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The effect of an innovative payment method on inpatient volume and bed resources and their regional distribution: the case of a central province in China

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Abstract

Background Since 2020, China has piloted an innovative payment method known as the Diagnosis-Intervention Packet (DIP). This study aimed to assess the impact of the DIP on inpatient volume and bed allocation and their regional distribution. This study investigated whether the DIP affects the efficiency of regional health resource utilization and contributes to disparities in health equity among regions.

Methods We collected data from a central province in China from 2019 to 2022. The treatment group included 508 hospitals in the pilot area (Region A, where the DIP was implemented in 2021), whereas the control group consisted of 3,728 hospitals from non-pilot areas within the same province. We employed the difference-in-differences method to analyze inpatient volume and bed resources. Additionally, we conducted a stratified analysis to examine whether the effects of DIP implementation varied across urban and rural areas or hospitals of different levels.

Results Compared with the non-pilot regions, Region A experienced a statistically significant reduction in inpatient volume of 14.3% (95% CI 0.061–0.224) and a notable decrease of 9.1% in actual available bed days (95% CI 0.041–0.141) after DIP implementation. The study revealed no evidence of patient consultations shifting from inpatient to outpatient services due to the reduction in hospital admissions in Region A after DIP implementation. Stratified analysis revealed that inpatient volume decreased by 12.4% (95% CI 0.006–0.243) in the urban areas and 14.7% in the rural areas of Region A (95% CI 0.051–0.243). At the hospital level, primary hospitals experienced the greatest impact, with a 19.0% (95% CI 0.093–0.287) decline in inpatient volume. Furthermore, primary and tertiary hospitals experienced significant reductions of 11.0% (95% CI 0.052–0.169) and 8.2% (95% CI 0.002–0.161), respectively, in actual available bed days.

Conclusions Despite efforts to curb excessive medical service expansion in the region following DIP implementation, large hospitals continue to attract a large number of patients from primary hospitals. This weakening of primary hospitals and the subsequent influx of patients to urban areas may further limit rural patients' access to

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medical services. The implementation of the DIP may raise concerns about its impact on health care equality and accessibility, particularly for underserved rural populations.

Keywords Innovative payment method, Primary hospital, Inpatient distribution, Bed resources, Rural health, Health inequality

Background

The utilization of medical services typically results from collaborative decisions between hospitals and patients [1]. In an ideal health care system, all hospitals provide an optimal balance of service quantity and intensity concerning care quality and therapeutic effectiveness [2]. However, in reality, achieving this balance is challenging because stakeholders (payers, providers, and patients) may have conflicting interests regarding access, profitability, costs, cost control, safety, quality, convenience, patient-centeredness, and satisfaction [3]. Some doctors even earn a significant portion of their income from receive volume-based incentives [4]. Improving the efficient use of limited health resources is a global challenge. Excessive growth in service volume and the number of treated patients has reduced the efficiency of resource use and highlighted issues of overdiagnosis [5]. This does not help to alleviate ill health and poverty, correct inequalities, or save lives [6]. In China, hospital growth is rapid [7]. Recently, hospital bed expansion has increased dramatically. This has resulted in a sustained increase in the number of hospital admissions. Over the past decade, China's hospitalization rate has increased rapidly, from 14.6% to 8.1% in 2012 for urban and rural residents, respectively, to 17.6% and 16.3% in 2021, exceeding the OECD average of 14%. This results in the waste of limited health resources.

Guiding patients to seek health care in an orderly manner can significantly improve the efficiency of health care resource utilization. China has adopted a three-tier network for health care delivery comprising primary, secondary, and tertiary hospitals. The higher the hospital level is, the more complex the diseases they manage. With numerous primary hospitals and better medical accessibility, primary health care can significantly promote regional health equity [8]. However, underutilized primary health care services persist and have scarcely alleviated the overuse of secondary and tertiary hospital systems [9, 10]. Consequently, the operation of the three-tier health care network remains suboptimal.

Additionally, owing to China's dual urban–rural development structure, significant disparities exist, and some scholars have focused on this dimension. This supply mechanism creates imbalances in urban–rural health resource allocation and disparities in access to health services for urban and rural residents [11, 12]. Moreover, market forces that drive more resources into cities and large hospitals may further exacerbate the gaps between urban and rural areas and hospitals of different levels [13]. The efficiency of health care resource utilization remains low, and severe health inequalities persist between urban and rural areas and hospitals of different levels. Unfortunately, despite the significant progress of the new round of health care system reform launched in China in 2009, imbalances in medical resource allocation between large and primary hospitals persist [14, 15]. Inequality in medical resources and services remains a serious concern for researchers and policy-makers.

Innovative payment methods can transform incentive mechanisms for health care providers and improve the efficiency of health care resource utilization. The traditional fee-for-service payment method (FFS), which is driven by service volume, significantly reduces the efficiency of health care resource utilization. Conversely, diagnosis-related groups (DRGs) consolidate the costs of all services provided during a hospital stay into a single payment. However, both FFS and DRGs still incentivize excessive medical interventions. FFS payments encourage providers to increase the number of services delivered, whereas DRGs incentivize the treatment of more patients, increasing activity and costs [16, 17]. Without rigorous global budgeting mechanisms, both payment methods can lead to unsustainable expenditure growth by encouraging increased service volume or patient numbers [18].

