

Cost Analysis of Cervical Cancer Patients with Different Medical Payment Modes Based on Gamma Model within a Grade A Tertiary Hospital

Suo-Wei Wu, Tong Chen, Qi Pan, Liang-Yu Wei, Qin Wang, Jing-Chen Song, Chao Li, Ji Luo

Department of Medical Administration, Beijing Hospital, National Center of Gerontology, Beijing 100730, China

Abstract

Background: Cervical cancer shows a growing incidence and medical cost in recent years that has increased severe financial pressure on patients and medical insurance institutions. This study aimed to investigate the medical economic characteristics of cervical cancer patients with different payment modes within a Grade A tertiary hospital to provide evidence and suggestions for inpatient cost control and to verify the application of Gamma model in medical cost analysis.

Methods: The basic and cost information of cervical cancer cases within a Grade A tertiary hospital in the year 2011–2016 were collected. The Gamma model was adopted to analyze the differences in each cost item between medical insured patient and uninsured patients. Meanwhile, the marginal means of different cost items were calculated to estimate the influence of payment modes toward different medical cost items among cervical cancer patients in the study.

Results: A total of 1321 inpatients with cervical cancer between the 2011 and 2016 were collected through the medical records system. Of the 1321 cases, 65.9% accounted for medical insured patients and 34.1% were uninsured patients. The total inpatient medical expenditure of insured patients was RMB 29,509.1 Yuan and uninsured patients was RMB 22,114.3 Yuan, respectively. Payment modes, therapeutic options as well as the recurrence and metastasis of tumor toward the inpatient medical expenditures between the two groups were statistically significant. To the specifics, drug costs accounted for 37.7% and 33.8% of the total, surgery costs accounted for 21.5% and 25.5%, treatment costs accounted for 18.7% and 16.4%, whereas the costs of imaging and laboratory examinations accounted for 16.4% and 15.2% for the insured patient and uninsured patients, respectively. As the effects of covariates were controlled, the total hospitalization costs, drug costs, treatment costs as well as imaging and laboratory examination costs showed statistical significance. The total hospitalization costs, drug costs, treatment costs as well as imaging and laboratory examination costs of insured patient were 1.33, 1.42, 1.52, and 1.44 times of uninsured patients.

Conclusions: The analysis of different payment modes toward the medical economic characteristics based on Gamma model is basically rational. Medical payment modes are having certain influence toward the hospitalization expenses of cervical cancer patients in an extent, as drug costs, treatment costs, and examination costs appear to be the main causes.

Key words: Cervical Cancer; Cost Analysis; Medical Insurance; Medical Management

INTRODUCTION

As one of the most commonly seen gynecologic malignant tumors, cervical cancer is showing a growing tendency of incidence and medical cost in recent years.^[1] The treatment of cervical cancer is mainly based on surgeries combined with radiotherapy and chemotherapy that usually takes a long period of time, and the costs of therapies are growing year on year. As one of the medical insurance coverage disease types, its long therapeutic cycle and high treatment costs are bringing severe financial pressures to the patients and

medical insurance institutions that have gradually arouse the attention of health administrative departments. The

Address for correspondence: Dr. Qi Pan,

Department of Medical Administration, Beijing Hospital, National Center of Gerontology, Beijing 100730, China
E-Mail: panqi2922@bjhmoh.cn

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reasonable cost control of inpatient medical expenditures for cervical cancer is crucial in easing the economic burden of patients and medical insurance reimbursements.^[2] Extensive studies showed that among varied factors that affect the hospitalization expenses, payment modes can be counted as one of the most important aspects since medical insurances may compensate a great proportion of medical costs that are likely to increase the possibility of overtreatment despite the fact in reducing the financial burden of patients.^[3]

