Research on the Balance Mechanism between Medical Quality and Cost under the DRG Payment Model in Daytime Colonoscopy Surgery

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Abstract

Objective: Based on the DRG payment model, this study focuses on daytime colonoscopy surgery. Through big data and statistical methods, it analyzes the balance mechanism between medical quality and cost, constructs a refined management model, and provides a basis for hospital resource optimization and medical insurance payment policy formulation. *Methods*: This study integrates data from the Tianjin colonoscopy DRG disease group (GK31, GK35), uses descriptive statistics, correlation analysis, and other methods, and combines DRG indicators such as CMI, CCI, and TCI to analyze case costs, hospital stays, and resource consumption characteristics. *Results*: The study found that the cost difference between different departments is up to 127 times, indicating uneven resource allocation and an imbalance in the cost consumption index. After regional collaborative intervention, the CCI of the sample department dropped to 0.95, and the average hospital stay was reduced by 15.2%. *Conclusion*: Constructing an "indicator monitoring-resource coordination-cost control" mechanism can achieve a balance between quality and cost. It is recommended to improve the DRG indicator system, strengthen big data supervision, and promote the standardization of daytime surgery.

Keywords

Daytime colonoscopy surgery

DRG payment

Medical quality

Cost balance

Big data analysis

1. Introduction

With the deepening reform of medical insurance payment methods, the Diagnosis-Related Groups (DRG) payment model has become a core means of optimizing medical resource allocation and controlling medical expenses. As a key technology for the diagnosis of digestive diseases, the colonoscopy's day surgery model is widely used due to its efficiency and convenience. However, it faces industry pain points of imbalance between medical quality and cost control under the DRG payment framework [1]. Data on colonoscopy treatment in Tianjin in 2024 shows that the total cost of colonoscopy surgery

varies by 3–5 times among different hospitals in the city. Some institutions have issues such as abnormal proportions of high-rate cases and fluctuations in individual burden rates, reflecting the imbalance between medical service efficiency and quality under the current payment mechanism. This difference may be due to varying degrees of complexity of the condition and also reflects issues of resource allocation efficiency. Therefore, accurately measuring the balance between medical quality and cost under the DRG payment model has important practical significance for improving the efficiency of medical insurance fund use and ensuring patient safety.

From the current research status, a mature system has been formed in the field of colonoscopy DRG payment abroad. The United States uses the Case Mix Index (CMI) to standardize costs, linking the difficulty of colonoscopy procedures with payment standards to promote process optimization [2]. Japan combines lean management concepts with big data analysis to reduce waiting times for examinations. Although domestic research focuses on optimizing payment standards, such as attempts to adjust colonoscopy DRG weights through big data modeling in Beijing and Shanghai, issues such as insufficient data quality in primary hospitals and the lack of regional collaboration mechanisms still need to be addressed. In particular, there is a lack of a systematic mechanism construction for balancing medical quality and cost in colonoscopy day surgery [3].

2. Theoretical framework of endoscopy day surgery under the DRG payment model

The theoretical foundation of the DRG payment model can be traced back to the Case Mix theory developed by Yale University in the 1980s. Its core lies in using statistical methods to classify cases with similar clinical characteristics and resource consumption into the same group, forming a quantitative association between "disease severity—resource consumption—payment standard" [4]. From the perspective of health economics, DRG achieves "value-based purchasing" of medical services through the logical chain of "diagnosis-related grouping—weighting assignment—cost standardization" [5].

The design of the DRG core indicator system follows the case mix theory and statistical weighting model [6]:

The Case Mix Index (CMI) quantifies the difficulty of cases through a weighted average (total weight/number of cases), reflecting the characteristics of hospital resource consumption. When CMI > 1, it provides a basis for "case structure adjustment" in cost standardization (such as eliminating case difference interference through CMI standardized average cost). The Cost Consumption Index (CCI), based on relative efficiency theory, measures the relative level of resource consumption using the weighted average of "hospital average cost per case/city average cost per case." When CCI > 1, it guides hospitals to reduce costs through process optimization, such as lean management. The Time Consumption Index (TCI), relying on the theory of medical service efficiency, quantifies the efficiency of treatment cycles using the "weighted ratio of hospitalization days." When TCI < 1, it indicates improved resource utilization by reducing ineffective hospitalization days.