Price regulation is a method for implementing global budget payment goals or limits. Prices are adjusted annually under this budget constraint to ensure that expenditures remain within the designated limit each year. In Germany, prices are retrospectively determined by adjusting the monetary value of a single point on the fee schedule, considering differences between actual and projected service volumes [19]. However, there is no consensus on the impact of global budget payments on service utilization. In Taiwan, the implementation of global budget payments has led to a rapid increase in the number of patients [20]. A study in Taiwan highlighted that patients still preferred receiving treatment at larger hospitals [21]. Evidence regarding outpatient care in Germany and two Canadian provinces suggests that the number of patients increased significantly after global budget payments were implemented [22, 23]. These findings contrast with studies from the Netherlands, Maryland, USA, and Hungary, where implementing global budget payments did not significantly change patient numbers [24–26].

Since 2020, China has designated 71 municipal-level regions as pilot areas to implement the Diagnosis-Intervention Packet (DIP), an innovative payment method that combines a global budget and case-based payments. The global budget is allocated to the regional inpatient health care system to establish the annual budget cap. The DIP reform extracts data features from city case data over 3–4 years to group cases, creating a database called the DIP group. Fixed points for each DIP group are assigned on the basis of specific rules. The value of each point is dynamically adjusted at the end of the year according to the global budget and actual points accrued. The compensation amount for each DIP group is not predetermined. Thus, if the treatment expenses of a DIP group are lower than the reimbursed costs, the hospital receives the surplus from the health insurance fund. If the treatment expenses of a DIP group exceed the reimbursed costs, the hospital covers the excess amount. To mitigate researchers' concerns about national standard payments, with price adjustments being a common resource where hospitals might maximize their incomes individually, leading to high quantities and low prices, China incorporates performance-based payments into the DIP and sets regulatory indicators to assess and penalize hospitals for irregular behaviors. Each pilot region implements the DIP based on basic national regulations, but there are differences in the number of DIP groups, management methods, and regulatory strategies across regions.

Existing studies on DIP practices have focused primarily on isolated, self-directed pilot programs implemented locally before the 2020 unified national trial. For instance, two studies in Guangzhou, China, reported significant reductions in drug costs and postoperative complications following DIP implementation. However, they also reported an increased likelihood of inpatients undergoing at least one surgical procedure [27, 28]. A study in Chengdu, China, revealed that after DIP implementation, health care costs noticeably decreased, and treatment outcomes moderately improved [29]. However, we cannot definitively assess the effects of the DIP on regional health care resource allocation. Additionally, there is a disparity in capabilities among hospitals in urban and rural areas, as well as hospitals of different levels. Government financial support is limited, and each hospital relies on economic income for development. Hence, competition among hospitals is unavoidable. While the DIP aims to address the risk of regional hospitals increasing their inpatient numbers, we remain concerned that larger hospitals may continue diverting resources from primary hospitals owing to self-interest. The potential exacerbation of disparities among hospitals in this manner warrants further examination.

DIP reform was launched in Region A, designated the national pilot region, in 2021. Region A was selected as the pilot area for DIP reform and compared with non-pilot regions in a central province via difference-in-differences (DID) analysis. Our study aimed to analyze the impact of DIP implementation on both inpatient volume and bed resources. The analysis of bed resources is crucial because bed capacity directly affects the scale of inpatient admissions. Additionally, through heterogeneity analysis, we aimed to assess differences in effects among hospitals of different levels and between urban and rural hospitals within the region.

We aimed to address three key questions. First, does the implementation of the DIP effectively control the excessive expansion of inpatient volume and bed resources? Second, do larger hospitals further divert inpatient volume from primary hospitals, exacerbating the imbalance in medical resources among hospitals of different levels? Third, do urban hospitals exacerbate the diversion of inpatient volume from rural hospitals, thereby contributing to the imbalance in medical resources between urban and rural areas? The second and third key questions primarily aimed to assess the impact on health care accessibility for patients at the grassroots level and in rural areas, thereby influencing their medical equality post-DIP implementation. Through this study, we aimed to answer these questions and enhance our understanding of the impact of DIP on the efficiency of regional health resource utilization and regional health equality.

Materials and Methods

Study setting

Region A, a municipal-level region in central China, had a GDP of 575.64 billion yuan in 2023, ranking second in the province. It has a permanent population of 3.92 million people, with 3.68 million people enrolled in social medical insurance, achieving a coverage rate of 95.07%. Designated as the national pilot area, Region A initiated DIP reform in 2021. An annual regional DIP group catalog was established, with appendicitis chosen as the standard disease for appendectomy, and the points allocated to each DIP group were calculated. PV equals the predetermined regional budget divided by the total sum of points for all inpatient services provided by hospitals within the region. This price adjustment aims to align precisely with the predetermined global budget, ensuring that the health insurance fund does not face the risk of deficit and the provision of reasonable and affordable health care services. Thus, as shown in Eq. (1), each hospital's actual reimbursement depends on both the total points of the DIP groups it handles and the number of competing hospitals in the medical market. Various adjustment factors, including hospital rankings, the case mix index, and demographic profiles, further ensure the fairness of payment standards.

$$PV = \frac{Pre\_determined\ Regional\ Budget}{Point\ sum\ of\ all\ inpatient\ cases\ within\ a\ region} \tag{1}$$

$$Reimbursements = PV \times Hospital\ Point\ Volume \times Reimbursement\ ratio \times adjustment\ factors - Penalty\ amount \tag{2}$$

In Region A, the actual reimbursement for each hospital is directly influenced by the penalty amount indicated in Eq. (2), which incentivizes hospitals to deliver health care services aligned with best practices. Region A extensively relies on advanced big data technologies, facilitating the establishment of a supplementary directory through extensive data analysis. Notably, this directory serves critical purposes, detecting induced hospitalizations through a supplementary directory tailored for low-standard admissions and identifying issues of fragmented treatment resulting in repeated hospitalizations via a secondary admission auxiliary directory. Additionally, this study identified cases of the malicious expansion of inpatient volume by analyzing discharge rate trends. On the basis of the evaluation results, points were deducted for noncompliant cases in hospitals, with an additional deduction of three times the points. These evaluation results are crucial indicators for preallocating DIP funds to hospitals, with preallocation restrictions set from 0 to 100% on the basis of evaluation scores.

