Risk Management and Healthcare Policy Dovepress

Open Access Full Text Article ORIGINAL RESEARCH

The Impact of a New Case-Based Payment System on Quality of Care: A Difference-in-Differences Analysis in China

Xinyu Zhang[1,2], Mengcen Qian[1,3], Jiaqi Yan[1], Ruixin Wang[1], Dawei Lyu[1,4], Xiaohua Ying[1,3], Shenglan Tang[2,5,6]

[1]School of Public Health, Fudan University, Shanghai, People's Republic of China; [2]Global Health Research Center, Duke Kunshan University, Kunshan, Jiangsu, People's Republic of China; [3]Key Laboratory of Health Technology Assessment, National Health Commission (Fudan University), Shanghai, People's Republic of China; [4]Shanghai Healthcare Security Administration, Shanghai, People's Republic of China; [5]Duke Global Health Institute, Duke University, Durham, NC, USA; [6]SingHealth Duke-NUS Global Health Institute, Duke-NUS, Singapore, Singapore

Correspondence: Xiaohua Ying, School of Public Health, Fudan University, 130 Dong'an Road, Shanghai, 200030, People's Republic of China, Email xhying@fudan.edu.cn

Purpose: China has developed and widely piloted a new case-based payment, ie, the "Diagnosis-Intervention Packet" (DIP) payment, which has a granular classification system. We evaluated the impact of DIP payment on the quality of care in a large pilot city in China and explored potential mechanisms of quality change.

Methods: The city started to implement DIP payment with a hospital-level cap on July 1, 2019. Using a 5% random sample of discharge records from July 2017 to June 2021, we employed a difference-in-differences approach to compare two mortality measures (in-hospital mortality, mortality of surgical patients), two readmission measures (all-cause readmission within 30 days, readmission with the same principal diagnosis within 30 days) and a patient safety measure (operation associated complications or adverse event) in 13 pilot hospitals and 27 non-pilot hospitals before and after DIP payment reform.

Results: Of 122,637 discharge records included, 43,023 (35.1%) were from pilot hospitals. After DIP payment, the readmission rate within 30 days and readmission rate with the same principal diagnosis in pilot hospitals decreased significantly by 3.2 percentage points (P <0.001) and 1.8 percentage points (P <0.001), respectively. The in-hospital mortality rate, the mortality rate of surgical patients, and the rate of operation-associated complications or adverse events did not have significant changes. The decrease in quality measures was primarily driven by tertiary hospitals, was more obvious over time after the policy adoption, and was more pronounced in groups with higher intensity of care.

Conclusion: This study indicated that DIP payment with a cap in the study city was associated with improved quality of care among patients in pilot hospitals. The provider's behavior of increasing the intensity of care, especially for more severe patients, may partially contribute to the results.

Keywords: prospective payment system, Diagnosis-Intervention Packet (DIP), quality of healthcare, policy evaluation, China

Introduction

The prospective payment system (PPS) is widely used worldwide to contain rapidly increasing inpatient costs and avoid unnecessary services, and case-based payment is one of the popular methods.[1,2] Total expenditure per hospitalization in public hospitals in China has doubled from 5856.2 RMB in 2009 to 11468.6 RMB in 2022 (exchange rate: 6.74 RMB=US $1.00 in 2022).[3,4] Therefore, case-based payment has been piloted nationwide over the past three years, replacing the previously dominant fee-for-service (FFS) system. In addition to the traditional Diagnosis-Related-Groups (DRG) payment, China also developed a new case-based payment known as the "Diagnosis-Intervention Packet" (DIP) payment. The concurrent implementation of DRG/DIP payment in China is also referred to as the "dual-track" arrangement.[5] The DIP payment is distinguished from DRG payment mainly due to its more granular classification. In

Received: 26 July 2024
Accepted: 1 December 2024
Published: 11 December 2024

the DIP payment system, patient classification is based on the data-driven combination of the principal diagnosis and procedures, which could yield thousands of groups, while there are usually no more than 1000 groups in the DRG payment system. DIP groups with the same diagnosis while higher treatment intensity, ie, higher resource consumption, will receive higher reimbursement. With more straightforward classification rules and less involvement of clinical experts compared to DRG payment, DIP payment has rapidly rolled out in China.[6]

The premise of the same payment for a given group in the case-based payment is the similar healthcare quality across different providers. However, the payment system itself also has an important impact on the quality of care.[7] DIP payment could change the quality of care by influencing provider behaviors in two pathways (see a diagram of the analytical framework of our study in Figure S1).[8,9] First, as a PPS, the payment amount cannot be influenced by the service providers for a given DIP group, which is similar to the incentive under the DRG payment, and it may incentivize providers to select more profitable diseases or patients to minimize the cost. If hospitals admit patients with low-risk diseases or less severe patients with lower costs, their quality of care may be improved. Second, providers may also adapt their treatment strategy. To minimize costs, providers may also reduce services, even necessary ones, in a specific DIP group.[10] On the other hand, under the granular classification system with higher payment for groups with higher treatment intensity, which is a major difference from DRG payment, providers may increase the intensity of care by providing sophisticated treatment to maximize their revenue.[11,12] This hospital response is expected to be easier to implement and thus much stronger than in the DRG payment. However, the impact of such behaviors on the quality of care is unclear, depending on whether the behavior changes are moving towards or away from the best clinical practices.[8]

