Research on hospitalization costs of inguinal hernia surgery performed at county-level public hospitals in Anhui, China: Insights into Influencing Factors

Chen Qian1*, Chunhan Shen1*, Niannian Li2, Heng Wang3, Xue Zhang1, Ping Jiang1, Xinlong Gu1, Junjun Xue1, Yuhuan Ling1

1 Social Science and Health Management School, Anhui Medical University, Hefei, China
2 Department of Research Administration, The First Affiliated Hospital of Anhui Medical University, Hefei, China
3 Department of Dean’s Office, The First Affiliated Hospital of Anhui Medical University, Hefei, China
★ These authors contributed equally to this work.
* Corresponding author: Heng Wang, wangheng1969@163.com

Abstract

Background: Lancet gave a 99-point high score to the comprehensive level of diagnosis and treatment of inguinal hernia in China, and more than half of the inguinal hernia surgery procedures were completed in primary hospitals. At present, the hospitalization costs of inguinal hernia surgery patients in primary hospitals, the influencing factors, and the path between the factors are unclear. Innovative methods are needed to quantify the research and evaluation of hospitalization costs for inguinal hernia surgery patients to emphasise the impact of relevant measures on surgeons and hospital cost-control mechanisms.

Methods: A retrospective method was used to collect data from inguinal hernia surgery patients. The relationships between hospitalization costs and the following factors (age, gender, surgery, surgical method, surgical time, preoperative bed stay, postoperative bed stay, length of stay, and surgical costs) were analyzed using Spearman’s correlation analyzes, and how these factors influenced hospital expenditure was explored through structural equation modelling.

Results: According to Spearman’s rank correlation analysis, the hospitalization costs were related to the eight selected indicators (rs = -0.084 - 0.549, p < 0.01), and the surgical time was most relevant. The total effect of the surgical time on the hospitalization costs (total effect = 0.459) ranked first in the structural equation model, which means that the risk of hospitalization costs was higher with a longer surgical time. The choice of surgical method had a direct effect on the hospitalization costs (total effect = 0.291), and the effect was second only to the surgical time. Other research factors also had an indirect or direct impact on the hospitalization costs.

Conclusion: It is necessary to understand the hospitalization costs of inguinal hernia surgery patients and their influencing factors and interactions to form a scientific price incentive system and cost-control mechanism.
**Key words:** inguinal hernia; surgery; hospitalization costs; influencing factors; structural equation model

**Declarations**

**Abbreviations**

IHR: inguinal hernia repair; IHS: inguinal hernia surgery; LOS: length of stay; ICD-10: International Classification of Disease, the 10th revision

**Ethics approval and consent to participate**

According to the ministry of health <Ethics reviews on biomedical research involving human subjects>, WMA <The declaration of Helsinki> and CIOMS <International ethical guidelines for biomedical research involving>, The Ethics Committee of the First Affiliated Hospital of Anhui Medical University approved this project (procedural no. Quick-PJ 2020-09-12). This study is a secondary use of medical record data, so an informed consent exemption was approved. The use of medical records obtained administrative permission from the First Affiliated Hospital of Anhui Medical University.
Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Consent for publication
Not applicable.

Competing interests
The authors have no competing interests.

Funding
This study was supported by funding from The National Natural Science Foundation of China (No.71774001) (https://isis.nsfc.gov.cn/).

Author contributions
Study concepts: All authors. Study design: First authors. Data acquisition: Xue Zhang, Ping Jiang, Junjun Xue, Yuhuan Ling, and Xinlong Gu. Quality control of data and algorithms: Niannian Li. Data analysis and interpretation: Chen Qian. Statistical analysis: Chunhan Shen. Manuscript preparation: All authors. Manuscript editing: All authors. Manuscript review and approval: All authors.

Acknowledgments
The authors thank the Anhui Provincial Health Commission and the participating hospitals for their assistance.

Introduction
Surgical conditions represent an enormous but unrecognized source of disease burden globally. Research has indicated that 11% of the world’s disability adjusted life years (DALYs) result from surgical conditions likely to require[1]. Surgical treatment allows patients to regain functional status and engage in productive activity, but produces a certain economic burden for patients[2]. Although efforts are being undertaken worldwide to control medical expenses and alleviate pressure on patients' finances, policies and facilities leave a large gap between the provision of health services and public demand in a resource-poor environment, and "high treatment costs" remain severe. Innovative methods to quantify the medical costs of surgical treatment are needed to guide programmatic intervention and to inform advocacy efforts.

Inguinal hernia is one of the most common surgical procedures. More than 20 million
patients undergo groin hernia repair annually worldwide\textsuperscript{13}. In this study, we attempt to systematically explain the disease from the aspects of preclinical medicine, local anatomy, and clinical medicine\textsuperscript{4,5}. Inguinal hernia has become an important branch of surgery. Mock et al. defined inguinal hernia as a “priority 1 surgical condition” because it represents a significant global public health burden that can be treated with a simple, cost-effective surgical procedure\textsuperscript{6}. In addition, selective inguinal hernia repair (IHR) can prevent rare but serious and expensive complications, including strangulation, intestinal obstruction, and death\textsuperscript{7,8}. Surgery is considered the most cost-effective way to treat inguinal hernia over the long term\textsuperscript{9}.