Study design and data sources

In this study, an empirical analysis was conducted using hospital-level annual data obtained from the Provincial Health Commission. The data encompassed all public hospitals across 13 municipal-level regions of a central province from 2019 to 2022. During this timeframe, five regions began DIP/DRGs implementation, with Region A initiating DIP implementation in 2021, which was designated the treatment group. The other four regions with DIP/DRGs implementation varied in their approaches. One region solely adopted DRGs, inherently differing from DIP principles, and was thus excluded from the analysis. Although the DIP was implemented in the remaining three regions, its experimental nature, with regional variations across China, introduced unintended heterogeneity, complicating the empirical assessment. The performance evaluation approaches under the DIP framework also lack full standardization across regions, influencing the decision regarding their exclusion from the analysis. Additionally, the timing of implementation in three other regions varied from that in Region A, which started in 2021. Specifically, rollout in the other three regions began in 2022, while this study analyzed data from 2019 to 2022 for Region A. Due to the limited observational period (from 2019 to 2022) in this study, adequately controlling for potential lag effects impacting the outcomes remained challenging. Hence, these regions were excluded from the analysis.

The remaining eight non-pilot regions of the central province served as controls. During subsequent data processing, data points with gaps in outcome variables were excluded because of their potential impact on research outcomes. Additionally, observations that included data for only one year were omitted. These procedures resulted in a final sample size of 4236 hospitals, comprising 508 hospitals from Region A and 3728 hospitals from non-pilot regions. For observations where covariates had missing values, the random forest imputation method was employed to fill these gaps. Through this sample selection and processing procedure, the study aimed to ensure the reliability and validity of the findings by providing representative data for analysis.

Our study design included a comparative analysis of the shifts in service volume and bed resources between Region A and the non-pilot regions in the central province before and after the implementation of the DIP. Additionally, we conducted stratified analyses by urbanization level and hospital level to determine whether the effects of DIP implementation differed between urban and rural areas or across hospitals of different levels.

Outcome variables

Regarding the effects of the DIP on service volume and bed resources, hospitals face challenges in rapidly adjusting their bed capacity because of its relatively fixed nature. However, hospitals can manage inpatient volume by adjusting bed availability, either by increasing temporary bed capacity to increase the number of available bed days or by reducing the number of existing beds to decrease the number of available bed days, depending on demand. Accordingly, we selected four variables closely associated with inpatient services: inpatient volume, surgical volume, bed occupancy, and actual available bed days (referring to the total number of days that beds are physically available and ready for use within one year). Because the DIP is a medical insurance payment method specifically for inpatient services, these variables were considered relevant for assessing the impact of the program. Furthermore, given previous evidence suggesting potential spillover effects of inpatient payment reforms on outpatient utilization, we included outpatient visits as a variable to empirically examine cross-sector spillover effects [30]. To ensure the normality of the data distributions for subsequent statistical analyses, we applied a natural log transformation to the variables of inpatient volume, outpatient volume, and actual available bed days.

Independent variables

In this study, the independent variable was DIP coverage, a binary variable indicating whether hospitals were located in the DIP pilot region. The treatment group included all public hospitals in Region A, whereas the control group comprised all public hospitals in non-pilot areas of the central province.

Covariates

Considering potential confounding factors, we included covariates in the model to control for their effects. Hospitals, which were the focus of this study, are influenced by social characteristics and regional differences. Covariates were categorized into social characteristics, including urbanization level (urban and rural), population size, and gross domestic product (GDP), and hospital characteristics, comprising hospital category (primary health care center, general hospital, specialized hospital), hospital level (primary, secondary, tertiary), and the number of employees.

Statistical analysis

To assess the impact of the DIP on service volume and bed resources, we employed panel data and applied the DID method with individual and time fixed effects (FEs) via data from 2019 to 2022. The DID method allowed us to estimate the effect of the policy intervention by comparing changes in outcomes between the treatment group and the control group. In our study, the treatment group consisted of all public hospitals in Region A, whereas the control group comprised all public hospitals in the non-pilot areas of the central province. The implementation of the DIP in Region A in 2021 served as the intervention time point for this study. The DID model was exploited as follows Eq. (3):

$$Y_{ict} = \beta_0 + \beta_1 DIP_{ict} + \beta_2 X_{ict} + \tau_t + a_i + \epsilon_{ict} \quad (3)$$

where Y_{ict} denotes the outcome variable of hospital i in region c in year t, including inpatient volume, outpatient volume, surgical volume, bed occupancy, and actual available bed days. In the DID model, DIP_{ict} denotes a dummy variable for the DIP pilot region, which is marked by the point at which Region A became the DIP pilot region. X_{ict} is a set of covariates, including social characteristics and hospital characteristics. τ_t is a set of year fixed effects. a_i is a set of hospital fixed effects, and ϵ_{it} is the random error term. The coefficient β_1 was the core coefficient of interest in this study and represents the differences between Region A and the non-pilot regions in terms of the outcome variables. We aimed to investigate the policy effect of the DIP, that is, whether DIP implementation affected service volume and bed resources.

In this study, we performed three types of robustness checks to assess the reliability and sensitivity of our analytical results. First, the validity of DID implementation hinged on the parallel trend assumption, ensuring that the outcome variables of the treatment and control groups followed similar time trends before DIP implementation. Therefore, we utilized parallel trend tests to examine the common trend hypothesis.