Previous studies provided less empirical evidence on the association of case-based payment with the quality of care compared to costs and efficiency, especially in low- and middle-income countries.[13] Furthermore, these studies have inconsistent results.[14] Some studies found a decrease in the in-hospital mortality rate following DRG payment reform,[15,16] while others indicated no significant change.[17–20] Some found the readmission rate increased,[15,16,20] yet others reported no significant change or even a decrease.[14,17,19,21–24] In addition to different study populations and designs, the differences in the case-based payment policies and the policy context may largely contribute to the variation of study results. Specifically in China, studies generally concluded that DRG payment had no significant impact on the in-hospital mortality or readmission rate.[13,25] For DIP payment, one study found no significant change in the operation-associated infection rate.[6] Two other studies found no change in readmission volume or in-hospital mortality rate.[26,27] However, they merely incorporated quality measures as a part of the overall analysis and did not systematically examine the association of DIP payment with the quality of care or explore its underlying reasons. Therefore, it is crucial to comprehensively understand the quality changes and how they were achieved through hospital responses after the new DIP payment reform in the context of China. The findings of this study will reveal if unintended consequences regarding health outcomes emerged after the payment reform and indicate the provider behaviors to be closely monitored with the nationwide implementation of the DIP payment to avoid the deterioration of patient benefits. Since the DIP payment has the potential to be easily implemented and rapidly rolled out in resource-limited areas,[6] the results of our study could also yield implications for the payment system reform in other low- and middle-income countries.

Therefore, the objective of our study is to examine the impact of DIP payment reform on the quality of healthcare in hospitalized patients covered by basic medical insurance in a large pilot city in East China, which is one of the first DIP-pilot cities, and explore potential mechanisms of quality change to provide evidence for future payment system reform in China and other countries. We first observed the overall impacts of DIP payment reform on the quality of care. Then, we conducted a heterogeneous effect analysis among different hospital levels. We then examined the temporal dynamic effects after the reform. We also did additional analyses to explore the possible reasons for quality change.

Materials and Methods

Setting

Our study city is one of the largest and most developed cities in China. In 2022, it has a 19.9 million insured population, with the majority (16.2 million, 81.6%) covered by the employee basic medical insurance scheme (EBMIS).[28] Before the case-based payment reform, the city implemented FFS payment with a hospital-level cap.

The city started to pilot DIP payment with a hospital-level cap on July 1, 2019. The first batch of pilot hospitals included two public tertiary hospitals and all secondary acute care hospitals in two districts, with hospitalized EBMIS patients as the target population. Using the discharge data in the past three years, over 14,000 DIP groups were generated based on the combination of the first four digits of the ICD-10 (International Classification of Diseases, Tenth Revision) code of principal diagnosis with the ICD-9-CM-3 (International Classification of Diseases, 9th Revision, Clinical Modification) codes of procedures. Relative weight (RW) was calculated by dividing the average expenditure of a certain group by that of all discharge cases.

Data and Study Population

We included hospitalized EBMIS patients in public tertiary and secondary hospitals as our study population. Some secondary hospitals have been promoted by the local health authority to tertiary, but are still regarded as secondary by the payer. Thus, we further divided secondary hospitals into promoted secondary and other secondary hospitals. The intervention group was EBMIS patients in two tertiary hospitals, two promoted secondary and nine other secondary hospitals, which started the DIP payment pilot in July 2019. The control group was EBMIS patients in eight tertiary hospitals, three promoted secondary and 16 other secondary hospitals, which did not participate in DRG/DIP payment until July 2021.

Using a simple random sampling approach, we considered the representativeness and computational feasibility of the dataset to use a 5% sample selected from the full dataset of deidentified discharge records of EBMIS patients in this city from July 2017 to June 2021. The dataset contains information on patient and hospital characteristics, admission and discharge status, diagnoses and procedures, inpatient expenditure, DIP groups, and corresponding RW at the discharge level. In terms of data processing, we dropped 0.0006% of the discharge records with missing gender information before sampling.

Outcome Measures

We included five primary quality outcomes from aspects of effectiveness and safety.[29] For effectiveness indicators, we included in-hospital mortality, mortality of surgical patients, all-cause readmission within 30 days, and readmission with the same principal diagnosis within 30 days. The measure of patient safety was operation-associated complications or adverse events. All measures are binary variables at the discharge level.

In-hospital mortality is commonly used as an important quality indicator in acute care hospitals. It was recognized by discharge status as "death" at the individual level. All-cause readmission is another widely used quality measure. However, only the unexpected readmission following prior care can accurately indicate low quality. To better reflect the actual quality of care, we followed some studies to use an additional indicator of readmission with the same principal diagnosis (defined as the same first three digits of ICD-10 codes),[30,31] as quality problems are more likely to arise in diagnostically related admissions.[31] Although it may include false positive cases and miss true positive ones,[31] it could serve as a supplement and mutual verification with the all-cause readmission. The indicator of operation-associated complications or adverse events was aggregated by 19 specific conditions (Table S1) defined by the National Health Commission of China.[32]

Statistical Analysis

We used difference-in-differences (DID) approach with linear regression at the discharge level to explore the association of DIP reform with the quality of care. For patient i in hospital h in time t:

$$Y_{iht} = \alpha Treatment + \beta Treatment \times Post + \gamma X_{iht} + H_h + \tau_t + \varepsilon_{iht} \tag{1}$$

where Y_{iht} is the outcome variable; *Treatment* is a dummy equal to one for patients in 13 DIP pilot hospitals (intervention group) and zero for 27 non-DIP pilot hospitals (control group). *Post* is a dummy equal to one for discharges after July 1, 2019. The interaction term between *Treatment* and *Post* is the variable of interest. X_{iht} is a set of control variables, including sex, age group, principal diagnosis, Charlson Comorbidity Index (CCI, a commonly used measure of patient severity based on secondary diagnoses) group,[33] and interactions between sex and age group or CCI group. H_h is the region and hospital fixed effects, and τ_t is the time fixed effects at the year-month level. ε_{iht} is the error term, and standard errors are clustered at the hospital-year-month level. We tested the parallel trend assumption by replacing *Post* in the interaction term in equation (1) with a series of year-month dummies during the study period.

