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Hospitalization costs of oral cancer patients in Southeast of China: a quantile regression analysis

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Abstract

Background Scant research has systematically examined the hospitalization costs of oral cancer patients in China. Therefore, this study aims to systematically analyze the hospitalization costs and identify the factors influencing these costs among oral cancer inpatients.

Methods Basic information and cost data for oral cancer patients who were admitted to the hospital for the first time between July 2015 and May 2022 were collected from one grade-A tertiary hospital in Fuzhou city of Southeastern China. Quantile regression (QR) model was used to evaluate the relationship between oral cancer patients and hospitalization costs.

Results A total of 1114 patients with oral cancer were included in this study. The median (interquartile range (IQR)) of total hospitalization costs was ¥42.73 (¥22.92–¥71.41) thousand. Overall, the distribution of total hospitalization costs (discounted in accordance with the Consumer Price Index) was flat during the study period ($P = 0.437$). According to the QR results, oral cancer patients' hospitalization costs were considerably affected by TNM stage, surgery, adjuvant therapy, length of stay (LOS) and tumor location. Among the above influencing factors, the highest ranking of importance was surgery, followed by TNM staging, LOS and tumor location.

Conclusions This study analyzed the hospitalization costs of oral cancer patients using a large sample of data for consecutive 8 years. Study results suggests that TNM stage, surgery, adjuvant therapy, LOS and tumor location were significant factors influencing hospitalization costs. Policymakers may use these findings to develop cost-control strategies for surgical interventions or advanced-stage treatments.

Keywords Oral cancer, Hospitalization costs, Quantile regression, Random forest

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Introduction

Oral cancer is the most common malignancy of the head and neck. According to GLOBOCAN 2022, an estimated 0.39 million new cases of oral cancer were diagnosed globally, resulting in approximately 0.19 million deaths, among them, in China, there were an estimated 0.04 million new cases and 0.02 million deaths attributable to oral cancer [1]. Oral cancer patients are usually treated with complex surgery, with additional adjuvant treatment providing for patients in advanced stages [2]. The medical costs associated with oral cancer treatment present a considerable financial burden to patients, families, and healthcare systems. Therefore, it is particularly important to understand medical costs among hospitalized patients with oral cancer.

From 2009 to 2019, the new medical reform in China has been implemented for ten years, and a medical insurance system with near-universal coverage has been basically established [3]. Since 2013, the coverage rate of basic medical insurance has consistently remained above 95% [3]. However, as medical insurance coverage has expanded, the increased access to treatment for patients has led to higher costs associated with diagnosis and treatment. Describing costs of disease could give a full picture of the importance of the health issues, helping policymakers not only to prioritize health care, prevention, and treatment policies, but also assess the effectiveness of policies in the health sector. In view of this, many researches obtained hospitalization costs from the healthcare system or hospital medical records for oral cancer patients and systematically characterized and analyzed the factors influencing these hospitalization costs [4–8]. However, in China, scant research has been conducted focusing on the hospitalization costs of oral cancer patients.

Generally, hospitalization costs data exhibit skewness and contain a large number of discrete values. Quantile regression (QR) is less affected by outliers and provides more robust analytical results [9]. Additionally, QR can examine the cost predictors corresponding to the quantile of interest, presenting an excellent choice to guide targeted cost-benefit policies [10, 11]. However, as far as we know, few scholars used QR model to investigate the influencing factors of hospitalization costs for oral cancer patients.

Therefore, we used QR model to conduct a comprehensive analysis of various factors affecting on the hospitalization costs of oral cancer for 8 consecutive years in a tertiary comprehensive hospital in Fuzhou city of Southeastern China. Our findings are expected to identify significant factors related to hospitalization costs, so as to serve as basis for controlling and reducing the economic burden of oral cancer patients.

Method

Data source and study population

We reviewed and collected data from medical records of hospitalized patients who were admitted during July 2015 and May 2022 in a Grade-A hospital in Fuzhou city of Southeastern China. Basic information (age, gender, education levels, clinical classification, tumor site, TNM stage, the year of admission, method of payment and therapeutic regimen) and details of various hospitalization costs were collected. Hospitalization cost was defined as the total costs of hospital stay, which include out-of-pocket costs. Cases with incomplete information, errors, and non-substantive diagnosis and treatment were manually eliminated. According to the International Classification of Diseases 10th Revision (ICD-10), primary oral cancer was diagnosed based on the following ICD codes [12]: C00 lip, C01 base of tongue, C02 other and unspecified parts of tongue and, C03 gum, C04 floor of mouth, C05 hard palate and C06 buccal mucosa.

Outcome variables

Total hospitalization cost was calculated by summing all the following costs: general medical service costs, diagnostic costs, treatment costs, medicine costs, blood and blood product costs, consumables costs and other costs (including rehabilitation therapy costs, traditional Chinese medicine treatment cost and other costs). Hospitalization cost was defined as the total direct medical costs incurred during the hospital stay and does not include indirect costs such as lost productivity or caregiver expenses.

In order to produce a reliable analysis, before performing hospitalization costs analysis, we discounted the hospitalization costs from 2015 to 2022 in line with the Consumer Price Index (CPI), taking 2015 as the benchmark year. CPI data were sourced from the National Bureau of Statistics of China [13]. The CPI from 2015 to 2022 is shown in Table 2, with CPI = 100 in 1978 as reference.

Statistical analysis

Total hospitalization cost was in skewed distribution (Fig. 1A, $P < 0.001$), and therefore was described by median with interquartile range (IQR). Mann-Whitney test or Kruskal-Wallis test was used to examine significant differences among different groups.