As a type of sophisticated statistical model, gamma distribution has been widely applied in cost analysis in recent years due to its universal characteristics in the research of health economics.^[4] It is believed that logarithmic linked Gamma model is more suitable for cost analysis since the estimated values are closer to the actual value in compare with multiple linear regression method according to relevant researches. In view of the skewed distribution of the cost, the Gamma model is able to process the data with log linked gamma distribution to ensure the integrity of original information and avoid conversion bias.^[5] However, extensive studies of medical cost analysis using Gamma model are still rare. This paper chose the inpatient cervical cancer cases within a Grade A tertiary hospital of the year 2011–2016 as research samples to verify the application of Gamma model in medical cost analyses. Furthermore, it is hoped that the study of different medical payment modes toward hospitalization expenses can provide solid basis and rational suggestions of cost control for hospitals as well as health administrative and medical insurance departments.

METHODS

Acquisition and reduction of data and materials

The data and information of patients whose main diagnoses are labeled as cervical cancer from January 1, 2011, to December 31, 2016, within a Grade A tertiary hospital of Beijing were collected through the medical record management system. The data and materials collected included the general situation of the patients (such as age, gender, operations, payment modes, length of hospital stays, admission conditions, treatments, and follow-up situations) and medical costs information including total costs, bed charges, drug costs, treatment costs, examination costs, and other costs.^[6] In regards of eliminating the impact of price fluctuation toward the study to realize the comparability of time span,^[7] the costs of hospitalization were adjusted according to consumer price index in the “China statistical

yearbook – Category of health” of the year 2011–2016, with 2016 as the base year [Table 1].

Statistical analysis

The basic information of patients was examined through Kolmogorov-Smirnov normality test.^[8] Since age, length of hospital stay, and medical costs were not subject to normal distribution, median numbers were adopted in the description, while percentages were adopted to indicate the constitution of each cost item toward the total, and a relative number was used in describing categorical variables.^[9] Meanwhile, Chi-square test was used to analyze the difference between the basic information of medical insured and uninsured patients. Setting each medical cost item as dependent variables and set age, marriage status, payment modes, therapeutic options, surgical treatments, pathological type, lymphatic metastasis, as well as distant metastasis and recurrence of the patients as independent variables to construct the logarithmic linked Gamma model.^[10] Analyze the variance of inpatient medical expenditures of patients with and without medical insurance as well as the influencing factors of hospitalization expenses. Meanwhile, marginal costs of medical insured patients and uninsured patients were estimated in the study.^[11] All the data and material collected were entered into Excel 2010 software for Microsoft (Microsoft Corporation, Washington, USA), and statistical analyses were performed using SPSS software version 21.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

General situations

A total of 1321 cases of cervical cancer were enrolled in this study, among which 65.9% were medical insured patients and 34.1% were uninsured patients. The median length of hospital stay was 10.5 days and the median age of the enrolled cases was 49.3 years, and 79.9% of patients were performed with surgeries. The general situations of medical insured patients and uninsured patients were shown in Table 2, in which the marital status and treatment options were statistically significant, while other factors showed no significant difference between the two groups.

Inpatient medical expenditure of insured and uninsured patients

In the study, the inpatient medical expenditures of medical insured and uninsured patients were RMB

Table 1: Adjustment of medical cost according to CPI of 2011–2016

Years	CPI	Medical costs before the adjustment	Medical costs after the adjustment
2016	1.020	Y1	$Y1' = Y1$
2015	1.013	Y2	$Y2' = Y2 \times 1.020$
2014	1.013	Y3	$Y3' = Y3 \times 1.020 \times 1.013$
2013	1.020	Y4	$Y4' = Y4 \times 1.020 \times 1.013 \times 1.013$
2012	1.034	Y5	$Y5' = Y5 \times 1.020 \times 1.013 \times 1.013 \times 1.020$
2011	1.032	Y6	$Y6' = Y6 \times 1.020 \times 1.013 \times 1.013 \times 1.020 \times 1.034$

CPI: Consumer price index.

