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Full length article

# Structural changes in nursing charges under diagnosis-related group (DRG) payment: A retrospective observational study in a tertiary general hospital in China

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ABSTRACT

*Background:* In the context of diagnosis-related group (DRG) payment, evidence on structural changes in nursing charge composition in general wards remains limited.
*Objective:* This study aimed to examine the nursing charge structures and their changes in priority departments within a DRG environment, and to identify whether nursing care is financially undervalued.
*Study design:* Retrospective observational study.
*Methods:* This retrospective observational study analyzed 215,961 DRG-paid inpatient records (2022–2024) from a large general hospital in Shandong Province. Patients were stratified by relative weight (RW). The analysis was conducted using logistic regression, the entropy weight method, and structural change analysis.
*Results:* Surgery (OR = 46.78, 95%CI 43.76–50.01) and age ≥ 60 (OR = 4.27, 95%CI 3.99–4.57) were the strongest factors associated with high RW. From 2022–2024, nursing charges in the cardiology department cumulatively decreased by 2.16%, with a contribution rate of 4.63% to the structural changes. Graded nursing care consistently accounted for over 93% each year, while specialized nursing care was consistently maintained at a low level. In the cardiovascular surgery department, nursing charges decreased cumulatively by 0.05% during this period, with a contribution rate of 0.22% to structural changes. Graded nursing care constituted the predominant share, accounting for 79.49%–82.54%. Specialized nursing care represented a key component, consistently exceeding 17%.
*Conclusion:* This study analyzed nursing charge structure changes in internal medicine and surgery departments. The observed shifts in nursing charge patterns may indicate that the value of nursing care is not fully captured under DRG-based payment. However, this interpretation is based solely on billing data and should therefore be made cautiously. Further research incorporating more granular, nursing-sensitive measures is needed to validate these findings. Integrating nursing workload into DRG may be important for stabilizing valuation and workforce.

## 1. Introduction

A diagnosis-related group (DRG) is a patient classification system that groups hospital cases based on diagnoses, procedures, and patient characteristics to standardize the allocation of reimbursement and resources.[1] Originating in the United States in the 1970s,[2] the DRG payment system has been adopted by a growing number of countries and regions for inpatient care. It aims to contain healthcare

*Abbreviations:* ADRG, adjacent diagnosis-related group; CI, confidence interval; CMI, case-mix index; CRSV, contribution rate of structural variation; DRG, diagnosis-related group; DSV, degree of structure variation; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; MDC, major diagnostic category; OR, odds ratio; RW, relative weight; Entropy-TOPSIS, entropy-technique for order preference by similarity to ideal solution; VIF, variance inflation factors; VSV, value of structure variation

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expenditures while enhancing transparency, efficiency, and quality of care.[3,4] Strong cost-containment pressure disproportionately affects nursing services.[5]

Nursing costs refer to the actual economic outlay incurred by hospitals in delivering nursing services, encompassing labor, materials, and overhead. In practice, these costs are typically treated as service charges and, alongside other fixed hospital costs, are included in the DRG reimbursement framework in most countries.[6] The DRG system does not directly account for nursing care, as it primarily classifies hospital cases based on diagnoses, procedures, comorbidities, and length of stay (LOS).[7] This omission of nursing costs contributes to variability in healthcare expenditures, since hospitals may incur different actual nursing labor costs depending on patients' varying care needs.[8,9]

Nursing charges are a major part of nursing costs and are reflected in inpatient billing records. The nursing charge structure refers to the relative distribution of charges across different nursing service categories. The current nursing charge structure is primarily determined by the categories of nursing services associated with a single disease.[10] Within the overall composition of inpatient charges, this structure tends to be overlooked and is given little emphasis.[11] Currently, there is a notable paucity of independent studies focusing specifically on the nursing charge structure in routine internal medicine or surgery wards. Furthermore, this structure under the DRG payment system remains insufficiently investigated.

The current study aims to explore trends in hospital nursing charges relative to total hospital expenditures, as well as the internal composition of nursing charges, within a DRG environment. Specifically, this study: (1) characterizes high-resource-consumption inpatient groups using relative weight (RW) stratification and identifies associated factors; (2) identifies priority departments by integrating DRG and nursing workload indicators; and (3) analyzes the overall structure and composition of nursing charges in priority internal medicine and surgery departments.

## 2. Methods

### 2.1. Study design and data source

The present study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (Supplementary Table 1).[12] It was approved by the Ethics Committee of the First Affiliated Hospital of Shandong First Medical University (Shandong Provincial Qianfoshan Hospital), Approval Number [2026]S624, dated April 28, 2026. We conducted a retrospective study using electronic health records from a large Grade A tertiary general hospital in Shandong Province, covering the period from 2022 to 2024. Data were extracted from the hospital's electronic health record system on May 1, 2026, covering all DRG-paid inpatient discharges between January 1, 2022 and December 31, 2024. The inclusion criteria were DRG-paid inpatients with a LOS $>$ 48 h and complete clinical and billing records. We excluded cases with an LOS $>$ 60 days, incomplete billing records, and DRG-ungroupable cases due to coding errors (Fig. 1).