The Ordinary Least Squared (OLS) approach concentrates solely on conditional mean. While, the analysis results will vary greatly, if there are a large number of discrete data. QR models, which can examine the cost predictors corresponding to the quantile of interest, which can obtain more comprehensive and robust analysis results [14]. In this study, QR model was used to explore the influencing factors of hospitalization

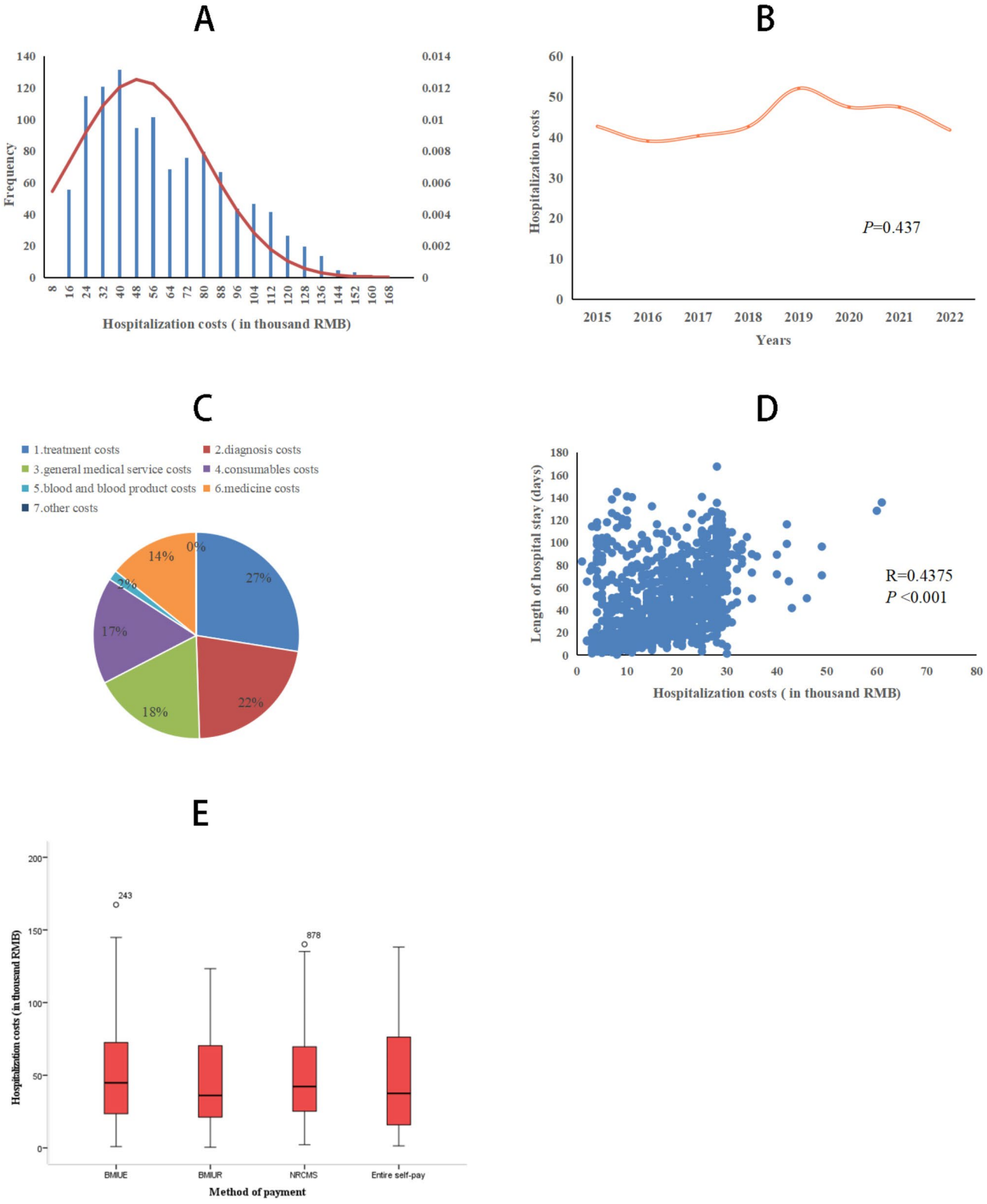

Fig. 1 **A** Distribution of hospitalization costs for oral cancer patients; **B** Trends of hospitalization costs of oral cancer patients; **C** Composition of hospitalization costs of oral cancer patients; **D** The Scatter Chart of hospitalization costs and length of stay; **E** The Box plot of different payment methods for hospitalization costs (BMIUE: Basic Medical Insurance for Urban Employee; BMIUR: Basic Medical Insurance for Urban Residents; NRCMS: New Rural Cooperative Medical Scheme)

costs at the 10th, 25th, 50th, 75th, and 90th percentiles. The coefficient at the lower percentile reflects the association between influencing factors and medical costs for patients with lower hospitalization costs, while the coefficient of the higher percentile reflects the association between influencing factors and medical costs for those with higher hospitalization costs. The importance ranking of independent variables on the degree of impact of hospitalization costs were obtained by and random forest regression tree model.

All statistical analyses were conducted using R software (version 4.3.1). Two-sided statistical tests with $P < 0.05$ were considered statistically significant.

