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Analysis of Hospitalization Costs and Influencing Factors of AKI in Adult Patients

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Abstract: *Objective:* To investigate the economic burden of patients with acute kidney injury (AKI) by analyzing the distribution of hospitalization expenses and its influencing factors in the Affiliated Hospital of Hebei University. *Methods:* The hospitalization information of patients with AKI from January 2020 to January 2023 was collected and sorted through the hospital charging system and the factors affecting the total hospitalization cost were analyzed by multiple linear regression. *Results:* Univariate analysis showed that age, occupation, marriage, length of hospitalization, recovery of renal function, and stage of AKI had significant effects on hospitalization cost ($P < 0.05$). The result of the multiple linear regression analysis model showed that age ($t = 4.11$, $P < 0.0001$), length of hospitalization ($t = 16.10$, $P < 0.0001$), recovery of renal function ($t = 3.26$, $P < 0.0001$), AKI stage ($t = 5.23$, $P = 0.002$) are factors affecting the economic burden of patients with AKI. *Conclusion:* AKI patients should be managed according to age stratification to effectively control the progression of the disease and improve the quality of the medical services provided. This will reduce the economic burden of patients.

Keywords: Acute kidney injury; Hospital expenses; Age classification; Influencing factor

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1. Introduction

Acute kidney injury (AKI) is a syndrome characterized by a decrease in glomerular filtration rate (GFR) and a series of clinical symptoms caused by the decline in renal function in a short period due to various reasons [1]. AKI is often accompanied by the retention of metabolites such as creatinine and urea nitrogen, resulting in electrolyte and acid-base balance disorders, where multiple system damage often occurs in severe cases [2]. As a syndrome, not only does AKI cause structural damage to the kidney but also functional damage. According to recent studies, AKI occurs in 5%–10% of hospitalized patients in developed countries, while developing countries may have higher rates [3–6]. Furthermore, the treatment and rehabilitation process requires abundant medical resources and is costly [7]. In addition, AKI can cause many complications, aggravating the condition

and medical burden of critically ill patients. In the past decade, the incidence of AKI has been rising every year due to the increased aging of the population. According to statistics, millions of people are diagnosed with AKI every year [8]. Individuals at high risk include the elderly, patients in intensive care, and patients undergoing complex operations [9–11]. Not only does it increase the mortality rate of hospitalized patients but it also increases the possibility of chronic kidney disease (CKD) and end-stage kidney disease, further adding on to the economic burden of patients and their families [12]. Currently, there is little research data on the prognosis and treatment cost of AKI patients. This paper analyzed the relevant data on the hospitalization cost of AKI patients and its influencing factors, which aims to optimize the allocation of medical resources and improve the efficiency and quality of medical services.

2. Data and methods

2.1. General information

All inpatients in the Affiliated Hospital of Hebei University from January 2020 to January 2023 were screened using the hospital medical record management system and diagnosed according to the 2012 Global Organization for Improving the Prognosis of Kidney Diseases (KDIGO) [13]. A study cohort was formed consisting of AKI patients with a complete medical history, where epidemiological data, clinical laboratory indicators, and detailed billing information were collected. The data of all 716 patients were collected.

Inclusion criteria: (1) Patients over 18 years old; (2) diagnosed with AKI according to KDIGO; (3) complete medical history. Exclusion criteria: (1) Patients undergoing maintenance blood purification therapy; (2) history of renal structural or functional abnormalities; (3) history of kidney transplantation or nephrectomy.

2.2. Collecting information

The collection of information included demographic characteristics (gender, age, marital status) and admission time of all hospitalized AKI patients. It also encompassed vital signs (blood pressure, heart rate, body temperature), past medical history (hypertension, diabetes, coronary heart disease, rate, body temperature), pulmonary heart disease, atherosclerosis, chronic obstructive pulmonary disease (COPD), CKD, glomerulonephritis, etc.), comorbidities (hypotension, surgery, sepsis, number of extrarenal organ failures, etc.), exposure to nephrotoxic drugs as well as hospitalization diagnosis and treatment outcomes. Additionally, the collection included hospitalization expenses including total costs incurred during the stay, such as external expenses and payment methods. The cost analysis included drug costs (Western medicine, proprietary Chinese medicine, and Chinese herbal medicine), surgical costs, diagnostic costs, examination costs, and clinical treatment costs.

