, while increased the out-of-pocket of patients, revealing a shift in health care expenses from health insurance fund to out-of-pocket.

Conclusions This study shares the lessons from China's health reform and provides enlightenment on how to effective implement health reform to improve health equity and achieve UHC in such low- and middle-income countries facing challenges in health financing.

Keywords Health insurance reform, Elderly, Health equity, Financial protection, Out-of-pocket

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Introduction

Universal Health Coverage (UHC) which means individuals have obtain the high quality health care they need without suffering financial hardship, is the key to achieving the World Bank Group's (WBG) twin goals of ending extreme poverty and increasing equity and shared prosperity, as well as the core element of Sustainable Development Goals (SDGs) adopted by the United Nations [1–4]. World Health Organization (WHO) and World Bank are calling on governments to prioritize investments in building resilient health systems to safeguard the health and well-being of all people and establish the UHC targeting that at least 80% health coverage of essential health care and 100% of financial projection by 2030 for all countries [5]. To achieve UHC, many countries, especially low- and middle-income countries (LMICs), implement health system reform to expend health coverage and improve health equity [6–10]. One of the most significant reform initiatives is that health systems in LMICs are undergoing reforms from retrospective payment to prospective payment systems by implementing Diagnosis related groups (DRGs) [11]. Such vulnerable populations as elderly, children and low-income groups, were paid more attention in those reforms.

DRGs payment, as the most popular payment system, originated in the United States and first implemented in the 1980s [12], is essentially a case mix classification scheme, which comprehensively considers the main diagnosis, additional, surgical operation, complications, age and other factors of each case to classify and combine the cases into categories, and the fixed payment of each category is payable in advance to hospital based on the DRGs classifications [13–15]. Early stages of DRGs payment were implemented in high-income settings with rich health resources [12] and showed evidences to stimulate healthcare providers towards greater efficiency through controlling costs, improving financial protection, reducing length of stay and enhancing healthcare quality in those countries [15–17]. In the recent years, to improve the efficiency and quality of healthcare, health systems in many LMICs have undergone reforms from retrospective payment to prospective payment systems by implementing DRGs such as Thailand, Ghana, Serbia, and China [11, 18–20]. However, empirical evidences in LMICs reported mixed outcomes. For example, study from Thailand indicated DRGs payment system significant reduce health cost and admission to higher level institutions, while Ghana's evidence suggested implementing DRGs payment has the potential risk of guiding patients to over-treat and enter higher payment groups [19, 20]. Hence, more evidences directly related to health equity and financial protection from LMICs should receive significant attention, especially for vulnerable populations.

Elderly populations, due to their health and socioeconomic status, have higher rates of health care utilization than other age groups, and also suffer more health inequities and financial hardship [21–24]. China has the world's largest and most rapidly-ageing population and is facing ongoing unique challenges in addressing elderly population health [25, 26]. The mismatch between large population and limited medical resources in China has resulted in widespread discontent among Chinese people towards inaccessible and unaffordable health care services. To address these challenges, China successively launched various health insurance reform and increased fiscal investment to expend health insurance coverage and improve health care delivery [27, 28]. As a result, by the end of 2015, more than 95% of Chinese population had been covered by primary health insurance. However, high coverage resulted in growth of China's real health expenditure was much faster than growth of gross domestic product (GDP). Additionally, the traditional fee-for-services (FFS) payment for national health insurance system, which was case-based payment, resulted in adverse consequences, such as long average length of stay, excessive service provision and inefficient hospital networks, it also has significantly increased health expenses and caused economic pressure on the government budget [29, 30]. Meanwhile, out-of-pocket payments have also continued to increase, which can easily lead to financial hardship for patients and affect the accessibility and affordability of health care [31].

To improve efficiency and sustainability of public health spending and enhance health equity, in 2020, China's National Healthcare Security Administration announced plans to implement the latest round of health insurance payment reform by implementing DRGs payment nationwide to replace FFS payment, and starting from 2021, each province will progressively adopt and extensively implement the DRG payment system based on their local conditions. Theoretically, the DRGs payment can regulate medical service behavior and suppress provider-induced demand, thereby reducing medical costs and saving healthcare expenses [32]. Evidence from the United States and Germany demonstrates that the implementation of DRGs payment contributes to reduce total medical expenses, out-of-pocket payments, and unnecessary additional expenditures [33]. In the initial stage of DRGs payment reform in China, it is necessary to observe the effect of health insurance reform on health care and make necessary adjustments to improve the reform effect. Scholars have explored the implementing effect of this health reform, but evidence is mixed [34–36]. For instance, scholars have noted that the pilot implementation of DRG payment in Beijing has reduced health expenditures and out-of-pocket costs for patients [31]. However, evidence from rural residents in other

provinces suggests that the DRG payment reform has increased health expenses and out-of-pocket payments [37]. Meanwhile, research evidences concerning elderly population, a group that relies more heavily on public health resources, remains insufficient.

Therefore, this study aims to assess the effect of implementing health insurance payment reform on health care received by elderly, as well as to evaluate its effect on cost sharing to identify whether improve financial protection of elderly under this reform. Specifically, we collected hospitalization data of elderly patients from three Chinese provinces between 2013 and 2023 to investigate the effect of health insurance reform on health care expenses received by elderly and cost sharing by employing linear regression method. Evidences from this study can provide important implications for identifying effective implementation strategy to improve health care and financial protection for elderly. We also hope that this study will share lesson and enlightenment on how to effective implement health reform to improve health equity and achieve UHC in LMICs facing challenges in health financing.