Results

Table 1 displays the baseline and clinical characteristics of the study population. A total of 1114 oral cancer patients were included in this study. The average age of the oral cancer patients was 59.18 ± 13.06 years, with 64.45% of the male. Of all patients, 94.96% paid for hospitalization costs using social basic medical insurance, 88.40% received surgery and 51.74% received adjuvant therapy during hospital stay.

The results indicated that the median total hospitalization costs for oral cancer patients was considerable—the costs were ¥42.73 thousand. Changes in the hospitalization costs for patients with oral cancer from 2015 to 2022 were shown in Table 2; Fig. 1B. Generally, total hospitalization costs did not change significantly over 8 years ($P = 0.437$). In terms of the proportion of costs, a higher proportion of these were for treatment costs and diagnosis costs, accounting for almost 50% of the total costs (Fig. 1C). Meanwhile, correlation analysis showed that LOS was highly correlated with the total hospitalization costs ($R = 0.4375$, $P < 0.001$, Fig. 1D). Additionally, the hospitalization costs did not differ between the 4 payment methods (Fig. 1E).

The univariate analysis results in Table 3 showed that TNM stage, surgery, adjuvant therapy, length of stay (LOS) and tumor location had a significant impact on total hospitalization cost ($P < 0.05$).

Then, a multivariate analysis was conducted, and the following variables were included: (1) general demographic characteristics, such as gender, age, occupation, etc.; (2) variables with significant differences identified by univariate analysis, such as TNM stage, surgery and adjuvant therapy, etc.; and (3) variables potentially influential on hospitalization costs based on professional judgment or previous research findings, such as pathological grading and method of payment, etc. Table 4 described the effect sizes of each variable on different hospitalization costs segments for oral cancer inpatients. According to the QR results, higher TNM stage was significantly

Table 1 Baseline and clinical characteristics of the study population

Variables	*N* (%)
Sex	
Male	718(64.45)
Female	396(35.55)
Age (years)	
< 50	247(22.17)
50–60	278(24.96)
60–70	326(29.26)
≥ 70	263(23.61)
Occupation	
Farmer	241(21.63)
Worker	106(9.52)
Office worker and other	767(68.85)
Education level	
Illiteracy	58(5.24)
Primary-middle school	772(69.74)
High school and above	277(25.02)
BMI (kg/m^2)	
18.5–23.9	643(57.72)
< 18.5	133(11.94)
≥ 24	338(30.34)
Pathological grading	
Well	378(47.55)
Moderate-poor	417(52.45)
TNM stage	
I	146(16.80)
II	191(21.98)
III	175(20.14)
IV	357(41.08)
Surgery	
No	125(11.60)
Yes	953(88.40)
Adjuvant therapy	
No	487(48.26)
RT	232(22.99)
CT	84(8.33)
CRT	206(20.42)
Length of stay (days)	
< 12	260(23.34)
12–19	273(24.51)
19–26	292(26.21)
≥ 26	289(25.94)
Tumor location	
Tongue	382(34.51)
Gum	96(8.67)
Floor of mouth	68(6.14)
Buccal mucosa	126(11.38)
Palate	80(7.23)
Others	355(32.07)
Method of payment	
BMIUE	634(57.07)
BMIUR	126(11.34)
NRCMS	295(26.55)
Entire self-pay	56(5.04)

BMIUE Basic Medical Insurance for Urban Employee, *BMIUR* Basic Medical Insurance for Urban Residents, *NRCMS* New Rural Cooperative Medical Scheme

Table 2 Trends of hospitalization costs of oral cancer patients, in thousand RMB

Years	CPI	RMB	Total costs	General medical service*	Diagnosis*	Treatment*	Medicine*	Consumables*	Blood and blood product*	Others*
2015	615.2	100.00	42.69(27.08–71.64)	10.82(5.58–15.83)	10.53(6.96–13.51)	13.76(5.37–21.95)	11.02(4.73–17.78)	0(0–0)	0(0–0)	0.08(0.04–0.08)
2016	627.5	98.04	39.06(20.94–72.40)	7.67(3.97–11.88)	10.24(7.08–13.94)	11.09(2.99–24.19)	8.41(3.39–14.17)	0(0–2.72)	0(0–0)	0.08(0.02–0.10)
2017	637.5	96.50	40.32(23.51–70.21)	6.02(3.52–7.63)	9.62(6.36–12.41)	12.06(4.79–26.70)	6.39(3.05–9.14)	4.29(2.03–8.56)	0(0–0)	0(0–0.04)
2018	650.9	94.52	42.61(20.50–64.34)	7.40(4.30–10.92)	10.13(6.74–12.75)	10.58(4.17–24.66)	5.88(2.97–8.95)	2.90(1.12–4.97)	0(0–0)	0(0–0)
2019	669.8	91.85	52.05(35.05–83.12)	11.22(6.51–22.95)	11.92(8.95–17.05)	20.57(7.76–24.32)	6.27(4.11–8.44)	2.47(1.38–3.48)	0(0–1.57)	0(0–0)
2020	686.5	89.61	47.43(22.95–73.79)	5.88(3.22–9.71)	10.47(7.62 - 3.00)	15.36(5.55–19.86)	4.95(2.45–9.62)	6.54(1.43–19.19)	0(0–0.08)	0(0–0)
2021	692.7	88.81	47.42(21.92–71.55)	5.97(3.10–8.66)	11.58(7.30–15.41)	12.78(4.16–17.56)	5.06(1.64–7.77)	10.25(2.95–21.35)	0(0–0.08)	0(0–0)
2022	706.6	87.06	41.79(25.05–73.19)	4.93(2.16–7.89)	11.75(7.30–15.31)	9.58(4.50–17.17)	4.38(1.82–7.12)	11.64(6.32–25.90)	0(0–0.11)	0(0–0)
P	-	-	0.437	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.029	< 0.001

