

Path Analysis on Medical Expenditures of 855 Patients with Chronic Kidney Disease in a Hospital in Beijing

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Abstract

Background: Investigate into the medical expenditures of chronic kidney disease (CKD) patients through path analysis method of three consecutive years within a Grade-A tertiary hospital in Beijing to conduct the main influencing factors in diagnosis-related groups (DRGs) grouping of the diagnosis, and reassess the present grouping process to provide information and reference on cost control for hospitals and medical management departments.

Methods: Eight hundred and fifty-five inpatient cases whose first diagnosis were defined as CKD in the year 2014–2016 within the hospital were selected as the sample of the study, multiple linear regression and path analysis method were adopted in DRGs grouping process to investigate the main influencing factors of total medical expenditures and DRGs grouping process.

Results: The maximum proportion of the medical costs within CKD patients was the costs on treatment, with the highest of 35.3% on the year 2014, the second was the costs on drug, which accounted for <30% during consecutive years, and the third was the costs on examination, which accounted for about 20% on average. The main influencing factors of medical expenditures included the type of dialysis, length of hospitalization, the admission of Intensive Care Unit (ICU), and so on. The coefficients toward the effect for total costs were 0.416, 0.376, and 0.094, respectively.

Conclusions: It is suggested that the type of dialysis and the admission of ICU were the major influencing factors of inpatient medical expenditures on CKD patients, and should be taken into consideration into the reassessment of DRGs grouping process to realize the localization and generalization of prospective payment system based on DRGs within the regional area and promote the implementation of medical cost control measures to reduce the economic burdens among patients and the society.

Key words: Chronic Kidney Disease; Diagnosis-related Groups; Medical Expenditures

INTRODUCTION

Chronic kidney disease (CKD) is the general term for chronic structural and functional renal disorders caused by various factors that last over 3 months and above. The common clinical manifestations of CKD include the variation in the components of blood and urine, pathological damage and imaging abnormalities of the kidney, the decrease of glomerular filtration rate (GFR), and so on. The staging of CKD can be divided into 5 grades according to the GFR of patients. Patients will have to rely on renal replacement therapy for the maintenance of life in end-stage CKD. It is a chronic disease of high prevalence according to the latest statistics of epidemiological study, the incidence of CKD among the population is about 11.8% in China and is still on the rise.^[1] Relevant researches showed that the

average dialysis age of Grades 4 and 5 CKD patients was about 3.7 years and the average costs of each follow-up treatment was about RMB 5000 Yuan or more. Due to the high consumption of medical resources as well as the repeatability in treatment, families of CKD patients are bearing huge economic burdens, and the problem has already become a serious social issue in health management and economics.^[2]

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The definition of prospective payment system based on diagnosis-related groups (DRGs-PPS) is prospective payment management system based on DRGs,^[3] which means that the diagnoses of diseases with similar treatments are classified into certain related groups according to the international classification of diseases, and 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] As one of the most advanced concepts of medical management, the methodology and operation of DRGs-PPS has been playing a significant role in controlling health expenditures and standardizing the medical behavior around the world in recent years.^[5] In China, the investigations and operations of DRGs-PPS in medical cost control have been going on for more than a decade.^[6] However, relevant studies on the diagnosis of CKD are still insufficient. To be specific, it is widely realized that differences exist in the current DRGs grouping system and the practical operations due to the diversity of diseases, regions and populations. To research into the costs management of CKD as well as promote the localization of DRGs-PPS of the diagnosis in Beijing, the research aimed to identify the main influencing factors of the inpatient medical expenditures as well as the key points in the process of DRGs grouping. In this study, 855 cases of CKD patients in the year 2014–2016 within a Grade-A tertiary hospital in Beijing were selected as the research samples. By analyzing the health expenditures of the sample cases, it is hoped to give suggestions for hospitals in strengthening medical cost control as well as providing references for health administrative departments in medical insurance policy-making and the verification of DRGs grouping process.

METHODS

Ethical approval

The study was exempt from the ethical approval as a retrospective big-data analysis study. All patient records and information were anonymized and de-identified before analysis.

Acquisition and extraction of data and material

The basic medical information and hospitalization expenditures data of inpatients whose first diagnoses were labeled as CKD (of all five stages) from January 1, 2014 to December 31, 2016 in a Grade-A tertiary hospital in Beijing were collected through the medical record management system. Altogether the basic information of 892 cases was collected within the three consecutive years.

