

Path Analysis of Hospitalization Expenses of 2,164 Appendicitis Patients at County-Level Public Hospitals in Anhui Province, China

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Abstract

Background and objective

Appendicitis resection is one of the most common surgical procedures in China. Hospitalization expenses are a major determinant of appendicitis treatment. This study explored the factors influencing hospitalization expenses of appendicitis surgery patients in Anhui province and provided a scientific basis for reasonably controlling medical expenses.

Methods

A multi-stage random cluster sampling method was used to collect case information on 2,164 patients who underwent appendicitis surgery at 6 county-level public hospitals in Anhui province, China. Path analysis was used to study the factors influencing hospitalization expenses of appendicitis surgery patients.

Results

The average length of stay (LOS) was 5.62 ± 2.64 days, with a median of 5 days; the average hospitalization expenses were $6,109.60 \pm 2,109.44$ CNY, with a median of 5,511.93 CNY. The direct effect of LOS was 0.535, which was the most important direct factor affecting hospitalization expenses, and the remaining path coefficient was 0.699. Surgical grades, surgical methods, and chronic appendicitis directly affected hospitalization expenses, with direct effects of 0.149, 0.081, and -0.037; surgical costs, anesthesia costs, disease outcomes, age, acute simple appendicitis, and operative duration (OD) not only directly affected hospitalization expenses, but also indirectly affected hospitalization expenses through the LOS, and the total effects were 0.283, 0.045, 0.200, 0.202, -0.162, and 0.062, respectively. The total number of surgeons and assistants only indirectly affected the hospitalization expenses through the LOS, and the indirect effect was 0.020.

Conclusions

The LOS is the most important factor affecting hospitalization expenses. Controlling hospitalization expenses is an effective method of reducing the economic burden of patients undergoing appendicitis surgery and decreasing hospital medical expenditures. Based on controlling the average LOS, combined with other comprehensive measures such as decreasing the OD and health education, strengthening controllable factors, and effectively managing the unreasonable increase in hospitalization expenses.

Background

As a common inflammatory disease of the abdominal cavity, appendicitis is a common cause of abdominal and periumbilical pain in patients in emergency surgery. Surgical resection has been the preferred treatment [1, 2]. Compared with non-surgical treatment, the success rate of appendectomy is high and the length of stay (LOS) is short, which is the gold standard for the treatment of appendicitis [3].

Among the more than 200 million operations performed each year worldwide, appendectomy is one of the most common operations that cause significant medical expenses [4, 5, 6]. Several studies calculated the lifetime risks of appendicitis and appendectomy [7, 8, 9]. Overall, 2.9% of males and 16% of females undergo appendectomy in the US [10]. The US estimated the burden of surgical disease and the results showed that appendicitis resections were numerous, accounting for the majority of hospitalizations in emergency general surgery (EGS) [11, 12]. Appendectomy has also been recognized as one of the most uneven clinical burdens in EGS [13]. Among EGS diseases, appendicitis is one of the seven most expensive. It is estimated that the US spends billions of dollars annually to treat this disease.

In low-and middle-income countries (LMIC), the incidence of appendicitis is also high [14]. As the world's most populous and largest developing country, China has limited medical and health resources. Cost control for patients undergoing appendicitis surgery is of considerable significance to reduce the burden of medical treatment and the increase in medical expenses [2].

According to official statistics, the per capita medical expenses of appendicitis patients were 7,619.64 CNY, 8,233.5 CNY, and 8,605.5 CNY, respectively, in 2016, 2017, and 2018. The number of discharges from public hospitals for appendicitis were 789,164, 803,434, and 856,609, respectively. The numbers of appendicitis discharges from county-level hospitals were 505,456, 511,057, and 550,657, respectively. County-level hospitals accept most patients with appendicitis, and the per capita medical expenses and the number of discharges showed an increasing trend.

Appendectomy was first performed by Claudius Amyand in 1736 but the nineteenth-century surgeons Fitz, Morton, Trèves, McBurney, and Murphy first described appendicitis and recommended early appendectomy as its treatment [15]. Most research focuses on comparing the clinical efficacy and cost-effectiveness of open appendectomy (OA) and laparoscopic appendectomy (LA), and single or multiple factors such as region, CT scan, and antibiotic treatment have a clinical effect on appendicitis patients and the influence of economic expenses and other factors [1, 16, 17, 18, 19]. Few studies focus on the influence of surgical factors such as operative duration (OD), time to appendectomy (TTA), and disease outcomes on hospitalization expenses of appendicitis patients. Many surgical outcome studies focus on situations that affect the majority of the population that have a high mortality rate and risk of treatment complications [20, 21]. In contrast, patients with common operations such as appendicitis usually survive. Therefore, research on the clinical outcomes of appendicitis surgery uses other indicators that reflect the quality and value of medical care, such as the LOS and hospitalization expenses [22, 23]. To obtain the best therapeutic value in the treatment of appendicitis depends on the cost, so it is appropriate to pay attention to hospitalization expenses [24].