2.3. Statistical methods

Statistical analysis was performed using the SAS 9.4 software to examine the incidence rates, etiology factors, clinical manifestations, and renal prognosis among hospitalized AKI patients. Non-parametric tests were utilized to compare the baseline characteristics of AKI patients while multiple linear regression was conducted to analyze factors influencing the overall hospitalization cost. Results were considered statistically significant at $P < 0.05$.

3. Results

3.1. Composition of hospital expenses for AKI patients

As shown in **Table 1**, the average treatment cost of AKI patients was about 19,946.06 yuan (P25 = 11,020.01,

P75 = 55,296.06), among which the average cost of Western medicine was much higher than that of Chinese medicine, at 5055.51 yuan.

Table 1. Composition of hospital expenses (yuan) for AKI patients

Expense type	Number of patients (*n*)	Median	P25	P75
Total cost	715	19,946.06	11,020.01	55,296.06
Western medicine cost	712	5055.51	2297.87	16,830.83
Cost of Chinese medicine	505	522.97	230.49	1036.24
Check consumables cost	701	47.24	24.26	80.77
Treatment supplies cost	714	949.96	169.10	4799.93
Surgical consumables cost	585	410.00	170.75	1178.00

3.2. Comparison of hospitalization costs for AKI patients

As shown in **Table 2**, there was a statistically significant difference in hospitalization costs across different age groups (H = 47.17, $P < 0.0001$), with the total cost being the highest for patients over 65 years old as compared to other age groups. The variation in hospitalization costs among patients at different stages of AKI was also statistically significant (H = 69.53, $P = 0.0021$). The greater the severity of the disease, the higher the associated hospitalization costs observed. Furthermore, there was a statistically significant difference in renal function recovery (H = 45.97, $P = 0.0013$), with patients without renal function recovery having higher costs than those who recovered. Different occupations, marital status, and length of hospitalization also exhibited variations in hospitalization costs that were statistically significant ($P < 0.05$).

Table 2. Comparison of hospitalization costs (yuan) of AKI patients

Attributes		Patients (*n*)	Median	P25	P75	*H/Z*	*P*
Sex	Male	434	19,818.60	10,291.08	60,880.80	0.07	0.79
	Female	281	19,949.36	12,015.37	50,394.29		
Age	< 40	125	15,612.91	9777.20	32,180.94	47.17	< 0.0001
	40–65	248	14,118.10	9540.99	39,481.37		
	> 65	342	30,214.57	13,639.00	81,314.67		
Payment Method	All expenses paid	104	22,451.07	11,653.68	74,066.16	0.65	0.72
	Resident medical insurance	437	19,448.37	11,240.30	52,319.39		
	Employee medical insurance	174	21,256.15	10,041.59	55,256.99		
Occupation	Worker	45	12,687.40	9130.75	27,076.19	12.99	0.0046
	Peasant	487	20,266.62	11,179.35	54,249.57		
	Clerk	138	29,103.88	11,451.22	85,089.49		
	Other	44	14,656.58	9807.69	45,281.06		
Marital status	Married	631	19,577.25	11,045.92	55,256.99	15.43	0.0015
	Spinster	45	14,249.32	8897.51	41,266.61		
	Widowed	35	41,396.04	28,924.86	99,425.05		
	Divorced	4	32,621.61	11,365.28	1,10,498.74		

Table 2 (Continued)

Attributes		Patients (*n*)	Median	P25	P75	*H/Z*	*P*
Length of hospitalization (d)	< 8	239	13,571.69	8011.26	35,335.85	179.81	< 0.0001
	8–14	274	14,332.97	10,884.63	31,801.21		
	15–21	117	30,626.84	17,310.47	90,156.73		
	22–28	46	60,107.93	34,096.15	1,10,232.75		
	> 28	39	2,06,117.15	88,103.20	3,08,560.71		
AKI stages	I	401	16,556.23	11,421.37	57,568.55	69.53	0.0021
	II	199	29,616.56	15,621.93	86,716.36		
	III	116	31,614.67	26,943.68	99,843.66		
Renal function	Recovered	489	21,149.97	12,046.26	53,640.37	45.97	0.0013
	No recovery	227	42,789.56	28,094.74	98,655.69		

3.3. Multiple linear regression analywsis

As shown in **Table 3**, multivariate analysis results showed that the age, length of hospitalization, stages of AKI, and recovery of renal function were factors affecting the total hospitalization costs of AKI patients.