CPI = 100 in 1978 as reference; RMB = 100 in 2015 as reference

RMB renminbi

*Median (IQR)

Table 3 Univariate analysis of hospitalization costs, in thousand RMB

Variables	Median	P25	P75	*P* Value
Sex				0.713
Male	43.39	21.28	72.49	
Female	42.24	24.91	69.13	
Age (years)				0.437
< 50	39.92	24.46	74.84	
50–60	42.84	21.08	72.41	
60–70	45.85	24.30	70.21	
≥ 70	40.53	19.98	68.28	
Occupation				0.411
Farmer	45.38	23.51	65.18	
Worker	38.40	22.48	68.28	
Office worker and other	43.01	22.95	73.20	
Education level				0.771
Illiteracy	42.90	25.60	64.37	
Primary-middle school	42.40	22.05	71.60	
High school and above	44.36	22.93	71.10	
BMI (kg/m^2)				0.053
18.5–23.9	44.73	25.58	72.93	
< 18.5	40.58	14.09	79.30	
≥ 24	40.69	21.08	65.46	
Pathological grading				0.803
Well	52.67	31.98	75.44	
Moderate-poor	51.18	29.73	77.87	
TNM stage				< 0.001
I	28.06	18.51	39.56	
II	38.66	28.36	60.46	
III	52.71	31.39	75.22	
IV	65.00	42.30	90.42	
Surgery				< 0.001
No	49.09	28.62	74.40	
Yes	13.93	9.79	20.75	
Adjuvant therapy				< 0.001
No	36.15	19.80	62.29	
RT	58.58	32.43	82.83	
CT	36.27	16.90	63.66	
CRT	53.80	31.79	78.70	
Length of stay (days)				< 0.001
< 12	24.81	11.84	58.64	
12–19	27.84	18.03	49.09	
19–26	45.33	31.59	65.83	
≥ 26	70.13	46.11	91.94	
Tumor location				< 0.001
Tongue	42.69	27.71	75.44	
Gum	67.91	39.71	95.02	
Floor of mouth	67.85	23.41	89.86	
Buccal mucosa	57.64	38.50	68.82	
Palate	40.16	20.13	59.24	
Others	29.85	17.55	54.95	
Method of payment				0.540
BMIUE	44.76	23.54	72.93	
BMIUR	35.34	21.06	70.29	
NRCMS	42.13	24.95	70.19	
Entire self-pay	39.11	15.66	78.91	

RMB renminbi, *BMIUE* Basic Medical Insurance for Urban Employee, *BMIUR* Basic Medical Insurance for Urban Residents, *NRCMS* New Rural Cooperative Medical Scheme

associated with higher hospitalization costs, and the effect sizes increased with increasing of quartile points. Similarly, surgery was highly associated with the hospitalization cost from the 10th percentile to the 90th percentile. Hospitalization costs were higher for surgical inpatients than for non-surgical inpatients, with regression coefficients ranging from 16.16 (10th percentile) to 38.67 (90th percentile). Besides, adjuvant therapy was also significantly related to hospitalization costs. In addition to treatments, it can be seen from Fig. 2 that, LOS was correlated with hospitalization costs. Specifically, taking LOS ≥ 26 days as an example, the regression coefficients exhibited a decreasing trend as the quantile increased (from lower to higher costs), with the coefficient at the 10th percentile being 20.39 and dropping to 2.443 at the 90th percentile. This suggests that the positive effect of hospitalization duration on costs diminishes progressively as the cost level rises. The analysis results also found that the effect of tumor location (gum) on the hospitalization costs was greater at the upper quantiles than lower quantiles (coefficients 7.997 for 10th percentile; coefficients 31.30 for 90th percentile). Compared with patients in the Basic Medical Insurance for Urban Employee (BMIUE), the hospitalization costs of participants in the Basic Medical Insurance for Urban Residents (BMIUR) or New Rural Cooperative Medical Scheme (NRCMS) were lower. Specifically, for BMIUR, the coefficients were − 8.310 at the 10th percentile and − 15.70 at the 90th percentile; for NRCMS, the coefficients are − 4.777 at the 10th percentile and − 6.308 at the 25th percentile. However, there were no significant differences in hospitalization costs among oral cancer patients across different occupations and educational levels.

Due to space constraints, the text only shows the analysis results of influencing factors of total hospitalization costs, please refer to Supplementary Tables 1-3 for detailed results of subcategory costs. In general, LOS, surgery, TNM stage and tumor location had significant effects on treatment costs, diagnosis costs and general medical service costs. More specifically, surgery is highly correlated with treatment costs (regardless of which percentile levels). The distribution of general medical service costs at the higher quantiles was more impacted by surgery than at the lower quantiles. Additionally, the higher TNM stage and the longer LOS had greater impacts on treatment costs, diagnosis costs and general medical service costs.