Second, additional two-tailed truncation sensitivity analyses were performed on the original dataset. Specifically, we trimmed extreme observations beyond the 5% cutoff points from each tail of the distributions. Two-tailed truncation at the 5% level was considered an appropriate data cleansing technique for our study on the basis of sample size and distribution characteristics. This approach aimed to reduce bias induced by outliers while maintaining over 90% of the original observations, thereby maximizing statistical power. The previously established regression model was then rerun on the truncated datasets, comparing parameter estimates and significance levels across truncation widths. This data-driven two-tailed truncation approach at ±5% improved the validity, generalizability, and interpretability of our core findings by reducing the impact of nonrepresentative outlier observations.

Third, we utilized a placebo test employing nonparametric permutation inference to further examine the robustness of our findings. Specifically, we conducted 500 random iterations where the actual treatment assignments were randomly shuffled while keeping all other variables unchanged. This process resulted in a null distribution of the DID estimates under the hypothetical scenario in which the policy had no true effect. For each iteration, we performed DID regressions on the placebo sample to estimate the pseudotreatment effects. The resulting coefficients and p values from these regressions were collected to construct the placebo distributions. We then compared these distributions to the actual results obtained for the original sample. If the distribution of p values was centered above the 0.05 level, our findings were unlikely to be due to chance alone.

Examining the overall data alone is inadequate for revealing variations in characteristics within regions or between hospitals. Therefore, we conducted additional heterogeneity tests on the basis of societal and institutional factors. Specifically, we examined the urbanization level and hospital level separately to validate the inherent impacts of DIP implementation on regional health care resource allocation. We aimed to investigate whether the relationship between DIP implementation and outcome variables varied across these important dimensions.

Results

Descriptive statistics

Table 1 presents a comprehensive statistical summary of Region A and the non-pilot regions in the central province. The mean values and standard deviations of both outcome variables and the covariates are displayed. The sample of regions was categorized into two distinct periods: before the implementation of the DIP (2019–2020)

Table 1 Summary statistics

Variables	**2019–2020**						**2021–2022**					
	(1)		**(2)**		**(3)**		**(1)**		**(5)**		**(6)**	
	Overall		**Region A**		**Non-pilot regions**		**Overall**		**Region A**		**Non-pilot regions**	
	Mean/*N*	**SD**	**Mean/*N***	**SD**	**Mean/*N***	**SD**	**Mean/*N***	**SD**	**Mean/*N***	**SD**	**Mean/*N***	**SD**
Outcome variables												
Ln (Inpatient volume + 1)	7.67	1.39	7.68	1.27	7.70	1.41	7.57	1.52	7.44	1.45	7.59	1.53
Ln (Outpatient volume + 1)	10.67	1.08	10.72	1.08	10.66	1.08	10.68	1.13	10.78	1.12	10.67	1.13
Surgical volume	1177.98	4826.63	1444.24	5969.63	1141.91	4651	1294.8	5457.75	1440.37	6282.58	1274.85	5336.38
Bed occupancy (%)	67.07	130.83	67.15	22.08	67.06	139.18	57.6	23.47	55.63	22.55	57.87	23.58
Ln (Actual available bed days + 1)	10.20	1.16	10.29	1.11	10.19	1.16	10.25	1.13	10.26	1.09	10.24	1.13
Covariates												
Regional characteristics												
Urbanization level												
Urban area	1298		150		1148		1280		148		1132	
Rural area	831		104		727		827		106		721	
Ln (Population + 1)	5.73	0.55	6	0.03	5.69	0.58	5.69	0.55	5.97	0.01	5.65	0.57
Ln (GDP + 1)	7.59	0.67	8.38	0.02	7.49	0.64	7.74	0.67	8.57	0.05	7.63	0.64
Hospital characteristics												
Hospital category												
Primary health care center	1760		194		1566		1730		195		1535	
General hospital	334		50		284		345		51		294	
Specialized hospital	35		10		25		32		8		24	
Hospital level												
Primary hospital	1749		200		1549		1719		197		1522	
Secondary hospital	304		42		262		293		41		252	
Tertiary hospital	76		12		64		95		16		79	
Number of employees	180.34	374.09	196.42	393.52	178.16	371.43	188.23	392.82	200.41	392.68	186.56	392.92

and after the implementation of the DIP (2021–2022). Descriptive statistics enabled the observation of variation trends in the outcome variables in both the pilot and non-pilot regions. Following the reform, the actual available bed days decreased in Region A, whereas they increased in the non-pilot regions. The other four outcome variables exhibited consistent changes in both groups.

Parallel trend test

Figure 1 illustrates the common trends of the four outcome variables in Region A compared with the non-pilot regions. Before the implementation of the DIP, the trends