In today's health care environment with limited resources, rising health expenditures make it increasingly important to maintain medical quality while controlling costs [25, 26]. In China, the rapid increase in hospitalization expenses is an issue of public concern and a problem that urgently needs to be solved in the reform of county-level public hospitals. As leaders of the rural tertiary medical and health service network and the link between urban and rural medical and health service systems, county-level public hospitals have become a key link in alleviating the problem of expensive medical care for the general public.

Anhui province is located in eastern China. As the end of 2018, it had a population of approximately 70 million, and the urban population accounted for approximately 32.65%. The province is one of the four major medical reform pilot provinces; it has been at the forefront of national medical reform and county-level hospital reform and has created many innovative measures to promote throughout the country and has made considerable achievements [27]. Anhui province has continuously increased its economic investment in the health care industry. In recent years, per capita hospitalization expenses have increased only slightly and the proportion of personal health expenditures in the total health care expenditures has gradually decreased.

This study included 2,164 patients with appendicitis surgery at 6 county-level hospitals in Anhui province in 2018 as research subjects and conducted a path analysis of the factors that lead to increasing hospitalization expenses to ascertain inner connection and provide references to reduce the economic burden of patients with appendicitis surgery.

Methods

Sample and data collection

A multi-stage cluster random sampling method was used in this study. First, we randomly selected six counties based on geographic location in northern and southern Anhui: Linqun, Taihe, Mengcheng, Wuwei, Jingcounty, and Dongzhi. We then randomly chose a county-level hospital from each of the aforementioned counties as the investigation scene (coded as A, B, C, D, E, and F, respectively).

The patients' information was exported from the hospitals' medical record management system, including the patient's gender, age, admission date, disease outcomes, main diagnosis, diagnostic code, surgical code, surgical grades, surgical

name, operator, surgical date, TTA, surgical start time, surgical end time, discharge date, LOS, and hospitalization expenses, among others. The inclusion criteria were the International Classification of Disease, Tenth Revision (ICD-10) code K36.x02 or K35; the International Classification of Disease, Ninth Revision Clinical Modification, Third Revision (ICD-9-CM-3) code 47.0; and the discharge time was January 1 to December 31, 2018. The exclusion criteria were missing data or errors too difficult to correct and the data was obviously abnormal. According to the inclusion and exclusion criteria, data from 2,164 appendicitis surgery patients were ultimately included.

This study was approved by the Ethics Committee of the First Affiliated Hospital of Anhui Medical University as a retrospective large data analysis study. All of the patients' records and information were anonymized and de-identified before analysis.

Since LOS Y1 and hospitalization expenses Y2 were both skewed, the frequency of the original score was converted into a relative cumulative frequency (percentage grades), which was regarded as the probability of a normal distribution. Then by checking the probability in the normal distribution table, the Z value corresponding to the value was converted into a Z score. The variable data (LOS and hospitalization expenses) that failed the normal distribution test were corrected to obtain NY1 and NY2, respectively.

NY1 and NY2 were considered endogenous variables, and other relevant factors were introduced into the model. SPSS version 19.0 (SPSS Inc., Chicago, IL, USA) was used for data statistics and processing, and a multiple stepwise linear regression was used to fit the path model. The significance was set at $P \leq 0.05$, in which the disordered multi-classification variables entered the equation model in the form of dummy variables (see Table 1).

Table 1
Variables and assignment

Variable name	Variable code	Dumb variable	Assignment
Gender	X1		Male = 1, Female = 2
Age (years)	X2		Actual value
Type of disease	X3-4	Acute comorbid appendicitis	0 0
		Acute simple appendicitis	1 0
		Chronic appendicitis	0 1
Disease outcomes	X5		Cure = 1, Better = 2, Other = 3
Surgical grades	X6		Grade I = 1, Grade II = 2, Grade III = 3, Grade IV = 4
Total number of surgeons and assistants	X7		One person = 1, Two persons = 2, Three persons = 3
Surgical methods	X8		OA = 1, LA = 2
Anesthesia costs (CNY)	X9		Actual value
Surgical costs (CNY)	X10		Actual value
TTA	X11-13	Daytime on weekdays	0 0 0
		Evening on weekdays	1 0 0
		Weekends	0 1 0
		Statutory holidays	0 0 1
OD (minutes)	X14		Actual value
Location	X15		North Anhui = 1, South Anhui = 2
LOS (days)	Y1		Actual value
Hospitalization expenses (CNY)	Y2		Actual value
*7:00–18:59 for the daytime and 19:00–6:59 the next day for the evening.			