Heterogeneous effects in different hospital levels were performed by subsample analysis in 10 tertiary, five promoted secondary, and 25 other secondary hospitals. We observed temporal dynamic changes by replacing *Post* in equation (1) with dummies for the first and second years after DIP reform.

We considered other events or policies during the study period and performed several robustness checks. First, we considered the COVID-19 outbreak by excluding data from December 2019 to March 2020, which was the most affected period in this city.[34,35] Second, since the volume-based procurement of coronary stents started in January 2021 and may influence the quality of related conditions, we excluded data on diseases using coronary stents. Third, the study city started to pilot the pay-for-performance in several inpatient services in late April 2021, so we dropped the data in May and June of 2021 to consider its potential influence on the quality of care. Finally, we excluded data from four hospitals as their records of secondary diagnoses were substantially missing, raising concerns about the quality of discharge records – more than 90% of the discharge records had no secondary diagnoses, which was more likely due to the low data quality rather than the low severity of patients.

To explore potential mechanisms of quality change, we conducted additional analyses guided by the aforementioned analytical framework of how DIP payment may change the quality of care by influencing provider behaviors. First, we introduced two additional mortality measures in low-risk groups to provide insights into the disease selection of hospitals and its potential associations with the quality of care. Second, we analyzed the level and trends of CCI and its association with quality measures to investigate the patient selection behavior and corresponding quality change. Third, we analyzed the change in intensity of care (measured by RW) and its association with the healthcare quality. Since the price of medical services has been continuously changing during the study period, which would affect the relative expenditure of each DIP group, we generated an "adjusted RW" by assigning the RW in 2021 to the same group for each year to balance the influence of price change and observe a cleaner change of healthcare intensity, ie, the change of provider behavior. The three pathways were circled respectively in Figure S1. More detailed methods are in Appendix 1 and Table S2.

All statistical analyses were performed using Stata/MP 16.0. Statistical significance was determined by 2-sided P <0.05.

Results

Sample Characteristics

A total of 122,637 discharge records were included, with 43,023 (35.1%) from pilot hospitals. Table 1 shows that the average patient age in DIP pilot hospitals was about three years lower than in non-pilot hospitals, and they both decreased after DIP payment. The proportion of patients with higher severity in pilot hospitals was slightly lower than in non-pilot hospitals, while it experienced a larger increase after the reform. In both groups, more than 50% of patients were in tertiary hospitals.

As shown in Table 1, the in-hospital mortality rate in DIP pilot hospitals was lower and experienced a larger decrease after the reform. The mortality rate of surgical patients, readmission rate, and readmission rate with the same principal diagnosis all decreased in pilot hospitals while increased in non-pilot hospitals. The rate of operation-associated complications or adverse events increased in both groups. Descriptive statistics of components of the patient safety measure and monthly trends of unadjusted outcome variables are provided in Table S3 and Figure S2.

Main Results

Table 2 presents the results of DID analyses. In the whole sample, compared to non-DIP pilot hospitals, two mortality measures in pilot hospitals decreased after DIP payment, though not significantly. Both readmission measures decreased significantly by 3.2 percentage points (P <0.001) for all-cause readmission rate and 1.8 percentage points (P <0.001) for readmission rate with the same principal diagnosis. The rate of operation-associated complications or adverse events increased slightly but was not significant.

Table 1 Sample Characteristics of Hospitalized Patients Covered by the Employee Basic Medical Insurance Scheme in the Study City

Variable	Pre-DIP Reform (July 2017–June 2019)		Post-DIP Reform (July 2019–June 2021)	
	DIP Pilot Hospitals (n=22,169)	Non-DIP Pilot Hospitals (n=38,334)	DIP Pilot Hospitals (n=20,854)	Non-DIP Pilot Hospitals (n=41,280)
Patient characteristics				
Age, mean (SD), years	57.81 (17.85)	60.67 (17.24)	56.29 (19.51)	59.50 (18.18)
Male sex, No. (%)	10,304 (46.48)	18,721 (48.84)	9762 (46.81)	21,003 (50.88)
Charlson Comorbidity Index, No. (%)				
0	14,210 (64.10)	23,036 (60.09)	12,595 (60.40)	23,966 (58.06)
1	3129 (14.11)	5906 (15.41)	3024 (14.50)	6428 (15.57)
2	2686 (12.12)	5336 (13.92)	2726 (13.07)	5779 (14.00)
≥3	2144 (9.67)	4056 (10.58)	2509 (12.03)	5107 (12.37)
Hospital level, No. (%)				
Tertiary (N=10)	11,636 (52.49)	19,961 (52.07)	10,957 (52.54)	23,504 (56.94)
Promoted secondary (N=5)	4579 (20.65)	7185 (18.74)	4306 (20.65)	7055 (17.09)
Other secondary (N=25)	5954 (26.86)	11,188 (29.19)	5591 (26.81)	10,721 (25.97)
Outcome variables, mean (SD), %				
In-hospital mortality rate	1.34 (11.52)	1.58 (12.45)	0.80 (8.89)	1.26 (11.14)
Mortality rate of surgical patients	0.30 (5.44)	0.33 (5.72)	0.23 (4.75)	0.35 (5.93)
Readmission rate within 30 days	18.58 (38.90)	21.36 (40.98)	17.94 (38.37)	23.71 (42.53)
Readmission rate with the same principal diagnosis within 30 days	10.51 (30.66)	11.49 (31.90)	10.28 (30.37)	13.01 (33.64)
Rate of operation-associated complications or adverse events	2.27 (14.91)	2.50 (15.62)	3.11 (17.35)	2.96 (16.95)

Abbreviations: DIP, Diagnosis-Intervention Packet; SD, standard deviation.