First, we analyzed the factors influencing RW grouping for all hospitalized patients from 2022 to 2024. Subsequently, based on the nine internal medicine departments and eight surgery departments specified in the Standards for the Establishment of Clinical Departments in Medical Institutions,[13] we used Entropy-Technique for Order Preference by Similarity to Ideal Solution (Entropy-TOPSIS) method to identify exemplar departments in internal medicine and surgery, respectively. Finally, we performed a structural analysis of nursing charges for the exemplar departments to identify changes in the nursing charge structure.

### 2.2. Study variable

RW is a specific indicator of DRG that measures the difficulty of diagnosis and treatment, disease severity, and the utilization of medical resources. Furthermore, it reflects resource intensity, such that higher RW values signify a higher cost burden.[14,15] RW was calculated as the average cost per case in that DRG divided by the average cost per case for all cases. Cases were stratified into three groups: RW $\leq$ 1, 1 $<$ RW $<$ 2, and RW $\geq$ 2.[16,17] Variables included age groups ($\leq$ 18, 19–44, 45–59, and $\geq$ 60 years), sex, surgery (yes/no), insurance type (resident vs employee medical insurance), and adjacent diagnosis-related group (ADRG) groupings (surgical, medical, and non-operating room). LOS was summarized as the median (interquartile range [IQR]). The covariates incorporated in the multinomial logistic regression were selected on the basis of prior literature and the characteristics of the patient RW groupings.[18,19]

This study focuses primarily on the analysis of the two principal departmental categories: internal medicine and surgery. In Entropy-TOPSIS analysis, DRG-related indicators, including nursing workload, were selected based on the published literature. A total of seven indicators were used to evaluate clinical departments. These included DRG group count, major diagnostic category (MDC) count, RW, case-mix index (CMI), nursing workload, average nursing charges, and discharge volume. DRG group count served as a measure of service coverage breadth. A greater number of DRG groups indicated a broader spectrum of diagnoses and procedures and allowed the quantitative assessment of institutional performance in DRG service delivery.[20] MDC count served as a measure of service coverage breadth, with a greater number indicating a broader case-mix and providing a quantitative basis for evaluating a hospital's overall DRG service capacity.[21] RW reflected workload, with a higher RW indicating a greater workload.[22] CMI was a continuous variable indicating the average relative resource intensity and technical difficulty; higher values implied greater clinical complexity and better DRG performance.[23] Nursing workload was evaluated by the weight per bed (total RW/the number of beds in the department), indirectly reflecting the high intensity and complexity that nursing work may entail.[24] Average nursing charges served as an indicator of the value of nursing labor and were calculated as the total nursing charges of discharged patients during a given period divided by the number of discharged patients in that period.[25] Discharge volume was closely associated with the overall nursing workload, as an increase in the number of discharged patients generally entails higher demands for admission assessments, daily nursing care, health education, and discharge instructions.[26] All seven indicators were positive, meaning that higher values represent better departmental performance.

In the current study, the nursing charge structure is defined as the proportional composition of different nursing charge categories (graded nursing care, specialized nursing care, and specialist nursing care) within the total nursing charges per case, reflecting how nursing resources are financially allocated across service types in hospital billing.[27,28] The three types of nursing charges are graded nursing care, specialized nursing care, and specialist nursing care, based on the National Technical Specifications for Medical Service Projects (2023 Edition)[27] and the Price List for Medical Service Items in Shandong Public Medical Institutions (2023 Edition).[28] Graded nursing care(Critical Care Nursing, Special Nursing Care, and Level I–Level III Nursing Care)is a patient classification system based on the severity of the patient's condition and their self-care ability according to the Chinese national standard, which determines the required frequency of nursing rounds and intensity of care.[29] Specialized nursing care encompasses protective isolation nursing, psychiatric patient nursing, and neonatal nursing, etc. Specialist nursing care encompasses perianal care, perineal care, and oral care, etc. In our study, nursing charges refer to nursing-related charges extracted from hospital billing records rather than directly measured nursing labor costs, nursing hours, or actual resource consumption.