Methods

Data sources

Economic development determines the concentration of health resources [38]. To exploring the implementing effect of health insurance reform from a national level in China, we selected study sites from different health resource agglomeration degrees. Specifically, we referred to per capita GDP in 2022 (with 11,954 USD per capita GDP at national level) to select Guangdong (14,178 USD per capita GDP), Shandong (11,954 USD per capita GDP) and Guangxi (7,228 USD per capita GDP), which representing the high-, middle- and low- health resource agglomeration degree in China. Figure 1 shows the study sites. This study identifies the sample population though elderly patients with cerebral infarction. The rationale for selecting cerebral infarction as the focus is as follows: cerebral infarction is one of the leading causes of death and disability worldwide, with China accounting for 40% of global cases, the highest proportion globally [39]. Additionally, as a common diseases among the elderly, there is currently no consensus on how to standardize the treatment of this disease under DRGs payment reform. Clinical experts call for more research to explore the impact of health insurance reform on patients with

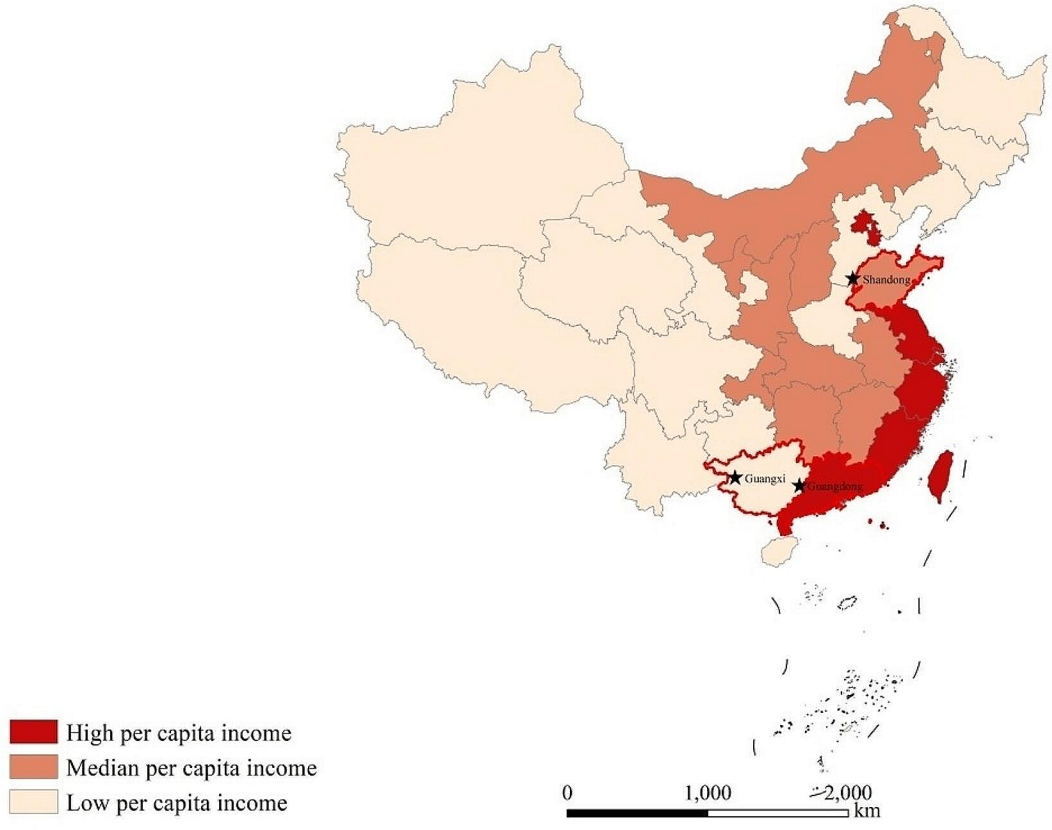

Fig. 1 Study site

cerebral infarction, aiming to achieve efficient utilization of medical insurance funds and enhance health equity. We identified hospitalization data from five tertiary general hospitals covering three provinces. The primary data sources were discharge data for cerebral infarction disease patients from five hospitals over the period of 2013 to 2023.

Measures and analysis

To assess the effect of implementing health insurance payment reform on health care for elderly, the main dependent variables refer to healthcare expenses and cost sharing to measure health equity and financial protection. Specifically, healthcare expenses include hospitalization-, treatment-, and drug- expenses, which are the specific amount paid by elderly i in hospital j in year t. Cost sharing consists of medical insurance fund and out-of-pocket, which are captured by the amount paid by those two sources.

The key explanatory variable is the health insurance reform. The DRGs pilot in China was rolled out in Beijing in 2010, subsequently, the pilot reform of the DRGs payment was widespread implemented in other provinces. In this study, the hospitals selected from three provinces began to implement DRGs payment reform taring in 2021 to replace traditional FFS payment, hence, we set up a dummy variable (*DRG*) to measure health insurance reform, *DRG* that equals to one if the discharge time was 2021 and later, and zero if the discharge time was before 2021.

Previous work has indicated various variables may affect healthcare received by patients [35, 40], we therefore, controlled for individual characteristics, such as patients' age, gender, married, length of stay, insurance type. Additionally, referring to prior studies, human resources and physical resources impact the delivery of healthcare services [41–43], such indicators include hospital numbers and health workers. To avoid the omitted variable issue, following [38, 44] macroeconomic characteristics correlated with health resources availability and health equity are included as control variables, including GDP per capita and Consumer Price Index (CPI).

To examine the determinant role played by DRGs payment reform in healthcare for elderly and their financial protection, we employ an OLS linear regression model for analysis. Additionally, health care expenses (e.g., hospitalization-, treatment-, drug- expenses) and the spending of cost sharing (medical insurance fund and out-of-pocket) were logarithmically transformed in the model considering the skewed distribution. All analyses were conducted using Stata 17.

Results

Descriptive data

The final sample was 46,714 elderly aged 60–106 years (M=71.34, SD=7.43) with health insurance, of whom, 35.56% from Guangdong (16,613 individuals), 35.66% from Shandong (16,655 individuals) and 28.78% from Guangxi (13,445 individuals). The descriptive statistics of the key indicators used in the empirical analysis was presented in Table 1 and showed that a majority of elderly were male and have the average value of length of stay with 9.5 days. During the FFS period, the average hospitalization, drug and treatment expenses for elderly patients were CNY 14264.900, CNY 1226.558, and CNY 5,978.030, respectively. After the implementation of DRGs payment, these costs were CNY 14030.850, CNY 1723.035, and CNY 3893.964, respectively. Additionally, after implementing DRGs payment reform, the costs covered by medical insurance fund and out-of-pocket were CNY 7122.927 and CNY 6315.773, respectively.

