


# BMJ Open Association between compliance with quality indicators and hospitalisation expenses in patients with heart failure: a retrospective study using quantile regression model in China

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**To cite:** Fu R, Feng S, Wu Y, *et al.* Association between compliance with quality indicators and hospitalisation expenses in patients with heart failure: a retrospective study using quantile regression model in China. *BMJ Open* 2020;**10**:e033926. doi:10.1136/bmjopen-2019-033926

► Prepublication history for this paper is available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2019-033926>).

Received 28 August 2019  
Revised 30 May 2020  
Accepted 01 June 2020



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## ABSTRACT

**Objective** To explore the association between compliance with quality indicators and hospitalisation expenses in patients with heart failure.

**Design** Generalised linear model and quantile regression model were used to examine the association between compliance with five quality indicators and hospitalisation expenses.

**Setting** Grade A hospital in Fujian Province, China.

**Participants** Data on 2568 heart failure admissions between 2010 and 2015 were analysed.

**Results** The median (IQR) of hospitalisation expenses of 2568 patients was ¥10.9 (¥6.9–¥31.6) thousand. The rates of compliance with five quality indicators were 90.3% for evaluation of left ventricular function, 43.8% for diuretics, 62.0% for ACE inhibitors (ACEI) or angiotensin receptor blockers (ARB), 67.4% for beta-blockers, and 58.9% for aldosterone receptor antagonists. After adjustment for gender, age, residence, method of payment, number of diseases before admission, number of diseases at admission, number of emergency treatments during hospital stay and length of stay, patients who received evaluation for left ventricular function, diuretics, or ACEI or ARB had lower hospitalisation expenses, and patients who received beta-blockers had higher hospitalisation expenses, compared with their counterparts in generalised linear models. Differences in hospitalisation expenses between compliance and non-compliance with quality indicators became larger across quantile levels of hospitalisation expenses, and were found to be statistically significant when quantile level exceeded 0.80 (¥39.7 thousand) in quantile regression models.

**Conclusions** The quality of care for patients with heart failure was below the target level. There was a negative relationship between compliance with quality indicators and hospitalisation expenses at the extreme quantile of expenses. More attention should be given to patients who may experience extreme expenses, and effective measures should be taken to improve the quality of care they receive.

## INTRODUCTION

Along with rapid economic development, health expenditures had continuously been

## Strengths and limitations of this study

- The study was the first to assess the association between compliance with quality indicators and hospitalisation expenses in Chinese patients with heart failure.
- Quantile regression model was a good method to explore the relationship between compliance with quality indicators and hospitalisation expenses, which were skewed to the right and were heteroscedastic.
- The patients in this study were admitted to a grade A hospital, and further study including other grade hospitals may be needed to verify whether compliance with quality indicators is associated with hospitalisation expenses.

on the rise in China. It has been reported that the country's national health expenditures (NHE) increased from ¥0.46 trillion (\$1=¥7.15) in 2000 to ¥5.16 trillion in 2017. NHE had both a 25% increase over the previous year in 2008 and 2016. The proportion of out-of-pocket payment to NHE decreased from 59.0% in 2000 to 28.8% in 2017.<sup>1</sup> However, the proportion of household health expenditure to household total consumer spending continuously increased to 7.3% and 9.7% in 2017 in urban and rural areas, respectively.<sup>1</sup> Of the households nationwide, 12.9% had catastrophic health expenses (CHE) in 2011 and the incidence of CHE reached 34.9% among rural inpatients in 2013.<sup>2 3</sup> Therefore, out-of-pocket payment remains a heavy economic burden for residents.

