

# DRG group analysis of hospitalization costs in elderly patients with cerebral infarction

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## Research Article

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# Abstract

## Background

Acute cerebral infarction is a serious disease threatening to human life and health, causing a serious disease burden on the patient himself, his family and society. The purpose of this study is to reasonably predict the cost of grouping DRG cases in patients with acute cerebral infarction and to provide reference for medical insurance payment decision-making.

## Methods

We used the case coding system to retrieve 1425 elderly hospitalized patients with cerebral infarction in 2021, and extracted the information from the first page of medical records, as well as used univariate and multiple linear regression analysis to screen node variables affecting hospitalization costs, and constructed a decision tree model for case group analysis of hospitalization costs.

## Result

The age of the samples was  $74.37 \pm 6.691$  years old, and the hospitalization time was  $13.15 \pm 10.629$  days. The total hospitalization costs were 9589.94 yuan (6892.905, 14480.625 yuan), and gender, marriage, cost category, admission route, treatment outcome, complications, and treatment method were statistically significant from the total hospitalization costs ( $P < 0.05$ ). The important factors affecting the total hospitalization costs include marriage, expense category, admission route, treatment outcome and treatment method ( $P < 0.05$ ). The standardized partial regression coefficient of treatment method is the largest, which shows that it has the greatest influence on the total hospitalization costs of elderly patients with cerebral infarction. The main independent variables affecting hospitalization costs of elderly patients with cerebral infarction include marriage, expense category, admission route, outcome and treatment method, which are important classification nodes variables of regression tree.

## Conclusion

The case grouping of hospitalization costs of elderly patients with cerebral infarction has good homogeneity and heterogeneity between groups, and the grouping is reasonable, which can provide some reference for the reform of medical insurance payment.

## 1 Background

Acute cerebral infarction (ACI) is a common clinical acute cerebrovascular disease. Stroke occurs more than 13.7 million people each year, with 5.8 million people dying each year as a consequence. Approximately 70% (9.5 million people) of incident strokes are ischemic<sup>[1, 2]</sup>. Stroke is one of the major health problems in the world<sup>[3]</sup>. ACI is a type of ischemic stroke. ACI is a serious disease threatening to human life and health, causing a serious disease burden on the patient himself, his family and society<sup>[4]</sup>.

Diagnosis-related groups (DRG) are further divided into relevant groups according to age, sex, length of stay, clinical diagnosis, surgery, comorbidity, complications and conversion, and medical insurance institutions pay medical expenses according to this grouping. DRG are widely used in Europe<sup>[5]</sup>, and DRG research in China is still in the exploratory stage. DRG is gradually recognized in medical insurance payment practice, and it is an important medical payment method in China now and in the future. DRG payment is based on DRG grouping, so it is very important to group DRG scientifically.

This study analyzed the hospitalization cost of elderly patients with cerebral infarction, and used the DRG grouping model established by the decision tree algorithm to have a good utilization value for the disease DRG grouping and hospitalization cost analysis. It is hoped that the cost of DRG cases can be reasonably predicted and provide reference for medical insurance payment decisions.

## **2 Methods**

### **2.1 Data source**

The data from the first page of medical record coding system in sample hospitals in 2021 were selected and included into the criteria: (1) Main diagnostic choices: ICD-10 coding I63.000-I63.908;; (2) Age  $\geq 60$  years old. Variables and assignments are shown in Table 1. Exclusion criteria: (1) There are missing items and general logic errors in the homepage information; (2) The hospitalization time is 1 day and there is no operation; (3) The hospitalization time is more than 100 days. The final study sample was included in 1,425 cases.

### **2.2 Research methods**

Firstly, the factors related to hospitalization costs of patients with cerebral infarction were analyzed by single factor analysis. Secondly, taking the hospitalization costs as dependent variables, the hospitalization days as influencing variables, and the statistically significant variables of single factor analysis as independent variables, and carrying out multiple linear regression analysis. The decision tree node variables were screened by single factor and multiple linear regression analysis. The decision tree model is automatically pruned by cross-validation method, and the number of sample groups is 10. The maximum depth of that decision tree is 3, the minimum sample number of the parent node is 100, the minimum sample number of child node is 50, and the inspection level of split node  $\alpha = 0.05$ . The Kruskal-Wallis test was used for inter-group heterogeneity of DRG, and the coefficient of variation (CV) test was used for intra-group homogeneity. The IBM SPSS26.0 was used for statistical analysis. All personally identifying information in the study was deleted, and personal privacy was protected.