29,509.1 Yuan and RMB 22,114.3 Yuan, respectively. Of the specifics, drug costs, surgery costs as well as treatment costs were the top three cost categories, with drug costs accounted for 37.7% and 33.8% of the total costs, surgery costs accounted for 21.5%

and 25.5%, treatment costs accounted for 18.7% and 16.4%, whereas the costs of imaging and laboratory examinations accounted for 16.4% and 15.2% among insured and uninsured patients, respectively, as shown in Table 3.

Table 2: Basic information of medical insured and uninsured patients (n (%))

Variables	Insured patients (n = 871)	Uninsured patients (n = 450)	χ^2	P
Age				
≤20 years	25 (2.8)	16 (3.6)	4.002	0.258
21–30 years	51 (5.8)	35 (7.7)		
31–40 years	121 (13.9)	68 (15.1)		
41–50 years	321 (36.9)	178 (39.6)		
51–60 years	221 (25.4)	109 (24.2)		
≥61 years	132 (15.2)	44 (9.8)		
Hospital stay				
1–10 days	350 (40.2)	213 (47.3)	6.852	0.079
11–20 days	273 (31.3)	133 (29.6)		
21–30 days	131 (15.1)	74 (16.4)		
≥30 days	117 (13.4)	30 (6.7)		
Marriage status				
Married	795 (91.3)	427 (94.9)	5.118	0.037
Unmarried	76 (8.7)	23 (5.1)		
Surgical treatments				
Yes	717 (82.3)	339 (75.3)	1.721	0.203
No	154 (17.7)	111 (24.7)		
Therapeutic options				
Surgery	144 (16.5)	106 (23.6)	11.975	0.029
Surgery in combine with chemotherapy or radiotherapy	395 (45.4)	189 (42)		
Surgery in combine with chemotherapy and radiotherapy	122 (14)	46 (10.2)		
Chemotherapy or radiotherapy	113 (13)	54 (12)		
Chemotherapy and radiotherapy	54 (6.2)	26 (5.8)		
Others	43 (4.9)	29 (6.4)		
Pathological type				
Squamous cell carcinoma	707 (81.2)	370 (82.2)	4.014	0.249
Adenocarcinoma	109 (12.5)	53 (11.8)		
Adenosquamous carcinoma	37 (4.2)	17 (3.8)		
Others	18 (2.1)	10 (2.2)		
Lymphatic metastasis				
Yes	448 (51.4)	264 (58.7)	2.513	0.121
No	423 (48.6)	186 (41.3)		
Distant metastasis and recurrence				
Yes	285 (32.7)	169 (37.6)	0.101	0.746
No	586 (67.3)	281 (62.4)		

Table 3: Hospitalization expenses and constitutions of medical insured and uninsured patients

Cost items	Insured patients		Uninsured patients	
	Median value (RMB Yuan)	Proportion (%)	Median value (RMB Yuan)	Proportion (%)
Treatment costs	5518.1	18.7	3626.7	16.4
Drug costs	9649.5	32.7	6811.2	30.8
Imaging and laboratory examination costs	4839.5	16.4	3361.4	15.2
Surgery costs	6344.5	21.5	5639.1	25.5
Other costs	324.6	1.1	398.1	1.8
Bed charges	1298.4	4.4	906.7	4.1
Nursing costs	1534.5	5.2	1371.1	6.2
Total costs	29,509.1	100	22,114.3	100

Influence of payment modes toward inpatient medical expenditures of cervical cancer patients

The results of Gamma analysis between different payment modes toward the inpatient medical expenditures of cervical cancer were shown in Table 4; as payment modes, therapeutic options as well as the recurrence and metastasis of tumor were counted as statistically significant. Further analyses on medical costs of the insured and uninsured inpatient costs as we regulated the covariates were shown in Table 5, while total costs, drug costs, treatment costs as well as examination costs were significantly different between medical insured and uninsured patients, as the total hospitalization costs, drug costs, treatment costs, and examination costs of insured inpatient were 1.33, 1.42, 1.52, and 1.44 times of uninsured patients, respectively.