The prevalence rate, hospitalisation rate, mortality and disease burden of malignant tumour and cardiovascular disease were all higher than other diseases.<sup>4 5</sup> Many

organisations and researchers have focused on the quality of care for malignant tumour and cardiovascular disease to improve clinical outcomes and reduce disease burden.<sup>6-9</sup> Optimal quality of care was defined as ‘the most reasonable treatment mode, which was developed using current evidence-based medicine and without increasing economic burden for patients, to increase the likelihood of desired clinical outcomes’.<sup>10</sup> Consensus was reached that the higher the compliance rates with quality indicators, the better the quality of care. In practice, compliance rates with quality indicators ranged from 53.4% to 81.7% for lung cancer,<sup>11</sup> from 45.1% to 95.6% for breast cancer,<sup>12 13</sup> from 94.2% to 99.2% for colorectal cancer,<sup>12</sup> from 5.1% to 82.5% for acute myocardial infarction,<sup>14</sup> and from 44.0% to 89.8% for heart failure.<sup>15</sup> All of these studies showed that there were considerable gaps between target level (100%) and clinical practice for malignant tumours and cardiovascular diseases.

Distinctly, health expenditures increased over time, but the quality of care was still not optimal. The reality deviated from the expectation that optimal quality of care would be achieved with appropriate health expenditures. Therefore, there is a great need to improve quality of care and control health expenditures. This study aimed to assess the association between compliance with quality indicators and hospitalisation expenses in patients with heart failure. The results of the study will provide support to improving the quality of care and reducing the expenses of patients with heart failure and will serve as basis for similar studies on other diseases.

## METHODS

### Quality indicators

The association between compliance with quality indicators and hospitalisation expenses in patients with heart failure (HF) was assessed using five quality indicators:

- ▶ HF-1: evaluation of left ventricular function: patients with heart failure should have their left ventricular function evaluated before arrival or during hospitalisation, or should be planned for after discharge.<sup>15 16</sup>
- ▶ HF-2: diuretics (loop diuretics and thiazide diuretics): patients with heart failure with fluid retention and without contraindications to diuretics (eg, gout, liver dysfunction, renal dysfunction, electrolyte disturbance, hypotension) should be prescribed a diuretic during hospital stay.<sup>15 16</sup>
- ▶ HF-3: ACE inhibitor (ACEI) or angiotensin receptor blocker (ARB): patients with heart failure without contraindications to ACEI or ARB (eg, allergy to ACEI, aortic stenosis, bilateral renal artery stenosis, renal dysfunction, hyperkalaemia) should be prescribed an ACEI or ARB during hospital stay.<sup>15 16</sup>
- ▶ HF-4: beta-blocker: patients with heart failure without contraindications to beta-blockers (eg, heart rate <60 beats per minute, conduction system disease, hypotension, asthma, severe obstructive lung disease) should be prescribed a beta-blocker during hospital stay.<sup>15 16</sup>

- ▶ HF-5: aldosterone receptor antagonist: patients with moderate or severe heart failure with left ventricular systolic dysfunction and without contraindications to aldosterone receptor antagonist (eg, hypotension, hyperkalaemia, renal dysfunction) should be prescribed an aldosterone receptor antagonist during hospital stay.<sup>15 16</sup>

### Data source and study population

This was a retrospective study of all patients with heart failure (code I50 in International Classification of Diseases-10) who were admitted to a grade A hospital in Fujian Province between 1 January 2010 and 31 December 2015. The medical record manager concealed the names and addresses of patients before we abstracted the data, and each patient was identified by a unique medical record number. Patient variables were abstracted, including medical record number, demographic characteristics, method of payment (social basic medical insurance, commercial insurance or self-paying), diseases before admission which were self-reported by patients, diseases at admission which were diagnosed by physicians, physical examination (eg, blood pressure, heart rate), biochemical examination (eg, serum potassium, serum creatinine), number of emergency treatments during hospital stay, therapies, associated main contraindications to therapies and hospitalisation expenses. Hospitalisation expenses were the total expenses during hospital stay, which included out-of-pocket expenses. To ensure the reliability of data, two collectors abstracted the same record with standardised definitions. The intercollector consistency was assessed at the end of each day and the agreement rate must be greater than 95%, otherwise the record was reviewed the next day.

We restricted study population to patients aged 18 years or older and excluded those who had left the hospital on the first day, who were admitted again in 30 days, who were pregnant, who were transferred from another hospital, who participated in a random clinical trial or who had metastatic cancer. The remaining 2568 patients comprised the study population.