## **3 Results**

### **3.1 Patient characteristics and single factor analysis**

The age of the samples was  $74.37 \pm 6.691$  years old, and the hospitalization time was  $13.15 \pm 10.629$  days. The total hospitalization costs were 9589.94 yuan (6892.905, 14480.625 yuan), and gender, marriage, cost category, admission route, treatment outcome, complications, and treatment method were statistically significant from the total hospitalization costs ( $P < 0.05$ , Table 1).

Table 1  
Basic characteristics and assignment of hospitalized patients with ACI

Variable name	Variable assignment	Number of cases	F/H	P
gender			32.89	0.000
	Male = 0	809		
	Female = 1	615		
Cost category			50.888	0.000
	Residents medical insurance =0	515		
	Workers medical insurance =1	919		
marriage			95.269	0.000
	Widowed / divorced = 0	193		
	Married = 1	1231		
Admission Route			26.52	0.000
	Outpatient = 0	953		
	Emergency = 1	471		
Treatment outcome			5.988	0.000
	Improved = 0	1389		
	Unhealed/dead = 1	35		
complication			271.343	0.000
	None = 0	27		
	Yes = 1	1397		
Treatment			29.615	0.000
	Medication = 0	881		
	Surgical = 1	543		

## 3.2 Multiple linear regression analysis and DRG analysis

The important factors affecting the total hospitalization costs include marriage, expense category, admission route, treatment outcome and treatment method ( $P < 0.05$ ). Variance expansion coefficient (VIF) is less than 10, which indicates that there is no multicollinearity between independent variables. The standardized partial regression coefficient of treatment method is the largest, which shows that it has the greatest influence on the total hospitalization costs of elderly patients with cerebral infarction (Table 2).

Table 2  
Multiple linear regression analysis of total hospitalization costs

variable	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	P	VIF
expense category	3233.917	1127.694	0.073	2.868	0.004	1.101
gender	1535.073	1089.707	0.036	1.409	0.159	1.102
marriage	3137.996	1521.167	0.050	2.063	0.039	1.025
Admission Route	8302.739	1129.865	0.184	7.348	0.000	1.068
treatment outcome	25377.519	3391.719	0.185	7.482	0.000	1.043
complication	-1668.268	3798.95	-0.011	-0.439	0.661	1.015
treatment method	10913.748	1095.049	0.249	9.966	0.000	1.070
a Dependent Variable: hospitalization costs						

Through the decision tree construction, a total of 8 DRG groups were formed ( $P < 0.05$ ), in which the treatment method was the first branch node that affected the total hospitalization costs, and the second key node was the admission route (Fig. 1). Rationality evaluation of DRG grouping:  $P < 0.01$  by Kruskal-Wallis test, and the heterogeneity between groups was statistically significant; The coefficient of variation (CV) of group 1, 2, 3, 4 and 6 is less than 1, which indicates that the homogeneity within the group is better. Generally speaking, DRG grouping is reasonable (Table 3).

Table 3

Results of DRG case grouping of hospitalization costs of elderly patients with cerebral infarction

group	Case group name	Mean	Std. Deviation	N	Percent	CV
DRG1	Medication, outpatient admission, married	9012.12	4769.55	552	38.80%	0.53
DRG2	Medication, outpatient admission, unmarried	8863.63	6893.01	105	7.40%	0.78
DRG3	Medication, emergency hospitalization, employee health insurance	12684.66	7632.56	138	9.70%	0.60
DRG4	Medication, emergency hospitalization, resident medical insurance	11605.46	6125.03	86	6.00%	0.53
DRG5	Surgical treatment, outpatient admission, employee health insurance	17036.09	23315.23	176	12.40%	1.37
DRG6	Surgical treatment, outpatient admission, resident medical insurance	13312.90	12462.82	120	8.40%	0.94
DRG7	Surgical treatment, emergency hospitalization, employee health insurance	36262.91	46289.74	147	10.30%	1.28
DRG8	Surgical treatment, emergency hospitalization, resident medical insurance	26285.49	29057.29	100	7.00%	1.11
Growing Method: CHAID						
Dependent Variable: hospitalization costs						
a Bonferroni adjusted						

