A Study on the Pay-Performance Evaluation System of Public Hospitals Based on the AHP Method and Entropy Power Method

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Abstract: To promote the high-quality development of public hospitals and mobilize the enthusiasm of the medical staff, this paper, by reviewing a large amount of literature and relevant documents, constructs a public hospital salary performance evaluation index system, and uses the hierarchical analysis method (AHP) and entropy weighting method to determine the weighting of the indexes to provide a reference for public hospitals to formulate strategies to improve the effectiveness of the salary performance system, to enhance the motivation of medical staff in a targeted manner.

1. Introduction

In February 2021, the 18th meeting of the Central Committee for Comprehensively Deepening Reform, considered and adopted the Opinions on Promoting the High-Quality Development of Public Hospitals, and pointed out that to promote the high-quality development of public hospitals is to always put the issue of solving the problems of good people in a prominent position, and to protect and give full play to the enthusiasm, initiative and creativity of the majority of medical staff. Medical staff is the core competitiveness of hospital development, and their motivation will directly affect the efficiency of their work and patient satisfaction. Mobilizing the motivation of medical staff is the realization path of public hospital reform. With the in-depth promotion of public hospital reform, how to effectively mobilize the motivation of medical staff has become a hot and difficult issue in society[1].

Duan Zhiying et al. (2010)[2] proposed measures to motivate medical staff through a preliminary study of various measures of public hospital reform. Lou Ye and Zheng Zhen's nephew (2016)[3] took Sanming's medical reform as an example and pointed out that the motivation of medical staff can only be fully mobilized if it is people-oriented and meets their needs at both material and spiritual levels. Gu Songtao et al. (2017)[4] studied clinicians' performance pay satisfaction, job performance, influencing factors and the relationship between them after the performance system reform from the perspective of clinicians, the main participants of the reform, and humanistic care. Wang Wo (2019)[5] constructed a performance evaluation tool for physician inpatient service pay that included three dimensions of service capacity, efficiency, and safety and six measures of DRGs group number, the actual number of people in charge, CMI, cost consumption index, time consumption index, and

mortality in low-risk groups. Liu Yinqi (2020)[6] systematically analyzed the factors influencing the work motivation of medical staff at the individual, organizational and social levels, and put forward relevant policy recommendations. Shen Chunhan (2021)[7] concluded that physician pay satisfaction in county-level general public hospitals in Anhui Province was composed of three dimensions: pay level, benefits, and pay structure/management. Wei Yanqing et al. (2021)[8] analyzed the factors influencing the work motivation of medical staff in public hospitals from the perspective of governance of multiple subjects, and put forward suggestions for mobilizing medical staff's work motivation.

Research by scholars has shown that the remuneration system is a key link to achieving the development of hospital human resources. By formulating and implementing a remuneration system and remuneration model suitable for hospitals, excellent talents can be attracted, and the motivation of employees can be fully transferred, so that employees have a sense of security and a sense of security for the expected wind, thus enhancing their sense of professional identity and their trust and sense of belonging to the unit[9]. Furthermore, performance management is an important tool for motivating hospital staff, improving the quality of medical services and service levels, promoting the sustainable and healthy development of hospitals, and optimizing the operational efficiency of hospitals in general[10]. This study combines the current status of research on the pay-performance index system of medical staff and constructs a pay-performance evaluation index system for public hospitals to provide new ideas for motivating medical staff in public hospitals and a new perspective for theoretical research on public hospital reform.

2. The Construction of a Performance Indicator System for Medical Staff Remuneration in Public Hospitals

2.1. Evaluation Methodology

2.1.1. Analytic Hierarchy Process

The analytic hierarchy process (AHP) is a multi-objective hierarchical analysis method that combines quantitative and qualitative approaches[11]. The specific steps are: (1) defining decision objectives, criteria, and alternatives; (2) scoring the criteria in a two-by-two comparison; (3) calculating the relative priority weights of sub-criteria; (4) combining the alternatives' priorities to calculate global priority weights; (5) consistency testing; and (6) sensitivity analysis[12].

2.1.2. The Entropy Weight Method

The entropy weighting method is an objective weighting analysis method that uses index data to determine the index weights. In the specific use process, the information entropy of each index is obtained through the degree of variation of each index, so that the information entropy can be used to calculate the weight of each index. Compared to subjective analysis methods such as Delphi and AHP, the entropy weighting method avoids the influence of subjective factors and produces the most scientific evaluation results possible.