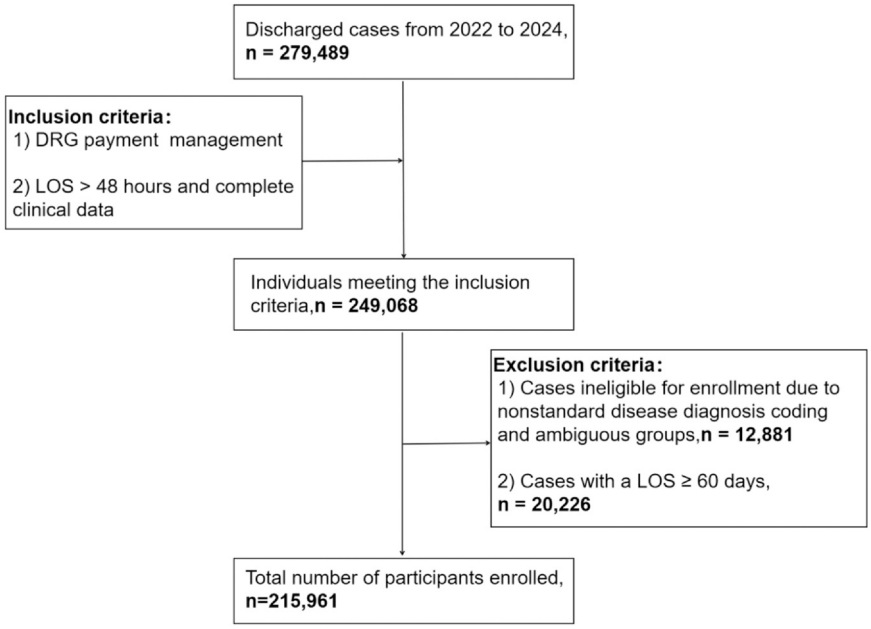



**Fig. 1.** Flowchart of the inclusion and exclusion criteria.

### 2.3. Statistical analysis method

Categorical data were presented as frequencies, rates, and constituent ratios. The chi-square test was used for comparisons between groups. Normality tests were performed for continuous variables. Normally distributed continuous variables were described as the mean ± standard deviation, and comparisons among multiple groups were performed using analysis of variance. Non-normally distributed continuous variables were expressed as the median (IQR), and group comparisons were conducted using the Kruskal-Wallis *H* test. To identify factors associated with RW group, we performed multinomial logistic regression with RW group as the dependent variable, using RW ≤ 1 as the reference category. The independent variables included age groups (≤ 18, 19–44, 45–59, and ≥ 60 years), sex, surgery (yes/no), insurance type (resident vs. employee medical insurance), and ADRG groupings (surgical, medical, and non-operating room). Logistic regression estimated odds ratios (ORs) and 95% confidence intervals (CIs). Multicollinearity among the variables was examined using variance inflation factors (VIF).[30] All VIF values were below 2.0, indicating no evidence of serious multicollinearity.

To comprehensively evaluate DRG and nursing data from tertiary hospitals between 2022 and 2024, we applied the Entropy-TOPSIS method. Entropy-TOPSIS method defined a positive-ideal solution and a negative-ideal solution across all indicators. Euclidean distances from each department to both solutions were computed, and the performance score $C_i\sim$ was calculated as $C_i = D^-/(D^+ + D^-)$, ranging from 0 to 1. Higher $C_i\sim$ values indicated better overall performance.[31] Through standardized data normalization and objective weighting, this approach effectively eliminates subjective bias and generates a composite score integrating both DRG and nursing workload indicators, producing a departmental ranking that enabled the selection of priority departments for subsequent in-depth charge structure analysis. Given the differences between internal medicine and surgery departments in terms of disease complexity, nursing operations, and workload, we conducted separate analyses for each category.[32,33]

The analysis of internal cost composition relies on three specific indicators to quantify structural variation: value of structure variation (VSV), degree of structure variation (DSV), and contribution rate of structural variation (CRSV).[34]

VSV serves as the principal metric for assessing both the magnitude and the directional trend of fluctuations within the composition of total costs. It quantifies the net change in a specific line item by measuring the variance between its initial value at the commencement of a defined period and its concluding value at the end of that interval. The formula is as follows:

$$VSV = X_{i1} - X_{i0}$$

DSV denotes the aggregate magnitude of shifts occurring within individual cost categories over a specified interval, thereby capturing the extent of compositional variation in the overall cost structure during that period. It is calculated in the following way:

$$DSV = \Sigma\ |VSV_i|$$

The CRSV is calculated as the ratio of the absolute VSV for a specific cost category to the magnitude of structural change. Thus, it quantifies the proportionate contribution of each cost category's variance to the total observed structural shift. The CRSV is calculated as follows:

$$CRSV = \frac{|VSV_i|}{DSV} \times 100\%$$

All analyses were performed with R version 4.2.2. The significance level was set at a two-sided $\alpha = 0.05$.

## 3. Results

### 3.1. Patient characteristics by RW group

Among the 215,961 discharges included in the analysis, 66.25% were categorized into the low RW group (RW ≤ 1), 12.84% into the medium RW group (1 < RW < 2), and 20.91% into the high RW group (RW ≥ 2). The median age of the total population was 59 (48, 69) years. Patients in the high-RW group were older, with a median age of 62 (53, 70) years; were more likely to have undergone surgery (97.98%); and had a longer median LOS (7 days). Significant between-group differences were detected for age, sex, surgery status, LOS, insurance type, and ADRG ($P < 0.001$). Both the CMI and the number of DRG groups increased with ascending RW, with the high-RW group demonstrating the highest median CMI (3.97) and the greatest clinical complexity (Table 1).