It is estimated that the present cost of repairing all symptomatic inguinal hernias in Ghana is US$53 million, whereas US$103 million will be required to eliminate hernias over the next 10 years\textsuperscript{10}. Seung-Rim reported that the costs of IHR in Korea gradually increased from $1,000 to $1,600, and a dramatic increase was observed in the use of laparoscopic inguinal hernia repair, from less than 3\% in 2007 to approximately 30\% in 2015\textsuperscript{11}. Inguinal hernia repairs in the US reached nearly 800,000 cases in 2003, and the repair of femoral hernias is estimated to cost US$3.2 billion annually\textsuperscript{12,13}.

China is the most populous developing country in the world. Epidemiological studies over the past decade have shown that the annual incidence of inguinal hernia is 3.6\%-5.0\%, and the prevalence of inguinal hernia is as high as 1.16\% in those over age 65\textsuperscript{14}. In 2017, The Lancet gave a 99-point high score to the diagnosis and treatment of inguinal hernia in China, ranking fourth in the world, due to lower costs and better results\textsuperscript{15}. At present, more than 50\% of inguinal hernia surgical procedures are completed in primary hospitals, but the costs and their influencing factors remain unclear. Research data on IHR expenditures come from institutional medical records. Therefore, medical expenses can be precisely tracked. The direct costs of inguinal hernia treatment include diagnosis, examination, consumables, and medicine, among others\textsuperscript{16}. For inguinal hernia patients, the length of stay (LOS)\textsuperscript{17}, surgical time\textsuperscript{18}, and surgical method\textsuperscript{19} all affect medical expenses.

Therefore, it is crucial to gain a population-level view of the inguinal hernia expenditures from the perspective of sociodemographic characteristics and the distribution of treatment cost characteristics for health care decision-making. Considering the aforementioned literature, both surgery and LOS have demonstrated an association with hospitalization costs in inguinal hernia patients. However, there is limited information to explain the association between other contributing factors and hospitalization costs of inguinal hernia patients. Thus, we investigated the mediating effect of surgery and LOS on the association between these variables and hospitalization costs among patients with inguinal hernia surgery (IHS). We hypothesised that IHS
would be associated with a high risk of hospitalization costs through prolonged LOS in the hospital. Moreover, the distribution of age and gender would be associated with surgery (e.g., method).

China is currently reforming its national health care system to establish a more equitable health system through a series of policies and interventions\(^\text{[20]}\). Assessing and describing traits of the costs of treatment in China is a necessary first step in achieving this goal. Therefore, analyzing the influencing factors of hospitalization costs in patients with IHS is essential.

Data calculated based on medical institutions’ expenditures to analyze the factors that may affect IHR and their related relationships may help determine decisions related to clinical operations and hospital management measures to protect patients’ rights and achieve the universal health care coverage strategy proposed by the WHO.

Methods

Data source and study design

China has a dual urban-rural structure. The primary medical and health service system is led by county-level public hospitals that serve the majority of the national population. When residents have medical needs, county-level public hospitals are their first choice\(^\text{[21]}\). Anhui Province is one of the first pilot provinces for medical and health reform in China. County-level public hospital reform has always been at the forefront in China\(^\text{[22]}\). We assessed the top 10 diseases by number of surgical procedures in Anhui’s county-level public hospitals. Inguinal hernia surgery ranked first. The data came from the medical records of IHS patients at 8 county-level public hospitals in Anhui Province from January 1, 2018, to December 31, 2018. According to the geographical distribution, 4 hospitals in southern Anhui (Wuwei County People's Hospital, She County People's Hospital, Jing County Hospital, and Dongzhi County People's Hospital) and 4 hospitals in northern Anhui Province (Linquan County People's Hospital, Taihe County People's Hospital, Guzhen County People's Hospital, and Mengcheng County First People's Hospital) were selected. In line with the International Classification of Diseases 10\(^\text{th}\) Revision (ICD - 10), we collected the relevant data on inguinal hernia patients whose main diagnostic code was K40.

Quality control and data management

The investigators involved in data extraction underwent training and had a fixed set of data collection methods. Patient medical records in the hospital information system were electronically imported to another data terminal for on-site investigation. The investigators used tools to sort cases and identify missing or outliers and suspicious errors so that they could examine and evaluate the quality of the extracted data. We confirmed incomplete data with the original medical
institution to ensure its accuracy and checked the patient information detail by detail, excluding outpatient and other non-surgical patient data. We ultimately obtained a total of 2,606 cases that were effectively analyzed.

We pre-processed the data after data collection. We selected the basic patient information (age and gender), surgery-related information (surgical method, time, and costs), preoperative bed stay, and postoperative bed stay as internal latent variables; we chose the length of stay and hospitalization costs as exogenous latent variables. Surgery was divided into two types of open or laparoscopic surgery. The surgical time was defined as the time from the first incision to the last suture. Preoperative bed stay refers to the number of days from admission to the date of surgery; postoperative bed stay refers to the number of days from the first day after surgery to the date of discharge. LOS was determined as the total number of days in the hospital for patients with IHS. We used Excel 2013 (Microsoft Corporation, Redmond, WA, USA) to summarize the data and calculate the indicators.