2.2. Sources of Performance Indicator Systems for Medical Staff Remuneration in Public Hospitals

According to existing relevant studies, the index currently focuses on performance appraisal, salary satisfaction, and salary distribution evaluation. This paper closely links the performance appraisal of medical staff in public hospitals with performance pay, and establishes a salary performance evaluation index system to motivate doctors in public hospitals.

Table 1: Public Hospital Pay-performance Evaluation Index System.

	Tier 1 indicators	Secondary indicators
Business level	Medical indicators	Average daily number of doctor visits[14]
		Average daily number of physician admissions[14]
		Annual emergency rate and number of surgical procedures[14]
		Average length of stay[22]
		Number of annual health check-ups[13]
	Quality of care	Cure rate[23]
		Diagnosis rate at 3 days of admission[13]
		Nosocomial infection rate[13]
Operating Conditions	Cost burden	Average outpatient medical costs[22]
		Average hospital medical costs[22]
		Pharmaceuticals as a percentage of operating revenue[13]
	Economic benefits	Operating expenses to operating income ratio
		Hundred dollars of operating income tied up in fixed funds[13]
Personal Development	Research and Technology	Scientific research and teaching skills[19]
		Innovation capacity[19]
	Staff Growth	Training & Upgrading
		Staffing structure
Quality of Service	Satisfaction	Outpatient satisfaction[23]
		Inpatient satisfaction[23]
	After Sales Management	Medical compensation rates[16]
		Effective patient complaint rate[16]

Chen Yao et al. (2007)[13] used the AHP method to construct a performance assessment index system from three aspects: business level, operation status, and satisfaction. Chen Xudong (2015)[14] constructed a performance assessment index system within the institution with efficiency, quality, finance, service, development, and technology as the first-level indicators and proposed an implementation method. Zheng Daxi (2016)[15] proposed the nature of the position, technical difficulty, degree of risk, quantity and quality of work, and other performance as the main assessment indicators, from which the performance pay component of doctors was determined. Shang Ruiping and others (2018)[16] analyzed the correlation between the balanced scorecard and the public interest of public hospitals to construct a performance appraisal index system with four dimensions of finance, internal processes, customers, and learning and growth as the first-level indicators in the reform of the remuneration system of public hospitals. Sheng Mengfei and Song Baoxiang (2018)[17] constructed a public hospital medical quality and safety evaluation index system based on the PATH theory through the Delphi method and hierarchical analysis, containing six first-level indicators of patient-centered, staff-oriented, medical effectiveness and efficiency, social responsibility, operational management and sustainable development. Xiong Ting et al. (2018)[18] constructed a medical service performance evaluation system for county-level public hospitals in Jiangsu province with doctor-patient relationship, overall evaluation, service management, medical costs and quality efficiency as the first-level indicators. Zhu Jin (2019)[19] constructed a public hospital performance

evaluation index system under the dimensions of finance, patient experience, public welfare, internal processes and learning and growth through the Delphi consulting method to provide an important tool for the government to carry out the supervision of public hospital services and public hospitals to improve the quality and effectiveness of medical services, and pointed out that the evaluation system was established from two aspects: the dean and the medical staff. Yan Zixi (2020)[21] constructed a three-level evaluation index system for employee pay satisfaction in NS Pharmaceutical Company through Delphi method and fuzzy comprehensive evaluation method, including pay level, pay management system, welfare benefits, pay promotion mechanism and implicit pay and benefits. Tan et al. (2021)[22] established a new performance appraisal model based on patient experience, quality and safety, discipline development and operational performance through BSC and AHP methods, and continuously optimized the appraisal system by combining national policy requirements and the current situation of the hospital, establishing and improving a three-tier index framework and five index scoring algorithms. Shan Miao Miao et al. (2021)[23] constructed a comprehensive evaluation index system for the economic operation of public hospitals with input, process and output as the first-level indicators through the Delphi method and hierarchical analysis. Han Lijian et al. (2022)[24] constructed an appraisal index system with workload assessment, operation assessment, quality assessment and science and education assessment as the first-level indicators by analyzing the requirements for remuneration allocation in public hospitals under the new situation and combining them with the practice of remuneration allocation in a tertiary general hospital in Beijing in the new era, and made relevant suggestions for optimizing the remuneration allocation policy.