The following formulas were used: the direct path coefficient of the independent variable to the dependent variable = standardized regression coefficient; the independent path X through the NY1 acted on the dependent variable NY2 between the path diameter coefficient = the direct path coefficient of the independent variable NY1 × (X and NY1 correlation coefficient); the total path coefficient = direct path coefficient + the connection diameter coefficient between each; and the remaining path coefficient $P_e = \sqrt{(1-R^2)}$, R^2 was the coefficient of determination.

Effect Decomposition Of The Path Model

Each effective influencing factor was simply correlated with NY1 (see Table 4), and the correlation coefficients r_i and r_j were obtained. It is preliminarily believed that the closer r_i and r_j are to 1, the greater the relationship between the two. However, because of the mutually restrictive relationship between various factors, r_i and r_j were the result of the synthesis of many factors, and the size of r_i and r_j could not fully explain the importance of the cause to the results. To understand the importance of the comprehensive components of r_i and r_j and the reasons for the results, we used the path diagram and path coefficient.

Table 4
Hospitalization expenses related to the analysis of the influencing factors

	X2	X3	X4	X5	X6	X7	X8	X9	X10	X14	NY1
X2	1.000	-0.011	0.059	0.017	-0.146**	-0.086**	-0.048*	0.024	0.061**	0.192**	0.171**
X3	-	1.000	-0.197**	-0.022	-0.031	-0.169**	-0.140**	-0.062**	0.055*	-0.049*	-0.133**
X4	-	-	1.000	0.011	-0.062**	-0.016	-0.053*	0.008	0.014	-0.032	-0.012
X5	-	-	-	1.000	-0.141**	-0.139**	0.002	0.037	-0.023	0.099**	0.122**
X6	-	-	-	-	1.000	0.087**	0.303**	0.055*	0.284**	-0.260**	-0.065**
X7	-	-	-	-	-	1.000	0.092**	-0.201**	-0.121**	-0.183**	0.038
X8	-	-	-	-	-	-	1.000	0.205**	-0.006	-0.050*	-0.011
X9	-	-	-	-	-	-	-	1.000	-0.060**	0.193**	-0.114**
X10	-	-	-	-	-	-	-	-	1.000	0.076**	0.128**
X14	-	-	-	-	-	-	-	-	-	1.000	0.261**
NY1	-	-	-	-	-	-	-	-	-	-	1.000
**Significantly correlated at 0.01 grades (two-sided).											
*Significantly correlated at 0.05 grades (two-sided).											

the effect decomposition of influencing factors of hospitalization expenses was carried out according to the aforementioned path model. Among them, the direct effect was derived from model 2, and the indirect effect was derived from the combination of the two models. The total effect was the sum of the direct and indirect effects. The path coefficient significance test was equivalent to the partial regression coefficient hypothesis test. The results are shown in Table 5. The order of the total path effect of each variable was LOS (0.535), surgical costs (0.283), age (0.202), disease outcomes (0.200), acute simple appendicitis (-0.162), surgical grades (0.149), surgical methods (0.081), OD (0.062), anesthesia costs (0.045), chronic appendicitis (-0.037), and total number of surgeons and assistants (0.020).

Table 5

Effect decomposition of the influencing factors on the hospitalization expenses of appendicitis surgery patients

Variable	Direct effect	Indirect effect	Correlation coefficient with NY1	Total effect
LOS	0.535	-	1.000	0.535
Total number of surgeons and assistants	-	0.020	0.038	0.020
Surgical costs	0.215	0.068	0.128**	0.283
Anesthesia costs	0.106	-0.061	-0.114**	0.045
Surgical methods	0.081	-	-0.011	0.081
Disease outcomes	0.135	0.065	0.122**	0.200
Surgical grades	0.149	-	-0.065**	0.149
Age	0.111	0.091	0.171**	0.202
Acute simple appendicitis	-0.091	-0.071	-0.133**	-0.162
OD	0.052	0.010	0.020	0.062
Chronic appendicitis	-0.037	-	0.261**	-0.037

**Significantly correlated at 0.01 grades (two-sided).

Drawing Of Path Diagram

Based on the direct and indirect path coefficients of various variables, combined with professional knowledge, we drew a path diagram of the influencing factors on the hospitalization expenses of appendicitis surgery patients (see Fig. 1), which visually shows the direct and indirect influencing factors and their mutual effects of appendicitis surgery patients.