**Table 1**
General characteristics by relative weight group.

| Characteristics | Total (N = 215,961) | RW ≤ 1 (n = 143,076) | 1 < RW < 2 (n = 27,721) | RW ≥ 2 (n = 45,164) | $\chi^2/H$ | P |
|---|---|---|---|---|---|---|
| Age [median (Q1, Q3)] | 59(48,69) | 59(46,69) | 57(45,67) | 62(53,70) | 2338.87 | < 0.001 |
| Age groups [n (%)] | | | | | 4145.87 | < 0.001 |
| ≤ 18 | 12,935(5.99) | 10,896(7.62) | 1070(3.86) | 969(2.15) | | |
| 19–44 | 33,353(15.44) | 22,841(15.96) | 5655(20.40) | 4857(10.75) | | |
| 45–59 | 63,969(29.62) | 41,335(28.89) | 9192(33.16) | 13,442(29.76) | | |
| ≥ 60 | 105,704(48.95) | 68,004(47.53) | 11,804(42.58) | 25,896(57.34) | | |
| Sex [n (%)] | | | | | 90.15 | < 0.001 |
| Males | 111,212(51.50) | 74,031(51.74) | 13,556(48.90) | 23,625(52.31) | | |
| Females | 104,749(48.50) | 69,045(48.26) | 14,165(51.10) | 21,539(47.69) | | |
| Surgery [n (%)] | | | | | 35700.21 | < 0.001 |
| No | 77,327(35.81) | 70,272(49.12) | 6142(22.16) | 913(2.02) | | |
| Yes | 138,634(64.19) | 72,804(50.88) | 21,579(77.84) | 44,251(97.98) | | |
| LOS [median (Q1, Q3)] | 5(3,8) | 4(2,7) | 5(4,9) | 7(4,12) | 23395.67 | < 0.001 |
| Insurance [n (%)] | | | | | 2454.09 | < 0.001 |
| Resident | 103,726(48.03) | 63,738(44.55) | 13,907(50.17) | 26,081(57.75) | | |
| Employee | 112,235(51.97) | 79,338(55.45) | 13,814(49.83) | 19,083(42.25) | | |
| ADRG [n (%)] | | | | | 54055.12 | < 0.001 |
| Surgical category | 93,714(43.39) | 41,309(28.87) | 16,583(59.82) | 35,822(79.32) | | |
| Medical category | 103,320(47.84) | 92,996(65.00) | 8072(29.12) | 2252(4.99) | | |
| Non-operating room-procedure group | 18,927(8.76) | 8771(6.13) | 3066(11.06) | 7090(15.70) | | |
| CMI | 1.46 | 0.68 | 1.42 | 3.97 | | |
| DRG groups [n (%)] | 824 | 460(55.83) | 163(19.78) | 201(24.39) | | |

*Notes:* CMI values are presented as group level aggregate means, calculated as the ratio of the total DRG weights to the number of cases within each relative weight group
*Abbreviations:* RW, relative weight; LOS, length of stay; ADRG, adjacent diagnosis-related group; CMI, case mix index; DRG, diagnosis-related group

**Table 2**
Logistic regression of different influencing factors, with the RW ≤ 1 group as the reference [OR (95% CI)].

| Predictors | 1 < RW < 2 | RW ≥ 2 |
|---|---|---|
| Age | | |
| ≤ 18 | 1.00 | 1.00 |
| 19–44 | 2.51 (2.34–2.69)* | 2.38 (2.22–2.57)* |
| 45–59 | 2.26 (2.11–2.41)* | 3.64 (3.41–3.91)* |
| ≥ 60 | 1.76 (1.65–1.88)* | 4.27 (3.99–4.57)* |
| Sex | | |
| Males | 1.00 | 1.00 |
| Females | 1.12 (1.09–1.15)* | 0.98 (0.96–0.99)* |
| Surgery | | |
| No | 1.00 | 1.00 |
| Yes | 3.39 (3.29–3.49)* | 46.78 (43.76–50.01)* |
| Insurance type | | |
| Resident | 1.00 | 1.00 |
| Employee | 0.79 (0.78–0.82)* | 0.59 (0.57–0.61)* |
| ADRG | | |
| Non-operating room procedure group | 1.00 | 1.00 |
| Medical category | 0.25 (0.24–0.26)* | 0.03 (0.02–0.03)* |
| Surgical category | 1.15 (1.10–1.20)* | 1.07 (1.04–1.11)* |

Notes: * $P < 0.05$
*P* values are based on logistic regression analysis, using "RW ≤ 1 group" as the reference group
*Abbreviations:* RW, relative weight; OR, odds ratio; CI, confidence interval; ADRG, adjacent diagnosis-related group

### 3.2. Factors associated with higher RW

Logistic regression analyses identified that surgical intervention and age were the strongest factors associated with high RW. Using the low-RW group (RW ≤ 1) as the reference, surgery was associated with an adjusted OR of 46.78 (95% CI 43.76–50.01) for RW ≥ 2. Patients aged ≥ 60 years had an OR of 4.27 (95% CI 3.99–4.57) for RW ≥ 2. Compared with non-operating room procedures, medical diagnosis was associated with markedly reduced odds of RW ≥ 2 (OR = 0.03, 95% CI 0.02–0.03), whereas the surgical category was associated with a modestly increased risk (OR = 1.07, 95% CI 1.04–1.11). For the 1 < RW < 2 group, surgery remained the strongest predictor (OR = 3.39, 95% CI 3.29–3.49), followed by the age group of 19–44 years (OR = 2.51, 95% CI 2.34–2.69). Female sex was associated with slightly increased odds (OR = 1.12, 95% CI 1.09–1.15). Surgical ADRG showed a modest positive association (OR = 1.15, 95% CI 1.10–1.20) (Table 2).