Main results

Table 2 presents that OLS results for Eq. (1) to examine the impact of DRGs payment reform on healthcare for cerebral infarction received by elderly patients (in columns 1–3), where the dependent variable are the log amount value of specific expenses in terms of hospitalization, drug and treatment), and for Eq. (2) to explore its effect on financial protection (in columns 4–5), where the dependent variable are the log amount of spending between medical insurance fund and out-of-pocket for elderly. All specifications control for individual and regional variables and with year and region fixed effects. Besides, the regressions are run with OLS with heteroskedasticity-robust standard errors. Variance inflation factor (VIF) has been checked and are below 5, indicating that the results are not affected by a multicollinearity issue.

As reported in Table 2 (columns 1–3), the estimated coefficients of *DRG* are negative statistically significant on drug expense and positive statistically significant on treatment expense, while it is positive but not statistically significant on hospitalization expense. The results showed clear evidences to investigate implementing DRGs payment reduce drug expenses and increase treatment expenses on treating cerebral infarction received by elderly, while it has no significant affect on hospitalization expense. Additionally, the results suggested comparing with drug expense, treatment expense is more sensitive to health insurance reform.

Regarding to cost sharing, the results show the estimated coefficients of *DRG* is negative statistically significant on spending of medical insurance fund (column 4), suggesting implementing DRGs payment was associated with significant reduce in spending of medical insurance

Table 1 Descriptive statistic of the samples. This table reports the summary statistics of all samples used in this study. Panel A provides details of original health expenses and costing sharing variable before and after DRGs payment. Panel B provides the variables for OLS model. In the OLS model, dependent indicators are log value of each item. LOS means length of stay, gender is coded as 1 for female and 2 for male. Married is coded as 1 for married patients and 2 for non-married patients. M_type indicates medical insurance type, where 1 indicates resident insurance and 2 indicates employee insurance. D_Admission means admission department for patient, and we encoded this variable based on the patient's admission department because we used data from different hospitals across various regions. GDP_pc means gross domestic product per capita, N_worker means health workers per 1,000 people in this region, and N_Hospital means total number of hospitals in the region

Panel A: Summary statistics of original expenditure variable before and after DRGs payment						
Variables	N	Mean	SD	N	Mean	SD
	FFS payment			DRGs payment		
Hospitalization Expense	33,484	14264.9	20436.52	13,230	14030.85	22,847
Drug Expense	33,484	1226.558	3922.99	13,230	1723.035	6025.505
Treatment Expense	33,484	5978.03	8998.112	13,230	3893.964	6025.505
Medical Insurance Fund	33,484	5641.801	11352.75	13,230	7122.927	13004.93
Out-of-pocket	33,484	8649.147	16178.61	13,230	6315.773	10257.42
Panel B: Descriptive statistic of the variables for OLS model						
Variables	N	Mean	SD	P25	Median	P75
Hospitalization Expense	46,714	9.186	0.761	8.645	9.128	9.604
Drug Expense	46,714	8.124	0.944	7.479	8.148	8.736
Treatment Expense	46,714	6.054	1.325	5.1	5.762	6.818
Medical Insurance Fund	46,714	7.098	3.109	7.351	8.105	8.802
Out-of-pocket	46,714	8.487	0.919	7.908	8.367	9.008
DRG	46,714	0.283	0.451	0	0	1
Age	46,714	71.34	7.43	65.3	70	76.3
Gender	46,714	1.582	0.493	1	2	2
Married	46,714	1.102	0.426	1	1	1
LOS	46,714	9.46	7.807	6	8	11
M_type	46,714	1.398	0.49	1	1	2
D_Admission	46,714	3.183	1.479	2	3	5
CPI	46,714	1.118	0.066	1.059	1.118	1.174
GDP _pc	46,714	10.97	0.332	10.822	11.051	11.182
N_worker	46,714	7.372	1.069	6.5	7.42	8.23
N_hospital	46,714	1849.271	897.006	803	2451	2640

fund, while it shows positive statistically significant on out-of-pocket (column 5), highlighting implementing DRGs payment increase out-of-pocket for elderly patients. Additionally, the spending of medical insurance fund (β=-1.8426) has a grater magnitude level than out-of-pocket (β=0.6248), indicating spending of medical insurance fund is more sensitive to implementing health insurance reform than out-of-pocket to health reform.

Robustness checks

Alternative sample of expanding elderly patients

In this section, we considered other samples for robustness check. We included elderly patients who were not covered by public health insurance and paid exclusively out-of-pocket. Specifically, we identified totally 48,799 elderly, of whom 46,714 with public health insurance and 2,085 without health insurance from 2013 to 2023. Table 3 reports the estimation results. Overall, our results expanding elderly patients are consistent with the baseline results using elderly with health insurance that indicating implementing DRGs payment reduce drug expense and increase treatment expense for elderly, meanwhile, the spending of medical insurance fund was reduced after implementation of DRGs payment, while out-of-pocket was increased.

Alternative sample of mitigating the impact of data imbalance

This study covers data from 2013 to 2023. Since the sample hospitals in this study began implementing DRGs payment in 2021, the DRGs payment phase in our dataset includes only the three years from 2021 to 2023. To reduce research bias from sample imbalance, we matched the length of the FFS and DRG data fro robustness testing. Additionally, to circumvent the effects of the pandemic, we excluded data from 2020 in this analysis. Specifically, we used data from 2017 to 2019 to represent the FFS phase and data from 2021 to 2023 for the DRGs phase. The results present in Table 4 and show that the analysis of the balanced data aligns with the baseline

Table 2 Impacts of the health insurance payment reform on health care received by elderly. This table reports OLS results on how DRGs payment reform affects the healthcare and financial protection received by elderly in this study. Models 1–3 shows results of the effects of health insurance reform on health expenses, and models 4 and 5 shows results of the effects of health insurance reform on financial protection. Dependent indicators were logarithmically transformed in the model considering the skewed distribution. ***, ** and * denote statistically significant levels of 1%, 5% and 10% respectively