Through reviewing a large amount of literature and relevant documents, various evaluation dimensions were selected and integrated. In the end, an evaluation system comprising 8 primary indicators and 21 secondary indicators was formed from the four dimensions of business level, operation status, personal development and service quality, this is shown in Table 1.

The evaluation system provides a comprehensive analysis of the remuneration and performance system of public hospitals in terms of four dimensions of medical staff's operational level, business status, personal development and service quality, with 21 specific indicators.

3. Analysis of Results

3.1. Calculation Process

3.1.1. AHP-Based Assessment Model-building Process

(1) Construction of judgment matrix

When each of the 21 indicators of the public hospital pay-performance evaluation system is assigned a separate value, the level of the pay-performance system can be assessed using AHP. In this study, 10 experts and scholars in the fields of hospital management, health administration and universities were invited to rate the relative importance of the primary indicators and each part of the secondary indicators between the two according to the 1-9 scale.

(2) Calculation of indicator weight index and consistency test

This study used SPSS software to analyze the data and provide assistance in model construction, calculation and analysis for the decision-making process using the hierarchical analysis method. The scores of the 10 experts on each indicator were brought in for consistency testing and the CR results were obtained to be less than 0.10, i.e. they passed the consistency test and the AHP weights of each indicator were calculated, as shown in Table 2.

Table 2: AHP-based public hospital pay-performance evaluation index system with weights at all levels.

	Tier 1 indicators	Weights	Secondary indicators	Weights	Portfolio weights
Business level	Medical indicators	2.05%	Average daily number of doctor visits	5.25%	0.11%
			Average daily number of physician admissions	9.55%	0.20%
			Annual emergency rate and number of surgical procedures	20.51%	0.42%
			Average length of stay	24.79%	0.51%
			Number of annual health check-ups	39.90%	0.82%
	Quality of care	3.42%	Cure rate	16.38%	0.56%
			Diagnosis rate at 3 days of admission	29.73%	1.02%
			Nosocomial infection rate	53.90%	1.84%
Operating Conditions	Cost burden	5.11%	Average outpatient medical costs	16.38%	0.84%
			Average hospital medical costs	29.73%	1.52%
			Pharmaceuticals as a percentage of operating revenue	53.90%	2.75%
	Economic benefits	7.03%	Operating expenses to operating income ratio	83.33%	5.86%
			Hundred dollars of operating income tied up in fixed funds	16.67%	1.17%
Personal Development	Research and Technology	12.17%	Scientific research and teaching skills	25.00%	3.04%
			Innovation capacity	75.00%	9.13%
	Staff Growth	16.52%	Training & Upgrading	83.33%	13.77%
			Staffing structure	16.67%	2.75%
Quality of Service	Satisfaction	21.94%	Outpatient satisfaction	75.00%	16.45%
			Inpatient satisfaction	25.00%	5.49%
	After Sales Management	31.77%	Medical compensation rates	25.00%	7.94%
			Effective patient complaint rate	75.00%	23.83%

3.1.2. Entropy Weighting Method to Determine Objective Weights

The analysis was carried out using SPSS software and 10 experts and scholars in the fields of hospital management, health administration and universities were brought in to rate the indicators and calculate the entropy value and entropy weight of each indicator, the specific results are shown in Table 3.

Table 3: Entropy weighting of public hospital pay-performance evaluation index system based on entropy weighting method.

	Tier 1 indicators	Entropy value	Entropy weight	Secondary indicators	Entropy value	Entropy weight	Portfolio entropy weights
Business level	Medical indicators	1	11.75%	Average daily number of doctor visits	1	9.54%	1.12%
				Average daily number of physician admissions	0.99	20.10%	2.36%
				Annual emergency rate and number of surgical procedures	0.99	27.46%	3.23%
				Average length of stay	0.99	22.84%	2.68%
				Number of annual health check-ups	0.99	20.06%	2.36%
	Quality of care	1	8.28%	Cure rate	1	12.83%	1.06%
				Diagnosis rate at 3 days of admission	0.99	54.73%	4.53%
				Nosocomial infection rate	1	32.44%	2.69%
Operating Conditions	Cost burden	1	8.59%	Average outpatient medical costs	1	24.34%	2.09%
				Average hospital medical costs	1	22.06%	1.90%
				Pharmaceuticals as a percentage of operating revenue	0.99	53.59%	4.60%
	Economic benefits	0.99	38.74%	Operating expenses to operating income ratio	0.99	38.53%	14.93%
				Hundred dollars of operating income tied up in fixed funds	0.99	61.47%	23.81%
Personal Development	Research and Technology	1	8.68%	Scientific research and teaching skills	0.99	71.62%	6.22%
				Innovation capacity	1	28.38%	2.46%
	Staff Growth	1	8.57%	Training & Upgrading	1	59.77%	5.12%
				Staffing structure	1	40.23%	3.45%
Quality of Service	Satisfaction	1	4.19%	Outpatient satisfaction	1	41.00%	1.72%
				Inpatient satisfaction	0.99	59.00%	2.47%
	After Sales Management	1	11.20%	Medical compensation rates	0.99	65.41%	7.33%
				Effective patient complaint rate	1	34.59%	3.87%