We classified a patient as to whether he or she was eligible for a quality indicator and whether he or she received the recommended therapy based on the definition of each quality indicator. The compliance rate with each quality indicator was calculated as the number of eligible patients who actually received the recommended therapy divided by the total number of eligible patients for that therapy.

### Hospitalisation expenses

To make the comparison of hospitalisation expenses across time meaningful, the amount of hospitalisation expenses from 2010 to 2015 was transformed by consumer price index (CPI) to the price level in 2010. The following is the transformation formula: real price=nominal price × (CPI of base year/CPI of object year). The CPI from 2010 to 2015 is displayed in [table 1](#), with CPI=100 in 1978

**Table 1** Consumer price index and real price from 2010 to 2015, in thousand RMB

Year	CPI	RMB	Low-expense			High-expense				
			n	P <sub>25</sub>	P <sub>50</sub>	P <sub>75</sub>	n	P <sub>25</sub>	P <sub>50</sub>	P <sub>75</sub>
2010	536.1	100.0	95	4.0	5.5	7.0	163	11.6	17.0	43.6
2011	565.0	94.9	169	5.6	7.9	10.7	77	27.7	42.8	61.5
2012	579.7	92.5	373	5.8	8.3	10.9	191	26.5	41.3	62.8
2013	594.8	90.1	252	5.6	8.0	10.4	192	31.3	44.6	64.4
2014	606.7	88.4	360	5.3	7.3	9.8	219	25.3	42.7	61.3
2015	615.2	87.1	313	5.9	7.9	10.7	164	27.8	40.6	60.2
Total	–	–	1562	5.5	7.6	10.2	1006	22.8	40.2	60.4

CPI=100 in 1978 as reference.

RMB=100 in 2010 as reference.

CPI, consumer price index; RMB, renminbi.

as reference.<sup>17</sup> Therefore, the real price of ¥100, which was the nominal price, was transformed to ¥94.9 [ $¥100 \times (536.1/565.0)$ ] in 2011, and so on (table 1).

### Statistical analysis

Quantiles for hospitalisation expenses and numbers and percentages for categorical variables were reported. The logarithm of hospitalisation expenses combined with data on time was used to classify the patients into low-expense group and high-expense group using cluster analysis.  $\chi^2$  test was applied to compare differences between the two groups. The association between compliance with quality indicators and hospitalisation expenses was analysed using generalised linear models with logarithmic link function and gamma distribution for hospitalisation expenses.<sup>18</sup> Quantile regression models were also used to determine if the association between compliance with quality indicators and hospitalisation expenses was homogeneous.<sup>19</sup> Gender, age, residence, method of payment, number of diseases before admission, number of diseases at admission, number of emergency treatments and length of stay as confounding factors were adjusted in each of these analyses. All statistical analyses were conducted using SAS V.9.2 software. Two-sided statistical tests with  $p < 0.05$  were considered statistically significant.

## RESULTS

### Hospitalisation expenses

The quantile levels from 0 to 1 of hospitalisation expenses are shown in figure 1. The median (IQR) was ¥10.9 (¥6.9–¥31.6) thousand. Of 2568 patients, 60.8% (1562) were classified in the low-expense group and the rest were classified in the high-expense group. The median (IQR) was ¥7.6 (¥5.5–¥10.2) thousand and ¥40.2 (¥22.8–¥60.4) thousand in the low-expense and the high-expense group, respectively. Hospitalisation expenses were lowest in 2010 and were similar from 2011 to 2015 in both groups (table 1).