Preprocessing of sample data and material

We preprocessed the data and material by eliminating the cases with missing items and basic information in medical records, and the number of valid cases collected summed up 855 in total.^[7] Of the valid samples, the inpatient medical expenditures were composed of seven items according to the medical information system: bed charges, costs of examinations, costs of treatments, costs of surgeries, costs of nursery, costs of

drugs as well as the costs for other items.^[8] The costs of drugs mainly include the costs of organic and inorganic chemicals drugs, costs of biological products, and the costs of Chinese herbal medicine and patent medicine; costs of examinations include the charges for imaging examination (such as computed tomography, magnetic resonance imaging, and so on) as well as the expenses of laboratory and pathology tests, surgery costs include the labor charges during the operation as well as the related materials and supplies costs; costs of treatment mainly refer to the expenditures on noninvasive treatment in clinical, which include the costs of renal dialysis, hyperbaric oxygen, physical therapy, *etc.*^[9]

Diagnosis-related groups grouping process of the sample patients

In the DRGs grouping process of the sample patients, the coefficient of variation <1.0 was adopted as the standard, as shown in Figure 1 to illustrate the grouping procedure.

Statistical analysis

In the study, multiple linear regression method was adopted in the prescreening of independent variables to identify the influencing factors of medical expenses within CKD patients, and the assignments of each variable are shown in Table 1. Since total costs, drug costs, and examination costs were similar to the normal distribution, the actual values of these items were adopted in the analysis. Then set the total medical costs as the dependent variable; gender, age groups, type of payment, admission status, number of additional diagnoses, length of hospitalization, type of dialysis, stage of the disease, the admission of Intensive Care Unit (ICU), drug costs, treatment costs, examination costs as independent variables to conduct multiple linear regression analysis, and build the regression equation. Similarly, set drug costs, examination

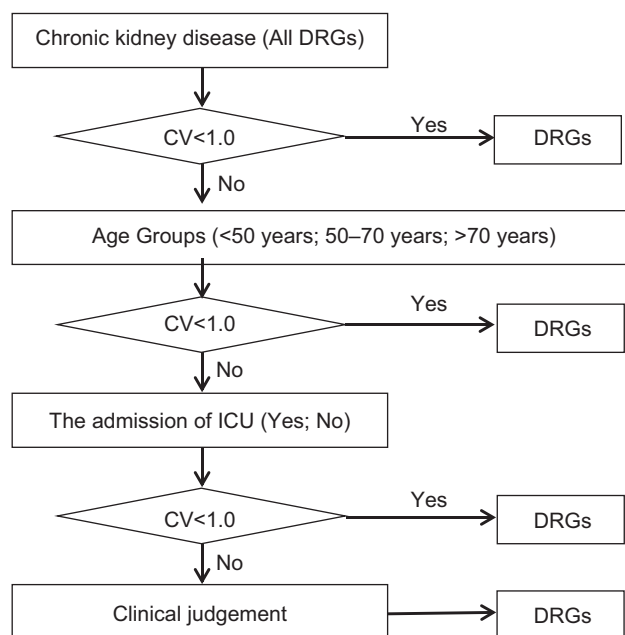


Figure 1: Grouping process of DRGs in chronic kidney disease cases. DRGs: Diagnosis-related groups; CV: Coefficient of variation; ICU: Intensive Care Unit.

Table 1: Dimensions and assignments of the independent variables to identify the influencing factors of medical expenses of CKD patients

Variables	Dimensions and assignments	Codes of the variables
Gender		
Male	0	X1
Female	1	
Age group		
<50 years	0	X2
50-70 years	1	
>70 years	2	
Type of payment		
Uninsured patients	1	X3
Insured inpatients	0	
Admission status		
Critical	1	X4
Emergency	2	
Regular	3	
Number of additional diagnoses	The actual number of additional diagnoses	X5
Length of hospitalization	The actual number of days	X6
Type of dialysis		
None	0	X7
Peritoneal dialysis	1	
Hemodialysis	2	
CRRT	3	
Stage of the disease		
Stage I	1	X8
Stage II	2	
Stage III	3	
Stage IV	4	
Stage V	5	
The admission of ICU		
No	0	X9
Yes	1	
Drug costs	The actual value	X10
Treatment costs	The actual value	X11
Examination costs	The actual value	X12
Total costs	The actual value	Y

CKD: Chronic kidney disease; CRRT: Continuous renal replacement therapy; ICU: Intensive Care Unit.

costs, treatment costs and length of hospitalization as dependent variables, respectively, to find out the main influencing factors of each item. Build the structural equation model in the light of the independent variables selected. All the data and material collected were entered into MS Excel 2010 software for Microsoft (Microsoft Corporation, Washington, USA), statistical analyses and the construction of structural equation model were performed using SPSS version 14.0 (SPSS Inc., Chicago, IL, USA).