**Statistical analysis**

We conducted a descriptive analysis of the data, and the Shapiro-Wilk normality test of the main indicators was used at first. We found that the hospitalization costs, LOS, and surgical time did not obey the normal distribution, but the data showed a normal distribution after logarithmic conversion. In addition, the age was converted into categorical variable to analysis based on experience and literature[23]. The median and interquartile range of hospitalization costs in different categories were calculated and the difference in costs between the different groups in the same category was analyzed. Spearman’s rank correlation test was used to examine the correlations between hospitalization costs, LOS, age, gender, surgical method, surgical time, preoperative bed stay, postoperative bed stay, and surgical costs.

The structural equation model was used for path fitting. Continuous variables that did not obey the normal distribution were entered into the equation in logarithmic form to test the significance of the correlation between the variables and determine their direct and indirect effects. The influencing factors and interrelationships of hospitalization costs of IHS patients were ultimately obtained.

SPSS 22.0 (SPSS Inc., Chicago, IL, USA) and AMOS 23.0 (SPSS Inc., Chicago, IL, USA) statistical were used for the analyzes. The significance for all of the statistical tests was indicated by a two-tailed p-value of 0.05.

**Results**

**Basic information on patients with IHS**

We collected 1,121 patients in southern Anhui province and 1,485 patients in the north to
Participate in the survey, a total of 2,606 inpatients. Males accounted for 2,301 (88.3%) and females accounted for 305 (11.7%). Most of the inpatients (936, 35.9%) were over 65 years old. Overall, 1,955 inpatients utilized open surgery (75.0%) and 651 (25.0%) adopted laparoscopic surgery. The surgical time of the majority of the inpatients (1,175, 45.1%) ranged from 45 minutes to 90 minutes and the length of stay of 54.2% of the inpatients was generally less than or equal to 5 days. The median costs of each variable of expenditure were as follows: south were US$713.6 and north were US$622.6 (for region); males were US$646.1 and females were US$620.0 (for gender); the inpatients over 65 years old were US$684.2 (for age); open were US$629.3 and laparoscope were US$826.7 (for surgical method); ranges from 45 minutes to 90 minutes were US$665.9 (for surgical time); and within 5 days were US$604.0 (for length of stay). More information on these variables and the differences between them is presented in Table 1.

Table 1. Basic information on the total IHR hospitalization expenditures

| Variables         | Total   | Proportion | hospitalization costs (USD) | P value |
|-------------------|---------|------------|-----------------------------|---------|
|                   |         |            | Median Cost | Upper 25th percentile | Lower 75th percentile |       |
| Region            |         |            |              |                     |                       | <0.01 |
| South             | 1121    | 43%        | 713.6        | 600.0               | 733.4                 |       |
| North             | 1485    | 57%        | 622.6        | 567.7               | 690.3                 |       |
| Gender            |         |            |              |                     |                       | <0.01 |
| Males             | 2301    | 88.3%      | 646.1        | 582.2               | 807.5                 |       |
| Females           | 305     | 11.7%      | 620.0        | 551.5               | 707.9                 |       |
| Age               |         |            |              |                     |                       | <0.01 |
| Age≤18            | 511     | 19.6%      | 554.4        | 508.2               | 623.4                 |       |
| 18<Age≤45         | 350     | 13.4%      | 639.9        | 579.9               | 813.6                 |       |
| 45<Age≤65         | 809     | 31%        | 660.3        | 595.9               | 837.3                 |       |
| Age>65            | 936     | 35.9%      | 684.2        | 614.6               | 859.9                 |       |
| Surgical method   |         |            |              |                     |                       | <0.01 |
| Open              | 1955    | 75.0%      | 629.3        | 574.8               | 708.1                 |       |
| Laparoscope       | 651     | 25.0%      | 826.7        | 594.8               | 978.2                 |       |
| Surgical time (minutes) | |            |              |                     |                       | <0.05 |
| Time≤45           | 1028    | 39.4%      | 591.9        | 541.9               | 649.3                 |       |
| 45<Time≤90        | 1175    | 45.1%      | 665.9        | 601.6               | 809.6                 |       |
| Time>90           | 403     | 15.5%      | 897.4        | 724.2               | 1106.9                |       |
| Length of stay (days) | |            |              |                     |                       | <0.01 |
| Los≤5             | 1412    | 54.2%      | 604.0        | 550.2               | 670.2                 |       |
| 5<Los≤10          | 1040    | 39.9%      | 694.3        | 615.6               | 879.1                 |       |
Note: region, sex, age, surgical method, surgical time and length of stay were coded as follows:
For region: south = 1 and north = 2. For sex: males = 1 and females = 2. For age: ≤ 18 = 1, 18 < age ≤ 45 = 2, 45 < age ≤ 65 = 3 and age > 65 = 4. For surgical method: laparoscope = 0 and open = 1. For surgical time: ≤ 45 mins = 1, 45 < mins ≤ 90 = 2 and > 90 mins = 3. For length of stay: Los ≤ 5 =1, 5 < Los ≤ 10 = 2, Los > 10 = 3.