Subsequently, the factors in QR analysis were incorporated jointly into the random forest regression tree model. The number of trees to grow (ntree) was set to 1000, and the number of variables randomly sampled as candidates at each split (mtry) was set to 3. The importance of the influencing factors was evaluated according to the mean decline accuracy (%IncMSE) and increase in

Table 4 Quantile regression analysis of total hospitalization costs in oral cancer patients

Variables	10th percentile	25th percentile	50th percentile	75th percentile	90th percentile
Age (ref = < 50; years)					
50–60	− 3.409	1.638	− 4.740	− 6.450	− 11.57*
	(3.902)	(3.273)	(3.600)	(5.508)	(6.027)
60–70	− 0.179	0.984	− 3.320	− 9.136*	− 17.25***
	(3.800)	(3.222)	(3.524)	(5.137)	(6.416)
≥ 70	− 0.0285	− 0.801	− 4.947	− 2.690	− 9.027
	(3.517)	(3.838)	(3.827)	(5.745)	(7.910)
Sex (ref = Male)					
Female	− 0.833	0.617	− 1.339	0.341	2.736
	(2.715)	(2.513)	(2.789)	(3.751)	(4.272)
Occupation (ref = Farmer)					
Worker	− 4.277	− 2.267	− 2.357	0.981	3.750
	(4.814)	(4.223)	(5.147)	(7.156)	(8.656)
Office worker and other	− 3.372	− 3.058	0.425	5.659	− 0.795
	(2.724)	(2.619)	(2.821)	(4.369)	(4.436)
Education level (ref = Illiteracy)					
Primary-middle school	− 1.163	− 3.376	− 3.049	− 1.660	6.148
	(4.017)	(3.938)	(4.392)	(5.756)	(7.303)
High school and above	− 4.225	− 3.578	− 4.489	1.863	5.752
	(4.553)	(4.174)	(5.320)	(6.674)	(8.714)
BMI (ref = 18.5–23.9; kg/m^2)					
< 18.5	− 4.504	− 0.672	9.394	5.240	6.888
	(4.872)	(5.222)	(5.801)	(5.233)	(6.814)
≥ 24	− 6.963**	− 6.200**	− 3.046	− 6.136	0.749
	(3.122)	(2.535)	(2.924)	(4.136)	(4.797)
Pathological grading (ref = Well)					
Moderate-poor	3.543	4.941**	2.839	5.237	− 0.867
	(2.629)	(2.334)	(2.725)	(3.729)	(3.947)
TNM stage (ref=I)					
II	2.793	3.797	5.680*	6.854	14.97**
	(3.138)	(2.796)	(3.283)	(5.061)	(6.029)
III	8.347**	9.695***	13.62***	23.52***	23.18***
	(3.922)	(3.323)	(4.112)	(5.503)	(6.725)
IV	11.27***	14.48***	22.70***	31.00***	32.77***
	(3.898)	(3.532)	(3.431)	(5.507)	(5.780)
Surgery (ref = No)					
Yes	16.16***	25.17***	27.46***	38.76***	38.67***
	(4.923)	(4.707)	(6.415)	(9.877)	(10.27)
Adjuvant therapy (ref = No)					
RT	6.074**	7.143***	4.355	3.864	0.459
	(2.890)	(2.570)	(3.140)	(4.447)	(4.963)
CT	− 3.064	− 0.468	8.281	9.589	9.182
	(5.656)	(7.634)	(6.166)	(8.385)	(6.395)
CRT	5.781*	9.161***	4.874	5.366	3.701
	(3.051)	(3.020)	(3.761)	(5.790)	(4.963)
Length of hospital stay (ref = < 12; days)					
12–19	6.328	− 4.106	− 1.830	− 12.57	− 14.08*
	(4.706)	(4.045)	(3.449)	(7.773)	(7.229)
19–26	12.64***	6.303*	5.875	− 9.011	− 14.32**
	(4.841)	(3.778)	(3.718)	(7.094)	(6.508)
≥ 26	20.39***	15.22***	19.38***	11.37	2.443
	(4.490)	(3.781)	(4.109)	(6.973)	(5.568)

Table 4 (continued)

Variables	10th percentile	25th percentile	50th percentile	75th percentile	90th percentile
Tumor location (ref = tongue)					
Gum	7.997	14.88***	22.46***	26.10***	31.30***
	(6.958)	(4.365)	(6.510)	(6.030)	(7.312)
Floor of mouth	4.491	10.50	12.34*	8.466	13.53
	(7.641)	(6.540)	(6.384)	(9.635)	(13.58)
Buccal mucosa	3.745	7.014*	4.619	− 3.190	− 1.812
	(4.446)	(3.815)	(3.692)	(4.933)	(6.133)
Palate	0.697	− 0.544	3.345	3.375	13.48
	(5.109)	(4.829)	(7.876)	(6.428)	(10.91)
Others	− 8.276***	− 8.196***	− 8.901**	− 6.423	− 1.605
	(3.073)	(3.116)	(3.477)	(5.169)	(5.331)
Method of payment (ref = BMIUE)					
BMIUR	− 8.310*	− 3.811	− 0.274	− 5.601	− 15.70***
	(4.583)	(4.756)	(4.083)	(3.920)	(4.990)
NRCMS	− 4.777*	− 6.308**	− 3.354	1.157	− 0.408
	(2.842)	(2.619)	(3.407)	(4.595)	(5.111)
Entire self-pay	1.172	2.419	12.61	6.501	− 0.590
	(5.452)	(7.084)	(9.189)	(9.129)	(9.858)
Constant	2.821	2.238	9.201	14.87	31.77**
	(8.340)	(9.163)	(11.16)	(16.46)	(16.12)

Standard errors in parentheses

RT radiotherapy, *CT* chemotherapy, *CRT* chemoradiotherapy, *BMIUE* Basic Medical Insurance for Urban Employee, *BMIUR* Basic Medical Insurance for Urban Residents, *NRCMS* New Rural Cooperative Medical Scheme

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

nodepurity (IncNodePurity), that is, the greater the %IncMSE or IncNodePurity, the higher the importance of the factors. The results showed that the top 4 factors affecting the hospitalization costs were surgery, TNM stage, LOS and tumor location (Fig. 3).