Results

General conditions of inpatient costs

The 2,164 patients included 1,201 males (55.50%) and 963 females (44.50%). The ratio was 1.25 for males and females. A total of 1,027 patients had acute simple appendicitis (47.46%), 1,048 patients had acute comorbid appendicitis (48.43%), and 89 patients had chronic appendicitis (4.11%), 498 patients had OA (23.01%), and 1,666 patients had LA (76.99%). The average age of the patients was 35.79 years. The average LOS was 5.62 ± 2.64 days, with a median of 5 days. The average hospitalization expenses were $6,109.60 \pm 2,109.44$ CNY, with a median of 5,511.93 CNY. The specific hospitalization expense information on the 2,164 patients is shown in Table 2.

Table 2
Analysis of LOS and hospitalization expenses of appendicitis surgery patients (N = 2164)

Variable	N (%)	LOS (days)		Hospitalization expenses (CNY)		P	
		Average	Median	Average	Median		
Gender	Male	1201 (55.50)	5.62	5	6114.90	5499.41	0.826
	Female	963 (44.50)	5.61	5	6102.99	5533.58	
Age (years)	≤ 17	575 (26.57)	5.31	5	5532.01	5288.79	< 0.001*
	18–33	516 (23.85)	5.16	5	6043.33	5478.55	
	34–52	559 (25.83)	5.59	5	6267.01	5806.96	
	≥ 53	514 (23.75)	6.46	6	6651.07	5831.12	
Type of disease	Acute comorbid appendicitis	1027 (47.46)	5.27	5	5829.31	5366.70	< 0.001*
	Acute simple appendicitis	1048 (48.43)	5.98	5	6421.99	5680.75	
	Chronic appendicitis	89 (4.11)	5.31	5	5665.48	5495.95	
Disease outcomes	Cure	2069 (95.61)	5.54	5	6010.37	5490.74	< 0.001*
	Better	93 (4.30)	7.10	6	7952.62	7007.16	
	Other	2 (0.09)	13.50	13.5	23065.50	23065.50	
Surgical grades	Grade I	141 (6.52)	6.45	5	5711.81	5242.61	< 0.001*
	Grade II	214 (9.89)	5.70	5	5928.51	5209.70	
	Grade III	1807 (83.50)	5.54	5	6157.21	5562.93	
	Grade IV	2 (0.09)	7.00	7	10518.56	10518.56	
Total number of surgeons and assistants	One person	122 (5.64)	5.64	5	6300.96	6041.16	0.001*
	Two persons	1570 (72.55)	5.59	5	6192.16	5496.50	
	Three persons	472 (21.81)	5.69	5	5785.52	5504.37	

Age, anesthesia costs, surgical costs, and OD were divided into 4 groups according to quartile interval.

*Significance.

Variable		N (%)	LOS (days)		Hospitalization expenses (CNY)		P
			Average	Median	Average	Median	
Surgical methods	OA	498 (23.01)	5.82	5	5769.89	5381.27	< 0.001*
	LA	1666 (76.99)	5.56	5	6211.14	5590.07	
Anesthesia costs (CNY)	≤ 669.00	549 (25.37)	5.78	5	5754.37	5531.66	0.001*
	670.00 ~ 760.00	682 (31.51)	5.68	5	6023.28	5637.71	
	761.00 ~ 864.00	478 (22.09)	5.63	5	6406.17	5497.88	
	≥ 865.00	455 (21.03)	5.32	4	6356.04	5308.65	
Surgical costs (CNY)	≤ 919.00	827 (38.22)	5.48	5	5594.80	5263.72	< 0.001*
	920.00-980.00	426 (19.69)	4.69	4	5810.93	5311.46	
	981.00-1026.00	374 (17.28)	6.10	6	6788.21	5826.92	
	≥ 1027.00	537 (24.81)	6.22	6	6666.71	6073.00	
TTA	Daytime on weekdays	922 (42.61)	5.51	5	6057.66	5547.65	0.100
	Evening on weekdays	564 (26.06)	5.76	5	6064.36	5474.02	
	Weekends	502 (23.20)	5.53	5	6099.39	5489.09	
	Statutory holidays	176 (8.13)	5.97	5	6555.79	5784.45	
OD (minutes)	≤ 31	670 (30.96)	4.87	5	5511.82	5301.39	< 0.001*
	32-41	441 (20.38)	5.39	5	5996.77	5542.92	
	42-60	544 (25.14)	5.56	5	6099.96	5595.46	
	≥ 61	509 (23.52)	6.85	6	7004.51	6008.24	
Location	North Anhui	1688 (78.00)	5.53	5	6141.36	5494.92	0.329

Age, anesthesia costs, surgical costs, and OD were divided into 4 groups according to quartile interval.

