

Research of Medical Expenditure among Inpatients with Unstable Angina Pectoris in a Single Center

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Abstract

Background: With the rising incidence as well as the medical expenditure among patients with unstable angina pectoris, the research aimed to investigate the inpatient medical expenditure through the combination of diagnosis-related groups (DRGs) among patients with unstable angina pectoris in a Grade A tertiary hospital to conduct the referential standards of medical costs for the diagnosis.

Methods: Single-factor analysis and multiple linear stepwise regression method were used to investigate 3933 cases between 2014 and 2016 in Beijing Hospital (China) whose main diagnosis was defined as unstable angina pectoris to determine the main factors influencing the inpatient medical expenditure, and decision tree method was adopted to establish the model of DRGs grouping combinations.

Results: The major influential factors of inpatient medical expenditure included age, operative method, therapeutic effects as well as comorbidity and complications (CCs) of the disease, and the 3933 cases were divided into ten DRGs by four factors: age, CCs, therapeutic effects, and the type of surgery with corresponding inpatient medical expenditure standards setup. Data of nonparametric test on medical costs among different groups were all significant ($P < 0.001$, by Kruskal-Wallis test), with $R^2 = 0.53$ and coefficient of variation (CV) = 0.524.

Conclusions: The classification of DRGs by adopting the type of surgery as the main branch node to develop cost control standards in inpatient treatment of unstable angina pectoris is conducive in standardizing the diagnosis and treatment behaviors of the hospital and reducing economic burdens among patients.

Key words: Angina, Unstable; Decision Trees; Diagnosis-related Groups; Health Care Costs

INTRODUCTION

The rapid growth in the costs of medical care and treatment has become an international issue.^[1] As one of the most advanced methods in the management of medical payment worldwide nowadays, diagnosis-related groups (DRGs) have a significant effect in controlling medical expenses and reducing the economic burden among patients.^[2] The definition of DRGs is diagnosis-related groups, which means the diagnoses of diseases with similar treatments are classified into certain related groups according to the International Classification of Diseases (ICD), and then each diagnostic groups are subdivided into more branching groups according to the variety of the age, gender, admission conditions, severity of the disease, comorbidity and complications (CCs) as well as other factors related to the condition of patients.^[3] The grouping results are used as the basis in calculating the payment standards for medical institutions in charging patients as well as medical insurance organizations.^[4] The guiding methodology of DRGs is by setting up the unified

payment criterion for certain classification of diagnoses to achieve the goal of standardizing medical resources utilization and the control of medical expenditure.^[5] In recent years, studies of prospective payment system based on DRGs (DRGs-PPS) has been vastly carried out in developed countries to guide health administrative departments as well as medical institutions in setting medical payment standards among common diagnoses, while similar researches in China are comparatively inadequate. Unstable angina pectoris is the clinical manifestation between stable angina pectoris and acute myocardial infarction as well as sudden death; it

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is one of the most common and high frequent diagnoses in cardiovascular system as well as causes for hospitalization in clinical. As the first symptom of coronary heart disease, the occurrence of unstable angina pectoris is more common among male patients and is positively correlated with age. Since it shows a tendency of the rapid development, it is crucial for the disease to be diagnosed and treated in time. In recent years, with the development in operative treatments and the improvement in medical materials, cardiac surgeries and interventional operations have been further advanced and had already been playing a fundamental role in the diagnosis and treatment of unstable angina pectoris.^[6] In this study, the inpatient medical expenditure of 3933 cases of unstable angina pectoris in 2014–2016 of a Grade A tertiary hospital in Beijing was used as the research objects. By adopting the combination of DRGs in analyzing the structure and influencing factors of hospitalization expenses, we aimed to set up the inpatient medical expenditure standards of unstable angina pectoris and to provide a reference in strengthening the control on inpatient medical expenditure as well as standardizing clinical behaviors of the hospital.^[7]

METHODS

Acquisition and preprocessing of data and materials

The basic information of patients whose main diagnoses are labeled as unstable angina pectoris between 2014 and 2016 in a Grade A tertiary hospital of Beijing was collected through the medical record management system. The preprocessing of the data and materials included eliminating the cases with missing items in the medical records as well as those with illogical and unreasonable mistakes of basic information.^[8] The number of effective cases after preliminary screening was 3933 in total.