Discussions

Cancer caused a high economic burden of disease in China [15, 16]. This study analyzed the hospitalization costs of oral cancer patients using a large sample of data for consecutive 8 years. The results indicated the hospitalization cost of oral cancer showed a steady trend during the study period. In addition, our study also identified several important independent variables that were associated with hospitalization costs, including surgery, TNM stage, adjuvant therapy, LOS and tumor location.

As China's economy has soared, so has spending on medical health provision and public health expenditures. Data showed that China's age-standardized incidence and age-standardized death rate of cancer were higher than the global average, bringing a heavy economic burden [17]. In 2009, China launched medical and health system reform [18–20]. During this period, Fujian Province, as a pioneer of medical reform, has implemented a series of medical reform policies to control medical costs [21]. Among them, the "Sanming model" was considered as one of the most representative medical system reforms, which has effectively reduced medical costs [22–24]. The systemic reform of the "Sanming model" has effectively curbed the growth of medical costs through a variety of measures, including: (1) pharmaceutical reform by adopting the "Two-Invoice System" to reduce unnecessary intermediaries and implementing prescription behavior monitoring to prevent over treatment; (2) payment method reform through a combination of fee-for-service (FFS) and diagnosis-related groups (DRG); and (3) adjusting medical service prices to correct distorted pricing structures [24]. In view of this, the Fujian provincial government promoted the "Sanming model" across the province in 2015 [25]. A study showed that the drug costs of cancer inpatients who participated in NRCMS dropped immediately after the Fujian medical reform [26]. The present study demonstrated a flat trend in hospitalization costs for oral cancer patients over the past 8 years from 2015 to 2022, thus confirming the effectiveness of medical reform policy in Fujian Province. Therefore, other provinces in China and other countries facing similar challenges can draw valuable lessons from the Fujian healthcare reform model, especially the "Sanming model" to control the continued rise in medical expenses. Nevertheless, while controlling hospitalization costs can alleviate the economic burden on patients and healthcare systems, the impact of cost burden reduction on patient outcomes—such as access to care, adherence to