### 3.3. Identification of priority departments and structural changes during 2022–2024

For the internal medicine department, the highest weights were observed for RW (0.19) and DRG group count (0.18), followed by discharge volume (0.17). In contrast, for the surgery department, average nursing charges carried the largest weight (0.23), with discharge volume (0.16) and DRG group count (0.15) ranking next (Table 3).

The Department of Cardiology achieved the highest $C_i$ value of 0.71, significantly outperforming all other internal medicine departments. It was followed by the Department of Neurology ($C_i$ = 0.63) and the Department of Gastroenterology ($C_i$ = 0.52). In contrast, several departments exhibited comparatively lower $C_i$ values, including Rheumatology and Immunology ($C_i$ = 0.04), Endocrinology ($C_i$ = 0.16), and Hepatology ($C_i$ = 0.22), indicating relatively lower composite scores in the evaluated DRG and nursing performance metrics. The Department of Cardiovascular Surgery attained the highest $C_i$ value of 0.57, ranking first among the eight surgery departments. It was closely followed by the Department of General Surgery ($C_i$ = 0.55) and the Department of Neurosurgery ($C_i$ = 0.48). Departments such as Plastic and Cosmetic Surgery ($C_i$ = 0.07) and Thoracic Surgery ($C_i$ = 0.19) ranked at the lower end of the spectrum (Table 4).

From 2022 to 2024, nursing charges in the Department of Cardiology exhibited a slight downward trend, with a decrease of 1.95 percentage points from 2022 to 2023. The decline then narrowed to 0.21 percentage points from 2023 to 2024, resulting in a cumulative decrease of 2.16 percentage points over the two-year period. Regarding

**Table 3**
Results of the entropy weighting method.

| Indicators | Entropy value | Coefficient of variation | Entropy weight | Rank |
|---|---|---|---|---|
| **Internal medicine** | | | | |
| RW | 0.75 | 0.25 | 0.19 | 1 |
| DRG group count | 0.76 | 0.24 | 0.18 | 2 |
| Discharge volume | 0.77 | 0.23 | 0.17 | 3 |
| Nursing workload | 0.80 | 0.20 | 0.15 | 4 |
| MDC count | 0.86 | 0.14 | 0.11 | 5 |
| CMI | 0.87 | 0.13 | 0.10 | 6 |
| Average nursing charges | 0.88 | 0.12 | 0.09 | 7 |
| **Surgery** | | | | |
| Average nursing charges | 0.67 | 0.33 | 0.23 | 1 |
| Discharge volume | 0.79 | 0.23 | 0.16 | 2 |
| DRG group count | 0.78 | 0.22 | 0.15 | 3 |
| Nursing workload | 0.79 | 0.21 | 0.14 | 4 |
| RW | 0.81 | 0.19 | 0.13 | 5 |
| CMI | 0.84 | 0.16 | 0.11 | 6 |
| MDC count | 0.88 | 0.12 | 0.08 | 7 |

*Abbreviations:* RW, relative weight; MDC, major diagnostic category; CMI, case mix index; DRG, diagnosis-related group

**Table 4**
Evaluation results of department prioritization.

| Department | $D^+$ | $D^-$ | $C_i$ | Rank |
|---|---|---|---|---|
| **Internal medicine** | | | | |
| Cardiology | 0.13 | 0.32 | 0.71 | 1 |
| Neurology | 0.16 | 0.27 | 0.63 | 2 |
| Gastroenterology | 0.20 | 0.21 | 0.52 | 3 |
| Geriatrics | 0.25 | 0.22 | 0.47 | 4 |
| Hematology | 0.33 | 0.11 | 0.26 | 5 |
| Nephrology | 0.33 | 0.10 | 0.23 | 6 |
| Hepatology | 0.34 | 0.10 | 0.22 | 7 |
| Endocrinology | 0.34 | 0.06 | 0.16 | 8 |
| Rheumatology and Immunology | 0.39 | 0.02 | 0.04 | 9 |
| **Surgery** | | | | |
| Cardiovascular surgery | 0.20 | 0.27 | 0.57 | 1 |
| General surgery | 0.22 | 0.27 | 0.55 | 2 |
| Neurosurgery | 0.27 | 0.25 | 0.48 | 3 |
| Orthopedic surgery | 0.27 | 0.21 | 0.43 | 4 |
| Urology | 0.30 | 0.13 | 0.30 | 5 |
| Anorectal department | 0.31 | 0.09 | 0.23 | 6 |
| Thoracic surgery | 0.35 | 0.08 | 0.19 | 7 |
| Plastic and cosmetic surgery | 0.38 | 0.03 | 0.07 | 8 |

*Abbreviations:* $D^+$, distance to the positive ideal solution; $D^-$, distance to the negative ideal solution; $C_i$, relative closeness