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Hospitalization Expense**	**Drug Expense**	**Treatment Expense**	**Medical Insurance Fund**	**Out-of-pocket**
DRG	0.0072	-0.0803***	0.2704***	-1.8426***	0.2724***
	(0.0089)	(0.0119)	(0.0164)	(0.0417)	(0.0124)
Age	-0.0021***	-0.0026***	0.0055***	-0.0114***	-0.0076***
	(0.0003)	(0.0004)	(0.0006)	(0.0016)	(0.0005)
Gender	0.0706***	0.0906***	0.0712***	0.0028	-0.0013
	(0.0050)	(0.0067)	(0.0093)	(0.0235)	(0.0070)
Married	0.0636***	0.1023***	0.0684***	0.1887***	0.0570***
	(0.0060)	(0.0081)	(0.0111)	(0.0282)	(0.0084)
LOS	0.0533***	0.0608***	0.1055***	0.0330***	0.0481***
	(0.0003)	(0.0004)	(0.0006)	(0.0015)	(0.0004)
M_type	-0.0022***	-0.0045***	-0.0036***	0.0527***	-0.0179***
	(0.0003)	(0.0004)	(0.0005)	(0.0012)	(0.0004)
D_Admission	0.0015***	0.0014***	-0.0006***	-0.0032***	0.0022***
	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0001)
CPI	0.8858***	-3.6562***	1.5501***	-22.0582***	3.6120***
	(0.2221)	(0.2976)	(0.4107)	(1.0416)	(0.3089)
GDP_pc	-0.1567***	0.8402***	0.4054***	15.8639***	-2.1944***
	(0.0523)	(0.0700)	(0.0966)	(0.2450)	(0.0727)
H_worker	-0.0077	-0.0325	0.0929**	1.2892***	-0.1782***
	(0.0209)	(0.0280)	(0.0386)	(0.0980)	(0.0291)
N_Hospital	-0.0003***	-0.0006***	-0.0003***	-0.0046***	0.0005***
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)
Constant	9.8493***	3.6562***	-1.7817*	-143.4549***	29.1200***
	(0.5785)	(0.7750)	(1.0694)	(2.7125)	(0.8044)
Year FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Observations	46,714	46,714	46,714	46,714	46,714
R-squared	0.5205	0.4400	0.4591	0.3677	0.3633

findings. Specifically, compared to FFS, the implementation of DRGs payment contributes to reducing drug expense and the utilization of medical insurance fund, while increasing treatment expense and out-of-pocket expense.

Considering eliminating the effect of the early implementation of health insurance reform and the effect of COVID

In the early period of policy implementation, uncertainty about reform implementation may confound the reform effect, we therefore, excluded the sample from 2021 (5,495 elderly) to minimize interference from the early period of DRGs payment implementation. The results indicated, compared in FFS payment, drug expense was reduced and treatment expense was increased in implementing DRGs payment reform. Meanwhile, the DRGs payment reform contributes to reduce spending of medical insurance fund while increase out-of-pocket by elderly, which are consistent with the baseline analysis.

Additionally, considering that the implementation of DRGs payment in the sample settings happened to be during COVID outbreaks, we excluded the sample data in 2020 (5,520 elderly) to reduce the potential impact of the pandemic period. Table 6 presents the results and reports DRGs payment implementation reduces hospitalization and drug expenses, but increases treatment expense. Regarding to cost sharing, consistent with the basic results, the DRGs payment reform saved public funds for medical insurance but increased out-of-pocket by elderly.

Alternative test of grouping samples into different demographic characteristics

To further investigate the impact of DRG payment reform on elderly patients with varying demographic characteristics, we stratified the patients by gender and

Table 3 Robustness test: alternative sampling. This table reports the results for robustness tests by expanding additional samples. We identified totally 48,799 elderly, of whom 46,714 with public health insurance and 2,085 without health insurance from 2013 and 2023. Dependent indicators were logarithmically transformed in the model considering the skewed distribution. ***, ** and * denote statistically significant levels of 1%, 5% and 10% respectively

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Hospitalization Expense**	**Drug Expense**	**Treatment Expense**	**Medical Insurance Fund**	**Out-of-pocket**
DRG	0.0002	-0.0921***	0.2599***	-1.7854***	0.2607***
	(0.0087)	(0.0118)	(0.0161)	(0.0452)	(0.0122)
Age	-0.0018***	-0.0022***	0.0059***	-0.0105***	-0.0070***
	(0.0003)	(0.0004)	(0.0006)	(0.0017)	(0.0005)
Gender	0.0697***	0.0891***	0.0693***	-0.0196	0.0036
	(0.0050)	(0.0067)	(0.0091)	(0.0256)	(0.0069)
Married	0.0629***	0.1031***	0.0588***	-0.0269	0.0838***
	(0.0057)	(0.0077)	(0.0105)	(0.0295)	(0.0080)
LOS	0.0537***	0.0614***	0.1063***	0.0367***	0.0482***
	(0.0003)	(0.0004)	(0.0006)	(0.0016)	(0.0004)
M_type	-0.0026***	-0.0049***	-0.0039***	0.0271***	-0.0154***
	(0.0003)	(0.0004)	(0.0005)	(0.0014)	(0.0004)
D_Admission	0.0015***	0.0013***	-0.0006***	-0.0019***	0.0021***
	(0.0001)	(0.0001)	(0.0002)	(0.0005)	(0.0001)
CPI	0.7423***	-3.8938***	0.9483**	-19.1289***	3.1829***
	(0.2132)	(0.2870)	(0.3924)	(1.1033)	(0.2977)
GDP_pc	-0.1632***	0.8306***	0.3504***	15.5529***	-2.1758***
	(0.0512)	(0.0689)	(0.0942)	(0.2648)	(0.0714)
H_worker	0.0057	-0.0097	0.1518***	1.0824***	-0.1444***
	(0.0200)	(0.0270)	(0.0369)	(0.1036)	(0.0280)
N_Hospital	-0.0003***	-0.0006***	-0.0003***	-0.0044***	0.0005***
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)
Constant	9.9838***	3.8736***	-0.9169	-141.6992***	29.1063***
	(0.5644)	(0.7598)	(1.0388)	(2.9205)	(0.7880)
Year FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Observations	48,799	48,799	48,799	48,799	48,799
R-squared	0.5205	0.4379	0.4602	0.2819	0.3518

marital status. Table 7 presents the results by grouping demographic characteristics, where Panel A refers to the sample with female, Panel B refers to the sample with male, Panel C refers to elderly with married, and Panel D refers to elderly with non-married. Specifically, regrading the gender grouping, the overall effect of implementing DRGs payment were comparable for both female and male patients, as both groups experienced reductions in drug expense and medical insurance fund payment, while increases in treatment expense and out-of-pocket payment. Moreover, the results suggest that male patients are more significantly affected by the reform in health insurance payment than female patients. Regarding to the marital status grouping, the results demonstrate that the trend of the impact of DRG payment reform on healthcare expenses remains largely consistent with the baseline findings. Additionally, the implementation of DRGs payment led to an increase in the hospitalization expense for elderly in the married group, whereas the hospitalization expense for elderly in the unmarried group were not significantly affected.