## 4 Discussion

Cardiovascular disease is the leading cause of death in the United States, causing about 1 million deaths and more than 400 billion dollars in treatment costs every year<sup>[6]</sup>. From the results of multiple regression and decision tree analysis, it can be seen that the treatment mode is an important factor that affects the DRG grouping of the hospitalization costs of elderly patients with ACI, and the hospitalization costs of the surgical treatment group are higher than those of the drug treatment group. Although the medication can alleviate the disease, it can't improve the lumen with already existing vascular stenosis. Vascular intervention surgery can not only effectively improve the vascular stenosis, but also accelerate the recovery of neurological function. At the same time, the cost of disposable surgical consumables and various stents will lead to the increase of hospitalization costs.

Secondly, the way of admission is also a node that affects grouping. The cost of hospitalization is higher for patients admitted to hospital through emergency treatment. Relevant research shows that the congestion problem in emergency department is becoming more and more serious, which may affect the efficiency and nursing quality of patients and emergency departments, and may lead to the increase of expenses and the extension of treatment time<sup>[7]</sup>. Some related studies show that the mortality rate in emergency department is very high<sup>[8]</sup>. Usually, patients admitted to the hospital through emergency department have acute course of disease and serious illness, and use more hospitalization costs.

Interestingly, among the patients treated with drugs, the hospitalization costs of married patients are more than those of unmarried or widowed patients. It can be considered here that complete families are more active in treating diseases, or are more willing to use some high-quality and high-priced drugs.

The expense category of patients is also an important node variable. The type of health insurance is an important factor affecting hospitalization costs. The hospitalization costs of workers' medical insurance patients are higher than those of residents' medical insurance patients. Because workers' medical insurance patients are better than residents' medical insurance in terms of economic income and living security. Therefore, patients with workers medical insurance are more willing to use better drugs or seek better medical services. In addition, because workers' medical insurance has a higher reimbursement rate, it actively encourages doctors to provide more comprehensive services and higher quality services<sup>[9]</sup>.

To sum up, the way of treatment, admission route, marriage and expense category of patients are the node variables that affect DRG grouping of hospitalization expenses. How to better and more reasonably reflect the patient's diagnosis and treatment process, form a refined DRG payment grouping mode, and provide the basis for the rational allocation of medical resources, still need to continue to explore.

## 5 Limitations

Our study is an analysis of the data in the hospital information system and does not include all possible factors for complete examination.

## 6 Conclusions

The main independent variables affecting hospitalization costs of elderly patients with cerebral infarction include marriage, expense category, admission route, outcome and treatment method, which are important classification node variables of regression tree. The case grouping of hospitalization costs of elderly patients with cerebral infarction has good homogeneity and heterogeneity between groups, and the grouping is reasonable, which can provide some reference for the reform of medical insurance payment.

## Declarations

## **Ethics approval and consent to participate:**

This experimental plan was approved by the Ethics Committee of Panzhihua Central Hospital. The data used by the study were obtained with informed consent of participants to participate in the study. All methods were implemented in accordance with the relevant guidelines and regulations.

## **Consent for publication:**

Not applicable.

## **Competing interests:**

The authors declare that they have no competing interests.

## **Availability of data and materials:**

The datasets generated and / or analysed during the current study are not publicly available due to the specificity of the study data, but are available from the corresponding author on reasonable request.

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## **Authors' contributions:**

Jing Yan and Jie Pang designed the study; Ming-Wei Luo, Ming-Yang Luo, and Shi-Wei Xie prepared the manuscript; Ming-Yang Luo performed the data analysis; and Jing Yan critically revised the manuscript. All authors have read and approved the final manuscript.