Table 2 Difference-in-Differences Estimates for the Quality of Care Associated with Diagnosis-Intervention Packet Payment

Parameter	Whole Sample (1)	By Hospital Level		
		Tertiary (2)	Promoted Secondary (3)	Other Secondary (4)
In-hospital mortality				
Coefficient	−0.001	−0.006	0.007	0.002
Standard error	(0.001)	(0.001)	(0.003)	(0.003)
P value	0.299	<0.001***	0.022**	0.499
Sample size	122,636	66,057	23,125	33,454
Mortality of surgical patients				
Coefficient	−0.001	−0.001	−0.004	−0.001
Standard error	(0.001)	(0.001)	(0.002)	(0.001)
P value	0.319	0.589	0.131	0.540
Sample size	43,546	26,103	7268	10,175
Readmission within 30 days				
Coefficient	−0.032	−0.045	−0.018	−0.013
Standard error	(0.008)	(0.012)	(0.010)	(0.009)
P value	<0.001***	<0.001***	0.054*	0.126
Sample size	122,637	66,058	23,125	33,454

(*Continued*)

Table 2 (Continued).

Parameter	Whole Sample (1)	By Hospital Level		
		Tertiary (2)	Promoted Secondary (3)	Other Secondary (4)
Readmission with the same principal diagnosis within 30 days				
Coefficient	−0.018	−0.021	−0.015	−0.011
Standard error	(0.005)	(0.008)	(0.008)	(0.007)
P value	<0.001***	0.009***	0.059*	0.087*
Sample size	122,637	66,058	23,125	33,454
Operation-associated complications or adverse events				
Coefficient	0.002	0.002	0.012	0.002
Standard error	(0.003)	(0.004)	(0.007)	(0.004)
P value	0.450	0.524	0.096*	0.551
Sample size	43,546	26,103	7268	10,175

Notes: Each column of each variable is a separate difference-in-differences regression. The coefficients, standard errors, and *P* values of interaction terms between post and treatment are reported for the whole sample (column (1)), tertiary hospitals (column (2)), promoted secondary hospitals (column (3)), and other secondary hospitals (column (4)). All specifications include the full set of control variables (ie, indicators for sex, age groups, principal diagnosis, and CCI group, interactions between sex and age group dummies, interactions between sex and CCI group dummies), regional and hospital fixed effects, and year-by-month fixed effects. Standard errors are clustered at the hospital-year-month level. * denotes *P* <0.1; ** *P* <0.05; *** *P* <0.01.
Abbreviation: CCI, Charlson Comorbidity Index.

For heterogeneous effects across hospital levels, the results in columns (2)-(4) of Table 2 showed that the in-hospital mortality rate decreased significantly in tertiary hospitals by 0.6 percentage points (*P* <0.001) while increased significantly by 0.7 percentage points (*P* =0.022) in promoted secondary hospitals, and remained statistically unchanged in other secondary hospitals. The mortality rate of surgical patients and the rate of operation-associated complications or adverse events had no significant change at any hospital level, aligning with the whole sample. Both measures of readmission rates only decreased significantly in tertiary hospitals by 4.5 percentage points (*P* <0.001) and 2.1 percentage points (*P* =0.009), respectively, and decreased more than in secondary hospitals.

Table 3 shows the temporal dynamic quality changes after DIP reform. The in-hospital mortality rate, all-cause readmission rate, and readmission rate with the same principal diagnosis decreased significantly in the second year of

Table 3 Temporal Dynamic Changes in the Quality of Care After Diagnosis-Intervention Packet Payment Reform

Parameter	First Year of Adoption (July 2019–June 2020) (1)	Second Year of Adoption (July 2020–June 2021) (2)
In-hospital mortality		
Coefficient	0.000	−0.003
Standard error	(0.002)	(0.002)
P value	0.831	0.042**
Sample size	122,636	122,636
Mortality of surgical patients		
Coefficient	−0.001	−0.001
Standard error	(0.001)	(0.001)
P value	0.382	0.444
Sample size	43,546	43,546

(*Continued*)

Table 3 (Continued).

Parameter	First Year of Adoption (July 2019–June 2020) (1)	Second Year of Adoption (July 2020–June 2021) (2)
Readmission within 30 days		
Coefficient	−0.005	−0.059
Standard error	(0.007)	(0.011)
P value	0.538	<0.001***
Sample size	122,637	122,637
Readmission with the same principal diagnosis within 30 days		
Coefficient	−0.004	−0.033
Standard error	(0.005)	(0.007)
P value	0.440	<0.001***
Sample size	122,637	122,637
Operation-associated complications or adverse events		
Coefficient	0.006	−0.001
Standard error	(0.003)	(0.003)
P value	0.081*	0.676
Sample size	43,546	43,546

Notes: Each column of each variable is a separate difference-in-differences regression. The coefficients, standard errors, and *P* values of interaction terms between post and treatment are reported for the first year (column (1)) and secondary year (column (2)) of policy adoption. All specifications include the full set of control variables (ie, indicators for sex, age groups, principal diagnosis, and CCI group, interactions between sex and age group dummies, interactions between sex and CCI group dummies), regional and hospital fixed effects, and year-by-month fixed effects. Standard errors are clustered at the hospital-year-month level. * denotes $P<0.1$; ** $P<0.05$; *** $P<0.01$.
Abbreviation: CCI, Charlson Comorbidity Index.

DIP payment adoption by 0.3 percentage points ($P=0.042$), 5.9 percentage points ($P<0.001$) and 3.3 percentage points ($P<0.001$), respectively. The changes in the mortality rate of surgical patients and the rate of operation-associated complications or adverse events were not significant in either of the two years.

As indicated in Figure 1, there were no pre-existing differential changes in outcome variables between the pilot and non-pilot hospitals prior to DIP reform. In the robustness checks (Table 4), the directions and significance of coefficients for all indicators remained consistent considering the outbreak of COVID-19, volume-based procurement of coronary stents, pilot of pay-for-performance, and the quality of discharge records.