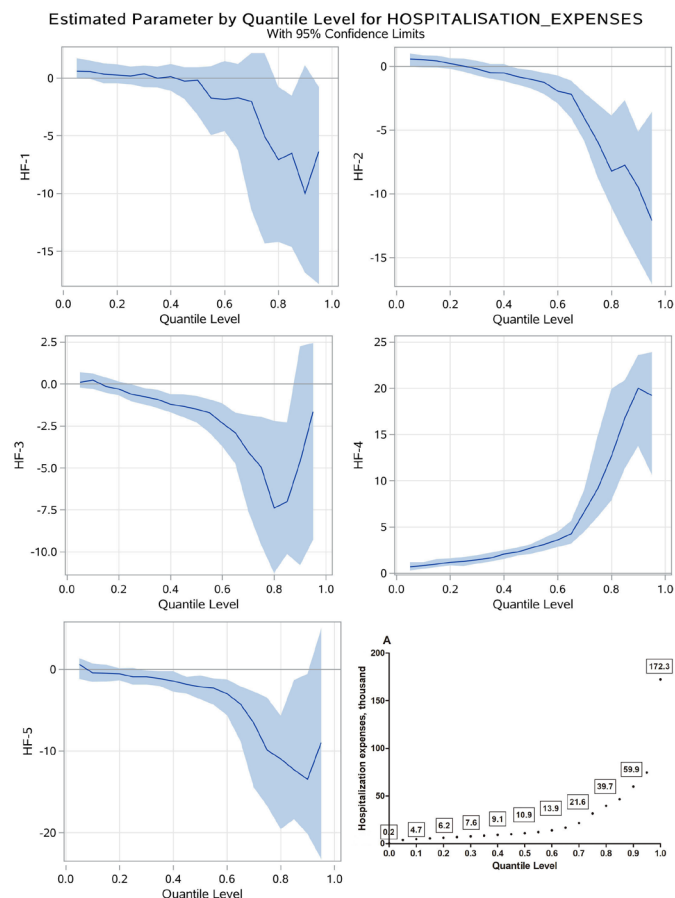
### Demographic characteristics

Table 2 displays the baseline and clinical characteristics of the study population. Of 2568 patients, 60.8% were male and 73.8% were aged  $\geq 60$  years; 89.6% paid for hospitalisation expenses using social basic medical insurance and 8.4% patients paid by themselves; 55% had more than one disease before admission; 66.4%, 40.4%, 32.9% and 30.1% had hypertension, arrhythmia, coronary heart disease and diabetes mellitus, respectively; and 48.5% had more than five diseases at admission. Of the patients, 17.8% received emergency treatment during hospital stay. Differences in gender, method of payment, number of diseases before admission, number of diseases at admission, number of emergency treatments and length of stay were statistically significant between the low-expense and the high-expense group ( $p < 0.05$ ).

### Compliance with quality indicators

In aggregate, 2319 (90.3%) of 2568 patients were evaluated for left ventricular function. A diuretic was provided in 821 (43.8%) of 1875 eligible patients. Of 2282 eligible patients, 1414 (62.0%) received an ACEI or ARB during their hospital stay. A total of 2145 patients were considered eligible for treatment with beta-blockers and 1445 (67.4%) received this treatment. An aldosterone receptor antagonist was given in 511 (58.9%) of 868 eligible patients. Of the five quality indicators, the compliance rate was highest for evaluation of left ventricular function and was lowest for diuretics (table 3).

The compliance rates for evaluation of left ventricular function, ACEI or ARB, and aldosterone receptor antagonist were statistically lower in the high-expense group than those in the low-expense group ( $p < 0.05$ ). The compliance rate with beta-blockers was statistically lower in the low-expense group than in the high-expense group ( $p < 0.05$ ) (table 3).



**Figure 1** Association between compliance with quality indicators and hospitalisation expenses (in thousand RMB) in quantile regression models. Five quantile regression models were conducted for each quality indicator and only eligible patients were included in each of these analyses. Adjusted for gender, age, residence, method of payment, number of diseases before admission, number of diseases at admission, number of emergency treatments and length of stay. The x axis shows the quantile level of hospitalisation expenses; the y axis shows the estimated regression coefficients with 95% confidence limits. HF, heart failure; HF-1, evaluation of left ventricular function; HF-2, diuretic; HF-3, ACE inhibitor or angiotensin receptor blocker; HF-4, beta-blocker; HF-5, aldosterone receptor antagonist; RMB, renminbi.