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## Figures

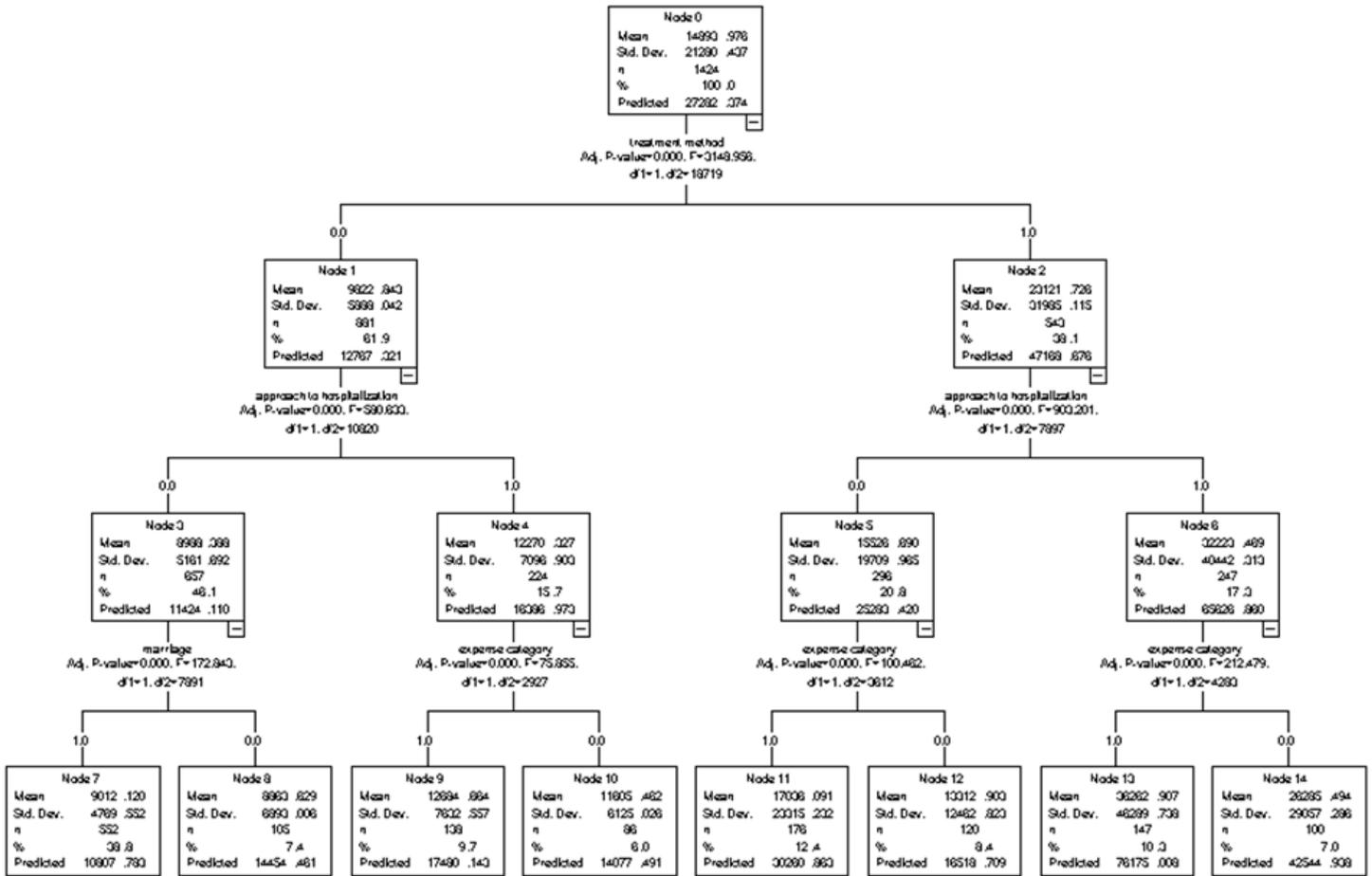


Figure 1

Decision tree model for hospitalization costs of elderly patients with ACI