Reduction of data

We established the dictionary library of CC according to ICD-10 and built the dictionary library of surgeries as well as nonsurgical operation according to ICD-9-CM-3.^[9] Then, we standardized the variable classifications of the original codes according to the requirements of decision tree analysis as shown in Table 1.

Statistical analysis

The variables we collected include gender, age, therapeutic effects, treatments, CCs, admission condition, and followed up situation of the patients. Single-factor analysis and multiple linear regression method were used to select and group the variables.^[10] Since the dependent variable (inpatient medical expenditure) is not subject to normal distribution ($Z = 0.69$, $P < 0.001$), Kruskal-Wallis test (nonparametric statistical analysis) was used in single-factor analysis, and multiple linear stepwise regression analysis was carried out after the conversion of hospitalization expense by square root data.^[11] All the data and material collected were entered into Excel 2010 software for Microsoft (Microsoft Corporation, Washington, USA), and statistical analyses were performed using SPSS software version 14.0 (SPSS Inc., Chicago, IL, USA).

Table 1: Quantification of influencing factors in inpatient medical expenditures of patients with unstable angina pectoris

| Variables | Methods for standardization |
|-----------------------|---|
| Gender | 1 = male, 0 = female |
| Age | 1 = age ≤ 50 years, 2 = age > 50 years |
| Therapeutic effects | 1 = valid (cured, improved), 0 = null (uncured) |
| Treatments | 1 = CABG, 2 = PTCA, 3 = STENT, 4 = combination of two or more operative methods |
| CC | 1 = with, 0 = without |
| Admission condition | 1 = moderate, 2 = emergent, 3 = dangerous |
| Followed-up situation | 1 = yes, 0 = no |

CABG: Coronary artery bypass grafting; PTCA: Percutaneous transluminal coronary angioplasty; STENT: Stent grafting; CC: Comorbidity and complication.

Combination of cases

Data mining decision tree Exhaustive Chi-squared Automatic Interaction Detection (E-CHAID) algorithm of SPSS statistical software was used to establish the combination of DRGs.^[12] The condition for the decision tree to stop growing was set to the maximum depth of 3, while the minimum sample number of the parent node was 100 and the minimum sample number of child nodes was 50. Each new classification of cutoff point that the decision tree produced should be confirmed by cost differences of statistical significance ($P < 0.05$) using variance analysis.^[13]

RESULTS

Inpatient medical expenditures of unstable angina pectoris

The medical cost of each case was chosen as the target variable of the 3933 patients, the mean inpatient medical expenditure with unstable angina pectoris was RMB 41,078.9 \pm 20,912.3 Yuan, with a median value of RMB 39,846.0 Yuan (range, 2587.1–11,6051.2 Yuan).

Selection of node variables

In the study, single-factor analyses and multiple linear stepwise regression method were used to select the grouping variables.^[14] The results of Kruskal-Wallis tests showed that gender, age, admission condition, curative effects, CCs, followed up situation, and the type of surgery were all statistically significant on the total cost of hospitalization ($P = 0.002$). Multiple linear stepwise regression analysis of the data (choosing the seven factors mentioned above as independent variables with the square root of medical costs as the dependent variable to select the factors influencing inpatient medical expenditures) showed that the type of surgery as the independent variable had the greatest influence on medical cost as shown in Table 2.

As for the research in multiple factors, multiple linear regression analysis was adopted in this study. We removed two variables (the admission condition and gender) out of the

Table 2: Multiple linear stepwise regression analysis of inpatient medical expenditures

| Variables | Nonstandardized coefficients | | Standardized coefficients | <i>t</i> | <i>P</i> | 95% <i>CI</i> of β | | Collinearity statistics | |
|-----------------------|------------------------------|----------------|---------------------------|----------|----------|--------------------------|-------------|-------------------------|------|
| | β | Standard error | β' | | | Lower limit | Upper limit | Tolerance | VIF |
| CABG | -11.94 | 2.61 | -0.80 | -4.93 | <0.001 | -18.02 | -7.63 | 0.52 | 1.79 |
| PTCA | 54.84 | 1.93 | 0.79 | 27.78 | <0.001 | 51.96 | 60.12 | 0.23 | 4.04 |
| STENT | 40.07 | 2.09 | 0.41 | 19.03 | <0.001 | 34.98 | 42.76 | 0.29 | 3.01 |
| Combination surgeries | 60.12 | 2.48 | 0.50 | 24.69 | <0.001 | 55.96 | 65.88 | 0.49 | 1.98 |
| Followed up situation | -12.85 | 1.08 | -0.17 | -12.35 | <0.001 | -14.97 | -11.05 | 0.91 | 1.07 |
| CC | 9.71 | 1.39 | 0.09 | 7.02 | <0.001 | 7.02 | 12.34 | 0.89 | 1.12 |
| Curative effects | -11.83 | 3.09 | -0.05 | -3.99 | <0.001 | -19.01 | -6.93 | 0.75 | 1.28 |
| Age | 2.56 | 1.15 | 0.04 | 2.67 | 0.020 | 0.39 | 4.94 | 0.82 | 1.16 |