Additional Results

Two mortality measures in low-risk groups had no change in the whole sample and across all hospital levels, except for a significant decrease in the mortality rate of low-risk DIP groups in tertiary hospitals (Tables S4 and S5). Table S6 and Figure S3 presented a similar trend of CCI between the pilot and non-pilot hospitals in the overall sample and a larger increase in CCI after DIP payment in pilot tertiary hospitals compared to non-pilot tertiary hospitals. When exploring the heterogeneous associations with quality measures in different patient severities, we found that compared to patients with lower severity, the in-hospital mortality decreased significantly, and the two readmission measures decreased more in more severe patients, as shown in Table S7. Tables S8 and S9 and Figure S4 demonstrated a significant increase in the intensity of care measured by RW in the whole sample and tertiary hospitals. We also observed a generally more obvious decrease in quality measures in groups with higher RW (Figures S5–S9), especially for two readmission measures in the whole sample and tertiary hospitals. An exception is that for promoted secondary hospitals, the in-hospital mortality rate significantly increased in the group with a higher intensity of care.

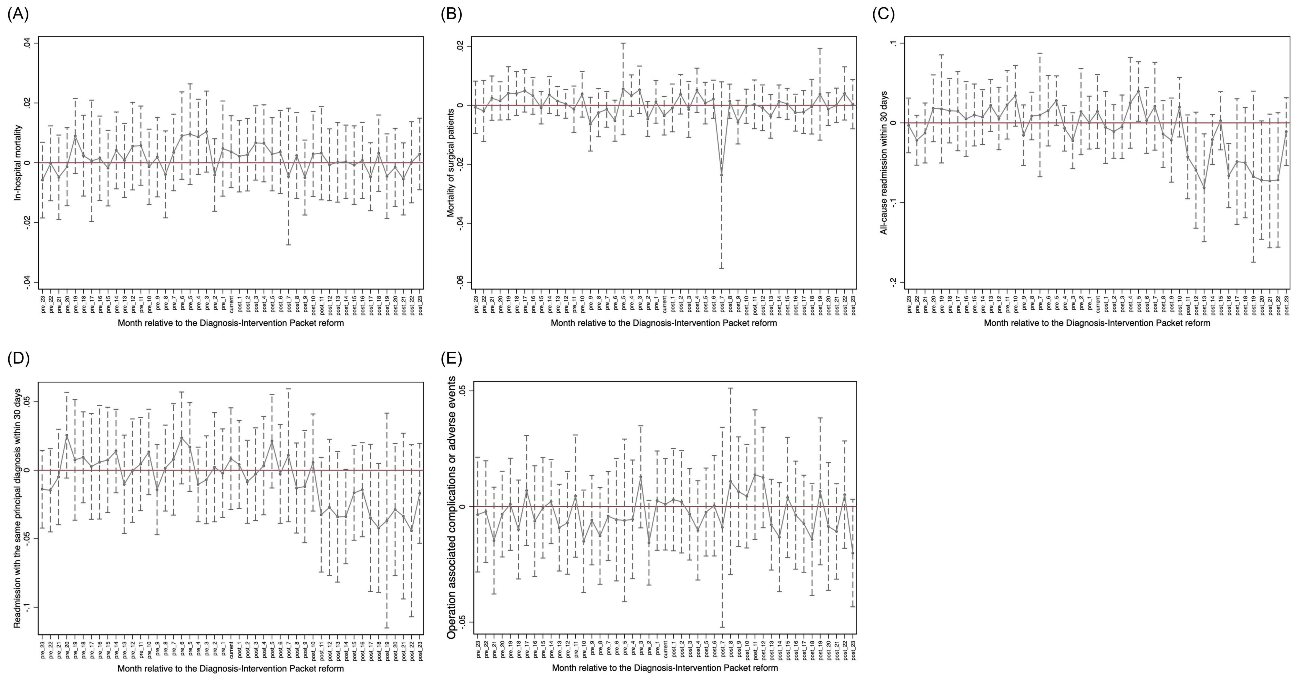

Figure 1 Tests on the validity of parallel assumptions of quality measures.

Notes: We replaced the post dummy in the interaction term in equation (1) with a series of year-month dummies. Changes in differences of the outcomes (A for in-hospital mortality, B for mortality of surgical patients, C for readmission within 30 days, D for readmission with the same principal diagnosis within 30 days, and E for operation-associated complications or adverse events) between patients in DIP pilot and non-DIP pilot hospitals relative to the first month of the study are plotted against the time to the DIP payment reform.

Abbreviation: DIP, Diagnosis-Intervention Packet.

Discussion

This study focused on the impact of the DIP payment reform in July 2019 on the quality of care in a large city in China. We found that DIP payment with a cap in the city was associated with improved healthcare quality. In particular, the readmission measures showed consistent results of both decreasing significantly, while the mortality measures and the quality safety indicator did not have significant changes. These results are robust considering other events or policies during the study period. Meanwhile, the quality improvement was primarily driven by tertiary hospitals and was more obvious over time after the policy adoption.

Table 4 Robustness Checks Considering COVID-19 and Other Policies During the Study Period

Parameter	COVID-19 (1)	Volume-based Procurement of Coronary Stents (2)	Pay-for-Performance (3)	Quality of Discharge Records (4)
In-hospital mortality				
Coefficient	−0.002	−0.001	−0.001	−0.002
Standard error	(0.001)	(0.001)	(0.001)	(0.001)
P value	0.262	0.513	0.281	0.174
Sample size	114,677	115,912	116,935	119,815
Mortality of surgical patients				
Coefficient	−0.001	−0.001	−0.001	−0.001
Standard error	(0.001)	(0.001)	(0.001)	(0.001)
P value	0.396	0.249	0.196	0.321
Sample size	41,021	41,667	41,522	43,138

(*Continued*)

Table 4 (Continued).