### Association between compliance with quality indicators and hospitalisation expenses

Overall, patients who were given evaluation for left ventricular function, diuretic, ACEI or ARB, or aldosterone receptor antagonist had lower hospitalisation expenses than their counterparts. The regression coefficients (95% confidence limit) in generalised linear model for these therapies were  $-0.13$  ( $-0.24$  to  $-0.02$ ),  $-0.22$  ( $-0.30$  to  $-0.14$ ),  $-0.15$  ( $-0.22$  to  $-0.08$ ) and  $-0.22$  ( $-0.32$  to  $-0.11$ ), respectively. Patients who were given beta-blockers had higher hospitalisation expenses than their counterparts, with regression coefficient of  $0.41$  (95% confidence limit:  $0.34$  to  $0.49$ ). The association between compliance with each therapy and hospitalisation expenses was independent of the other therapies, except for the aldosterone receptor antagonist (table 4).

The differences in hospitalisation expenses between compliance and non-compliance with quality indicators became larger across quantile levels of hospitalisation expenses (figure 1).

- The association between compliance with evaluation for left ventricular function and hospitalisation expenses was found to be significant at quantiles of 0.80, 0.85 and 0.95 (¥39.7 thousand, ¥46.6 thousand and ¥74.6 thousand). The regression coefficient (95% confidence limit) was  $-7.1$  ( $-14.2$  to  $-0.7$ ),  $-6.5$  ( $-14.6$  to  $-0.5$ ) and  $-6.4$  ( $-17.9$  to  $-0.8$ ), respectively (figure 1, HF-1).
- The association between compliance with diuretic and hospitalisation expenses was found to be significant at and after the quantile of 0.45 (¥9.9 thousand). The regression coefficient (95% confidence limit) was from  $-0.8$  ( $-1.5$  to  $-0.2$ ) to  $-12.1$  ( $-17.1$  to  $-3.4$ ) (figure 1, HF-2).
- The association between compliance with ACEI or ARB and hospitalisation expenses was found to be significant from the quantile of 0.25 to 0.85 (¥6.9 thousand to ¥46.6 thousand). The regression coefficient (95% confidence limit) was from  $-0.6$  ( $-1.0$  to  $-0.0$ ) to  $-7.0$  ( $-10.1$  to  $-2.2$ ) (figure 1, HF-3).
- The association between compliance with beta-blocker and hospitalisation expenses was found to be significant across all quantiles. The regression coefficient (95% confidence limit) was from  $0.7$  ( $0.2$  to  $1.2$ ) to  $19.2$  ( $10.6$  to  $23.9$ ) (figure 1, HF-4).
- The association between compliance with aldosterone receptor antagonist and hospitalisation expenses was found to be significant from the quantile of 0.30–0.90 (¥7.6 thousand–¥59.9 thousand). The regression coefficient (95% confidence limit) was from  $-0.9$  ( $-1.9$  to  $-0.2$ ) to  $-13.5$  ( $-20.3$  to  $-0.3$ ) (figure 1, HF-5).

As shown in figure 2, the association between compliance with quality indicators and hospitalisation expenses, which was analysed using a single quantile regression model with five quality indicators as independent variables, was similar to the results in figure 1, except for aldosterone receptor antagonist. The association between compliance with aldosterone receptor antagonist and hospitalisation expenses was found to be significant from the quantile of 0.15–0.25 (¥5.4 thousand–¥6.9 thousand). The regression coefficient (95% confidence limit) was from  $0.9$  ( $0.1$  to  $1.5$ ) to  $0.7$  ( $0.3$  to  $1.2$ ) (figure 2, HF-5).