Table 4: Multivariate analysis of the influencing factors of hospitalization expenses in cervical cancer patients using Gamma model

Variables	χ^2	P
Age	0.501	0.793
Marriage status	2.823	0.402
Payment modes	8.719	0.029
Therapeutic options	89.725	<0.001
Surgical treatments	0.251	0.596
Pathological types	5.107	0.163
Lymphatic metastasis	0.897	0.314
Distant metastasis and recurrence	12.998	<0.001

DISCUSSION

Influence of payment modes toward total inpatient medical expenditures among cervical cancer patients

As is widely known, payment modes have significant influence toward medical expenditures in clinical. According to the study, marital status and treatment options were statistically significant in inpatient medical expenditures between medical insured patient and uninsured patients.^[12] Notably, marital status is somehow related to the medical insurance type among some patients and that medical insurance status may influence patients' choices on treatment options.^[13] Thus, to exclude the influence of covariates, Gamma model was adopted to control the other covariates in further analyses, and results showed that the hospitalization expenses among cervical cancer patients with medical insurance were significantly higher than those without, this is in accordance with other domestic and foreign researches.^[14] Here are several possible reasons: first, the proportion of uninsured patients in China is still quite large since the medical insurance coverage is not complete, which may place limits to their medical behavior in a certain degree when seeking medical treatments.^[15] Second, according to relevant studies, different medical payment modes are having certain stimulations and inducements toward doctors in their therapeutic behaviors. This may largely attribute to the self-financing reality of Chinese hospitals since health-care funds in China are seriously insufficient, and that some medical service providers are inclined to provide excessive treatments due to economic-induced demands

Table 5: The results of Gamma analysis on different cost items of medical insured and uninsured patients

Variables	Payment modes	Marginal mean value (RMB Yuan)	χ^2	P
Treatment costs	Insured	9380.3	12.006	0.019
	Uninsured	7514.9		
	Average deviation	1865.4		
Drug costs	Insured	4545.0	4.832	0.031
	Uninsured	3925.1		
	Average deviation	619.9		
Imaging and laboratory examinations costs	Insured	8275.5	9.107	0.028
	Uninsured	7047.6		
	Average deviation	1227.9		
Surgery costs	Insured	8247.9	5.284	0.113
	Uninsured	8118.4		
	Average deviation	129.5		
Other costs	Insured	451.2	2.215	0.136
	Uninsured	402.3		
	Average deviation	48.9		
Bed charges	Insured	1752.8	5.791	0.119
	Uninsured	1500.8		
	Average deviation	252.0		
Nursing costs	Insured	2148.3	2.897	0.139
	Uninsured	2002.8		
	Average deviation	145.5		
Total costs	Insured	20,656.4	9.198	0.003
	Uninsured	17,980.0		
	Average deviation	2676.14		

since it is directly related to the profit of the hospitals and the income of medical staffs.^[16] Last but not least, the diagnosis of cervical cancer was selected as the trial item in the first diagnosis-related groups' prospective payment system categories in China, which might result to excessive medical services among patients with health-care insurance.^[17]

Influence of therapeutic options as well as recurrence and metastasis of tumor toward total inpatient medical expenditures among cervical cancer patients

According to Gamma model analysis, the results of therapeutic options as well as the recurrence and metastasis of tumor toward the inpatient medical expenditures of cervical cancer were statistically significant. In regard to the characteristics of cervical cancer, it was explicable that the medical costs of different therapeutic options vary significantly since a great amount of adjunctive therapies and maintenance therapy (such as chemotherapies, radiotherapy as well as immunotherapies) might be involved in the treatment. While the recurrence and metastasis of tumor reflect the severity of disease, the status of patients, and the difficulty in further treatment, it is obvious that the variance in the indicator has significant differences toward the overall medical costs among cervical cancer patients.