Discussion

This study, to our knowledge, was the first study to explore the effect of DRGs payment implementation on healthcare services received by elderly at national level, which is a primary area of health care reform at the current stage. We assessed this with analysis of two key indicators of healthcare services (healthcare expenses and cost sharing) to identify the implementation effect of DRGs payment on healthcare and financial protection received by elderly patients. The findings proposed that implementing DRGs payment reform reduce drug expenses but increase treatment expense of chronic disease for elderly patients in China. Additionally, there is no evidences to indicate implementing health insurance reform contribute to reduce hospitalization expense received by elderly. These findings seem to be contrary to the original purpose of health care reform. Additionally,

Table 4 Robustness test: alternative sample of using balanced data this table reports the results of using a shortened study period with balanced data to reduce the potential research bias caused by data imbalance, with 2017–2019 representing the FFS phase and 2021–2023 representing the DRGs payment phase. Dependent indicators were logarithmically transformed in the model considering the skewed distribution. ***, ** and * denote statistically significant levels of 1%, 5% and 10% respectively

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Hospitalization Expense**	**Drug Expense**	**Treatment Expense**	**Medical Insurance Fund**	**Out-of-pocket**
DRG	-0.0048	-0.0829*	0.4407***	-1.9934***	0.3217***
	(0.0319)	(0.0423)	(0.0574)	(0.1424)	(0.0412)
Age	-0.0027***	-0.0036***	0.0015*	-0.0141***	-0.0078***
	(0.0005)	(0.0006)	(0.0008)	(0.0021)	(0.0006)
Gender	0.0658***	0.0833***	0.0603***	0.0230	-0.0033
	(0.0071)	(0.0094)	(0.0127)	(0.0315)	(0.0091)
Married	0.0867***	0.1289***	0.1456***	0.1448***	0.0979***
	(0.0099)	(0.0132)	(0.0179)	(0.0444)	(0.0128)
LOS	0.0547***	0.0629***	0.1005***	0.0270***	0.0508***
	(0.0005)	(0.0006)	(0.0008)	(0.0021)	(0.0006)
M_type	-0.0032***	-0.0056***	-0.0025***	0.0609***	-0.0209***
	(0.0004)	(0.0005)	(0.0007)	(0.0018)	(0.0005)
D_Admission	0.0015***	0.0014***	0.0005**	-0.0061***	0.0029***
	(0.0001)	(0.0002)	(0.0002)	(0.0006)	(0.0002)
CPI	1.1399	-0.2600	-1.1277	29.4948***	-6.9357***
	(0.8282)	(1.0992)	(1.4893)	(3.6977)	(1.0693)
GDP_pc	0.4763**	1.1691***	-2.3626***	1.7122	0.3956
	(0.2333)	(0.3096)	(0.4195)	(1.0415)	(0.3012)
H_worker	-0.1561***	-0.3654***	0.6521***	-0.1716	0.1152*
	(0.0493)	(0.0655)	(0.0887)	(0.2202)	(0.0637)
N_Hospital	-0.0004***	-0.0005***	0.0001	0.0013***	-0.0006***
	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0001)
Constant	4.0351**	-1.3499	26.7875***	-45.9086***	12.4070***
	(1.9254)	(2.5552)	(3.4622)	(8.5960)	(2.4859)
Observations	24,487	24,487	24,487	24,487	24,487
R-squared	0.5101	0.4276	0.4542	0.2230	0.3531

the implementation of DRGs payment reduced the spending of medical insurance fund, while increased the out-of-pocket of patients, revealing a shift in health care costs from medical insurance funds to out-of-pocket and increase financial hardship for elderly.

Our findings provide several insights about the effect of DRGs payment reform on healthcare for elderly. Firstly, our findings provide evidence to indicate implementing DRGs payment increased the treatment expenses of healthcare for elderly patients and did not affect the reduction of hospitalization expenses, which are contrary to the previous evidence from high-income settings, such as the United States and European countries [45], and evidence from other disease predominating in the young population, such as appendicitis [40]. The original intention of implementing DRGs payment in China is to overcome escalating health care costs and improve efficiency and sustainability of health spending, expanding health coverage and access to healthcare. However, our evidences showed that the impact of health payment reform on health care expenses received by elderly patients does not appear to be as expected.

There are several possible explanations for the significant effect of DRGs payment on increasing healthcare expense for elderly patients. First, the essence of health coverage reform is the marketization of health care, requiring hospitals to bear their own profits and losses. Under this payment mechanism, hospital should ensure financial security by making profits from prescribing and dispensing drugs and providing high-technology tests, meanwhile, clinician compensation is tied to those profits. As a results, hospital and clinician may induce patients to use more healthcare tests or more expensive out-of-pocket treatment [40]. Second, due to the decline of physical function and easy to cause multiple diseases, the elderly have an increased frequency of hospital visits, which leads to an increased probability of receiving induced medical consumption and thus a greater propensity to incur higher healthcare expense. Third, the increase in health care costs due to the update of medical technology may also be a potential cause of the increase in health care costs for elderly population, although the increasing healthcare needs and costs of the elderly do not depend on the payment mechanism, it is likely to be a

Table 5 Robustness test: considering eliminating the effect of the early implementation of health insurance reform. This table reports the results that sample excluded the elderly from 2021 (5,495 elderly) to minimize interference from the early period of DRGs payment implementation. Dependent indicators were logarithmically transformed in the model considering the skewed distribution. ***, ** and * denote statistically significant levels of 1%, 5% and 10% respectively