*Significance.

Variable	N (%)	LOS (days)		Hospitalization expenses (CNY)		P
		Average	Median	Average	Median	
South Anhui	476 (22.00)	5.92	5	5996.98	5778.17	
Age, anesthesia costs, surgical costs, and OD were divided into 4 groups according to quartile interval.						
*Significance.						

Multiple linear regression analysis of the influencing factors on the hospitalization expenditures of appendicitis surgery patients

Using NY1 as the dependent variable and introducing effective variables such as age into the model for a multiple stepwise linear regression, the results showed that the regression equation was significant, the estimation accuracy was high, and the goodness of fit was good ($F1 = 55.095, P < 0.001$). Using NY2 as the dependent variable and introducing NY1 and each exogenous variable into the model, we performed a multiple stepwise linear regression analysis. The results are shown in Table 3 ($F2 = 226.257, P = 0.017, R^2 = 0.512$). The path analysis equation models were as follows:

Table 3
Multiple linear regression analysis of the influencing factors on the hospitalization expenses of appendicitis patients

Variable	Regression coefficient (B)	SE	Standardized regression coefficient (standard B)	t	P
Constant	-2.657	0.140	-	18.972	< 0.001
LOS	0.552	0.017	0.535	32.822	< 0.001
Surgical costs	0.177	0.013	0.215	13.205	< 0.001
Anesthesia costs	0.099	0.015	0.106	6.620	< 0.001
Surgical methods	0.193	0.039	0.081	4.977	< 0.001
Disease outcomes	0.637	0.073	0.135	8.779	< 0.001
Surgical grades	0.268	0.032	0.149	8.430	< 0.001
Age	0.099	0.014	0.111	7.109	< 0.001
Acute simple appendicitis	-0.181	0.032	-0.091	-5.746	< 0.001
OD	0.045	0.015	0.052	3.083	0.002
Chronic appendicitis	-0.187	0.078	-0.037	-2.394	0.017

$$NY1 = -1.362 + 0.215 \times X14 - 0.141 \times X9 - 0.233 \times X3 + 0.105 \times X2 + 0.510 \times X5 + 0.088 \times X10 + 0.141 \times X7 \quad (1)$$

$$NY2 = -2.657 + 0.535 \times NY1 + 0.215 \times X10 + 0.106 \times X9 + 0.081 \times X8 + 0.135 \times X5 + 0.149 \times X6 + 0.111 \times X2 - 0.091 \times X3 + 0.052 \times X14 - 0.037 \times X4 \quad (2)$$

Model 1 shows that the factors that indirectly affected the hospitalization expenses of appendicitis surgery patients include OD, anesthesia costs, acute simple appendicitis, age, disease outcomes, surgical costs, and the total number of surgeons and assistants. Among them, disease outcomes had the greatest influence on the LOS, which was positively correlated. Model 2 shows that the factors that directly affected the hospitalization expenses of appendicitis surgery patients included the LOS, surgical costs, anesthesia costs, surgical methods, disease outcomes, age, surgical grades, acute simple appendicitis, chronic appendicitis, and OD. Among them, the total number of surgeons and assistants indirectly affected hospitalization expenses only through the LOS; factors such as surgical methods, chronic appendicitis, and surgical grades directly affected hospitalization expenses; OD, anesthesia costs, acute simple appendicitis, disease outcomes, age, and surgical costs not only directly affected hospitalization expenses, but also indirectly affected hospitalization expenses through the LOS.

Conclusions

This study analyzed the direct and indirect effects of hospitalization expenses for patients undergoing appendicitis surgery. The research results provide evidence of a better understanding of how factors such as surgical methods affect hospitalization expenses. Hospitals should focus on bed turnover efficiency to reduce the number of bed days to reduce pressure and consider rational use of clinical pathways and day surgery to control hospitalization expenses. This study provided recommendations for policies and measures to reduce hospitalization costs for patients undergoing appendicitis surgery to promote the reform of county-level public hospitals. The unfavorable direct impact of the hospitalization costs of patients undergoing appendicitis surgery on the family economy may lead to debt or impoverish families. Reducing the hospitalization expenses of patients undergoing appendicitis surgery can help reduce poverty.