**Table 5**
VSV and DSV of inpatient charges in two priority departments.

| Charge category | VSV 2022–2023 | VSV 2023–2024 | VSV 2022–2024 |
|---|---|---|---|
| **Cardiology department** | | | |
| Medication | -9.63 | -1.95 | -11.58 |
| Laboratory | -1.36 | -3.65 | -5.01 |
| Examination | 0.35 | -0.43 | -0.08 |
| Treatment | -2.93 | 1.43 | -1.50 |
| Surgical | 0.04 | 0.23 | 0.27 |
| Supplies | 11.57 | -4.46 | 7.11 |
| Bed | -2.00 | -0.27 | -2.27 |
| Nursing | -1.95 | -0.21 | -2.16 |
| Consultation | -0.58 | -0.15 | -0.73 |
| Others | 6.49 | 9.46 | 15.95 |
| **DSV** | 36.90 | 20.81 | 46.66 |
| **Cardiovascular surgery department** | | | |
| Medication | -1.52 | -7.13 | -8.65 |
| Laboratory | 0.00 | 0.15 | 0.15 |
| Examination | -0.15 | 1.11 | 0.96 |
| Treatment | 0.03 | 2.93 | 2.96 |
| Surgical | 0.56 | 2.66 | 3.22 |
| Supplies | 3.70 | 0.96 | 3.66 |
| Bed | -0.07 | 0.17 | 0.10 |
| Nursing | -0.17 | 0.12 | -0.05 |
| Consultation | -0.01 | 0.10 | 0.09 |
| Others | -1.37 | -1.07 | -2.42 |
| **DSV** | 7.58 | 16.40 | 22.26 |

*Abbreviations*: VSV, value of structural variation; DSV, degree of structural variation

the contribution to structural changes in total charges, nursing charges in the Department of Cardiology consistently exerted a negative contribution throughout the study period, with a negative contribution rate of 5.28% from 2022 to 2023, which decreased to 0.94% from 2023 to 2024, resulting in a cumulative negative contribution rate of 4.63% from 2022 to 2024 (Table 5 and Table 6).

Nursing charges in the Department of Cardiovascular Surgery remained generally stable with no significant fluctuations, decreasing by 0.17 percentage points from 2022 to 2023, and then increasing by 0.12 percentage points from 2023 to 2024, resulting in a cumulative net decrease of 0.05 percentage points over the two-year period. Regarding the contribution to structural changes in total charges, the contribution of nursing charges in this department exhibited a phased shift: it represented a weak negative contribution from 2022 to 2023, with a contribution rate of 2.24%, shifted to a positive contribution from 2023 to 2024, with a contribution rate of 0.73%, and reverted to a cumulative negative contribution over the full 2022–2024 period, with a contribution rate of 0.22% (Table 5 and Table 6).

The composition of nursing charges in the Department of Cardiology was overwhelmingly dominated by graded nursing care, which consistently accounted for over 93% of the total nursing charges across the three years. The proportion peaked at 96.35% in 2022, declined to 93.65% in 2023, and remained at 93.69% in 2024, exhibiting a pattern of minor fluctuations before stabilizing. Specialist nursing care represented a consistently minimal share of the nursing charge structure, accounting for 0.27% in 2022, rising to a three-year high of 0.78% in 2023, and then falling back to 0.11% in 2024, showing notable volatility at a low level. Specialized nursing care served as an important component of the department's nursing charge structure, with its proportion increasing steadily year by year: from 3.38% in 2022 to 5.56% in 2023 and further to 6.20% in 2024, making it the only category among the three to demonstrate continuous growth (Table 7).

Although its overall proportion was markedly lower than that observed in the Department of Cardiology, the nursing charge structure in the Department of Cardiovascular Surgery was also dominated by graded nursing care. Graded nursing care accounted for 82.54% in 2022, decreased to a three-year low of 79.49% in 2023, and then rebounded to 81.30% in 2024, remaining relatively stable within the range of 79%–83%. Specialist nursing care accounted for a negligible

**Table 6**
CRSV in two priority departments (%).

| Charge category | 2022–2023 | 2023–2024 | 2022–2024 |
|---|---|---|---|
| **Cardiology department** | | | |
| Medication | 26.08 | 8.77 | 24.82 |
| Laboratory | 3.68 | 16.41 | 10.74 |
| Examination | 0.95 | 1.93 | 0.17 |
| Treatment | 7.93 | 6.43 | 3.21 |
| Surgical | 0.11 | 1.03 | 0.58 |
| Supplies | 31.33 | 20.05 | 15.24 |
| Bed | 5.42 | 1.21 | 4.86 |
| Nursing | 5.28 | 0.94 | 4.63 |
| Consultation | 1.57 | 0.67 | 1.56 |
| Others | 17.57 | 42.53 | 34.18 |
| **Cardiovascular surgery department** | | | |
| Medication | 20.05 | 43.48 | 38.86 |
| Laboratory | 0.00 | 0.91 | 0.67 |
| Examination | 1.98 | 6.77 | 4.31 |
| Treatment | 0.39 | 17.86 | 13.30 |
| Surgical | 7.38 | 16.22 | 14.47 |
| Supplies | 48.81 | 5.85 | 16.44 |
| Bed | 0.92 | 1.04 | 0.45 |
| Nursing | 2.24 | 0.73 | 0.22 |
| Consultation | 0.13 | 0.61 | 0.40 |
| Others | 18.07 | 6.52 | 10.78 |

*Abbreviations*: CRSV, contribution rate of structural variation

share of the nursing charge structure in this department and did not constitute a meaningful component. Specialized nursing care was a major component of the nursing charge structure, with a proportion substantially higher than that in the Department of Cardiology. It accounted for 17.46% in 2022, rose to a three-year high of 20.35% in 2023, and declined to 18.70% in 2024; this means it consistently remained above 17%, displaying a pattern of an initial increase followed by a slight decrease. According to Fisher's exact test, the difference in the composition of nursing charges between the two departments over the three-year period was statistically significant ($P < 0.001$) (Table 7).