Factors correlated with hospitalization costs

A correlation analysis was conducted to find the intercorrelations among the study variables. The results of Spearman's rank correlations are shown in Table 2. In particular, the hospitalization costs correlated significantly and positively with LOS (rs = 0.497, p < 0.01), age (rs = 0.359, p < 0.01), surgical method (rs = 0.258, p < 0.01), surgical time (rs = 0.549, p < 0.01), postoperative bed stay (rs = 0.305, p < 0.01), preoperative bed stay (rs = 0.055, p < 0.01), and surgical costs (rs = 0.345, p < 0.01). The hospitalization costs negatively correlated with gender. The surgical method also negatively correlated with both LOS (rs = -0.055, p < 0.01) and age (rs = -0.226, p < 0.01). The LOS also correlated with age (rs = 0.412, p < 0.01), surgical time (rs = 0.427, p < 0.01), postoperative bed stay (rs = 0.509, p < 0.01), preoperative bed stay (rs = 0.415, p < 0.01) and gender (rs = -0.087, p < 0.01) regardless of the hospitalization costs and surgical method.

Table 2. The correlation between variables (rs)

| Variables               | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 hospitalization costs | 1     |       |       |       |       |       |       |       |       |
| 2 Length of stay        | 0.497*| 1     |       |       |       |       |       |       |       |
| 3 Age                   | 0.359*| 0.412*| 1     |       |       |       |       |       |       |
| 4 Surgical method       | 0.258*| -0.055| -0.226*| 1     |       |       |       |       |       |
| 5 Surgical time         | 0.549*| 0.427*| 0.381**| 0.048*| 1     |       |       |       |       |
| 6 Postoperative bed stay| 0.305**| 0.509**| 0.173**| 0.009 | 0.170**| 1     |       |       |       |
| 7 Preoperative bed stay | 0.055**| 0.415**| 0.068**| -0.020| 0.046*| -0.008| 1     |       |       |
| 8 Surgical costs        | 0.345**| 0.014 | -0.208**| 0.502**| 0.009*| 0.145**| -0.032| 1     |       |
| 9 Gender                | -0.084**| -0.087**| -0.142**| 0.077**| -0.154*| -0.037| -0.008| 0.091**| 1     |

Note: rs = Spearman’s correlation coefficient. * p < 0.05, ** p < 0.01.

Testing the structural equation model (SEM)

Setting the SEM

The factors that affect the hospitalization cost of the disease are numerous and complex. Each variable can directly affect the hospitalization cost and can also affect the hospitalization cost through or as an intermediate variable. There is also an interactive relationship between the variables. Since various variables may not have a direct effect on hospitalization costs, path
analysis was used to comprehensively evaluate the factors directly affecting hospitalization costs or indirectly affecting hospitalization costs through the LOS. The total effect was obtained by adding the direct and indirect effects of exogenous variables.

**Fitting and evaluation of SEM**

We often use weighted least squares (WLS), maximum likelihood estimation (MLE), and asymptotically distribution free (ADF) for model estimation. The ADF method was used to estimate the model for the large sample size in the study. The multivariate normality distribution test was performed on the data, and the result was that the data did not conform to the multivariate normality (C.R. value > 5). Since the Bollen-Stine Bootstrap (n = 2,000) correction method proposed by Bollen and Stine in 1992 can correct the obtained fitting indexes to improve the model matching when the data do not meet the multivariate normality, we use Bollen-Stine Bootstrap (n = 2,000) method to recalculate all indicators for the results of the SEM are displayed in Table 3, which shows that each fitting index reached the goodness-of-fit indices, and the model had a good fitting effect on each variable.

| Item          | $\chi^2$/df | GFI  | AGFI | CFI  | TLI(NNFI) | IFI  | RMSEA |
|---------------|-------------|------|------|------|-----------|------|-------|
| Model value   | 1.017       | 0.976| 1    | 1    | 1         | 1    | 0.003 |
| Recommended   | $1<\chi^2$/df$<3$ | $>0.90$ | $>0.90$ | $>0.90$ | $>0.90$ | $>0.90$ | $<0.08$ |