Table 3. Multiple linear regression analysis of hospital expenses in AKI patients

	Regression coefficient	Standard error	Standardization coefficient	*t*	*P*
Constant	-76,393.32	13,206.74			
Age	13,288.32	3235.65	16.87	4.11	< 0.0001
Length of hospitalization	35,405.00	2198.76	259.28	16.10	< 0.0001
Marital status	6400.16	4674.72	1.87	1.37	0.17
Occupation	6269.39	3712.77	2.85	1.69	0.06
AKI stages	56,075.35	2246.23	14.98	5.23	0.002
Renal function recovery	3244.21	2160.24	6.39	3.26	< 0.0001

4. Discussion

This study found that the hospitalization costs of AKI patients accounted for a large proportion of Chinese and Western medicine costs, much higher than the cost of traditional Chinese medicine and consumables during hospitalization. Due to uncontrollable factors such as the complications, complexity of the disease, and the physical condition of the patient, the higher the number of complications, the more complicated the disease. This results in a greater proportion of Western medicine and medical resources used, thus increasing the hospitalization costs [13]. Some studies have found that the scientific intervention of pharmacists has achieved remarkable results in optimizing the structure of hospitalization costs and improving the utilization efficiency of medical insurance funds. In addition, pharmacist intervention can improve patients' medication compliance, reduce adverse reactions and disease recurrence rate, thus reducing the medical expenditure and economic burden of hospitalized patients [14,15].

The univariate analysis of this study showed that occupation, marital status, age, length of hospitalization, stages of AKI, and renal function recovery were all influencing factors of hospitalization cost. Further multiple

linear regression analysis also confirmed that the hospitalization cost was positively correlated with age, stages of AKI, renal function recovery, and length of hospitalization.

According to recent studies, the incidence of AKI varies greatly among different countries and regions but has an overall rising trend, especially in the elderly population and critically ill patients. The degree of aging of elderly patients is a risk factor for the occurrence of hospital-acquired AKI, as well as an increase in in-hospital mortality [16]. Other studies have found that the prognosis of elderly patients with AKI was closely related to hypoproteinemia, renal replacement therapy, and stage III AKI [17]. Moreover, AKI also increases the risk of poor prognosis in severely ill patients. In addition to avoiding the predisposing factors of AKI to reduce the incidence, it is also crucial to actively intervene in the prognostic risk factors of AKI. The early treatment goals of AKI patients include preventing the progression of kidney injury and promoting renal function recovery. Currently, there is no direct treatment method to improve renal function and it only relies on the prevention and treatment of related complications. For patients with severe AKI, renal replacement therapy is the cornerstone of supportive treatment [18]. However, this procedure is very costly. This study found that age factors, renal function recovery, and stages of AKI were closely associated with hospitalization costs, which was consistent with the findings of previous studies. In addition, the length of hospitalization was also closely related to the complexity of the patient's condition, prognosis, and cost of hospitalization.

This study has shown that age was an important factor that affects the hospitalization cost of AKI patients. By improving the prognosis of elderly AKI patients, the medical burden and economic pressure brought by the disease can be reduced. In addition, the severity of the disease and treatment plans should also be considered. The degree of renal function recovery and the stages of AKI are also important indicators to evaluate the condition and prognosis of AKI patients and are closely associated with hospitalization costs.

Currently, there is still a lack of effective treatment measures for AKI. Early diagnosis and prevention play an important role in improving the prognosis of AKI patients. An exact and adequate economic research is crucial in improving the prognosis and reducing the economic burden of AKI patients.

5. Conclusion

This study showed that by understanding the characteristics of AKI in detail and identifying factors affecting the prognosis, the economic burden and prognosis of the patients can be improved. Nonetheless, more information needs to be collected for relevant research. In the formulation of medical policies, the influence of the patient's condition and implemented treatment plans should be considered to rationally allocate medical resources and reduce hospitalization costs. At the same time, medical institutions should strengthen the management and efficiency of medical services provided for AKI patients.

Disclosure statement

The authors declare no conflict of interest.

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