Path analysis

Path analysis method is a kind of multivariate statistical analysis that mainly deals with problems of indirect factors

or factors that cannot be directly observed in multivariate analysis, as well as problems that are unable to be solved in single factor correlation due to multi-factors interactions. It is capable of identifying the direct and indirect effects among numerous influencing factors of complex diseases by means of stratification, and reflects in the form of path analysis charts. Besides, the method can also be used in calculating the intensity and degree of influence of different indicators toward the standardized results. Furthermore, it is helpful in analyzing and verifying the rationality of grouping as well as the localization of DRGs, to optimize the DRGs grouping process in the local area within a certain period. In this study, path analysis was used to analyze into different cost items and factors toward the total and the path analysis chart was drawn by software Amos Gmpics of SPSS version 14.0.

RESULTS

Compositions of average medical expenditures of chronic kidney disease patients

According to the statistics, the average treatment costs accounted for the largest proportion of medical expenditures each year, with the highest of 35.3% of the year 2014, and showed a slowly declining tendency in the following years. Drug costs accounted for <30% during the consecutive years, ranking the second. Examination costs accounted for about 20% on average, ranking the third. The constitutions of each cost items within the 3 years are shown in Table 2.

Multiple linear regression analysis of the influencing factors on the medical expenditures of chronic kidney disease patients

The DRGs grouping process of the sample cases are shown in Figure 1, and the regression equation was built as following:

$$Y = -1301.023 + 366.759 \times X2 + 99.651 \times X6 + 1.063 \times X10 + 1.623 \times X11 + 1.178 \times X12.$$

The equation was fitted by $R^2 = 0.931$, and the model testing of each variable was $P < 0.05$ as shown in Table 3. Then, set drug costs, examination costs, treatment costs, and length of hospitalization as dependent variables, respectively. The study found out the main influencing factors of drug costs were the admission of ICU, type of dialysis, the number of additional diagnoses, the stage of the disease, admission status as well as the length of hospitalization. The main influencing factors of examination costs were age groups, type of dialysis, complications, the stage of the disease, and length of hospitalization. The main influencing factors of treatment costs included the type of dialysis, complications, the number of additional diagnoses, the stage of the disease and length of hospitalization. Moreover, the main influencing factors of length of hospitalization included the type of dialysis, the number of additional diagnoses, as well as the stage of the disease.

Path analysis on the influencing factors of medical expenditures of chronic kidney disease patients

In the study, all the P values of path analysis were <0.05 , and 94% of the variance of the total hospitalization costs

in the model could be explained by the costs of treatment, costs of drug, costs of examination, length of hospitalization, type of dialysis, the admission of ICU, complications as well as age groups. The main adaptability indicators of the model had all reached fitness standards that exhibited suitable representatives in the study, with CMIN/DF (refers to Chi-square degree of freedom) = 1.478, Aikaikie information criteria = 138.721, root mean square error approximation = 0.019, goodness of fit index (GFI) = 0.989, adjusted GFI = 0.992, comparative fit index = 0.993, critical number = 987. The coefficients of different influencing factors toward total inpatient expenditures are shown in Table 4 and the strength, degree and the relationship of each influencing factors are shown in Figure 2.

Effect of various factors toward total hospitalization expenditures of chronic kidney disease patients

As shown in Table 4, the hospitalization expenditures of CKD patients were mainly composed of treatment costs, drug costs, and examination costs. Costs of treatments, drugs, and examinations were directly related to the total costs; while the type of dialysis, the admission of ICU, the number of additional diagnoses, complications, stage of the disease, as well as the admission condition had indirect effects toward total inpatient expenditures. Length of hospitalization and age groups had both a direct effect and indirect effect toward the total costs. Results also showed that type of dialysis had the greatest impact toward DRGs grouping, followed by the admission of ICU, complications, the number of additional diagnosis, age groups, and so on.