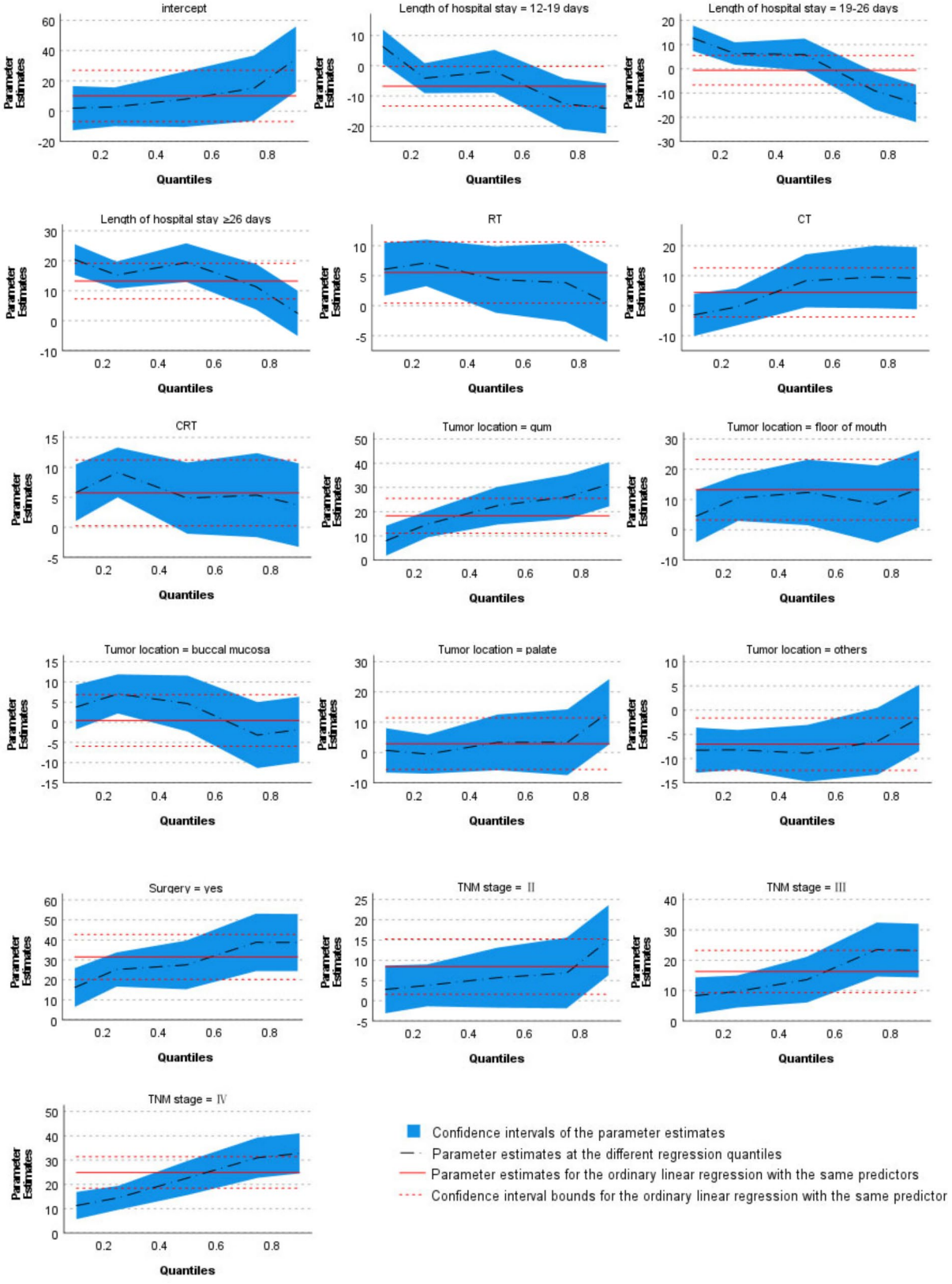

Fig. 2 Quantile regression results of the factors associated with the hospitalization costs of oral cancer patients (adjusted for sex, age, occupation, education level, BMI, pathological grading and payment method)

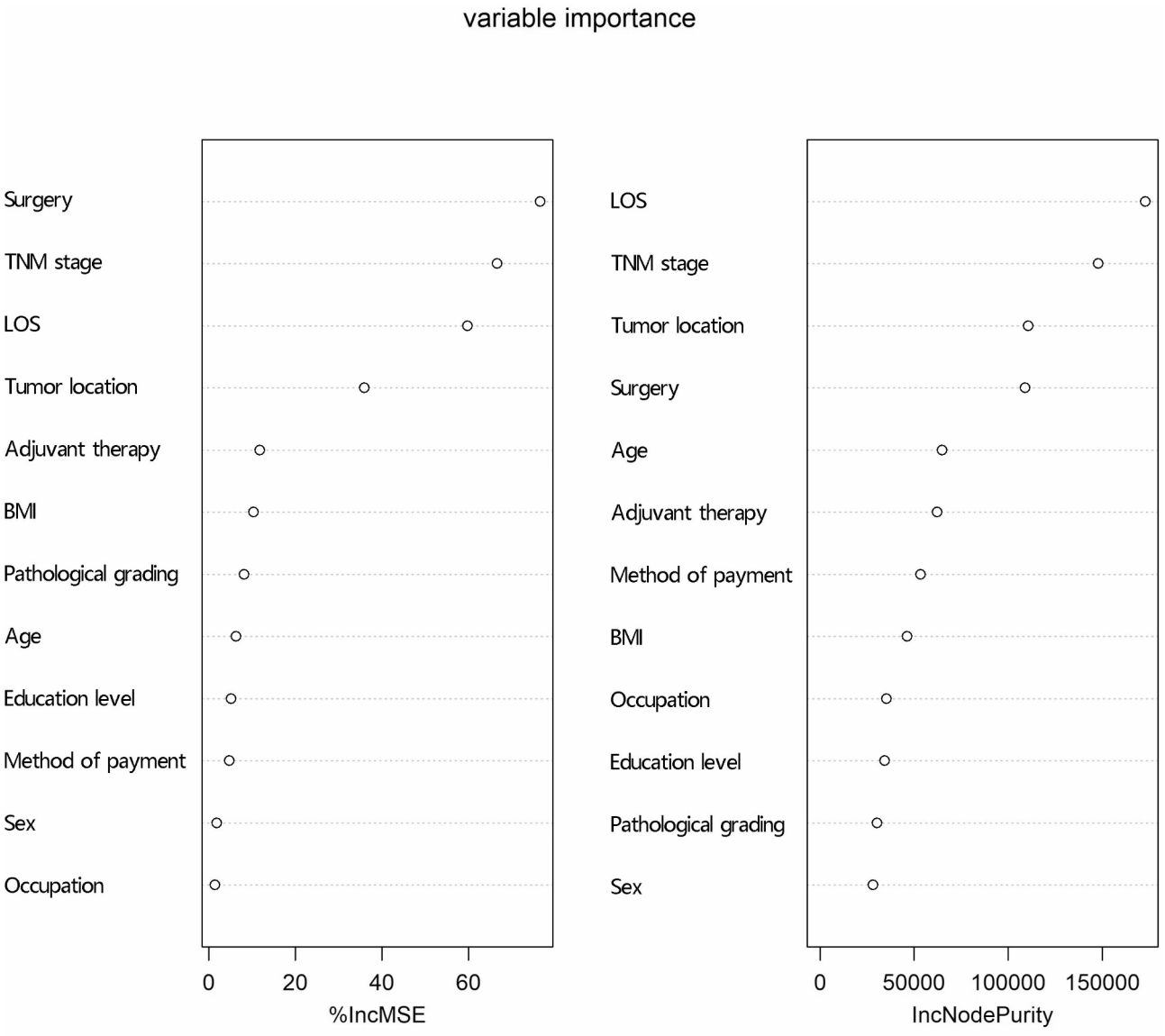

Fig. 3 Analysis on the importance of influencing factors of hospitalization costs of oral cancer

treatment, and mental well-being—remains uncertain. Further research is warranted to explore these effects comprehensively.

The present results showed that TNM stage was one of the main factors affecting the hospitalization costs of oral cancer patients. Specifically, patients at stage IV incurred substantially higher hospitalization costs compared to those at stage I (from the 10th percentile to the 90th percentile, with all *P*-values <0.01). A previous study conducted in Australia showed that hospitalization costs increase with pathological stage, and the total cost for oral cancer patients with stage IV was more than double that of patients with stage I [7]. Two Chinese data also showed that oral cancer patients with more advanced stages had a higher medical cost burden [5, 6]. Therefore, advanced patients deserve more attention, because they may experience extreme costs. Policy-making should prioritize early diagnosis programs to reduce late-stage treatment and cut down on hospitalization costs.