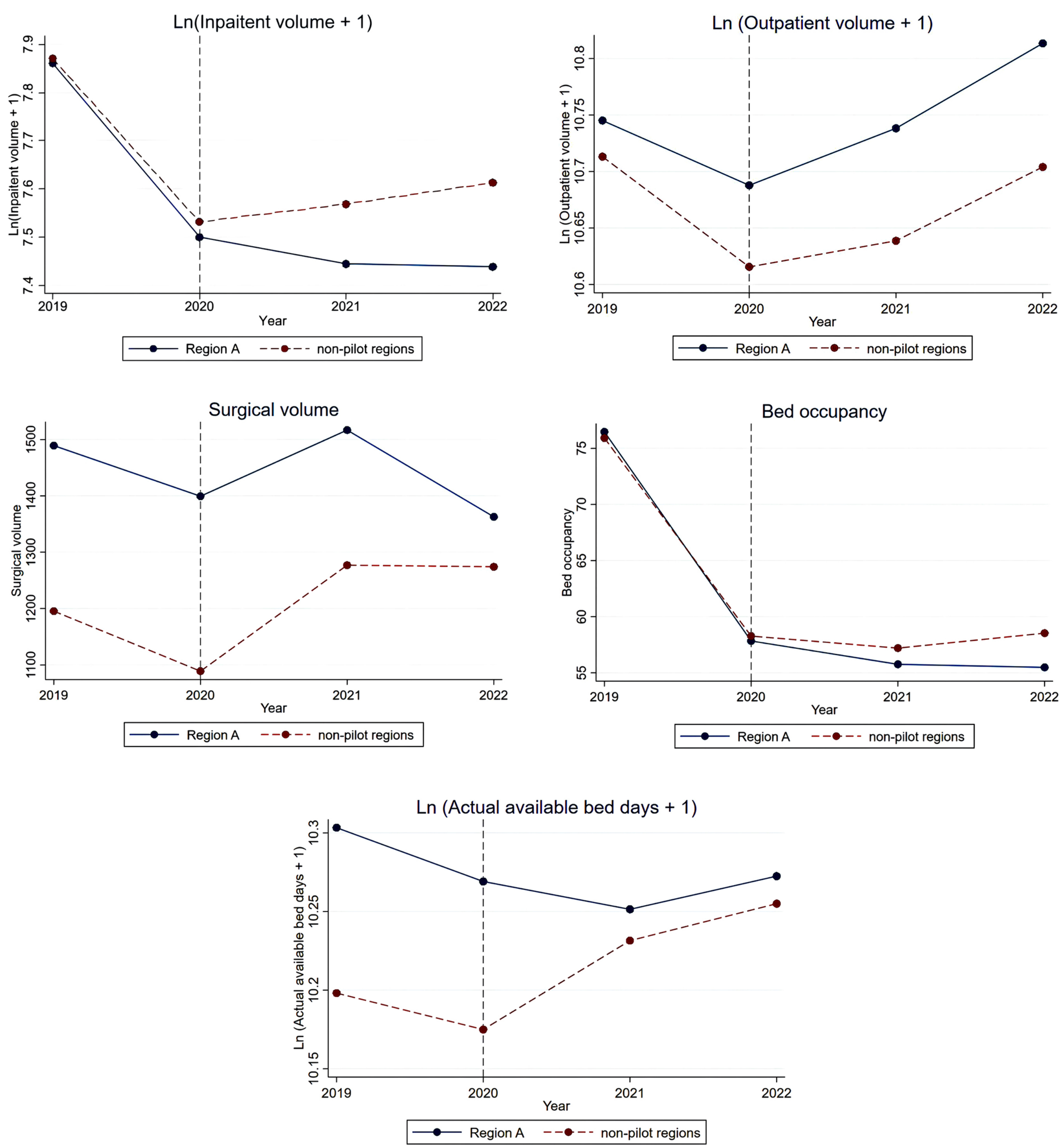

Fig. 1 The time trends of the five outcome variables. The solid lines refer to the time trends of the relevant variables for Region A, whereas the dashed lines refer to the time trends for the non-pilot regions in the central province

Table 2 Effect of DIP implementation on the five outcome variables

Variables	(1)	(2)	(3)	(4)	(5)
	Ln (Inpatient volume + 1)	**Ln (Outpatient volume + 1)**	**Surgical volume**	**Bed occupancy**	**Ln (Actual available bed days + 1)**
DID	-0.143*** (0.041)	0.004 (0.027)	92.772 (126.176)	5.855 (10.327)	-0.091*** (0.025)
Control variables	YES	YES	YES	YES	YES
Year fixed effect	YES	YES	YES	YES	YES
Hospital fixed effect	YES	YES	YES	YES	YES
Observations	4236	4236	4236	4236	4236
R-squared	0.955	0.970	0.895	0.285	0.967

Notes Standard errors are shown in parentheses. Significance levels of 0.1%, 1%, and 5% are denoted by ***, **, and *, respectively. All regressions controlled for year FEs, hospital FEs, and covariates

of the outcome variables (inpatient volume, outpatient volume, surgical volume, bed occupancy, and actual available bed days) in Region A were similar to those in the non-pilot regions. Thus, no discernible heterogeneity trend existed between Region A and the non-pilot regions. This observation strongly supports the appropriateness of implementing the DID method. Additionally, following the implementation of the DIP, the trends in hospitalization volume and actual available bed days in Region A diverged from those in the non-pilot regions, whereas the trends of the other variables remained relatively consistent.

Main effect of DIP implementation

Table 2 presents the effects of DIP implementation on inpatient volume, outpatient volume, surgical volume, bed occupancy, and actual available bed days. The coefficient of the DID analysis indicated the implementation of the DIP. The study findings indicated that after the implementation of the DIP, Region A experienced a significant decrease of 14.3% in inpatient volume compared with the non-pilot regions ($P<0.001$), as presented in Column (1). A notable reduction in the number of actual available bed days of 9.1% was observed ($P<0.001$), as indicated in Column (5). We observed a slight increase in outpatient volume of 0.4%, an increase in surgical volume of 92.77%, and an increase of 5.86% in bed occupancy. However, these changes did not reach statistical significance, suggesting that there were no significant adverse effects.