Table 2: Average medical expenditures (RMB) of CKD patients in the year 2014–2016, Yuan (%)

Cost items	2014	2015	2016
Treatment costs	3638.85 (35.3)	3366.16 (33.3)	3442.07 (31.9)
Drug costs	3048.01 (29.6)	3006.88 (29.7)	3223.90 (29.9)
Examination costs	2043.70 (19.8)	2142.56 (21.2)	2366.35 (21.9)
Surgery costs	652.70 (6.3)	652.79 (6.5)	709.58 (6.6)
Other costs	439.26 (4.3)	452.40 (4.5)	564.86 (5.2)
Bed charges	392.86 (3.8)	396.73 (3.9)	387.73 (3.6)
Nursery costs	95.89 (0.9)	102.23 (1.0)	105.84 (1.0)
Total costs	10311.28 (100.0)	10120.76 (100.0)	10800.34 (100.0)

CKD: Chronic kidney disease.

Table 3: Multiple linear regression analysis of influencing factors on total medical expenditures of CKD patients

Variable	Regression coefficient (b)	SE	Standardized regression coefficient (standard b)	t	P
Constant	-1301.023	258.91	-	-5.031	0.000
Age groups	366.759	119.756	0.030	2.993	0.001
Length of hospitalization	99.651	20.947	0.051	4.832	0.000
Treatment costs	1.623	0.024	0.698	78.065	0.000
Examination costs	1.178	0.058	0.179	19.214	0.000
Drug costs	1.063	0.020	0.591	63.372	0.000

CKD: Chronic kidney disease; SE: Standard error; -: Not available.

DISCUSSION

DRGs is considered to be an effective tool in controlling the irrational growth of medical costs, mainly because it is capable of taking various factors of medical insurance institutions, hospitals and patients into considerations all at once.^[10] Besides, it is able to balance the relationship of medical quality and medical expenses simultaneously. However, due to the differences of diagnoses groups, medical resources, and geographical locations, the compositions and influencing factors of the medical expenses shared varied characteristics.^[11] In the study, 855 cases of CKD patients within a Grade-A tertiary hospital in Beijing were selected as the subject of investigation. Multiple linear regression method was used to identify the main influencing factors of total inpatient medical expenditures. Meanwhile, path analysis method was adopted in finding the key DRGs grouping factors of the sample hospitals so that comparisons and reassessments could be made to provide a reference for medical management departments in promoting the adaptability of DRGs application regionally.^[12]

Comparison of the results with the current Beijing diagnosis-related groups grouping

The current DRGs grouping of CKD in Beijing are classified into six groups with the staging of disease as well as comorbidities and complications as the first and secondary grouping indicator, as shown in Table 5. As we compare it with the results of the study, it is obvious to see though the stage of the disease is taken into consideration, is not classified in detail, as the first grouping indicator was only a rough classification between renal failure stage and other CKD stages. This may not necessarily conclude the characteristics of the disease as CKD were classified into five stages. Besides, even though the complications of patients were used as the secondary grouping indicator, the current grouping results was not able to adequately reflect the severity of the disease since the major contents of the therapies (such as the admission of ICU, the type of dialysis and so on) were not included in the grouping process.^[13]

Influence of the type of dialysis on total medical expenditures of chronic kidney disease patients

Results showed that the type of dialysis exhibited the greatest influence on the total costs of CKD patients, with the effect coefficient of 0.416. It was not hard to understand that the difference in the type of dialysis represented the variance of the state and period of the illness.^[14] Besides, it is widely