**Analyzing the SEM results**

The SEM variables were roughly divided into three cases according to the way they affected the total hospitalization cost. The first was the direct effect, such as surgical methods, surgical costs, and LOS, and the effect of the LOS as a mediating variable on hospitalization cost was 0.282. The effects of the surgical method and costs were 0.291 and 0.220, respectively. The second was the indirect effect by affecting the LOS, such as gender, preoperative bed stay, and postoperative bed stay, and the effects were 0.069, 0.118, and 0.118, respectively. It affected the hospitalization costs directly and indirectly by the LOS, such as age and surgical time. The direct effects were 0.118 and 0.358, and the total effects were 0.151 and 0.459, respectively. Overall, the direct and total effects of the surgical time on hospitalization costs were the largest, that is, as the surgical time increased, the hospitalization cost was higher. The age and surgical time, surgical costs, postoperative bed stay, preoperative bed stay, and surgical method of the inpatients had a mutual influence relationship. Among them, age had a negative relationship with the surgical time and method and a greater relationship with the former. Gender negatively correlated with the surgical time and the relationship with the surgical method was meaningless (p > 0.05). The cost
of hospitalization with inpatients undergoing laparoscopic surgery was higher than that for inpatients undergoing open surgery, but the choice of surgical method had nothing to do with the surgical time. The inpatients’ surgical time positively correlated with the surgical costs and postoperative bed stay. The results of the estimated model are shown in Figure 1 and Table 4 and demonstrate the standardized path coefficients of the significant structural relationships among the tested variables (p < 0.05).

Table 4. Indirect and direct effects of the variables on the hospitalization costs

| Variables          | Path direction | Direct effect | Indirect effect | Total effect | P values |
|--------------------|----------------|---------------|-----------------|--------------|----------|
|                    |                | Model pathways | Path effect     | Model pathways | Path effect |         |
| Age                | Unidirection   | Age→hospitalization costs | 0.118 | Age→LOS→hospitalization costs | 0.033 | 0.151 | <0.01 |
|                    | Bidirection    | Age→surgical time | 0.423 | — | — | — | <0.01 |
|                    | Bidirection    | Age→surgical costs | -0.203 | — | — | — | <0.01 |
|                    | Bidirection    | Age→postoperative bed stay | 0.154 | — | — | — | <0.01 |
|                    | Bidirection    | Age→preoperative bed stay | 0.047 | — | — | — | <0.01 |
|                    | Bidirection    | age→surgical method | -0.226 | — | — | — | <0.01 |
| Gender             | Unidirection   | — | — | Gender→LOS→hospitalization costs | 0.069 | 0.069 | <0.05 |
|                    | Bidirection    | Gender→surgical method | -0.002 | — | — | — | 0.929 |
|                    | Bidirection    | Gender→surgical time | -0.101 | — | — | — | <0.01 |
| Surgery method     | Unidirection   | Surgery method→hospitalization costs | 0.291 | — | — | 0.291 | <0.01 |
|                    | Bidirection    | Surgical method→surgical time | 0.042 | — | — | — | 0.076 |
|                    | Bidirection    | Surgical method→surgical costs | 0.463 | — | — | — | <0.01 |
| Surgery time       | Unidirection   | Surgery time→hospitalization costs | 0.358 | — | — | 0.358 | <0.01 |
|                    | Bidirection    | Surgical time→surgical costs | 0.071 | — | — | — | <0.01 |
Figure 1 Path diagram of the structural equation model.
Discussion

Characterizing the hospitalization costs of patients with IHR is an important step in clarifying treatment-related factors, providing evidence-based evidence to key stakeholders, and rationalizing the utilization of patients' medical and health resources. This is not only the core territory of health economics, but also in line with the development trend of individualized treatment of patients with inguinal hernia. We found that the relationship between the selected study variables and hospitalization costs was significant, including age, gender, surgical method, surgical time, preoperative bed stay, postoperative bed stay, length of stay, and surgical costs. Of note, these findings are consistent with other studies\(^{[17-19,25,26]}\). However, it has not been reported how the factors affect each other and the hospitalization costs by which method.

In our study, the proportion of men with IHS far exceeds that of women, which is similar to most studies\(^{[27,28]}\). We suspect that this may be related to the pathogenesis of inguinal hernia. It is more likely for men to suffer from increased abdominal pressure as a result of lifestyle habits such as smoking and higher workloads, making them more susceptible to diseases than women\(^{[29]}\). In terms of the choice of surgical methods, only one-quarter of the patients underwent laparoscopic IHR. The vast majority of patients chose the traditional method (open IHR), and the overall minimally invasive surgical rate was low. The use of laparoscopy was related to the patients’ economic, clinical, and social factors, but we could not exclude the association with the distribution of medical and health resources in China in this study. High-quality medical resources are mainly concentrated in urban hospitals, and medical facilities and equipment are much better than county-level hospitals. Even if there is no difference in the diagnosis and treatment of diseases, people prefer to choose to urban hospitals with relatively complete medical facilities for therapy\(^{[30]}\). Although we divided the IHR into different groups, we found that the median hospitalization costs of the different groups were almost concentrated at approximately US$580--870. According to the disclosure of medical service information in the fourth quarter of 2018 in Anhui province, the cost of a single case of inguinal hernia was US$922.6, indicating that the effect of IHR cost control of county-level public hospitals was good\(^{[31]}\). Previous studies have shown that laparoscopic IHR has the advantages of less postoperative pain, faster recovery, and fewer LOS than open IHR\(^{[32,33]}\). We found that the surgical method had no statistical significance on preoperative bed stay (rs = 0.009, p > 0.05) and postoperative bed stay (rs = -0.02, p > 0.05) when we used the Spearman’s rank correlation to conduct a factor correlation study. Papachristou and Mitselou also reported similar observations\(^{[34]}\). This may be related to the medical environment and medical management characteristics of the data collection agency. The functional
positioning of county-level public hospitals is mainly to diagnose and treat common and frequently occurring diseases in China, so there is an excellent treatment technology and level for inguinal hernia. Laparoscopic surgery is not widely promoted at county-level medical institutions and the overall utilization rate is low at present, which may reduce the impact on LOS when analyzing large samples[35]. Based on the regression analysis of the structural equation model, we found that the use of laparoscopy had no effect on the length of surgery. This may have something to do with the way we processed the data, so we did not make a detailed distinction between unilateral and bilateral IHR. Laparoscopic surgery takes longer than unilateral open IHR because it takes time to establish the lung-peritoneal cavity, but not necessarily longer than bilateral hernia repair[34].