CI: Confidence interval; CABG: Coronary artery bypass grafting; PTCA: Percutaneous transluminal coronary angioplasty; STENT: Stent grafting; CC: Comorbidity and complication; VIF: Variance inflation factor.

model to select the optimal variable subset in the statistical analysis program, which is consistent with clinical practice.^[15] On this basis in combined with literature review and expert consultation, as well as analyzing the collinearity between the variables, four variables: the type of surgery, CCs, curative effects, and age were chosen as the classification node variables for further grouping of the sample data.

Grouping results

The 3933 cases of unstable angina pectoris were divided into ten combinations of DRGs in total, with the type of surgery being selected as the first layer of classification node variables by the E-CHAID decision tree model, effects as well as CCs as the second layer of node variables, and age as the third layer variable. To examine the rationality of the grouping results, we used nonparametric test to analyze the inpatient medical costs among different groups. The results are all $P < 0.001$ (by Kruskal-Wallis test), with $R^2 = 0.53$ and coefficient of variation (CV) = 0.524, which shows the larger the difference among the groups, and better the heterogeneity, the smaller of variations on medical costs and that the grouping results are more reasonable. The grouping results of E-CHAID decision tree model are shown in Table 3.

Formulating the inpatient medical expenditure standards of different combinations of diagnosis-related groups

To clarify the results, the original value of patients' medical costs will be adopted in the following analyses instead of its square root value.^[16] We first divided the cases into different groups and then adopted the median value as a standard reference value of the sample hospital; 75% of the inpatient medical expenditures of each combination plus 1.5 four points spacing ($P75 + 1.5 Q$) was adopted as the upper range value of cost control, cases exceeded the range were defined as excessive costs.^[17] Altogether 159 cases of excessive costs were found in the analyses, accounted for 4.04% of the total sample, and the excess costs summed up RMB 1,291,423 Yuan. The inpatient medical expenditure standards of different combinations of DRGs for unstable angina pectoris are shown in Table 3.

DISCUSSION

Selection of classification node variables

In light of the present situation of the medical records in China as well as the data available, four factors such as age, CCs, therapeutic effects, and the type of surgery were chosen as the classification node variables in the study. First, medical costs increase with age. The older the people, the worse of the health condition, the weaker the resistance to the disease as well as the slower in recovery, which will all result in the increase in medical costs.^[18] Second, with regard to the treatments, now more and more patients with unstable angina pectoris are choosing surgical operations for better curative effects. Currently, the common operative treatments include coronary artery bypass grafting (CABG), percutaneous transluminal coronary angioplasty (PTCA), and stent grafting (STENT). Among them, CABG is a kind of surgical operative method, whereas PTCA and STENT are characterized as invasive interventional treatments. Differences in operative types result in the difference in the cost of operations and medical materials, as well as the difference in CCs, length of hospital stay, and prognosis, which might all lead to the difference in medical expenditures.^[19] Thus, physicians should choose the surgical styles that are appropriate, safe, and effective according to the practical status of the patients.

Selection of statistical classification index

The length of hospital stay is widely chosen as the statistical classification index in the research of DRGs management in the United States, Britain, and other developed countries.^[20] While since the length of hospital stay is comparatively fluctuant, and that the control of hospitalization expenses is stricter that draws greater attention in China, we select inpatient medical expenditures as the statistical classification index to indicate the results of DRGs grouping in the study.^[21] Nevertheless, the length of hospital stay is still one of the crucial factors affecting inpatient medical expenditures. Although setting the length of hospital stay as an independent variable will be helpful in explaining the linear equation toward hospitalization expenses, it is a form of medical output that can neither be adopted in the analysis of medical expenditure structure nor be used as the classification node.