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Hospitalization Expense**	**Drug Expense**	**Treatment Expense**	**Medical Insurance Fund**	**Out-of-pocket**
DRG	0.0113	-0.0800***	0.2879***	-2.8096***	0.4053***
	(0.0107)	(0.0142)	(0.0195)	(0.0500)	(0.0147)
Age	-0.0022***	-0.0025***	0.0050***	-0.0109***	-0.0072***
	(0.0004)	(0.0005)	(0.0007)	(0.0017)	(0.0005)
Gender	0.0732***	0.0924***	0.0691***	-0.0099	0.0074
	(0.0054)	(0.0071)	(0.0098)	(0.0251)	(0.0074)
Married	0.0558***	0.0908***	0.0542***	0.2419***	0.0433***
	(0.0063)	(0.0084)	(0.0116)	(0.0296)	(0.0087)
LOS	0.0524***	0.0597***	0.1037***	0.0324***	0.0474***
	(0.0003)	(0.0005)	(0.0006)	(0.0016)	(0.0005)
M_type	-0.0018***	-0.0037***	-0.0023***	0.0440***	-0.0164***
	(0.0003)	(0.0004)	(0.0005)	(0.0013)	(0.0004)
D_Admission	0.0013***	0.0011***	-0.0007***	-0.0026***	0.0020***
	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0001)
CPI	0.7592***	-3.8285***	0.4190	-17.9937***	3.4629***
	(0.2288)	(0.3042)	(0.4177)	(1.0683)	(0.3141)
GDP_pc	-0.1274**	0.9347***	0.3274***	17.0970***	-2.2905***
	(0.0538)	(0.0715)	(0.0982)	(0.2512)	(0.0739)
H_worker	0.0037	-0.0166	0.1874***	1.1076***	-0.1887***
	(0.0215)	(0.0286)	(0.0392)	(0.1003)	(0.0295)
N_Hospital	-0.0003***	-0.0006***	-0.0004***	-0.0047***	0.0005***
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)
Constant	9.6581***	2.8352***	-0.1954	-159.6207***	30.3131***
	(0.5981)	(0.7954)	(1.0921)	(2.7931)	(0.8212)
Year FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Observations	41,219	41,219	41,219	41,219	41,219
R-squared	0.5232	0.4477	0.4636	0.4024	0.3807

prerequisite for improve healthcare and health equity for elderly population, as it indicates whether public health resources are skewed toward the elderly.

Secondly, we provide rare empirical evidence to explore the health insurance reform effect in financial protection for elderly. One of objective of health reform is to assess the healthcare without financial hardship, hence, it is necessary to explore the effect of DRGs payment on cost sharing. Previous study has indicated implementing DRGs payment contribute to save spending from medical insurance fund and out-of-pocket in high-income settings [31]. This study provided new evidence to support that implementing DRGs payment reduces the spending of medical insurance fund, while increases the spending of out-of-pocket. It means that more of the healthcare burden is shifted from public medical insurance fund to patients, which exacerbates the financial hardship for elderly patients. One potential reason to explain this reducing spending of medical insurance fund is that the use of medical insurance fund affects the performance appraisal of hospitals by the Health Commission, and some hospitals that exceed the medical insurance fund need to pay out of their own pockets. At the same time, hospitals will impose similar requirements on clinicians. Therefore, hospitals will intentionally save the use of medical insurance fund, and some hospitals even regard it as a political task. In this context, hospitals will use less reimbursed drugs and increase the out-of-pocket expense, such as high cost treatment, which will transfer the cost to patients and make patients bear high healthcare expense. Scholars also indicate that with the widespread implementation of DRGs payment, hospital might potentially mitigate cost reductions by transferring the payment burden of elderly and sicker patients, increasing readmission rate, or refusing to admit sicker patients [31].

These findings provide lessons and enlightenment on how to rethink effective implementation strategy for policy to enhance health equity for elderly and achieve UHC. In the following paragraphs, we will share these lessons.

Table 6 Robustness test: considering potential effect of the COVID this table reports the results that sample excluded the elderly from 2020 (5,520 elderly) to reduce the effect of the pandemic period. Dependent indicators were logarithmically transformed in the model considering the skewed distribution. ***, ** and * denote statistically significant levels of 1%, 5% and 10% respectively

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Hospitalization Expense**	**Drug Expense**	**Treatment Expense**	**Medical Insurance Fund**	**Out-of-pocket**
DRG	-0.0705***	-0.1764***	0.2549***	-0.9926***	0.1278***
	(0.0104)	(0.0137)	(0.0192)	(0.0503)	(0.0140)
Age	-0.0023***	-0.0028***	0.0056***	-0.0136***	-0.0070***
	(0.0004)	(0.0005)	(0.0007)	(0.0017)	(0.0005)
Gender	0.0691***	0.0882***	0.0673***	-0.0152	0.0044
	(0.0053)	(0.0071)	(0.0099)	(0.0258)	(0.0072)
Married	0.0611***	0.0933***	0.0639***	0.1562***	0.0493***
	(0.0064)	(0.0085)	(0.0118)	(0.0310)	(0.0087)
LOS	0.0540***	0.0610***	0.1064***	0.0283***	0.0500***
	(0.0003)	(0.0005)	(0.0006)	(0.0017)	(0.0005)
M_type	-0.0022***	-0.0043***	-0.0033***	0.0574***	-0.0184***
	(0.0003)	(0.0004)	(0.0005)	(0.0014)	(0.0004)
D_Admission	0.0013***	0.0012***	-0.0008***	-0.0034***	0.0020***
	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0001)
CPI	2.4530***	-1.6855***	1.3548***	-34.4072***	6.1750***
	(0.2422)	(0.3202)	(0.4482)	(1.1723)	(0.3274)
GDP_pc	-0.2205***	0.7488***	0.6138***	15.1292***	-2.2270***
	(0.0535)	(0.0708)	(0.0990)	(0.2591)	(0.0724)
H_worker	-0.0779***	-0.1202***	0.0924**	1.8815***	-0.2932***
	(0.0214)	(0.0283)	(0.0396)	(0.1035)	(0.0289)
N_Hospital	-0.0002***	-0.0005***	-0.0004***	-0.0048***	0.0006***
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)
Constant	9.2249***	2.9919***	-3.6831***	-125.9007***	27.3072***
	(0.5923)	(0.7832)	(1.0963)	(2.8676)	(0.8009)
Observations	41,194	41,194	41,194	41,194	41,194
R-squared	0.5200	0.4422	0.4637	0.3812	0.3920