Parameter	COVID-19 (1)	Volume-based Procurement of Coronary Stents (2)	Pay-for-Performance (3)	Quality of Discharge Records (4)
Readmission within 30 days				
Coefficient	−0.038	−0.034	−0.030	−0.032
Standard error	(0.008)	(0.008)	(0.008)	(0.008)
P value	<0.001***	<0.001***	<0.001***	<0.001***
Sample size	114,678	115,913	116,936	119,816
Readmission with the same principal diagnosis within 30 days				
Coefficient	−0.022	−0.021	−0.017	−0.017
Standard error	(0.005)	(0.005)	(0.005)	(0.005)
P value	<0.001***	<0.001***	0.001***	<0.001***
Sample size	114,678	115,913	116,936	119,816
Operation-associated complications or adverse events				
Coefficient	0.002	0.002	0.003	0.002
Standard error	(0.003)	(0.003)	(0.003)	(0.003)
P value	0.531	0.395	0.328	0.512
Sample size	41,021	41,667	41,522	43,138

Notes: Each column of each variable is a separate difference-in-differences regression. The coefficients, standard errors, and *P* values of interaction terms between post and treatment are reported. In column (1), we dropped data from December 2019 to March 2020 to consider the impact of COVID-19. In column (2), we dropped data on diseases using coronary stents (ICD-10 codes: I20.0, I20.8, I20.9, I21, I24.9, I25.1, I25.2, Z95.5) to consider the impact of volume-based procurement of coronary stents on January 20, 2021. In column (3), we dropped data in May and June of 2021 to consider the impact of the pay-for-performance pilot. In column (4), we dropped data in four hospitals with a potential problem of the lower quality of discharge records. All specifications include the full set of control variables (ie, indicators for sex, age groups, principal diagnosis, and CCI group, interactions between sex and age group dummies, interactions between sex and CCI group dummies), regional and hospital fixed effects, and year-by-month fixed effects. Standard errors are clustered at the hospital-year-month level. *** *P* <0.01.
Abbreviations: ICD-10, International Classification of Diseases, Tenth Revision; CCI, Charlson Comorbidity Index.

That the quality of care has been maintained, or even improved after case-based payment was consistent with several previous studies. For example, studies on in-hospital mortality in Poland,[17] England,[19] Japan,[20] and two cities[13,25] in China all showed no significant change after DRG or DRG-like payment. Another two studies on DIP payment in a different city in China also have similar results.[26,36] Regarding the readmission rate, while some studies reported an increase after the reform, such as patients in Switzerland[15] and Japan,[20] many other studies found no change[14,17,19,21,25,37] or even a significant decrease.[22] The no change in the patient safety measure was consistent with a study in another DIP pilot city.[6]

There was no evidence of the selection of less severe patients since we did not observe an overall decrease in CCI in pilot hospitals, and the quality improvement was even more obvious in patients with higher severity, which was consistent with another study focused on the patient selection behavior after the DIP reform in this city.[38] Regarding the intensity of care, a previous study theoretically demonstrated that providers tend to increase the intensity of care for higher payments when providing different payments for different treatment intensities.[12] Our study empirically supported this inference by finding a significant overall increase in RW. Moreover, this behavior change partially contributed to the quality improvement, as quality measures in groups with higher intensity of care improved more. These two findings supported each other as sophisticated care would be generally provided to more severe patients. Another noteworthy point is that, despite the increase in RW, it would not necessarily result in an unexpected rise in total inpatient expenditure due to the cap. No change in the patient safety indicator could be attributed to the sustained focus of national and local health authorities prior to the payment system reform, leaving limited space for additional improvements.

The more obvious quality improvement in tertiary hospitals was consistent with our expectations and other studies. For example, a study from Korea found that the readmission rate in large hospitals declined more than in small hospitals after the DRG reform.[22] A general explanation is that tertiary hospitals had a greater capacity to adapt and improve their clinical and administrative practices after the payment reform, which was also supported by our interviews with managers of pilot hospitals. Specifically, we found that tertiary pilot hospitals admitted more severe patients after DIP payment, meanwhile significantly increased the intensity of care. Moreover, the in-hospital mortality rate in the higher-intensity group exhibited a more obvious decrease than the lower-intensity group in tertiary hospitals, while the same indicator in the higher-intensity group, on the contrary, increased significantly in promoted secondary hospitals. Thus, similar hospital responses may not necessarily lead to similar quality changes, which may depend on hospitals' clinical and administrative competence. Another possible explanation is that promoted secondary hospitals admitted patients with high-risk diseases after the reform, possibly transferred from tertiary hospitals. The evidence is that two mortality measures in low-risk groups did not have significant changes in secondary hospitals.

The more obvious quality improvement over time was also aligned with our expectations and what other studies have found already.[6] At the beginning of policy implementation, providers had limited knowledge about the policy and its incentives and thus did not have immediate responses. As time went by, hospital administrators and physicians had a deeper understanding of the new policy through several training programs. Their knowledge was further reinforced after they received reimbursements, leading to stronger responses to the reform.

To our knowledge, this is the first empirical evidence of the comprehensive impacts of DIP payment on the quality of care and its underlying mechanisms. Using a range of quality measures, we found that the case-based payment with a cap applying a more granular classification system has the potential to improve quality, which was previously a major concern of policymakers and was thus in need of empirical evidence. We found that the quality improvement was at least partially attributed to the increase in intensity of care, especially in more severe patients. This major difference with the DRG payment may contribute to the broad roll-out of DIP payment in other cities in China and the payment reform in other low- and middle-income countries. However, we should keep in mind that quality improvement is not the main objective of case-based payment reform but a guarantee of its further roll-out. Long-term monitoring of the influences of DIP payment and its associations with specific diseases is also necessary. In addition, the differential impacts on tertiary and secondary hospitals need to be paid close attention in case the benefits of secondary hospitals and their patients are unevenly affected.