Discussion

Many scholars have used *t*-test, chi-squared test, multiple regression analysis, and other methods to explore the influencing factors of hospitalization expenses and achieved certain results [28, 29, 30]. However, the influencing factors of hospitalization expenses are complex, and there are often correlations between various factors. Some factors may have an indirect impact on hospitalization expenses by affecting the LOS. Path analysis is an extension of multiple regression. It is a structural equation model that does not contain any latent variables [31]. It is a powerful statistical technique and a more complex and realistic model than multiple regression with a single dependent variable. We used path coefficients and standardized direct, indirect, and total effects to accurately assess the impact of each factor on the dependent variable. The direct impact of standardization refers to the impact of one variable on another variable without mediation by other variables in the path diagram; the indirect impact refers to the impact of one variable on other variables and mediation through other variables; the total standardized effect is the sum of that direct and indirect effects that represents the overall impact of one variable on another variable. Therefore, path analysis can analyze the direct and indirect effects of various factors on dependent variables, reveal the relationship between variables, and compensate for the regression model's deficiencies. Therefore, this study adopted this method.

The Influence Of Los On Hospitalization Expenses

As one of the important indicators reflecting the progress of the disease, the LOS is the greatest factor influencing the hospitalization expenses of appendicitis surgery patients. The direct effect is 0.535, indicating that the longer the LOS, the higher the hospitalization expenses. A longer LOS will not only increase medical costs and waste medical resources, but also increase patients' financial burden. Therefore, to ensure medical quality, how to effectively shorten LOS has become a key

issue in reducing hospitalization expenses. The hospital can shorten the average LOS by formulating diagnosis and treatment standards or clinical pathways, optimizing the diagnosis and treatment process, reducing the number of days of hospitalization before surgery and the number of inefficient and ineffective hospitalization days for patients. In addition, the hospital should also recommend that patients see a doctor and formulate referral standards based on their condition. Patients who meet the standards should be promptly referred to township health centers or community health service centers for rehabilitation, thereby effectively decreasing the postoperative hospital stay. Based on the perspective of health economics, decreasing the number of days in the hospital can expedite hospital bed turnover and increase the medical resources utilization rate; the number of patients admitted to the hospital per unit time will increase, and the total income will increase, which not only reduces average expenses, but also patients' economic burden.

The influence of surgical grades and methods on hospitalization expenses

These two variables are factors that only had a direct effect on hospitalization expenses in this study and the total effect was positive. The surgical grades were positively correlated with hospitalization expenses, indicating that the average hospitalization expenses of appendicitis surgery patients will show an increasing trend as the surgical grades increase, which was consistent with the results of the descriptive analysis. The increase in hospitalization expenses may be related to the increased difficulty of the operation and the increase in medical equipment consumables.

Surgical methods positively correlated with hospitalization expenses, indicating that the average hospitalization expenses of patients undergoing LA were higher than the average hospitalization expenses of patients undergoing OA, which was consistent with the results of the descriptive analysis. Appendectomy is one of the most common surgical procedures in pediatrics and the general population. LA has been recognized as a surgical technique that can optimize patient safety, quality, and cost [32, 33]. The benefits of LA include reduced surgical site infection, less postoperative pain and need for analgesia, earlier return to a normal diet, and shorter LOS. Long-term benefits include reduced adhesion formation, earlier resumption of normal activities, and cost savings due to earlier resumption of work [32, 34, 35]. Relevant studies have shown that LA is not fully accepted in some places. This may be because LA requires more manpower and material resources and higher hospital expenses, although it may save money if the patient can resume work faster [35, 36, 37, 38, 39]. The cost of LA is considered to be higher than OA. Prior studies reported a higher incidence of patients with simple appendicitis [40], similar to the results of this study. Analysis of age groups shows that the average LOS of patients does not gradually increase with age. The average LOS of 18- to 33-year-old patients is lower than that of other age groups. This may be due to the low coexistence characteristics of young patients, morbidity, and better tolerance to surgical pressure (see Table 6). Relevant studies reported that there was no benefit to cost control or decreasing the LOS for patients undergoing LA at approximately 50 years old. The total costs of patients with LA over 50 years old has decreased significantly [41, 42]. This is inconsistent with the results of this study, which may be due to different regions and sample selections, so further research is needed.