### DISCUSSION

Cardiovascular disease had been the major public health problem in China which resulted in huge labour losses and heavy disease burden.<sup>5</sup> Heart failure as the end stage of cardiovascular diseases accounted for 20% of hospitalisations and 40% of deaths due to cardiovascular diseases.<sup>20</sup> The China Health Statistics Yearbooks reported that the per capita hospitalisation expenses for patients with heart failure in grade A hospitals ranged from ¥8.9 thousand in 2010 to ¥11.1 thousand in 2017.<sup>1</sup>

**Table 2** Baseline and clinical characteristics of the study population

Variable	Total		Low-expense		High-expense		$\chi^2$	P value
	n	%	n	%	n	%		
Gender, male	1561	60.8	847	54.2	714	71.0	72.01	<0.001
Age, years							3.86	0.277
<45	101	3.9	67	4.3	34	3.4		
45–59	571	22.2	346	22.2	225	22.4		
60–74	1151	44.8	714	45.7	437	43.4		
≥75	745	29.0	435	27.9	310	30.8		
Residence								
Urban	1456	56.7	907	58.1	549	54.6	3.04	0.081
Rural	1112	43.3	655	41.9	457	45.4		
Method of payment							6.90	0.032
Social basic medical insurance	2301	89.6	1406	90.0	895	89.0		
Commercial insurance	51	2.0	22	1.4	29	2.9		
Self-payment	216	8.4	134	8.6	82	8.1		
Number of diseases before admission								
0	335	13.0	217	13.9	118	11.7	10.03	0.018
1	823	32.0	525	33.6	298	29.6		
2	798	31.1	471	30.2	327	32.5		
≥3	612	23.9	349	22.3	263	26.1		
Diseases at admission								
Cerebral disease	567	22.1	412	26.4	155	15.4	42.79	<0.001
Lung disease	550	21.4	250	16.0	300	29.8	69.40	<0.001
Coronary heart disease	844	32.9	407	26.1	437	43.4	83.80	<0.001
Valvular heart disease	610	23.8	381	24.4	229	22.8	0.90	0.344
Renal disease	281	10.9	202	12.9	79	7.9	16.20	<0.001
Liver disease	343	13.4	223	14.3	120	11.9	2.92	0.088
Hyperlipidaemia	612	23.8	400	25.6	212	21.1	6.93	0.009
Diabetes mellitus	773	30.1	445	28.5	328	32.6	4.93	0.027
Electrolyte disturbance	692	26.9	349	22.3	343	34.1	42.93	<0.001
Anaemia	270	10.5	135	8.6	135	13.4	14.84	<0.001
Arrhythmia	1037	40.4	660	42.3	377	37.5	5.80	0.016
Myocardosis	449	17.5	149	9.5	300	29.8	174.47	<0.001
Hyperuricaemia	557	21.7	376	24.1	181	18.0	13.32	<0.001
Aortosclerosis	711	27.7	445	28.5	266	26.4	1.28	0.258
Hypertension	1705	66.4	1039	66.5	666	66.2	0.03	0.869
Number of diseases at admission								
≤5	1323	51.5	858	54.9	465	46.2	18.57	<0.001
>5	1245	48.5	704	45.1	541	53.8		
Number of emergency treatments								
0	2109	82.1	1404	89.9	705	70.1	170.3	<0.001
1	353	13.7	133	8.5	220	21.9		
>1	106	4.1	25	1.6	81	8.1		
Length of stay, days								
>10	918	35.7	364	23.3	554	55.1	268.83	<0.001
≤10	1650	64.3	1198	76.7	452	44.9		

**Table 3** Compliance with quality indicators of the study population

Indicator	Total		Low-expense		High-expense		$\chi^2$	P value
	Compliance	%	Compliance	%	Compliance	%		
HF-1	2319/2568	90.3	1438/1562	92.1	881/1006	87.6	14.07	<0.001
HF-2	821/1875	43.8	495/1158	42.8	326/717	45.5	1.33	0.248
HF-3	1414/2282	62.0	929/1417	65.6	485/865	56.1	20.53	<0.001
HF-4	1445/2145	67.4	839/1353	62.0	606/792	76.5	47.81	<0.001
HF-5	511/868	58.9	282/443	63.7	229/425	53.9	8.56	0.003

HF-1, evaluation of left ventricular function; HF-2, diuretic; HF-3, ACE inhibitor or angiotensin receptor blocker; HF-4, beta-blocker; HF-5, aldosterone receptor antagonist.  
HF, heart failure.