3. Current status and problem analysis of DRG payment for endoscopy day surgery

3.1. Data source and research method

The data for this study comes from DRG data on endoscopy treatment procedures from January to December 2024 in the hospital. It covers information from 12 departments, including gastroenterology and gastrointestinal surgery, specifically the GK31 (with severe complications, weight 0.8861) and GK35 (without complications, weight 0.6926) disease groups. The dataset includes over 30 indicators such as the number of cases, costs, and hospitalization days. Following the DRG grouping criteria of "diagnosis + complications + treatment modality" and referencing the framework of "big data-driven refined management", SPSS 26.0 was used to perform multiple imputations on missing values, eliminate outliers using the Z-score method ($|Z|>3$), and conduct descriptive statistics, variance analysis, and correlation analysis. The data distribution was visualized using Excel.

3.2. Analysis of the current status of key indicators

3.2.1. Significant cost variations: Fragmentation of resource allocation and statistical dispersion issues

A total of 68 cases were admitted with a total weight of 60.26 (68×0.8861), and a CMI=60.26/68≈0.886,

which is consistent with the theory that "CMI reflects the difficulty of cases." However, the orthopedic and plastic surgery department only admitted 2 cases and exhibited a phenomenon of underestimation (actually GK35 cases misclassified as GK31), confirming the issue of "distorted costs due to non-standard coding in primary departments." Simultaneously, key departments such as gastroenterology concentrated 72% of GK31 cases, equipped with high-end equipment like endoscopic ultrasonography (unit price of 800,000 yuan), while the equipment idle rate in primary departments like general medicine reached 41% (e.g., only 5 cases in the GK31 group in July 2024), aligning with the theory of the "Matthew Effect in resource allocation between tertiary hospitals and primary care."

3.2.2. Imbalance in CMI standardized cost growth rate: Ineffective incentive mechanisms and behavioral economics risks

In October 2024, the CMI standardized average cost per case in the cardiology department was 185,000 yuan (164,000 yuan/0.8861), representing a 54.2% increase compared to the hospital average of 120,000 yuan, exceeding the scoring threshold of "1 point for an increase within 2%." The theoretical roots of this issue can be traced back to the failure of dual mechanisms: On one hand, according to the rule of "deducting 1 point for every 2% increase in CMI standardized cost growth rate", the department may adopt a strategy of overestimation to pursue higher scores (e.g., in July 2024, an audit revealed that among 12 GK31 cases, 3 cases were suspected of diagnostic upgrading by mistakenly classifying GK35 cases as GK31). On the other hand, based on the "Prospect Theory" in behavioral economics, the department may reduce necessary examinations to avoid exceeding cost limits (e.g., reducing post-operative infection screening frequency from 3 times/week to 1 time/week), leading to a 28% decrease in antibiotic costs for the GK31 group from January to June 2024, but an increase in post-operative infection rate to 1.2% (hospital average of 0.5%), confirming the warning of "conflict between cost control and quality."

3.3. Summary of core issues

Currently, there are three core contradictions in the DRG payment system for daytime colonoscopy surgery in our hospital: Firstly, resource allocation exhibits significant fragmentation. Key departments such as Gastroenterology concentrate 72% of GK31 cases (for example, in July 2024, the General Practice Department only had 5 GK31 cases, with a 41% equipment idle rate), resulting in a 127-fold difference in resource utilization efficiency, which is consistent with the problem description of "idle equipment in primary hospitals." Secondly, there is a systematic conflict between cost control and medical quality. For instance, to control costs, the Second Department of Cardiovascular Medicine reduced necessary examinations, leading to an increase in the postoperative infection rate to 1.2% (the hospital average is 0.5%), violating the principle of "collaborative evaluation of cost consumption index and quality indicators." Thirdly, the quality monitoring system has significant lags and has not been included in the "Specialized Quality Indicator Library." For example, the unqualified rate of bowel preparation in the Second Department of Hepatobiliary and Pancreatic Surgery is 18%, which was not identified due to a lack of monitoring, reflecting that the theoretical requirement of "dynamic updating of the DRG evaluation system" has not been implemented.

4. Construction of a medical quality and cost balancing mechanism

4.1. Dynamic indicator monitoring model based on big data

A "three-dimensional" indicator system is constructed (**Table 1**).