3.1.3. Determination of Combined Weights

The subjective and objective weights derived from the table above were integrated and processed to determine their combined weights, as shown in Table 4.

Table 4: Determination of combined weights.

	Tier 1 indicators	Subjective weights	Objective weights	Combined weights	Secondary indicators	Subjective weights	Objective weights	Combined weights
Business level	Medical indicators	2.05%	11.75%	2.26%	Average daily number of doctor visits	0.11%	1.12%	0.03%
					Average daily number of physician admissions	0.20%	2.36%	0.10%
					Annual emergency rate and number of surgical procedures	0.42%	3.23%	0.29%
					Average length of stay	0.51%	2.68%	0.30%
					Number of annual health check-ups	0.82%	2.36%	0.42%
	Quality of care	3.42%	8.28%	2.66%	Cure rate	0.56%	1.06%	0.13%
					Diagnosis rate at 3 days of admission	1.02%	4.53%	1.00%
					Nosocomial infection rate	1.84%	2.69%	1.07%
Operating Conditions	Cost burden	5.11%	8.59%	4.13%	Average outpatient medical costs	0.84%	2.09%	0.38%
					Average hospital medical costs	1.52%	1.90%	0.62%
					Pharmaceuticals as a percentage of operating revenue	2.75%	4.60%	2.75%
	Economic benefits	7.03%	38.74%	25.60%	Operating expenses to operating income ratio	5.86%	14.93%	18.93%
					Hundred dollars of operating income tied up in fixed funds	1.17%	23.81%	6.04%
Personal Development	Research and Technology	12.17%	8.68%	9.93%	Scientific research and teaching skills	3.04%	6.22%	4.10%
					Innovation capacity	9.13%	2.46%	4.87%
	Staff Growth	16.52%	8.57%	13.31%	Training & Upgrading	13.77%	5.12%	15.27%
					Staffing structure	2.75%	3.45%	2.06%
Quality of Service	Satisfaction	21.94%	4.19%	8.64%	Outpatient satisfaction	16.45%	1.72%	6.12%
					Inpatient satisfaction	5.49%	2.47%	2.94%
	After Sales Management	31.77%	11.20%	33.46%	Medical compensation rates	7.94%	7.33%	12.60%
					Effective patient complaint rate	23.83%	3.87%	19.99%

3.2. Analysis of the Results of the Public Hospital Salary Performance Evaluation Index System Based on the AHP Method and Entropy Power Method

Using the AHP method and the entropy weighting method to calculate the weights of the public hospital pay-performance evaluation index system, it can be seen from the table above that

In the four dimensions of business level, operation status, personal development and service quality, there are a total of eight first-level indicators in medical indicators, medical quality, cost burden, economic efficiency, scientific research technology, staff growth, satisfaction, and after-sales management, and their combined weight values are 2.26%, 2.66%,4.13%, 25.60%, 9.93%, 13.31%, 8.64%, and 33.46%. There is some variation in the weighting of the items, with the highest weighting of 33.46% for post-sales management and the lowest weighting of 2.26% for medical indicators.

For the 21 secondary indicators such as average number of doctor visits per day, average number of doctor admissions per day, annual emergency rate and number of surgeries, average length of stay, and the annual number of health check-ups, their weight values were 0.03%, 0.10%, 0.29%, 0.30%, 0.42%, 0.13%, 1.00%, 1.07%, 0.38%, 0.62%, 2.75%, and 18.93%, 6.04%, 4.10%, 4.87%, 15.27%, 2.06%, 6.12%, 2.94%, 12.60% and 19.99%. There was some variation in the weighting between the items, with the highest weighting of 19.99% for the effective patient complaint rate and the lowest weighting of 0.03% for the average number of doctor visits per day.