Obviously, the corresponding results in this study (from ¥21.0 thousand in 2010 to ¥24.6 thousand in 2015) were much higher than the official figures. It implied that the patients in Fujian Province had heavier disease economic burden.

Echocardiography has always been used for evaluating left ventricular function and is associated with more use of evidence-based medicine to achieve desired clinical outcomes.<sup>21</sup> Diuretics are the only drug used to adequately control fluid retention and is the key factor that affects the effectiveness of other drugs.<sup>22</sup> ACEI or ARB, beta-blocker, and aldosterone receptor antagonist all showed associations with reduction in risk of readmission and mortality.<sup>16–23</sup> These therapies as quality indicators had been applied by accreditation organisations in several countries to assess the quality of care in patients with heart failure.<sup>24–26</sup> Ideally, the compliance rates with these recommended therapies should approach or reach 100%. However, the compliance rates in this study were not optimal and different from those of patients in north-east China.<sup>15</sup>

Furthermore, it was found that hospitalisation expenses of patients who received the recommended therapies were lower than those of patients who did not. By comprehensive consideration of the findings from five quality indicators, the negative relationship between compliance with the recommended therapies and hospitalisation expenses was significant when the quantile level exceeded 0.8 (¥39.7 thousand). The results hinted that higher expenses did not always come with better quality of care. Patients may have increased quality of care along with increased expenses, but this changes when expenses reach a certain degree. These findings could be because compliance with quality indicators relieves symptoms, prevents the condition from deteriorating, reduces the risk of adverse outcomes, shortens the length of stay and prevents extreme expenses. In this study, patients who did not receive the recommended therapies also had valvular heart disease, coronary heart disease, chronic obstructive pulmonary disease, digestive diseases and renal failure, and/or received emergency treatment during hospital stay. Physicians focused more on the therapies for these comorbidities and neglected effective therapies for heart

failure, and these comorbidities cost more. It is suggested that more attention should be given to patients who may experience extreme expenses and to the quality of care they receive for heart failure.

To achieve the balance of optimal quality of care and appropriate hospitalisation expenses for patients with heart failure, several suggestions are proposed. Health administrations should widely publicise the importance of quality assessment, and quality of care should be regularly supervised and assessed.<sup>27</sup> Effective measures should be taken to improve quality of care, such as initiating and participating in improvement initiatives,<sup>28–31</sup> and unnecessary therapies should be reduced.

Several issues should be considered in the interpretation of the findings. First, the association between compliance with quality indicators and hospitalisation expenses was assessed based on the assumption that compliance with quality indicators would result in lower risk of adverse outcomes, and the length of stay as an outcome variable was adjusted in the analyses. Second, the reasons for non-use of recommended therapies according to patient preference were documented in medical records and these patients were excluded from the association analyses. However, patients' income may influence compliance and hospitalisation expenses. The method of payment, which could reflect patients' social economic status to some extent, was adjusted for in the analyses. Third, this study was retrospective and the link between quality and expenses did not prove causality. Finally, the patients in this study were admitted to a grade A hospital, which had higher health expenditures compared with hospitals of other grades. Further study that includes other grade hospitals is needed to verify whether compliance with quality indicators is associated with hospitalisation expenses.

## CONCLUSIONS

In China, the quality of care for patients with heart failure was below the target level. There was a negative relationship between compliance with quality indicators and hospitalisation expenses at the extreme quantile of expenses. More attention should be given to patients





of China (2017YFC0907100 to ZH) and Startup Fund for Scientific Research, Fujian Medical University (2016QH010 to RF).

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Obtained.

**Ethics approval** This was a retrospective study based on abstraction of medical records with approval from the Ethical Committee of Fujian Medical University.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon reasonable request from the corresponding author.

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