The patients’ age and gender had indirect effects on the hospitalization costs through the LOS; the indirect effects of the former were 0.033 (p < 0.01) and the latter were 0.069 (p < 0.01). We consider that the LOS will be longer and the hospitalization costs will be higher due to the higher prevalence, poorer health, longer recovery times, and greater need for medical resources in older patients. Men had lower LOS than women, which may be related to differences in physiological characteristics, disease tolerance, and prognosis of patients of different genders[36].

Surgery is not only associated with increased costs, but also with the prolonged LOS[37,38]. Our research results suggest that the LOS has a regulatory effect on the hospitalization costs of patients with IHS, indicating that the LOS plays a role in buffering the impact of various factors on the hospitalization costs. The LOS is often seen as a key indicator of medical resource consumption[39]. The longer the LOS, the more medical resources are consumed and the higher hospitalization costs. In other words, shortening the LOS is an effective way of reducing the hospitalization costs for patients with inguinal hernia. In our study, preoperative and postoperative stays were included as part of the LOS, and they also affect hospitalization costs negatively. It is suggested that unnecessary inspection items should be reduced and the hospital bed turnover rate should be accelerated to reduce the LOS while ensuring the quality of diagnosis and treatment. We recommend that hospitals consider rational use of clinical pathways and day surgery to establish standardized treatment models and procedures for inguinal hernia from a developmental perspective.

We found that the surgical time was the main factor affecting hospitalization costs (total effect = 0.459). The direct effect of surgical time on the hospitalization costs was 0.358, and the indirect effect was 0.10 through the LOS, both of which had a positive impact. This means that increased surgical time will cause a risk of prolonged LOS, which is similar to results found by Gupta et al.[18]. Furthermore, the direct effect of surgical time on hospitalization costs can be
understood as a longer operation often means that the disease is more complicated and difficult, and doctors need to invest more mental and physical effort. To embody the value of doctors' labour, the surgical costs will increase, increasing the total cost. As confirmed in this study, there was a correlation between the surgical time and the surgical costs (path coefficient = 0.071, p < 0.01). This also conforms to the pricing trends of medical services that are being reformed in China[40]. The pricing of medical services in China should highlight the value of technical services of medical personnel in the future, taking into account the resource investment of doctors in providing medical services, which should include the workload. Hospitals should also pay attention to this point while carrying out the performance compensation reform of doctors. The importance of this discovery for doctors is that they should pay more attention to the effect of surgical time and control it reasonably to effectively avoid increased resource consumption caused by unnecessary operations when performing IHR.

Surgeons not only need to be proficient in their own skills, but also constantly learn and master new technology. They must meticulously evaluate and select procedures and techniques that they are capable of mastering, which will help improve practice and operations[41]. Laparoscopic IHR is such a good example. We found that laparoscopic surgery required higher medical costs than laparotomy, which is undoubtedly related to the use of surgical equipment and patch materials (total effect = 0.291). The costs of laparoscopic surgery can be significantly reduced if minimal use of disposable instruments and avoidance of preperitoneal balloon and tacker for mesh fixation[42]. There have been many studies comparing hospitalization costs as part of prospective data collection, and the results show the risk of higher costs associated with laparoscopic surgery. However, a recent cost analysis report on laparoscopic IHR demonstrated that this method may be more cost-effective than open surgery in the long run[43]. County-level public hospitals and surgeons need to update surgical methods, such as laparoscopic IHR. It does not have a fixed cost and is usually not included in the "package pricing" transaction. Doctors can make a comprehensive comparison and use the most cost-effective choice with patients.

Although some studies have shown the role of certain factors in influencing the hospitalization cost of patients with IHS, there have been no studies using appropriate statistical models to verify the structural relationship. On this basis, we used a structural equation model to explore the specific degree of influence and interrelationship between variables to achieve a better interpretation effect.

**Limitations**

This study has some limitations. First, We did not consider the relationship between the
details on medical expenses, diagnosis costs, and other specific medical and hospitalization costs. The lack of information such as medical insurance type, disease severity, and outcome is also a drawback. The current explanation for the relationship between hospitalization costs of surgical patients and other influencing factors is still limited. Increasing the number of latent variables in the model needs to be further explored in the future. Furthermore, statistical significance does not always equal clinical relevance. It is beneficial to conduct research on the results and costs of patients with IHS at other medical institutions because it will help determine whether our results are generalisable or exceptional. Future studies should be conducted at different provincial or national levels. The multicenter, large-sample research can be used to support quality control and health policy formulations of inguinal hernia treatment.