Robustness check

We conducted a series of robustness checks to validate our results. As shown in Fig. 1, the prepolicy trends in the five outcomes were similar between Region A and the non-pilot regions. Despite hospital-level differences between the groups, their changing patterns over time maintained parallel trajectories, fulfilling the required parallel trends assumption for the DID method. Additionally, we applied a two-tailed 5% truncation to mitigate the potential influence of outliers by reducing their leverage on effect estimates. This involved removing outliers at each tail to achieve a more normal data distribution. We then applied the DID method to analyze the two primary outcomes: inpatient volume and actual available bed days. Table 3 presents the re-evaluation results after applying 5% truncation, showing that both outcomes remained statistically significant. This confirmed that our main findings are robust to alternative model specifications.

Table 3 Estimated results of inpatient volume and actual available bed days after applying two-tailed truncation at the 5th percentile

Variables	(1)	(2)
	Ln (Inpatient volume + 1)	**Ln (Actual available bed days + 1)**
DID	-0.131*** (0.029)	-0.056*** (0.018)
Control variables	YES	YES
Year fixed effect	YES	YES
Hospital fixed effect	YES	YES
Observations	3817	3817
R-squared	0.960	0.981

Notes Standard errors are shown in parentheses. Significance levels of 0.1%, 1%, and 5% are denoted by ***, **, and *, respectively. All regressions controlled for year FEs, hospital FEs, and covariates

Figure 2 illustrates the outcomes of 500 placebo regressions simulating coefficient distributions for the variables of inpatient volume and actual available bed days. Across the replicated experiments, the absolute magnitudes of the estimated regression coefficients followed a normal distribution centered at zero. Furthermore, a significant majority of the computed p values exceeded the conventional significance threshold of 0.05 across the 500 replications. Taken together, these results from the simulation test substantiate the stability of our primary findings against stochastic disturbances in the sample, indicating

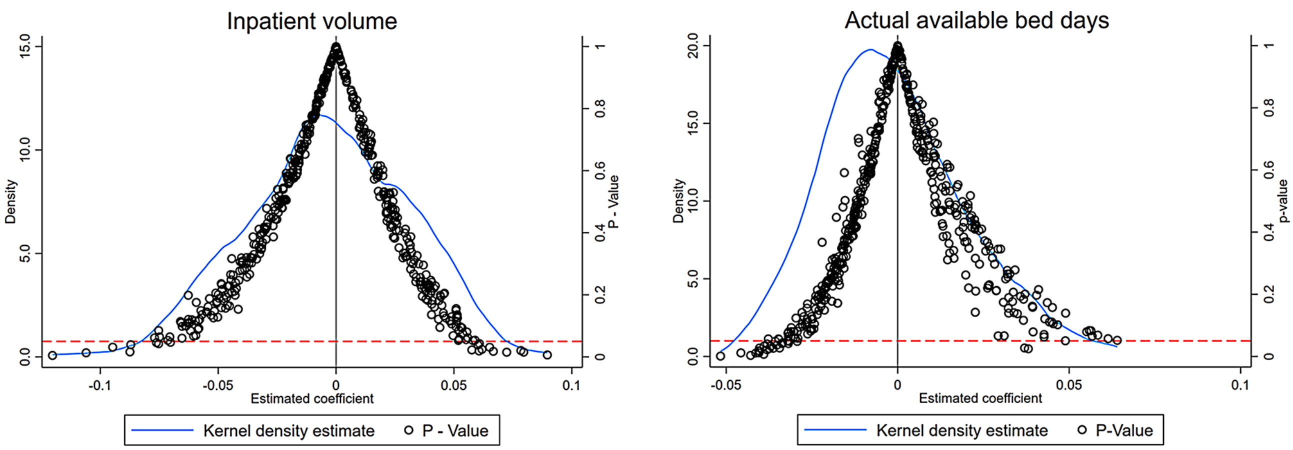

Fig. 2 Placebo test results for inpatient volume and actual available bed days. The dashed line represents the critical threshold at a significance level of 5%

Table 4 Estimated results from the stratified regression analyses of inpatient volume and actual available bed days by urbanization level

Variables	(1)	(2)	(3)	(4)
	Ln (Inpatient volume + 1)		Ln (Actual available bed days + 1)	
	Urban area	Rural area	Urban area	Rural area
DID	-0.124* (0.060)	-0.147** (0.049)	-0.065* (0.029)	-0.115* (0.049)
Control variables	YES	YES	YES	YES
Year fixed effect	YES	YES	YES	YES
Hospital fixed effect	YES	YES	YES	YES
Observations	2578	1658	2578	4236
R-squared	0.948	0.974	0.983	0.933

Notes Standard errors are shown in parentheses. Significance levels of 0.1%, 1%, and 5% are denoted by ***, **, and *, respectively. All regressions controlled for year FEs, hospital FEs, and covariates

that the significant effects were unlikely to result solely from random fluctuations.

Heterogeneity

We conducted stratified analyses to explore heterogeneous treatment effects across different levels of urbanization, as shown in Table 4. In the analysis stratified by urbanization level, we observed significant decreases ($P<0.05$) in both inpatient volume and actual available bed days following DIP implementation. The inpatient volume decreased by 12.4% in the urban areas and 14.7% in the rural areas. Moreover, the actual available bed days decreased by 6.5% in the urban areas and by 11.5% in the rural areas. A between-group comparison indicated disproportionately sharper declines in the outcome variables among rural hospitals.