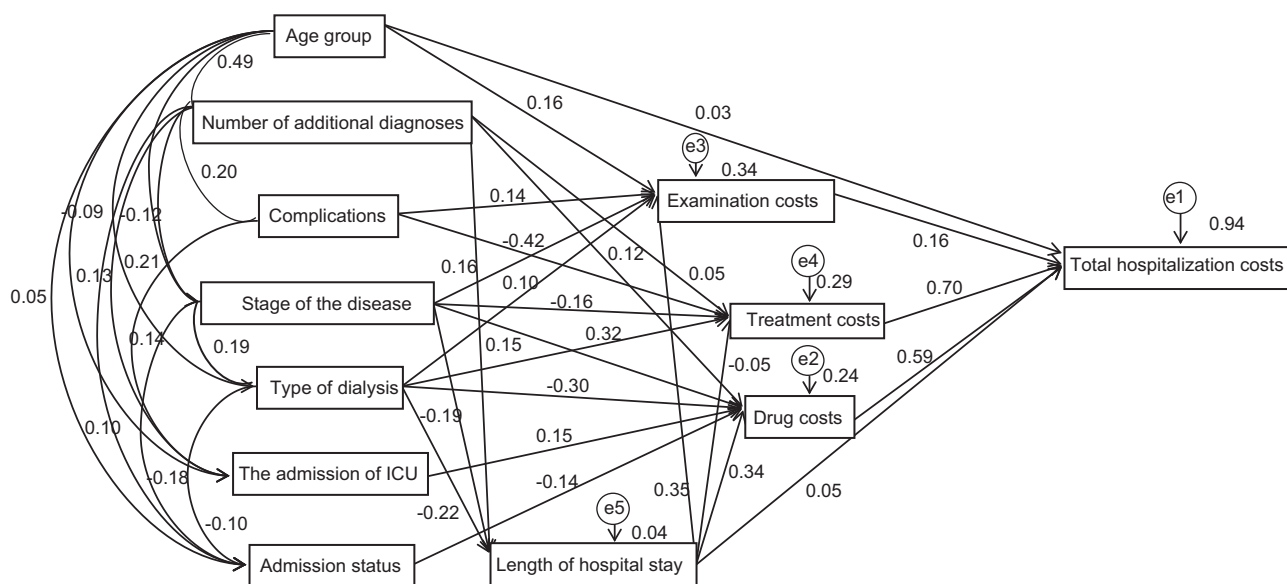


Figure 2: Path analysis of inpatient medical expenditures of chronic kidney disease. e1–e5: represents the estimated variance of different cost items towards total hospitalization costs. ICU: Intensive Care Unit.

Table 4: Coefficients of different influencing factors towards total inpatient expenditures of CKD patients

Variables	Total hospitalization costs		
	Total effect coefficient	Direct effect coefficient	Indirect effect coefficient
Treatment costs	0.701	0.701	–
Drug costs	0.592	0.592	–
Type of dialysis	0.416	–	0.416
Examination costs	0.157	0.157	–
Length of hospitalization	0.376	0.051	0.325
Admission of ICU	0.094	–	0.094
Complications	0.080	–	0.080
Number of additional diagnoses	0.077	–	0.077
Age groups	0.049	0.025	0.024
Admission status	–0.069	–	–0.069
Stage of the disease	–0.072	–	–0.072

CKD: Chronic kidney disease; ICU: Intensive Care Unit; –: Not available.

accepted that the cost of hemodialysis is much higher than that of peritoneal dialysis. Furthermore, continuous renal replacement therapy has already become a routine and most widely utilized treatment in the cases of end-stage renal failure patients, which inevitably leads to higher costs. Thus, the results suggested since dialysis has become the key treatment measure of patients with end-stage kidney diseases, the type of dialysis should be reconsidered as an important factor in DRGs grouping process.

Influence of the admission of Intensive Care Unit on total medical expenditures of chronic kidney disease patients

According to the study, the admission of ICU is the second greatest influencing factor of medical expenditures within the

sampled patient, with the coefficient of 0.094. This indicates that the admission of ICU could be used as a secondary indicator in DRGs grouping. As we dig deeper into the causes, the admission of ICU reflects the severity of the disease, and that the application of expensive drugs and materials are frequently involved in the treatment, which may result to higher medical costs.^[15] Relevant studies have also indicated that the impact of the admission of ICU on health expenditures is primarily due to drug costs and other related treatment costs.^[16]

Number of additional diagnoses, complications, and the stage of disease have less impact on total medical expenditures of chronic kidney disease patients

Results showed that the influence of the number of additional diagnoses, complications, and the stage of disease on total health expenditures of CKD patients was 0.094, 0.080, and 0.072, respectively, indicating it was less reasonable in setting those factors as the first and second indicators in DRGs grouping. As we mentioned above, the possible reason is that these factors may failed to directly illustrate the characteristic and oncology of the disease.^[17] Thus, it is suggested that medical management departments reconsider the necessity and accuracy for choosing the stage of disease and complications as the first and second subgroup factors in DRGs grouping of the area.^[18]