Policy tilt matters. Elderly need frequent access to health care and face high health costs. The per capita health expenditure of the elderly in China showed an increasing trend year by year, from 6223 yuan in 2013 to 8998 yuan in 2020, and is expected to exceed 10,000 yuan in the end of 2023 [46]. Meanwhile, the elderly are more likely to suffer health inequities due to their health status and social vulnerability, thus need more support from public health resources. Although China has made many efforts to reduce the health care costs for elderly population, such as expending health coverage and increasing the financial standard of health reimbursement. However, those policies are not sufficient to establish effective protection mechanisms for elderly populations, especially for elderly in low-income regions. For example, according to the latest policy, the individual contribution of urban elderly medical insurance will be 380 yuan in 2024, while the average pension of these elderly population is only 100 yuan. The elderly are vulnerable to financial hardship due to access to necessary health care services, hence, more policy tilt is needed to help them improve their health care.

Cost sharing is a prerequisite for promoting health equity. The improvement in health will probably depend on who shares and the nature of those benefits. We found implementing DRGs payment reduces spending of medical insurance fund and save public health resources, whereas more health care costs are shifted concomitantly to elderly patients. That means elderly patients bear an increasing burden of health care costs. Although the implementation of DRGs payment most directly impacts the expenditure of public health insurance funds, any health insurance payment method should consider cost-sharing to avoid cost-shifting that could undermine health equity. In China, 130 million elderly population came from rural areas, accounting for 41.53% of the national elderly population [46]. The main income of many elderly population comes from child support, basic old-age insurance payments, or living allowance, and even a small percentage increased in out-of-pocket could limit access to health care or push them into poverty. Hence, public medical insurance fund is the main pathway to help them get the necessary health care services. However, China currently lacks extensive special policies for elderly, who receive the same reimbursement

Table 7 Alternative test: Effect of DRG payment on healthcare by elderly with varying demographic characteristics. This table reports the results for alternative test by grouping samples with varying demographic characteristics. Panel A reports sample with female, panel B reports sample with male, Panel C reports sample with married, and Panel D reports sample with unmarried. Dependent indicators were logarithmically transformed in the model considering the skewed distribution. ***, ** and * denote statistically significant levels of 1%, 5% and 10% respectively

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Hospitalization Expense**	**Drug Expense**	**Treatment Expense**	**Medical Insurance Fund**	**Out-of-pocket**
Panel A: Sample with female patient					
DRG	0.0123	-0.0775***	0.2497***	-1.8224***	0.2503***
	(0.0132)	(0.0184)	(0.0245)	(0.0608)	(0.0169)
Control variables	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Constant	11.1662***	4.7627***	-2.1910	-129.6080***	27.6414***
	(0.8752)	(1.2273)	(1.6323)	(4.0451)	(1.1270)
Observations	19,518	19,518	19,518	19,518	19,518
R-squared	0.5353	0.4440	0.4762	0.3557	0.4093
Panel B: Sample with male patient					
DRG	0.0053	-0.0807***	0.2864***	-1.8295***	0.2873***
	(0.0120)	(0.0156)	(0.0220)	(0.0566)	(0.0174)
Control variables	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Constant	9.2194***	3.1900***	-1.0443	-150.7534***	29.9807***
	(0.7696)	(1.0009)	(1.4145)	(3.6329)	(1.1137)
Observations	27,196	27,196	27,196	27,196	27,196
R-squared	0.5049	0.4328	0.4481	0.3776	0.3408
Panel C: Sample with married patient					
DRG	0.0209**	-0.0578***	0.2887***	-1.8245***	0.2976***
	(0.0092)	(0.0124)	(0.0169)	(0.0422)	(0.0128)
Control variables	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Constant	11.0672***	5.3382***	-0.0800	-142.3786***	31.2642***
	(0.6113)	(0.8219)	(1.1241)	(2.8032)	(0.8521)
Observations	44,084	44,084	44,084	44,084	44,084
R-squared	0.5102	0.4303	0.4553	0.3567	0.3477
Panel D: Sample with unmarried patient					
DRG	-0.0143	-0.1583***	0.3382***	-1.8382***	0.1425***
	(0.0411)	(0.0522)	(0.0815)	(0.2388)	(0.0550)
Control variables	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Constant	1.7889	-3.1788	-5.6993	-43.9950***	4.5957
	(2.5004)	(3.1780)	(4.9600)	(14.5394)	(3.3498)
Observations	2,630	2,630	2,630	2,630	2,630
R-squared	0.5333	0.4755	0.4992	0.4193	0.4302

rates as other age groups. Additionally, health insurance reform has not significantly changed the cost-sharing ratios. For example, in Guangxi, the reimbursement rate for urban residents hospitalized in tertiary hospitals remained at 55% during both the FFS and DRGs periods. Although China offers medical assistance to extremely impoverished elderly, this assistance requires proactive application. Due to a lack of awareness about health policies among elderly, they often fail to benefit from these provisions in a timely manner. China's health reform aims to achieve UHC, that is to ensure people obtain high quality health care without financial hardship, rather than designs to control public insurance fund expenditure. With the aging population, investment in health

for elderly population to improve financial protection for elderly is essential to obtain UHC and health equity.

Health care expense is determinant factor. Health care expense is the major driver to determine the access to health care, to achieve UHC, health reform should offer affordable access to health care. Regrettably, our evidences indicate a increasing trend of health care expenses for elderly population after implementing DRGs payment reform. This reflects that the current mechanism of health reform does not address the core problem of improving health care and health equity. Although China is constantly expanding the list of drug reimbursement under medical insurance, some advanced drugs and treatment technologies are not covered by medical insurance, which undoubtedly increases the health care expenses of patients. High drug and treatment costs can lead elderly population to have negative attitudes towards accessing health care services, which will lead to the neglect of primary health care and aggravate health risks.