Limitations

Our study has several limitations. First, we did not explore the association of DIP payment with process measures of quality since the administrative discharge records we used did not contain further detailed information on the adherence to clinical guidelines and timeliness of care, etc., which could be more responsive to the policy reform. Second, we only observed the short-term influence in this city, and uncertainties remain in the long run and in other pilot cities. Although our study found a more obvious quality improvement during the first two years after the DIP payment, the quality outcomes and potential unintended results of the stronger provider responses in a longer period are unknown and need observation in the future. Third, due to data limitations, we did not observe the potential spill-over effects from EBMIS patients to other patients. Fourth, COVID-19 may have a lasting influence on hospital health services. However, we did not find a deterioration in the quality of care due to the increase in patient severity after the pandemic.

Conclusion

In this study evaluating the quality change after DIP payment in a large pilot city in China, DIP payment with a cap was associated with improved quality of care among patients in pilot hospitals. The provider's behavior of increasing the intensity of care, especially for more severe patients, may partially contribute to the results. This may contribute to the further roll-out of DIP payment in other cities in China and the payment reform in other low- and middle-income countries.

Abbreviations

PPS, prospective payment system; FFS, fee-for-service; DRG, Diagnosis-Related-Groups; DIP, Diagnosis-Intervention Packet; EBMIS, employee basic medical insurance scheme; ICD-10, International Classification of Diseases, Tenth Revision; ICD-9-CM-3, International Classification of Diseases, 9th Revision, Clinical Modification; RW, relative weight; DID, difference-in-differences; CCI, Charlson Comorbidity Index.

Data Sharing Statement

The data that support the findings of this study are available from the Healthcare Security Administration of the study city. However, restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are, however, available from the corresponding author upon reasonable request and with permission of the Healthcare Security Administration of this city.

Ethics

The institutional review board of the School of Public Health, Fudan University, approved this study (approval number: IRB#2020-TYSQ-03-20) and waived informed consent owing to no contact with patients and the use of nonidentifiable data. All procedures performed in this study comply with the principles of the Declaration of Helsinki.

Funding

This work was supported by the National Natural Science Foundation of China (Grant number: 72074051) and the National Healthcare Security Research Center (Capital Medical University) in China (Grant number: YB2020B01). The funding sources had no involvement in study design, data collection, data analysis, interpretation of data, writing of the manuscript, or the decision to submit it for publication.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Asia Pacific Observatory on Health Systems and Policies. Case-based payment systems for hospital funding in Asia: an investigation of current status and future directions. Available from: http://iris.wpro.who.int/handle/10665.1/12202. Accessed December 12, 2023.
2. Fu R, Shen Y, Noguchi H. The best of both worlds? The economic effects of a hybrid fee-for-service and prospective payment reimbursement system. *Health Econ*. 2021;30(3):505–524. doi:10.1002/hec.4205
3. National Health Commission of China. China Health Statistical Yearbook (2014). Available from: https://navi.cnki.net/knavi/YearbookDetail?pcode=CYFD&pykm=YSIFE. Accessed December 12, 2023.
4. National Health Commission of China. Statistical bulletin of health development of China in 2022. Available from: http://www.nhc.gov.cn/guihuaxxs/s3585u/202309/6707c48f2a2b420fbfb739c393fcca92.shtml. Accessed November 10, 2023.
5. He AJ. Scaling-up through piloting: dual-track provider payment reforms in China's health system. *Health Policy Plan*. 2023;38(2):218–227. doi:10.1093/heapol/czac080
6. Qian M, Zhang X, Chen Y, Xu S, Ying X. The pilot of a new patient classification-based payment system in China: the impact on costs, length of stay and quality. *Soc Sci Med*. 2021;289:114415. doi:10.1016/j.socscimed.2021.114415
7. Watts IT, Wenck B. Financing and the quality framework. *Aust Fam Physician*. 2007;36(1–2):32–34.
8. Ellis RP, McGuire TG. Provider behavior under prospective reimbursement. Cost sharing and supply. *J Health Econ*. 1986;5(2):129–151. doi:10.1016/0167-6296(86)90002-0
9. Ellis RP, McGuire TG. Hospital response to prospective payment: moral hazard, selection, and practice-style effects. *J Health Econ*. 1996;15(3):257–277. doi:10.1016/0167-6296(96)00002-1
10. Ellis RP. Creaming, skimping and dumping: provider competition on the intensive and extensive margins. *J Health Econ*. 1998;17(5):537–555. doi:10.1016/s0167-6296(97)00042-8
11. Bäuml M, Kümpel C. Hospital responses to the refinement of reimbursements by treatment intensity in DRG systems. *Health Econ*. 2021;30(3):585–602. doi:10.1002/hec.4204
12. Hafsteinsdottir EJ, Siciliani L. DRG prospective payment systems: refine or not refine? *Health Econ*. 2010;19(10):1226–1239. doi:10.1002/hec.1547
13. Jian W, Lu M, Liu G, Chan KY, Poon AN. Beijing's diagnosis-related group payment reform pilot: impact on quality of acute myocardial infarction care. *Soc Sci Med*. 2019;243:112590. doi:10.1016/j.socscimed.2019.112590
14. Vuagnat A, Yilmaz E, Roussot A, et al. Did case-based payment influence surgical readmission rates in France? A retrospective study. *BMJ Open*. 2018;8(2):e018164. doi:10.1136/bmjopen-2017-018164
15. Kutz A, Gut L, Ebrahimi F, Wagner U, Schuetz P, Mueller B. Association of the Swiss diagnosis-related group reimbursement system with length of stay, mortality, and readmission rates in hospitalized adult patients. *JAMA Network Open*. 2019;2(2):e188332. doi:10.1001/jamanetworkopen.2018.8332