## 4. Discussion

### 4.1. High-resource patient phenotypes: alignment with DRG core logic and geriatric nursing complexity

The present study identified surgery and age ≥ 60 years as the two factors most strongly associated with elevated DRG-RW, whereas the medical category yielded a near-zero OR, which is consistent with the core design principles of implemented DRG payment systems.[35,36] The substantial positive association with surgical intervention can be attributed to the inherent logic of DRG systems, in which operative procedures typically represent higher technical difficulty, greater resource consumption, and more intensive ancillary service use. Conversely, the markedly lower odds associated with the medical-category reflect the fact that medical category cases generally involve fewer procedure-based resource components and are therefore less likely to be classified into high-RW groups under the current DRG assignment logic. Our findings confirm that the Chinese DRG system follows the international consensus of prioritizing procedural intensity, comorbidity burden, and patient complexity as key drivers of resource allocation.

High-RW patients were characterized by older age, longer LOS, and predominant surgery status, reflecting a globally consistent high-resource patient phenotype.[37] Advanced age was independently associated with higher RW, which can be explained by increased comorbidities, reduced physiological reserve, and higher demand for prolonged labor-intensive nursing care.[38] Unlike discrete medical procedures, geriatric nursing relies heavily on time-consuming, process-oriented care that is poorly captured by traditional DRG classification.[39] Process-oriented care that is poorly captured by traditional DRG classification. This gap reflects a key limitation of conventional DRG classification, which is primarily driven by diagnoses, procedures, and LOS rather than nursing workload or patient acuity. As shown in our data, patients in the medical diagnosis group require continuous labor-intensive nursing input that is not adequately reflected in DRG RWs.

### 4.2. Departmental prioritization using Entropy-TOPSIS

By integrating DRG indicators with nursing indicators and charge measures, we established a robust framework to identify priority departments. The Entropy-TOPSIS method identified cardiology and cardiovascular surgery as priority departments. This dual-method approach enhances methodological rigor compared with single-evaluation methods commonly used in national studies.[40] Using Entropy-TOPSIS, cardiology and cardiovascular surgery ranked highest among the evaluated internal medicine and surgery departments. Similar prioritization patterns have been reported in previous studies.[41–43] This framework provides complementary information beyond single DRG indicators; this may help hospital managers identify departments for further nursing-resource assessment and inform resource allocation under DRG payment.

### 4.3. Nursing charges share and charge structure divergence

The divergent evolution of the nursing charge share between internal medicine and surgery represents the most clinically meaningful finding, mirroring international observations across DRG-adopting countries.[44]

In the Department of Cardiology, the nursing charge share declined significantly with more than 93.0% of nursing charges coming from time-based graded nursing care. This pattern does not confirm that DRG payment directly caused the reduction; however, it reveals an observable association under DRG payment.[42] Similar compression of nursing charges suggesting undervaluation has been reported in the United States, Europe, and other Asian countries implementing DRG

**Table 7**
Proportion of nursing charges (%).

| Nursing charge category | 2022–2023 | 2023–2024 | 2022–2024 | *P* |
|---|---|---|---|---|
| **Cardiology department** | | | | < 0.001 |
| Graded nursing care | 96.35 | 93.65 | 93.69 | |
| Specialist nursing care | 0.27 | 0.78 | 0.11 | |
| Specialized nursing care | 3.38 | 5.56 | 6.20 | |
| **Cardiovascular surgery department** | | | | < 0.001 |
| Graded nursing care | 82.54 | 79.49 | 81.30 | |
| Specialist nursing care | 0.00 | 0.09 | 0.00 | |
| Specialized nursing care | 17.46 | 20.35 | 18.70 | |

*Notes:* Fisher's exact test was performed to compare the distribution of the three nursing charge categories between the two departments

policies.[45,46]

In the Department of Cardiovascular Surgery, the nursing charge share remained stable with specialized nursing care accounting for 17%–20% of total nursing charges. This stability arises because surgical nursing is implicitly bundled with high-workload procedures, creating indirect compensation that protects nursing expenditure.[41] This phenomenon is not unique to China; it represents a global DRG design limitation that prioritizes procedural care over complex medical nursing.[47]

The observed divergence in nursing charge composition between the two departments may partly reflect inherent case-mix differences, as indicated by their distinct CMI and RW distributions. The structural differences observed not only mirror DRG payment design but also the underlying patient composition and associated care demands.