Table 5 presents the heterogeneous treatment effects across hospitals. At the hospital level, the intervention resulted in a decrease in inpatient volume of 19.0% among primary hospitals in Region A ($P<0.05$). Secondary and tertiary hospitals also showed attenuated yet statistically insignificant decreases of 3.8% and 6.5%,

Table 5 Estimated results from the stratified regression analyses of inpatient volume and actual available bed days by urbanization level

Variables	(1)	(2)	(3)	(4)	(5)	6)
	Ln (Inpatient volume + 1)			Ln (Actual available bed days + 1)		
	Primary Hospital	Secondary Hospital	Tertiary Hospital	Primary Hospital	Secondary Hospital	Tertiary Hospital
DID	-0.190*** (0.049)	-0.038 (0.063)	-0.065 (0.071)	-0.110*** (0.030)	-0.049 (0.054)	-0.082* (0.039)
Control variables	YES	YES	YES	YES	YES	YES
Year fixed effect	YES	YES	YES	YES	YES	YES
Hospital fixed effect	YES	YES	YES	YES	YES	YES
Observations	3468	597	171	3468	597	171
R-squared	0.922	0.983	0.995	0.910	0.990	0.995

Notes Standard errors are shown in parentheses. Significance levels of 0.1%, 1%, and 5% are denoted by ***, **, and *, respectively. All regressions controlled for year FEs, hospital FEs, and covariates respectively. For actual available bed days, primary and tertiary hospitals experienced meaningful reductions of 11.0% and 8.2%, respectively. The decrease in primary hospitals was more pronounced. Patients were increasingly concentrated in secondary and tertiary hospitals.

Discussion

We analyzed the impact of DIP implementation on service volume and bed resources in Region A compared with non-pilot regions in a central province of China. The results show that following DIP implementation, compared with the non-pilot regions, Region A experienced a statistically significant reduction in inpatient volume of 14.3% and a notable decrease of 9.1% in actual available bed days. The study did not find any evidence of patient consultations diverting from inpatient to outpatient services due to the reduction in hospital admissions in Region A after DIP implementation. Stratified analysis revealed that inpatient volume decreased by 12.4% in the urban areas and 14.7% in the rural areas of Region A. At the hospital level, primary hospitals experienced the greatest impact, with a decrease of 19.0% in inpatient volume. Additionally, primary and tertiary hospitals experienced meaningful reductions of 11.0% and 8.2%, respectively, in the actual available bed days.

DIP implementation curtails excessive growth in inpatient volume

As indicated in the background, China has experienced a steady increase in inpatient volume, with hospitalization rates significantly increasing over the past decade. Compared with those in the control regions, the inpatient volume and actual available bed days were effectively reduced in Region A after DIP implementation. This reduction led to a marked improvement in health care service efficiency. These outcomes were likely attributable to the performance-based payment mechanism implemented in Region A after DIP implementation. These findings are consistent with existing research [31]. FFS and DRGs tend to prioritize quantity over value, incentivizing hospitals to increase service volume [16, 17]. In contrast, performance-based payment systems enable more effective supervision of service providers, encouraging them to align their behavior with performance objectives [32]. For example, initiatives such as the Merit-based Incentive Payment System (MIPS) in the United States have successfully mitigated doctors' incentives to increase their patient caseload [33]. Similarly, observations from Hennepin Health, a county-based safety net in Minnesota, have demonstrated a significant decrease in inpatient service volume, underscoring the effectiveness of payment reforms [30]. Additionally, integrated care pilot programs in England have led to a reduction in planned hospital admissions [34].

Region A employs big data information systems to oversee and regulate unjustifiable medical practices, such as admitting patients with lower standards and fragmented treatment resulting in repeated hospitalizations. Enforcing penalties equivalent to three times the case number and incorporating these metrics into critical assessments for the preallocation of medical insurance funds in the subsequent year increases the consequences for hospital noncompliance. Consequently, what was once an economically beneficial practice of intentionally increasing service volume now incurs financial losses. The homoeconomicus assumption, a fundamental concept in economics, posits that humans are rational and self-interested agents [35]. In a market economy, hospitals, like any other entity, pursue their own interests. When regulatory measures and penalties impact hospital revenues, they curtail the incentive for hospitals to relentlessly increase their service volume. The observed reduction in the number of available bed days corroborates this assertion. Increasing the hospital scale and bed availability are crucial strategies for increasing the service volume. Consequently, as unreasonable increases in the number of hospital admissions are curbed, hospitals are compelled to mitigate inefficient expenditures by reducing the number of available bed days.

DIP implementation weakens the exacerbation of health care inequality among primary hospitals

At the hospital level, primary hospitals were significantly impacted, as evidenced by a marked decrease in both inpatient volume and actual available bed days. In contrast, secondary and tertiary hospitals remained unaffected in terms of inpatient volume, with only tertiary hospitals experiencing a reduction in actual available bed days. The total medical insurance payment received by each hospital is determined by three factors: the DIP case payment points, the PV, and the number of cases. Although pricing adjustments are made at the of the year, necessitating a recalculation of the PV on the basis of the global budget, the points assigned to each DIP group remain constant throughout the year. Furthermore, PV adjustments are contingent upon the cumulative points of all hospitals in the region, making these adjustments difficult to ascertain until the end of the fiscal year. Consequently, hospitals perceive the pricing schedule as relatively fixed, potentially inducing the prioritization of quantity over other considerations. The extant literature suggests that payment methods characterized by fixed pricing schedules are output driven. This approach incentivizes the increase in inpatient volume, including unnecessary services, while reducing the input required for each service [36]. As a result, competition for patient cases becomes a crucial strategy for hospitals to attain a larger share of settlements.