Table 6
LA vs OA in appendicitis patients from 0 to 90 years old

Age (years)	LA (N = 1,666)				OA (N = 498)			
	LOS (days)		Hospitalization expenses (CNY)		LOS (days)		Hospitalization expenses (CNY)	
	Average	Median	Average	Median	Average	Median	Average	Median
≤ 17	5.26	2.22	5594.64	1127.49	5.47	2.99	5308.86	1696.03
18–33	5.19	2.42	6135.77	2429.92	5.03	2.99	5694.12	1424.63
34–52	5.61	2.72	6385.20	1952.13	5.53	2.75	5834.65	1503.01
≥ 53	6.26	2.86	6835.89	2745.53	6.95	3.43	6176.17	2507.29

The influence of surgical costs, anesthesia costs, disease outcomes, age, and OD on hospitalization expenses

These five variables not only directly affect hospitalization expenses, but also indirectly affect hospitalization expenses through the LOS, and the total effect is positive. This demonstrates that hospitalization expenses will increase as surgical and anesthesia costs increase. A series of comprehensive service expenses, medical equipment consumables, and examination and diagnosis expenses incurred during surgery directly led to the increase in hospitalization expenses. With the innovation and development of medical devices, surgical costs are also increasing. To reduce hospitalization expenses, surgeons should improve the level of medical technology, shorten OD, reduce the loss of medical devices, and control unreasonable surgical costs.

Disease outcomes are positively correlated with hospitalization expenses, indicating that the average hospitalization expenses of patients who are converted to other are higher than that of patients who are converted to improved, and the average hospitalization expenses of improved patients are higher than that of cured patients. Patients with better outcomes have a relatively short LOS, consume less medical equipment and medical supplies, and have lower hospitalization expenses. The direct effect is greater than the indirect effect, indicating that the outcome mainly directly affects hospitalization expenses.

Age is uncontrollable and the third major factor affecting hospitalization expenses. Age is positively correlated with hospitalization expenses. This may be due to aging and damage to human organs, as well as the gradual weakening of physical functions with age, various complications, and accompanying diseases, resulting in a relatively long LOS and higher hospitalization expenses. In this regard, the public should increase their awareness of appendicitis and carry out health education, such as avoiding irregular eating, strenuous exercise after meals, spicy and irritating food, and indigestible food such as raw, cold, and hard food. The general public should be instructed to develop good dietary and living habits to fundamentally prevent the occurrence of diseases and achieve early detection and treatment to reduce the economic burden.

Hospitalization expenses will increase as the OD increases. This is not difficult to understand, mainly because of the increase in medical equipment, consumables, and medical supplies. Properly controlling the OD can effectively reduce the hospitalization expenses of appendicitis surgery patients.

The influence of acute simple appendicitis and chronic appendicitis on hospitalization expenses

The total effect of these two variables is negative. Acute simple appendicitis is negatively correlated with hospitalization expenses, indicating that compared with patients with acute comorbid appendicitis, patients with acute simple appendicitis have lower average hospitalization expenses. This is mainly related to the condition's complexity. Patients with more serious comorbidities and those with comorbidities have more complicated conditions than patients without comorbidities and will consume more sanitary supplies and medicines during the treatment process, which in turn increases the expenses of medicines. Expenses such as examination expenses also increase hospitalization expenses. This is inconsistent with the results of the descriptive analysis and may be caused by this study's small cohort. Studies have shown that for patients undergoing acute appendicitis with abscesses and other complications, conservative treatment is better than immediate surgical treatment at reducing morbidity, hospitalization expenses, and loss of quality of life [43].

Chronic appendicitis is negatively correlated with hospitalization expenses and only directly affects hospitalization expenses, indicating that compared with patients with acute comorbid appendicitis, the average hospitalization expenses of chronic appendicitis patients are lower. This is consistent with the results of the descriptive analysis. This is mainly related to the condition's complexity. Patients with acute appendicitis have more complicated and urgent conditions than those with chronic appendicitis. During treatment, they will consume more sanitary supplies and medicines, which in turn increases the costs of medicines and inspections and ultimately leads to an increase in hospitalization expenses.

The influence of the total number of surgeons and assistants on hospitalization expenses

The total number of surgeons and assistants only indirectly affects the hospitalization expenses through the LOS and is positively correlated with hospitalization expenses, indicating that the higher the total number of surgeons and assistants, the higher the hospitalization expenses. This is inconsistent with the aforementioned descriptive analysis results. It is possible that the path analysis results are more scientific and accurate, so further analysis and research are needed.

The Influence Of Other Factors On Hospitalization Expenses

In this study, the TTA had no significant influence on hospitalization expenses. However, previous studies showed that hospital work efficiency during weekends is lower than during workdays [44, 45, 46]. Compared with patients admitted on weekdays, patients admitted on weekends have a higher mortality rate and less reliable diagnostic imaging results [47, 48]. Although the incidence of many medical emergencies does not change between workdays and weekends, there are several factors that can negatively affect patient outcomes during workdays and weekends, such as a reduction in the number of medical staff and access to laboratories and diagnostics [49, 50]. In addition, inexperienced medical staff and imaging workers can take off work in shifts after work, which may become a problem that reduces the efficiency of medical care on weekends and weekday evenings [51]. Doctors can advance or postpone the TTA for patients with acute uncomplicated appendicitis and acute comorbid appendicitis according to the patient's urgency and through communication and negotiation. Surgery should be scheduled during the day on weekdays, which will help improve the utilization and effectiveness of hospitals' medical resources and reduce medical expenses [52, 53]. Prior studies demonstrated that the readmission rate after appendectomy is estimated to be between 1% and 19% [54, 55, 56], which showed that improving the efficiency of diagnosis and timely management, especially the value of nursing care, is beneficial to hospitals [57]. Primary medical and health care providers should guide patients to develop good dietary and living habits to reduce the readmission rate and effectively decrease hospitalization expenses.