4. Discussion

4.1. Scientific and Reliability Analysis of Indicator Systems

Importance of public hospital pay-performance evaluation indicators.

The 21 factors affecting the remuneration performance system of public hospitals were analyzed using hierarchical analysis (AHP) and entropy weighting method, and their corresponding influence weights were derived. The factor "effective patient complaint rate" scored the highest and had the greatest impact on the remuneration performance system of public hospitals, while the factor "average number of doctor visits per day" scored the lowest and had less impact on the remuneration performance system of public hospitals.

The hierarchical analysis method (AHP) can effectively determine the weight of each factor in the public hospital pay-performance evaluation system, but in its decision-making process, the judgment matrix and the assignment of each factor are based on experience and questionnaires, and only a set of scores can be assigned to each factor, so subjective factors have a greater impact on the pay-performance level of public hospitals.

The entropy-based method of calculating public hospital pay and performance levels allows several experts to score the same public hospital pay and performance system as needed, and the scores are weighted and normalized by the entropy method, making the scoring of public hospital pay and performance systems more objective.

It is recommended that in the actual evaluation process, a combined approach based on the AHP + entropy method can be used to conduct a comprehensive evaluation of public hospital pay-performance levels.

4.2. The Patient Experience Dimension Reflects the Performance of Public Hospitals

Most of the current performance appraisal methods are designed from the point of view of medical staff, whether it is economic efficiency indicators, workload indicators, medical quality indicators, etc., all of which are considered and designed from the point of view of medical staff and are not in line with the "patient-centered" service concept. The ownership of hospitals can be different, and the

business objectives of hospitals can be different, but the medical work of hospitals should all belong to the public interest. The target of hospital services is the patient, and the end product of the hospital is also the patient. The evaluation of the performance of the medical staff should not only be based on how much they have done, but also on how much of their products are qualified. Therefore the perspective of evaluation should be shifted from that of the medical staff to that of the patients.

Therefore, theoretically, the motivation of the medical staff in public hospitals can be perceived by patients, so the patient experience is the most important thing to be looked at. The patient experience dimension is designed to understand how patients describe their experience and feelings about receiving healthcare, taking into account not only patient satisfaction but also highlighting patients' feelings and perceptions of outcomes. The Patient Experience Dimension provides an objective measure of the patient experience and a practical way to measure patient-centeredness.

4.3. Integrated Patient Satisfaction and Complaint Feedback Provide Patients with Self-help, Standardisation and Sustainable Optimisation of Quality Care

Public hospitals standardize the reception and handling of hospital complaints and nip problems in the bud, which is an important means to continuously improve the quality level of medical services and prevent medical disputes. An effective patient complaint rate can help the hospital to gain a deeper understanding of patients' real feedback, improve the efficiency and effectiveness of problem-solving, effectively achieve a patient-centered, innovative service model and strive to improve patient satisfaction. Patients can make comments and feedback on the problems in the whole treatment service of the hospital, and the hospital can promptly understand the needs of patients and where the problems lie, rectify them in time and improve the quality of service. At the same time, the results of the satisfaction survey and complaint evaluation will be combined with the medical ethics and performance evaluation of the medical staff, providing an important basis for the year-end evaluation of merit and title promotion, to mobilize the enthusiasm and enthusiasm of the majority of medical staff, and truly put the "patient-centered" service concept into practice.

5. Conclusion

Based on literature combing, this paper establishes an index system for evaluating the remuneration performance of public hospitals, combined with the objectives of high-quality development of public hospitals covered in relevant documents, and uses hierarchical analysis and entropy weighting method to determine the weights of indicators at all levels. Among the 8 level 1 indicators, after-sales management has the largest share, which is in line with the basic logic of public hospital evaluation. 8 level 1 indicators and 21 level 2 indicators, after adjustment, all passed the consistency test and have high credibility. Public hospitals can determine strategies to effectively enhance the effectiveness of their pay and performance systems and target the motivation of their medical staff based on the ranking of the weights of the pay and performance impact indicators. Although the research process tries to follow the principles based on comprehensiveness, scientificity and impartiality, the assessment of public hospitals is a very complex process and inevitably deviations may occur. In addition, the healthcare system is constantly being reformed and policies are time-sensitive, and certain indicators in this paper need to be constantly adjusted.

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