### *4.4. Implications for international DRG refinement and nursing sustainability*

Recent evidence from both Europe and North America has begun to link standardized nursing data to DRG frameworks. DRG weight has been shown to be associated with nursing diagnoses and nursing actions in hospitalized children, suggesting that nursing data may explain both resource intensity and outcomes such as prolonged hospitalization or intensive care unit (ICU) transfer.[46,48] Two additional studies demonstrated that care complexity correlates with medical complexity, LOS, and intra-hospital or ICU transfer risk.[49,50] Machine learning approaches have identified specific nursing diagnoses most strongly associated with ICU transfer,[51] and standardized terminologies have been advocated as essential for rendering nursing complexity visible within reimbursement systems.[52] A North American observational study found that DRG reimbursement and nurse staffing allocation systems were ineffective in explaining nursing care complexity, with median DRG rates being similar between high- and low-complexity nursing care cases.[53] Collectively, these studies suggest that nursing complexity is not inherently invisible to DRG-type systems, provided that standardized nursing data are systematically collected and linked to classification frameworks.

Our findings support a growing international consensus that DRG systems should incorporate nursing-related indicators to ensure sustainability.[54] Our findings reflect changes in the financial representation of nursing services rather than direct measures of nursing workload, intensity, or value; they suggest that DRG systems may be capable of capturing nursing care complexity as a measurable component of patient complexity. Billing items and actual nursing workload are not isomorphic. A growing body of evidence confirms that DRG based payment systems insufficiently capture nursing complexity.[52] In hospital practice, a substantial portion of nursing work is implicit, process-oriented, and not bound to specific procedural tasks.[55] In an observational study conducted across 25 acute care inpatient units, nearly 60% of observed nursing activities did not fit into categories readily available in or easily abstracted from the electronic health record, undocumented activities accounted for over half of all observation tasks.[56] These activities are essential to care quality yet lack corresponding chargeable service items in most fee schedules.

## 5. Strengths and limitations

The present study has three main strengths. First, it analyzed 215,961 DRG-paid inpatient records over three years, providing robust evidence on the structural changes in the nursing charge structure during 2022–2024 within a DRG environment, which goes beyond common cross-sectional or ICU focused studies. Second, a multi-method analytical framework integrating multinomial logistic regression, Entropy-TOPSIS, and structural change analysis was applied to identify priority departments and quantify charge structure changes, ensuring methodological rigor and replicability. Third, the current study revealed a novel and clinically meaningful divergence in nursing charge share and composition between an internal medicine department and a surgery department under the same DRG payment system, highlighting the potential undervaluation of nursing in medical settings, a finding rarely quantitatively demonstrated in Chinese tertiary hospital contexts.

This study has several limitations. First, nursing-related charges were derived from billing data based on the cost of service items and used as proxies for actual nursing resource consumption. However, these costs differ from direct measures such as actual nursing labor costs, workload hours, or validated patient acuity scores. Second, the findings of this single-center study mainly reflect local practice and policy contexts, which might limit generalizability. Further investigation is required to validate these findings across multiple departments and centers. Third, the comparability of charge variations over time may be affected by not applying medical price indices or regional cost adjusters across different time points to standardize charges to real price levels, and by the potential influence of the COVID-19 pandemic on charges in 2022. Lastly, because no pre-reform data were available, the independent effect of DRG reform on nursing charge composition cannot be estimated.

## 6. Conclusion

This study analyzed nursing charges using large scale DRG inpatient billing data. Surgery and advanced age were the primary factors associated with elevated RW. Entropy-TOPSIS identified priority internal medicine and surgery departments, and structural variation degree analysis of 2022–2024 data revealed a downward trend in nursing charges in these departments. These shifts suggest that nursing value may be underestimated under DRG payment, but this inference rests solely on billing data and requires cautious interpretation, with confirmation needed using more granular nursing sensitive data. These findings highlight the need to improve the financial visibility of nursing services and to incorporate standardized nursing workload indicators into DRG-based hospital management.

## CRediT authorship contribution statement

**Ye Jiang:** Writing – original draft, Visualization, Investigation, Formal analysis, Data curation, Resources, Software. **Sha Yang:** Methodology, Writing – review & editing. **Jing Li:** Methodology, Writing – review & editing. **Xiaoying Kong:** Methodology, Writing – review & editing. **Yang Yang:** Methodology, Writing – review & editing. **Jiahui Lao:** Methodology, Writing – review & editing. **Jia Cao:** Methodology, Writing – review & editing. **Qian Zhou:** Writing – review & editing. **Fang Tang:** Writing – review & editing, Project administration, Methodology, Conceptualization, Supervision. All authors have read and approved the final version of this manuscript.

## Ethics approval and consent to participate

This study was approved by the Ethics Committee of the First Affiliated Hospital of Shandong First Medical University (Shandong Provincial Qianfoshan Hospital) (approval number: [2026]S624).

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## Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declaration of Competing Interest

The authors declare that they have no conflicts of interest.

## Declaration of Generative AI and AI-assisted technologies in the writing process

The authors declare that no Generative AI or AI-assisted technologies were used in the writing process.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.hcr.2026.100096.

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