**Conclusion**

In China, the health care coverage and access to the best clinical treatment services for patients with inguinal hernia can continue to be strengthened. The model used in this investigation of hospitalization costs of IHS patients clearly describes the influencing factors and the path of relationships between them. We must pay attention to the functioning variables and their interrelationships when explaining the hospitalization costs for patients with IHS. Doctors should consider how to control the details of surgical operations (selection of surgical methods, control of surgical time, and use of surgical materials) when performing IHR to provide maximum health and economic benefits for patients. Hospitals should focus on bed turnover efficiency to compress bed days to relieve pressure and consider rational use of clinical pathways and day surgery to control hospitalization costs. The health administrative department should consider the value of the doctor’s labour and be aware of the procedure’s actual resource consumption when formulating IHR cost standards. The purpose of this study is to provide suggestions for the gradual formation of scientific medical cost management methods and to promote county-level public hospital reform. It also provides a reference for saving health system expenses and quickly releasing the potential social benefits of patients.

**References**

[1] Murray CJ, Vos T, Lozano R et al (2013) Disability-adjusted lifeyears (DALYs) for 291 diseases and injuries in 21 regions,1990-2010: a systematic analysis for the Global Burden of Disease Study. Lancet 380(9859):2197-2223
[2] Grimes CE, Henry JA, Maraka J et al (2014) Cost-effectiveness of Surgery in Low- and Middle-income Countries: A Systematic Review. World J Surg 38:252-263
[3] Hernia Surge Group, Simons M, Smietanski M, Bonjer H, Bittner R, Miserez M, Aufenacker TJ, Chowbey P, Tran H, Sani R (2017) International guidelines for groin hernia management. Hernia 22:1-165
[4] Wessem KJ, Simons MP, Plaisier PW, Lange JF (2003) The etiology of indirect inguinal hernias: congenital and/or acquired? Hernia 7:76-9
[5] Öberg S, Andreason K, Rosenberg J (2017) Etiology of Inguinal Hernias: A Comprehensive Review. Front Surg 4:52
[6] Mock C, Cherman M, Juillard C et al (2010) Developing priorities for addressing surgical conditions globally: furthering the link between surgery and public health policy. World J Surg 34:381-385
[7] Butters M, Redecke J, Koning J (2007) Long-term results of a randomized clinical trial of Shouldice, Lichtenstein and transabdominal preperitoneal hernia repairs. Br J Surg 94:562-565
[8] Yang B, Jiang Z, Li Y et al (2015) Long-term outcome for open pre-peritoneal mesh repair of recurrent inguinal hernia. Int J Surg 19:134-136
[9] Vale L, Ludbrook A, Grant A (2003) Assessing the costs and consequences of laparoscopic vs. open methods of groin hernia repair: a systematic review. Surg Endosc 17:844-849
[10] Beard JH, Oresanya LB, Dicker RA et al (2013) Characterizing the Global Burden of Surgical Disease: A Method to Estimate Inguinal Hernia Epidemiology in Ghana. World J Surg 37:498-503
[11] Han SR, Kim HJ, Kim NH (2019) Inguinal hernia surgery in Korea: nationwide data from 2007-2015. Ann Surg Treat Res 97(1):41-47
[12] Rutkow IM (2003) Demographic and socioeconomic aspects of hernia repair in the United States in 2003. Surg Clin North Am 83(5):1045-51
[13] Nguyen MT, Berger RL, Hicks SC et al (2014) Comparison of outcomes of synthetic mesh vs suture repair of elective primary ventral herniorrhaphy: a systematic review and meta-analysis. JAMA Surg 149(5):415-421
[14] Tang J (2017) Prospect of hernia and abdominal wall surgery in the country. Chin J Surg 55(1):15-19
[15] GBD 2015 Healthcare Access and Quality Collaborators (2017) Healthcare Access and Quality Index based on mortality from causes amenable to personal health care in 195 countries and territories, 1990-2015: a novel analysis from the Global Burden of Disease Study 2015. Lancet 90(10091): 231-266
[16] Han F (2012) Analysis of influencing factors of hospitalization cost of inguinal hernia single disease. Chinese Journal of Health Statistics 29(2):264-266
[17] Yuan J (2014) Research on cost control of inguinal hernia disease. Modern Hospital 14(9):120-122
[18] Gupta A, Cadwell JB, Merchant AM (2020). Social determinants of health and outcomes of ventral hernia repair in a safety-net hospital setting. Hernia. https://doi.org/10.1007/s10029-020-02203-9
[19] Ielpo B, Nunez-Alfonsel J, Duran H, Diaz E, Fabra I, Caruso R et al (2018) Cost-effectiveness of Randomized Study of Laparoscopic Versus Open Bilateral Inguinal Hernia Repair. Ann Surg 268(5):725-730