In addition to staging, our study found that surgery was one of the largest contributor to hospitalization costs for oral cancer patients. The hospitalization costs of surgical inpatients were higher than those of non-surgical inpatients (from the 10th percentile to the 90th percentile, with all *P*-values <0.01), which were in line with previous studies [8, 27]. Furthermore, the study also found that patients who received radiotherapy or chemoradiotherapy had higher hospitalization costs than those who did not receive adjuvant therapy. Consequently, fundamentally, the difference in hospitalization costs largely

depend on treatment procedures of patients. Hospitals are obliged to constantly optimizing surgery-related resource allocation in order to alleviate the medical burden of patients.

Generally, as the LOS increases, the consumption of health resources also increases, leading to an increase in hospitalization costs. The present study found that patient's LOS intimately influenced the hospitalization costs. Previous researches also indicated that increasing hospitalization costs were strongly associated with prolonged LOS [4, 5, 28]. The hospitalization costs were directly could be decreased by lowering the LOS, thus further reducing the LOS is still an effective method to control hospitalization costs for patients with oral cancer. Policy makers should take effective measures, such as optimize the process of diagnosis and treatment, clinical pathway management, and a two-way referral system will be implemented to prevent unnecessarily prolonged hospital stays, thereby effectively controlling healthcare costs.

The type of health insurance, to a certain extent, can reflect potential factors such as the residence of patients, their general income. Generally, BMIUE participants, benefiting from higher reimbursement rates and a more favorable socioeconomic status, tend to have more opportunities to obtain better medical resources compared with those insured by NRCMS or BMIUR. Our study reveals that the hospitalization expenses of oral cancer patients enrolled in the NRCMS or BMIUR were lower than those of patients participating in the BMIUE. Previous study also discovered that the medical expenditures of lung cancer patients who adopted NRCMS as their form of health insurance were lower than those of patients with BMIUE [29]. This finding suggests that policymakers should consider implementing appropriate adjustments to the medical insurance benefits for urban and rural residents, with the aim of enhancing the quality of their healthcare utilization and minimizing the instances where individuals abandon treatment on account of economic issues.

The distribution of hospitalization costs data was skewed by normality test, indicating that a lot of valuable information would be lost even if the costs data was adopted by multiple linear regression after taking logarithms. QR models can estimate parameter of any conditional quantile of hospitalization costs, to explore the correlations between influencing factors and costs in the entire distribution [14]. Compared to OLS regression, QR can provide strong robustness when there were outliers or dependent variable was skewed or data was heteroscedasticity. Meanwhile, QR analysis is conducive to grasping the comprehensive panorama of medical expenses for the entire population and comprehending the circumstances of lower quantiles (e.g., individuals with lower expenses) and higher quantiles (e.g., individuals with higher expenses). For example, in the process of formulating medical insurance reimbursement policies, comprehending the characteristics of high-expense individuals enables the targeted design of compensation mechanisms for high medical expenses. Therefore, QR is more suitable for the analysis of hospitalization costs, as it enables the derivation of more comprehensive and precise analytical outcomes. Take the above factors into consideration, in this study, QR method was adopted to analyze the factors influencing the hospitalization costs of patients with oral cancer.

This study identified some factors related to hospitalization costs of oral cancer patients. While, this study also had several limitations. Firstly, patients in the present study were collected from a tertiary comprehensive hospital, which has higher medical costs than other grades hospitals. Further studies involving secondary and other tertiary health care facilities are needed to validate the results. Secondly, we only examined hospitalization costs of oral cancer patients who were admitted for the first time, which may underestimate the true total cost. Patients' post-hospital health care costs should be additionally included in the future. Thirdly, indirect costs (e.g., rehabilitation costs, lost productivity) should also be taken into account in the future study, to more fully assess the economic burden of oral cancer. Finally, other variables that could potentially influence hospitalization costs, such as the type of surgery and reconstruction of patients, as well as the requirement for longer hospitalization, were not included in our study. They should be taken into consideration in future studies.

Conclusions

The hospitalization costs for oral cancer patients in southeastern China have remained relatively stable over the past several years. Besides, patients' clinical factors (TNM Stage and tumor location) and therapeutic factors (surgery, adjuvant therapy and LOS) were all significantly correlated with hospitalization costs. The findings of this study can provide scientific basis for policymakers to develop strategies for controlling and reducing hospitalization costs, such as promoting early diagnosis to reduce late-stage treatments, and investing in cost-effective surgical technologies, etc.

Abbreviations

IQR	Interquartile range
LOS	Length of stay
QR	Quantile regression
ICD- 10	International Classification of Diseases 10th Revision
CPI	Consumer Price Index
OLS	Ordinary Least Squared
BMIUE	Basic Medical Insurance for Urban Employee
BMIUR	Basic Medical Insurance for Urban Residents
NRCMS	New Rural Cooperative Medical Scheme
DRG	Diagnosis-related groups

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
B.H. contributed to the conception and design. X.B. wrote the manuscript. X.B., W.H., Y.L., F.C., F.L. and J.W. contributed to data collection and analysis. Y.Q., B.S. and L.L. reviewed the manuscript. All authors reviewed the final manuscript.

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Data availability
The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
All procedures performed in this study involving human participants were in accordance with the ethical standards of the Institutional Review Board (IRB) of Fujian Medical University (2011053). Written informed consent was obtained from all individual participants included in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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