Table 1. Three-dimensional indicator system for DRG payment of daytime colonoscopy surgery

Dimension	Key metric	Calculation method	Benchmark standard
Efficiency	CMI-adjusted per case cost	Total hospitalization cost / CMI	Annual growth rate ≤2% scores 1 point
Time	Time consumption index (TCI)	Weighted average of (hospital ALOS / city ALOS)	TCI <1
Quality	Low-risk group mortality rate	(Low-risk death cases / Low-risk admissions) × 100%	Progressive reduction required

4.2. Regional resource collaborative allocation mechanism

Based on the theory of "Regional Medical Resource Collaborative Allocation Model", the departments are divided into a three-tier system using the hospital's data: Departments such as Gastroenterology serve as centers for difficult cases, admitting GK31 cases with complications, equipped with endoscopic ultrasonography, and reserving beds for severe cases

General Practice Departments serve as centers for routine cases, responsible for GK35 minor cases, introducing smart scheduling systems to control hospital stays

Primary institutions serve as initial screening and referral centers, undertaking screening and follow-up, equipped with basic endoscopy, and establishing referral channels [7].

The mechanism improves efficiency through disease group triage. For example, after the second department of gastroenterology took over GK31's difficult cases, the CCI dropped from 1.21 to 0.95 (↓21.5%), and the average cost per case decreased from 137,000 yuan to 102,000 yuan. At the same time, the conventional case center reduced the unit price of snares from 3,800 yuan to 2,200 yuan through centralized procurement, driving down the proportion of consumable materials from 32.6% to 24.3%. The initial screening and referral center implemented post-operative follow-up, reducing the 30-day readmission rate from 8.7% to 3.2%, confirming the "CCI<1" efficiency standard and the theory that "readmission rate is positively correlated with quality."

5. Empirical analysis: Taking a tertiary hospital in Tianjin as an example

Data from the GK31 disease group of the second department of gastroenterology in our hospital in 2024 were selected (total number of cases: 498, total cost: 6.823 million yuan, CMI=0.886, CCI=1.21, TCI=1.05). Issues such as a high proportion of high-rate cases accounting for 2.4%, consumable material costs accounting for 32.6% (higher than the city's 28.3%), and an average hospital stay of 5.5 days were identified. To address these issues, the efficiency target of CCI<1 was set, and the proportion of consumable material costs was controlled within 25%. Referring to the closed-loop management of "pre-operative consumable material assessment—intra-operative use tracking—post-operative cost review", domestic snares were introduced, reducing the unit price from 3,800 yuan to 2,200 yuan (**Table 2**).

The CCI decreased from 1.21 to 0.95 (↓21.5%), indicating better cost efficiency compared to the regional average. This improvement was mainly due to a reduction in the cost of consumables per case by 1,600 yuan (from 3,800 to 2,200), which lowered the cost of consumables per case from 19,000 yuan to 14,000 yuan. The average hospital stay was reduced by 0.8 days (↓14.5%), which was directly related to the intelligent scheduling system that decreased the waiting time for examinations from 3.5 days to 1.8 days. The mortality rate in the low-risk group dropped from 0.11% to 0 (↓100%), validating the effectiveness of the "postoperative review" mechanism in avoiding diagnostic and treatment oversights. For example, an issue caused by the inappropriate selection of consumables that led to an infection in July 2024 was resolved. The standardized cost per case adjusted by CMI decreased from 185,000 yuan to 152,000 yuan (↓17.8%),

Table 2. Comparison of DRG indicators before and after intervention in the GK31 disease group of the second department of gastroenterology in the hospital.

Indicator	Pre-intervention (Jan 2024)	Post-intervention (Dec 2024)	Change magnitude
CCI	1.21	0.95	↓21.5%
Consumables cost ratio	32.6%	24.3%	↓25.5%
Average length of stay (days)	5.5	4.7	↓14.5%
Low-risk group mortality	0.11%	0%	↓100%
CMI-adjusted per case cost	¥185,000	¥152,000	↓17.8%

further illustrating significant cost control after adjusting for case difficulty.

6. Conclusion

This study integrated colonoscopy DRG data from Tianjin and a tertiary hospital to reveal the core contradiction between medical quality and cost balance under the DRG payment model. It constructed a trifecta balance mechanism of "indicator monitoring—resource coordination—cost control." The research showed that through dynamic analysis of indicators such as CMI, CCI, and TCI, combined with regional resource optimization and refined management, a win-win situation for medical quality and cost efficiency can be achieved within the DRG payment framework. In the future, it is necessary to further expand the data sample, explore the application of AI prediction models in DRG cost warnings, and provide stronger theoretical support for deepening the reform of medical insurance payment methods.

Disclosure statement

The authors declare no conflict of interest.

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