Transformation of idea in the diagnosis and treatment of chronic kidney disease

As it was mentioned above, the progression of end-stage CKD will necessarily lead to renal failure when patients have to rely on dialysis therapy for the maintenance of life. Although the treatments of dialysis have made great progress in recent years, the mortality of end-stage renal failure patients is still high, and repeated treatments will result to poor life quality. Meanwhile, the results of the study suggested since the costs of dialysis have a great impact on

Table 5: Current BJ-DRGs grouping of CKD and average medical expenditures of the each groups in 2016

Group code	Diagnostic description	Average medical expenditures (RMB, Yuan)
LR15	Renal failure without comorbidities or complications	7848.2
LR13	Renal failure with moderate comorbidities or complications	10003.4
LR11	Renal failure with major comorbidities or complications	16322.6
LS15	CKD without comorbidities or complications	4702.8
LS13	CKD with moderate comorbidities or complications	7894.2
LS11	CKD with major comorbidities or complications	9799.4

BJ-DRGs: Diagnosis-related groups of Beijing; CKD: Chronic kidney disease.

total medical expenditures, it is crucial to emphasize the idea of tertiary prevention in different stages of CKD to prevent or delay the occurrence of further damages, so as to improve the survival rates and life quality as well as reduce the economic burdens of patients.^[19]

Applicability of diagnosis-related groups grouping in different regions

Studies showed that the application of DRGs varied in different regions and hence that it should be carried out in the light of the practical situation of the area. The differences among price level, consumption level and disease characteristics within different regions are all having a direct impact on the standard of medical services and costs. Most countries in Europe and America have carried out extensive field investigations, data analyses and application management of medical expenditures during the whole process of DRGs application, to continuously improve the adaptability of DRGs in medical payment.^[20] Thus, it is strongly recommended that the process of calculation, analysis as well as the verification of DRGs-PPS been taken into serious account according to the practical situation of the region to promote the localization of DRGs system in regulating medical behavior and strengthen medical cost control effectively.

Interpretation of medical insurance policy for chronic kidney diseases

CKD patients (especially for end-stage kidney diseases) require lifelong treatment of high medical costs, which may bring serious financial burden to the patient's family. Therefore, the diagnosis has been brought into the scope of medical insurance, and the proportion of reimbursement has been increasing in the past few years along with the rapid growth in the overall medical costs. How to balance the relationship of cost control to ensure the sustainability and prevent the excessive use of medical insurance funds, meanwhile easing the financial burden of patients is a necessity for medical administration department to consider.

As one of the most advanced methods in the management of medical payment nowadays, DRGs-PPS is playing a significant role in regulating medical behaviors and controlling medical expenditures. The experience of other countries and regions as well as the analysis and estimation of local medical data and information are crucial in providing sufficient basis for complex diseases in the local DRGs payment policy, and balance the interest of medical insurance departments, hospitals, and patients.

Since the process of DRGs grouping largely rely on the practical situation of different areas, the price level, consumption level as well as the characteristics of the disease in different areas might have a certain impact toward the grouping results. Since the research was based on a single center hospital, considering the different situation in various regions as well as the limitation of the data and material, the generalization of the results should be more careful in other circumstances.

The results showed that the cost of treatment, drugs and examinations had the greatest effects on the total health expenditures, suggesting that the major cost sources of CKD patients are the categories as mentioned. The research also illustrated that the process of DRGs grouping should be combined with the actual situation in the area of the hospital along with the experience of other countries and regions, and refined the grouping criteria in the region through the analysis of practical medical data for the better adaptability in the area. In specific, the study suggested that the main factors affecting DRGs grouping of CKD inpatient expenditures were the type of dialysis and the admission of ICU and that should be reconsidered as the DRGs grouping indicator. Besides, the study illustrated that the concept of tertiary prevention of CKD in different stages should be emphasized to prevent or delay the occurrence of further damages to reduce medical expenditures of patients. Thus, it is advisable for health administrative departments to reevaluate the grouping indicators of DRGs grouping based on the practical situation of the region within in a certain period to improve the adaptability and control the unreasonable growth of health expenditures.

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Conflicts of interest

There are no conflicts of interest.

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