Influence of payment modes toward different medical cost items among cervical cancer patients

In the research, Gamma model was also applied in analyzing the average medical expenses toward different cost items in the control of other covariates. Moreover, results showed that drug costs, treatment costs, and examination costs of medical insured patients are 1.42, 1.52, and 1.44 times of uninsured patients. On the contrary, since other costs items (such as surgery costs, bed charges as well as nursing costs) are nonnegligible and irreplaceable for the treatment, no significant difference between medical insured and uninsured patients was shown in the study. Furthermore, it is believed that the differences in drug costs will gradually be narrowed between medical insured and uninsured patients, and the gaps of other cost items will be relatively expanded with the implementation of health-care reform policies when the profits of drug makeups were cancelled, and the usage of unnecessary drugs was further cut down by the hospital.^[18]

Application of Gamma model in medical cost analysis

The statistical methods that most frequently used in medical cost analysis including multiple linear models, logistic regression as well as various multivariate statistical analyses.^[19] As for the cost analyses of nonnormal distributions, the most commonly used method is the construction of the multiple linear model by the logarithm transformation of the original data. However, the application of the method calls for strict conditions, and the intercept estimation bias may exist in the predictive values of exponentiation cost estimations.^[20] Logistic regression does not require normal distribution and homogeneity of variance, but the integrity of data information was reduced through the classification of the continuous cost data.^[21] In comparison,

the Gamma model processes the data with the log linked gamma distribution with regard to the skewed distribution characteristics of the cost data, ensures the integrity of the original data information, and avoids the conversion bias.^[22] The results of similar studies show that the Gamma model is more suitable for a medical cost analysis by comparing the results of multiple linear regressions and the logarithmic link Gamma model since the estimated average cost values through Gamma model are closer to the actual value.^[23] Thus, the analysis of medical expenditures based on Gamma model could be applied to other similar single diseases such as uterine benign diseases, normal deliveries, and other common diagnoses of gynecology.

Since the study was based on a single-centered hospital, considering the differences in economic level, medical insurance policies as well as epidemiology of the disease, the generalization of the results should be more careful in other regions and circumstances.

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Conflicts of interest

There are no conflicts of interest.

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基于Gamma模型不同支付方式宫颈癌患者的单中心费用研究

摘要

背景：宫颈癌作为一种最常见的妇科恶性肿瘤，近年来发病率不断攀升。其日益增加的医疗费用给患者和医保机构带来了重大经济压力。本研究旨在通过对某三级甲等医院不同支付方式的宫颈癌患者医疗经济学特性进行研究，以此对医疗机构就单病种费用管控提出政策建议，同时验证Gamma模型在医疗费用研究中的应用。

方法：收集某三甲医院2011–2016年间宫颈癌患者的基本信息及费用信息。应用Gamma模型对不同支付方式患者的医疗费用项目差异进行分析。此外，研究还通过边缘均数计算不同支付方式对于宫颈癌患者不同费用项目类别的影响。

结果：研究通过医疗病案系统共收集2011–2016年1321例宫颈癌患者的基本信息。1321例患者中，65.9%为医保患者，34.1%为非医保患者。医保患者的平均医疗支出为29,509.1元，非医保患者平均医疗支出为22,114.3元。支付方式，治疗方法的选择以及肿瘤的复发和转移情况对于两组患者的医疗费用具有显著性影响。在具体费用类别方面，医保和非医保患者的药品费用分别占总体住院费用的37.7%和33.8%，手术费用分别占总体的21.5%和25.5%，治疗费用分别占18.7%和16.4%，影像检查费用分别占总体的16.4%和15.2%。两组患者在控制协变量后，总体住院费用，药品费用，治疗费用及影像检查费用呈现出显著性差异。医保患者的总体住院费用，药品费用，治疗费用及影像检查费用分别是非医保患者的1.33, 1.42, 1.52和1.44倍。

结论：基于Gamma模型对不同支付方式的单病种患者医疗经济学特性进行分析具有可行性。不同的医疗支付模式对于宫颈癌患者住院费用具有一定影响，根据本研究结果，药品费用，治疗费用及影像检查费用是造成费用差异的主要因素。