Notwithstanding efforts to curb excessive service expansion, including low-standard admissions and fragmented hospital care, in secondary and tertiary hospitals after DIP implementation, these institutions continue to attract patients from primary hospitals owing to their superior medical capabilities. Consequently, this has resulted in a significant decrease in patient volume at primary hospitals. Moreover, secondary and tertiary hospitals possess significantly greater amounts of bed resources than primary hospitals do. However, curbing behaviors such as low-standard admissions and fragmented treatment resulting in repeated hospitalizations, which contribute to unwarranted increases in inpatient volume, may result in excessive empty beds and incur unrecoverable sunk costs. This phenomenon intensifies the incentive to attract patients from primary hospitals. As the DIP system expands annually, primary hospitals, facing a reduction in inpatient volume, are compelled to gradually decrease their bed resources, thus perpetuating a detrimental cycle. The continuous expansion of the market share for secondary and tertiary hospitals greatly diminishes the survival space for primary hospitals. Moreover, the reduction in the number of available bed days at tertiary hospitals is due mainly to overexpansion, resulting in an oversupply of beds that cannot be compensated for by attracting patients from primary hospitals. As a result, tertiary hospitals are forced to decrease the actual available bed days.

The implementation of the DIP exacerbates disparities in both health care accessibility and equality. Primary hospitals play a crucial role in providing basic medical services [8]. In China, market dynamics have persistently exacerbated the divergence between large hospitals and primary hospitals [13]. Historically, there has been an inherent imbalance in the medical treatment hierarchy and resource allocation among hospitals of varying levels in China [37]. This phenomenon originates from the lack of robustness in China's hierarchical medical system. In pursuit of profit maximization, large hospitals are keen to expand their patient base [38]. Furthermore, Chinese patients who trust the superior medical capabilities of large hospitals increasingly seek treatment at these hospitals [39]. The implementation of the DIP is likely to further exacerbate this imbalance, thereby decreasing the efficiency of the tertiary health care network and hindering patients' access to medical services. The weakening of primary hospitals will erode regional health equality [40].

DIP implementation exacerbates urban–rural hospital disparities, impacting rural patient health care equality

While both urban and rural areas have experienced notable declines in both inpatient volume and actual available bed days, the reduction in rural regions is more pronounced. Upon further analysis on the basis of hospital grade, it became evident that the decline primarily affected the inpatient volume and actual available bed days of primary hospitals. This phenomenon suggests a scenario where secondary and tertiary hospitals in urban areas attract patients from rural areas, potentially leading to primary hospital developmental challenges in rural areas due to patient outflow. Excessive utilization of urban inpatient services may impede the utilization and enhancement of rural inpatient services [41]. The loss of patients to urban hospitals may reduce the revenue of rural hospitals and hinder their ability to invest in medical infrastructure and staff training, thereby exacerbating health care disparities. These findings align with related studies on Taiwan's global budget. In Taiwan, urban hospitals and medical centers compete to increase inpatient service volume, resulting in a relative decrease in the quantity of inpatient services provided by rural hospitals [42]. As high-quality medical resources continue to be concentrated in urban areas, there is a risk of health care inequality between urban and rural regions [43]. Over time, as rural health care capacity diminishes, rural patients may face heightened indirect and direct economic burdens because they are compelled to seek medical care in urban areas.

This study has several strengths. First, its retrospective design leveraged robust annual hospital data from official sources, ensuring the quality and reliability of the data utilized. Second, the use of the DID method strengthened the internal validity of our findings and provided a more reliable assessment of the causal effects of the DIP. Third, we compared changes in key outcomes between hospitals in pilot regions that adopted DIP measures and hospitals in non-pilot regions of the same province that continued with the old payment system. This helps isolate the policy impact from other external influences. Fourth, we categorized hospitals on the basis of their level and urbanization status to further investigate the impact of DIP implementation on inpatient volume and bed resources across rural and urban areas, as well as at hospitals of different levels. This analysis aimed to explore potential disparities in regional health care equality.

This study has several limitations. First, as the DIP is still in the pilot stage, the localized operations in Region A may impact the generalizability of the results. On the one hand, the locally-specific disease categories, adjustment coefficients, regulatory indicators, and performance evaluation measures established within the national framework might limit the broader applicability of the findings. On the other hand, given the location of the cities in the central region, the results may have limited relevance to more developed coastal cities. Nevertheless, the fact that the DIP is a national pilot program means that the issues and characteristics revealed could provide valuable insights for other regions planning to implement the program. The challenges and successes observed in Region A could serve as important lessons for future roll-outs, despite the potential limitations in direct applicability. Second, this study utilized a single-location design and assessed only a limited set of socioeconomic parameters. Future research with larger, multisite samples could help corroborate these initial findings. Third, owing to data source and time period limitations, we were not able to obtain complete information on all relevant variables, potentially omitting some influencing factors. Fourth, despite stratifying hospitals for analysis, there may still be unexplored variations within each category.

Conclusions

This study investigated the impact of the DIP, an innovative payment method, on inpatient volume and bed resources in Region A compared with non-pilot regions in a central province, China. The findings revealed a significant reduction in inpatient volume and actual available bed days in Region A following DIP implementation, particularly in primary hospitals. Despite efforts to mitigate excessive service expansion in secondary and tertiary hospitals, they continue to attract patients from primary hospitals, exacerbating the decline in primary hospital services. Moreover, DIP implementation exacerbated urban−rural hospital disparities, with rural areas experiencing a more pronounced decline. This suggests a concerning trend where rural patients face increased economic burdens and reduced access to medical care due to the weakening of primary hospitals and the flow of patients to urban areas. Overall, the implementation of the DIP may raise concerns about its impact on health care equity and accessibility, particularly for underserved rural populations.

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Author contributions
KL and LX contributed to the conception and design of the study. KL and YY conducted the data reduction and analyses. KL and YX wrote the manuscript. All authors read and approved the manuscript before submission.

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Data availability
The data supporting the findings of this study are available from the Provincial Health Commission. However, restrictions apply to the availability of these data, which were used under license for the current study and are therefore not publicly available. Data are however available from the corresponding author upon reasonable request and with permission of the Provincial Health Commission.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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