[20] Liu X, Mao YH, He XM, Zhang YJ, Sun Y (2017) Analysis on Inpatient Health Expenditures
of Renal Cell Carcinoma in a Grade-A Tertiary Hospital in Beijing. Chin Med J 130:2447-52
[21] Wang C, Li N, Wang H, Yin H, Zhao Y(2018) Study on essential drug use status and its influencing factors among cerebral infarction inpatients in county level hospitals of Anhui Province, China. PLOS ONE 13(4):e0193513
[22] Li NN, Wang CH, Ni H, Wang H (2017) Efficiency and Productivity of County-level Public Hospitals Based on the Data Envelopment Analysis Model and Malmquist Index in Anhui, China. Chin Med J 130:2836-43
[23] Wang TT, Yu LH, Lang JJ, Zhang ZZ (2019) Analysis of factors influencing the hospitalization costs of lung cancer patients with surgery based on structural equation model. Chinese Health Economics 38(6): 61-63
[24] Bollen KA, Stine RA (1992) Bootstrapping Goodness-of-Fit Measures in Structural Equation Models. Sociological Methods & Research 21(2):205-229
[25] Davila DG, Parikh N, Frelich MJ, Goldblatt MI (2016) The increased cost of ventral hernia recurrence: a cost analysis. Hernia 20:811-817
[26] Liang XP (2015) Analysis on the hospitalization costs for single disease of inguinal hernia. Chinese medical records 16(11):54-56
[27] Burchar J, Pedersen M, Bisgaard T, Pedersen C, Rosenberg J (2013) Nationwide Prevalence of Groin Hernia Repair. PLOS ONE 8(1):e54367
[28] Rutkow IM (2003) Demographic and socioeconomic aspects of hernia repair in the United States in 2003. Surg Clin North Am 83: 1045-51
[29] Vad MV, Frost P, Rosenberg J, Andersen JH, Svendsen SW (2017) Inguinal hernia repair among men in relation to occupational mechanical exposures and lifestyle factors: a longitudinal study. Occup Environ Med 74(11): 769-775
[30] Gu Y, Sun J, Hu S, Nicholas S, Wang J (2019) hospitalization Costs and Financial Burden on Families with Children with Depression: A Cross-Section Study in Shandong Province, China. Int J Environ Res Public Health 20;16(19):3526
[31] Medical service information disclosure in the fourth quarter of 2018. Anhui Provincial Health Commission. http://www.xcsyy.com/article.asp?id=3003. Accessed June, 2020
[32] Wellwood J, Sculpher MJ, Stoker D, Nicholls GJ, Geddes C, Whitehead A, Singh R, Spiegelhalter D (1998) Randomised con-trolled trial of laparoscopic versus open mesh repair for inguinal hernia: outcome and cost. BMJ 317:103-110
[33] Neumayer L, Giobbie-Hurder A, Jonasson O, Fitzgibbons R Jr, Dunlop D, Gibbs J, Reda D, Henderson W (2004) Open mesh versus laparoscopic mesh repair of inguinal hernia. N Engl J Med 350:1819-1827
[34] Papachristou EA, Mitselou MF, Finokaliotis ND (2002) Surgical outcome and hospital cost analyzes of laparoscopic and open tension-free hernia repair. Hernia 6:68-72
[35] Yang F, Yu B, Du K, Wang T (2013) Research on clinical path and change of medical expenses of inguinal hernia in county hospitals before and after case-based reimbursement reform. Medicine and Society 26(1): 8-10
[36] Li J, Yu B (2007) A review of studies on the economic burden of disease. Chinese Health Economics 26(11): 72-74
[37] Karthikesalingam A, Markar SR, Holt PJ, Praseedom RK (2010) Meta-analysis of randomized controlled trials comparing laparoscopic with open mesh repair of recurrent inguinal hernia. Br J Surg 97(1):4-11
[38] Coronini-Cronberg S, Appleby J, Thompson J (2013) Application of patient-reported outcome measures (PROMs) data to estimate cost-effectiveness of hernia surgery in England. J R Soc Med 106(7):278-287

[39] Jia Q, Cui Z, Li C, Li P, Ma J (2013) Application of structural equation model in influencing factors analysis of hospitalization cost of patients with liver cirrhosis in medical insurance. Chinese Chronic Disease Prevention and Control 21(3): 274-276

[40] Suggestions on implementing the comprehensive Reform of county-level public Hospitals. State Council. http://www.gov.cn/zhengce/content/2015-05/08/content9710.htm, Accessed May, 2020

[41] Spencer Netto F, Quereshy F, Camilotti BG, Pitzul K, Kwong J, Jackson T et al (2014) Hospital costs associated with laparoscopic and open inguinal herniorrhaphy. JSLS. https://doi.org/10.4293/JSLS.2014.00217

[42] Eltair M, Hajibande S, Hajibande S et al (2019) Meta-analysis of laparoscopic groin hernia repair with or without meshfixation. International Journal of Surgery 71 :190-199

[43] Abbas AE, Ellatif MEA, Noaman N, Negm A, El-Morsy G, Amin M, Moatamed A (2012) Patient-perspective quality of life after laparoscopic and open hernia repair: a controlled randomized trial. Surg Endosc 26:2465-2470