16. Lang HC, Chi C, Liu CM. Impact of the case payment reimbursement method on the utilization and costs of laparoscopic cholecystectomy. *Health Policy*. 2004;67(2):195–206. doi:10.1016/s0168-8510(03)00119-2
17. Bystrov V, Staszewska-Bystrova A, Rutkowski D, Hermanowski T. Effects of DRG-based hospital payment in Poland on treatment of patients with stroke. *Health Policy*. 2015;119(8):1119–1125. doi:10.1016/j.healthpol.2015.04.017
18. Chok L, Bachli EB, Steiger P, et al. Effect of diagnosis related groups implementation on the intensive care unit of a Swiss tertiary hospital: a cohort study. *BMC Health Serv Res*. 2018;18(1):84. doi:10.1186/s12913-018-2869-4
19. Farrar S, Yi D, Sutton M, Chalkley M, Sussex J, Scott A. Has payment by results affected the way that English hospitals provide care? Difference-in-differences analysis. *BMJ*. 2009;339(aug27 2):b3047. doi:10.1136/bmj.b3047
20. Hamada H, Sekimoto M, Imanaka Y. Effects of the per diem prospective payment system with DRG-like grouping system (DPC/PDPS) on resource usage and healthcare quality in Japan. *Health Policy*. 2012;107(2–3):194–201. doi:10.1016/j.healthpol.2012.01.002
21. Cheng SH, Chen CC, Tsai SL. The impacts of DRG-based payments on health care provider behaviors under a universal coverage system: a population-based study. *Health Policy*. 2012;107(2–3):202–208. doi:10.1016/j.healthpol.2012.03.021
22. Choi JW, Kim SJ, Park HK, Jang SI, Kim TH, Park EC. Effects of a mandatory DRG payment system in South Korea: analysis of multi-year nationwide hospital claims data. *BMC Health Serv Res*. 2019;19(1):776. doi:10.1186/s12913-019-4650-8
23. Jeon MJ, Choo SP, Kwak YH, Kim DW, Kim EH. The effect of diagnosis-related group payment system on the quality of medical care for pelvic organ prolapse in Korean tertiary hospitals. *PLoS One*. 2019;14(8):e0220895. doi:10.1371/journal.pone.0220895
24. Kondo A, Kawabuchi K. Evaluation of the introduction of a diagnosis procedure combination system for patient outcome and hospitalisation charges for patients with Hip fracture or lung cancer in Japan. *Health Policy*. 2012;107(2–3):184–193. doi:10.1016/j.healthpol.2012.08.010
25. Yuan S, Liu W, Wei F, et al. Impacts of hospital payment based on Diagnosis Related Groups (DRGs) with global budget on resource use and quality of care: a case study in China. *Iran J Public Health*. 2019;48(2):238–246.
26. Chen YJ, Zhang XY, Tang X, Yan JQ, Qian MC, Ying XH. How do inpatients' costs, length of stay, and quality of care vary across age groups after a new case-based payment reform in China? An interrupted time series analysis. *BMC Health Serv Res*. 2023;23(1):160. doi:10.1186/s12913-023-09109-z
27. Lai Y, Fu H, Li L, Yip W. Hospital response to a case-based payment scheme under regional global budget: the case of Guangzhou in China. *Soc Sci Med*. 2022;292:114601. doi:10.1016/j.socscimed.2021.114601
28. National Bureau of Statistics of China. China Statistical Yearbook (2023). Available from: https://navi.cnki.net/knavi/YearbookDetail?pcode=CYFD&pykm=YINFN. Accessed December 12, 2023.
29. World Health Organization. Quality of care: a process for making strategic choices in health systems. Available from: https://apps.who.int/iris/handle/10665/43470?locale-attribute=en&show=full. Accessed December 12, 2023.
30. Chen L. Applicability analysis of employ readmission rate to evaluate the quality of inpatient healthcare in China. *Chinese Hospital Manage*. 2016;36(01):48–50.
31. Ashton CM, Wray NP. A conceptual framework for the study of early readmission as an indicator of quality of care. *Soc Sci Med*. 1996;43(11):1533–1541. doi:10.1016/s0277-9536(96)00049-4
32. General Office of the National Health Commission of the People's Republic of China. Notification of Accreditation Standards for Tertiary Hospitals (2020). Available from: http://www.nhc.gov.cn/yzygj/s7657/202012/c46f97f475da4d60be21641559417aaf.shtml. Accessed December 28, 2020.
33. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373–383. doi:10.1016/0021-9681(87)90171-8
34. Chen Y, Cai M, Li Z, Lin X, Wang L. Impacts of the COVID-19 pandemic on public hospitals of different levels: six-month evidence from Shanghai, China. *Risk Manag Healthc Policy*. 2021;14:3635–3651. doi:10.2147/rmhp.S314604
35. Yang Y, Le KJ, Liang C, et al. Changes in inpatient admissions before and during COVID-19 outbreak in a large tertiary hospital in Shanghai. *Ann Transl Med*. 2022;10(8):469. doi:10.21037/atm-22-1594
36. Tang X, Zhang X, Chen Y, Yan J, Qian M, Ying X. Variations in the impact of the new case-based payment reform on medical costs, length of stay, and quality across different hospitals in China: an interrupted time series analysis. *BMC Health Serv Res*. 2023;23(1):568. doi:10.1186/s12913-023-09553-x
37. Jian W, Lu M, Chan KY, et al. Payment reform pilot in Beijing hospitals reduced expenditures and out-of-pocket payments per admission. *Health Aff*. 2015;34(10):1745–1752. doi:10.1377/hlthaff.2015.0074
38. Zhang X, Tang S, Wang R, Qian M, Ying X, Maciejewski ML. Hospital response to a new case-based payment system in China: the patient selection effect. *Health Policy Plan*. 2024;39(5):519–527. doi:10.1093/heapol/czae022