Path analysis increases the interpretability of model fitting results. The path coefficient can be used to calculate the effect of factors that have not been studied but actually have an impact, that is, the remaining path coefficient, which can prompt whether it is necessary to further search for other influencing factors. $R^2 = 0.512$, indicating that 51.20% of hospitalization expenses can be explained by the factors in the equation. $Pe = 0.699$, which is slightly higher than the direct path coefficient of hospitalization days, indicating that there are other factors that have a greater impact on hospitalization costs. This demonstrates that there are still some factors that have a greater impact on hospitalization costs, such as drug expenses and payment methods. There were many missing data in this research, which made the residual path coefficient higher, which was the main limitation of this study. In addition, the cost was related to the economic development grades. This research only selected Anhui province, which has a middle national economic development grade. In the future, the scope of research should be expanded to find national factors in comprehensively developed and undeveloped areas. This was another limitation of this study that should be further researched.

Abbreviations

LOS: length of stay; OD: operative duration; CNY: Chinese yuan; TTA: time to appendectomy; OA: open appendectomy; LA: laparoscopic appendectomy; EGS: emergency general surgery; LMIC: low- and middle-income countries; ICD-10: International Classification of Disease, Tenth Revision; ICD-9-CM-3: International Classification of Disease, Ninth Revision, Clinical Modification, Third Revision.

Declarations

Ethics approval and consent to participate

The Ethics Committee of the First Affiliated Hospital of Anhui Medical University approved this project (procedural no. Quick-PJ 2020-11-07).

Consent for publication

We have obtained the agency's publishing consent.

Availability of data and materials

The data that support the findings of this study are available from the First Affiliated Hospital of Anhui Medical University, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the First Affiliated Hospital of Anhui Medical University.

Competing interests

The all co-authors have no competing interests.

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Figures

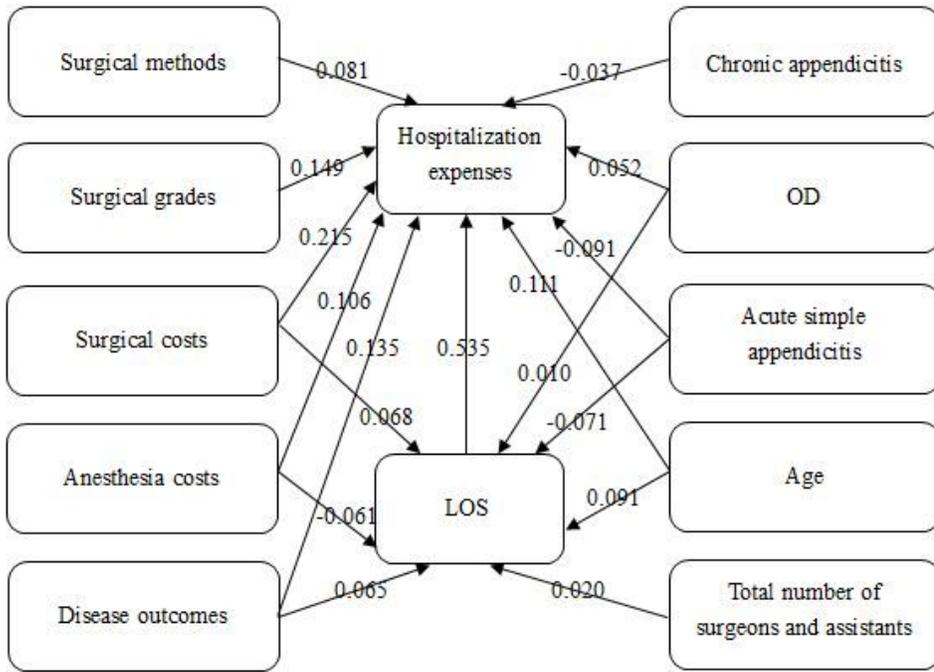


Figure 1

Path diagram of the influencing factors on the hospitalization expenses of appendicitis surgery patients.