Based on the underlying discussion above, we propose several policy implications for China and other LMICs facing challenges in health financing, as well as regions experiencing pressure on public funds during the post-COVID 19 pandemic, to enhance health equity in elderly healthcare and achieve the UHC goals.

First, the proportion of medical insurance reimbursement should be more skewed to the elderly. At present, the public health insurance reimbursement rates in China vary depending on the level of the hospital. For example, for elderly individuals covered by rural medical insurance, the reimbursement rates are 60%, 40% and 30% for township or county hospitals, second level hospitals, and tertiary level hospitals, respectively, with various reimbursement restricted conditions. However, elderly in LMICs are already facing financial crises and rely more on public health services. Therefore, policymakers in LMICs should expand the reimbursement rates for health services for elderly and provide a hierarchical reimbursement design based on the age of the elderly. For instance, a separate cost-sharing policy could be established for elderly patients, with reimbursement rates increasing as patients age, thereby reducing their out-of-pocket expenses. Additionally, the reimbursement rate for elderly patients treated at tertiary hospitals should be increased, and the cost compensation for these hospitals should be enhanced to prevent discrimination against elderly patients. Meanwhile, LMICs should cover more commonly used drugs and treatment techniques for elderly in public health insurance. It is particularly important to establish a dynamic reimbursement update mechanism to promptly capture and update commonly used drugs and treatment technologies for elderly to achieve health equity.

Second, improving financial protection for elderly is essential in health reform to achieve health equity in LMICs. Commercial insurance is rarely applicable to the elderly, whose cost sharing primarily relies on public health insurance funds and the out-of-pocket. The increased financial hardship from out-of-pocket expences significantly affects the elderly's access to healthcare services. International experience indicates that any single health payment method must be integrated with other policies to promote health equity, to reduce the financial hardships elderly individuals face when accessing healthcare services, LMICs should implement additional fiscal policies to mitigate the impact of DRGs payment and increase the allocation of health and financial resources to the elderly. Governments can allocate a larger proportion of health resources to the elderly, develop various forms of medical subsidies tailored to their healthcare needs, and exempt high-aged elderly individuals from personal health insurance premiums nationwide, ensuring that elderly patients receive affordable and effective healthcare services. Additionally, evidences from this study and other such LMICs indicated DRGs payment reform have the potential risk of guiding patients to overtreat and enter higher payment groups. Hence, referring to the experience from other high-income countries, setting the out-of-pocket limit was seen as an important mechanism for elderly financial protection in LMICs. China and other LMICs can set the out-of-pocket maximum for common and serious diseases in the elderly. Setting the out-of-pocket maximum can effectively reduce hospital-induced medical services and avoid shifting healthcare costs to elderly patients.

This study has two strengths. First, most studies used the China health and Retirement Longitudinal Study (CHARLS) data to investigate healthcare services received by elderly, however, the CHARLS data is self-reported and updated every two to three years, recall bias is inevitable. To the best of our knowledge, this is the first study to obtain hospital discharge data from 2013 to 2023 at national level, to explore the effect of health insurance reform on health care and financial protection for elderly using a nationally representative population. Second, in the initial stage of health insurance reform in China, this study provides rare empirical evidences to highlight the health insurance reform should strengthen policy support and financial protection for elderly.

Additionally, our study has several limitations that should be considered. First and foremost, due to the sensitivity and difficulty in obtaining health insurance data, despite our best attempts to expand the sample size, we are still concerned that these findings may not be nationally representative. Therefore, future studies are welcome to include data from more provinces to address this limitation. Secondly, the data coverage of our study

spans from 2013 to 2023, which China began planning to promote DRGs payment reform nationwide from 2020. Our study's sample stared implementing DRGs payment in 2021, so the DRGs payment phase includes data only from 2021 to 2023, leading to data imbalance issues. Although we shortened the study period in robustness checks and used balanced data to verify the stability of our baseline results, this remains a potential limitation of this study. Thirdly, this study only explores the implementation effect of health coverage reform in the initial stage. We recognize that the reform effects are often most significant during the initial implementation stage and may stabilize or change over time. Additionally, the study's data covered the period of the pandemic, raising concerns about potential biases during this time. Therefore, further evaluation of implementation effects and observation over longer period is needed. Fourthly, due to the extreme difficulty of obtaining health insurance data, our study only focuses on cerebral infarction as a common chronic diseases among the elderly, which may introduce potential sample biases, We welcome future research to include a wider range of disease and investigate the effect of health reform on other elderly diseases, providing a more comprehensive understanding of implementation effects of health reform in China. Finally, this study focuses on the health reform effects of a country like China, which faces challenges in healthcare financing and has a large elderly healthcare service market. Future research can verify and complement our findings by studying similar cases in other LMICs or regions with different healthcare financing backgrounds, offering a broader perspective for global health care.

Conclusion

At a critical stage when countries are working to promote UHC, this study is the first to assess the implementing effect of health reform on health care for elderly at national level in China, to explore whether the ongoing health care reform contribute to improve health equity and financial protection. We found the implementing of health insurance reform reduces drug expenses but increases health care expenses received by elderly. Additionally, this reform reduces spending of medical insurance fund and save public health resources, whereas more health care expenses are shifted concomitantly to elderly and increased financial hardship for elderly. Those evidences highlight the proportion of medical insurance reimbursement should be more skewed to the elderly, meanwhile, cost sharing is a prerequisite for promoting health equity. This study shares the lessons from China's health reform and provides enlightenment on how to effective implement health reform to improve health equity and achieve UHC in such similar LMICs facing challenges in health financing.

Author contributions
H.W. wrote and critical reviewed the manuscript, analyzed data and results and X.X. conceptualized and designed the study. All authors read and approved the final manuscript.

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Data availability
The data that has been used are confidential.

Declarations

Ethics approval and consent to participate
This study was conducted with the approval of the Ethics Committee of Guangxi Academy of Medical Sciences (IIT-2023-79).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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