Table 3: Results of DRGs grouping and standards in inpatient medical expenditures (RMB, Yuan) of patients with unstable angina pectoris

| DRGs | Name of the DRGs | Number of cases | Mean value | Median value | P ₂₅ | P ₇₅ | Upper limit |
|---------|--|-----------------|------------|--------------|-----------------|-----------------|-------------|
| DRGs 1 | Cases without operation, effective | 256 | 18,348.37 | 11,708.65 | 17,261.89 | 23,762.76 | 49,655.59 |
| DRGs 2 | Cases without operation, not effective | 104 | 12,994.67 | 7869.79 | 10,003.59 | 15,408.89 | 30,414.28 |
| DRGs 3 | Cases of CABG, without CC | 106 | 7930.83 | 7644.18 | 5224.80 | 10,263.91 | 18,101.11 |
| DRGs 4 | Cases of CABG, with CC | 159 | 11,146.04 | 9015.11 | 7566.73 | 13,754.37 | 25,104.46 |
| DRGs 5 | Cases of PTCA, without CC | 174 | 38,408.76 | 35,371.83 | 11,661.34 | 42,742.20 | 60,234.21 |
| DRGs 6 | Cases of PTCA, with CC, age ≤50 years | 537 | 46,840.46 | 40,972.08 | 18,368.75 | 53,495.84 | 81,048.97 |
| DRGs 7 | Cases of PTCA, with CC, age >50 years | 1581 | 49,082.88 | 44,698.32 | 19,686.15 | 56,771.64 | 86,300.86 |
| DRGs 8 | Cases of STENT, without CC | 155 | 34,851.38 | 29,821.96 | 16,573.55 | 45,895.13 | 70,755.48 |
| DRGs 9 | Cases of STENT, with CC | 552 | 39,374.44 | 39,355.16 | 19,653.96 | 48,061.12 | 77,542.06 |
| DRGs 10 | Cases of the combinations of two or more operative methods | 309 | 52,806.38 | 47,445.12 | 27,022.76 | 65,187.89 | 10,5722.03 |

DRGs: Diagnosis-related groups; CABG: Coronary artery bypass grafting; PTCA: Percutaneous transluminal coronary angioplasty; STENT: Stent grafting; CC: Comorbidity and complication. Group 1 vs. 2, $Z = 21.73$; group 3 vs. 4, $Z = -11.28$; group 5 vs. 6, $Z = -8.59$; group 7 vs. 8, $Z = 18.03$; group 9 vs. 10, $Z = -13.20$, all $P < 0.001$.

However, it is an important indicator in reflecting the severity of the disease and a vital instructor of medical quality as well as the working efficiency of the hospital.^[22]

Grouping results

Altogether the investigated cases were divided into ten combinations of DRGs, and the type of surgery was chosen as the main classification node, which was correlated with the practical situation of patients with unstable angina pectoris in China. We were able to obtain the referential medical standards of patients with different types of surgical treatments of unstable angina pectoris from the study. Among the cases of nonoperative groups, the referential and the upper limit medical expenditures of the effective group are both higher than the invalid group. Through comprehensive analyses of the basic characteristics of the two groups, we found that the rate of patients in emergency when admission, the occurrence of CCs, and the length of hospital stay were all higher in the effective group than the invalid group, and that the differences were statistically significant ($P < 0.05$), indicating that the clinical features and physical conditions of the patients might be the reason for the increase of medical costs.

Improving the quality of medical record is beneficial for diagnosis-related groups management

Since the standards of DRGs prepayment are set based on the first page contents of medical records, its quality will directly affect the rationality and availability of DRGs grouping.^[23] Therefore, strengthening the training of clinical, medical records and statistical management staffs on standardizing the content of medical as well as upgrading the functions of electronic medical records and HIS information system of the hospital is crucial for DRGs management.^[24]

Nevertheless, the study had several limitations. Since the study was based on a single-centered hospital, differences in the characteristics of the population as well as the practical situation of different medical institutions and areas should be carefully considered. Furthermore, due to the accessibility

of the data and information of the patients, more samples should be adopted for the generalization of the conclusion.

In conclusion, the study proposed a payment model for unstable angina pectoris cases based on the concept of DRGs management, which provided a basic methodology for further research that could be extended to more DRGs.^[25] Furthermore, it offered references for medical administrative department in setting up standards for DRG-PPS as well as reducing medical expenditures in public health management.^[26]

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Conflicts of interest

There are no conflicts of interest.

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