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# Application of Fuzzy Comprehensive Evaluation Method for Evaluating the Performance of Basic Section in Hospitals

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***Abstract:***

In this paper, the fuzzy comprehensive evaluation method is used to assess the performance of a hospital's primary department. By using the five dimensions of productivity, quality, operation, social benefit and development indicators in the performance evaluation of a hospital's basic departments, the weights of each factor were determined by combining the principle of balanced scorecard and expert consultation method, and the fuzzy affiliation degree of each evaluation dimension was obtained by using the fuzzy comprehensive evaluation method, and the evaluation results were analyzed accordingly. The proportion of "good", "average" and "poor" is 47%, and according to the principle of maximum affiliation, the overall performance of the primary department of a hospital is 47%, 35% and 18% respectively. According to the principle of maximum affiliation, the overall performance of the basic department is evaluated as "good". It can be seen that the fuzzy comprehensive evaluation method can better solve the problem of the uncertainty of multiple indicators in the performance appraisal of the basic departments of the hospital, and the use of comprehensive evaluation method makes the evaluation results more reasonable and objective.

***Keywords****: Fuzzy comprehensive evaluation method, Basic section in hospital, Evaluation of performance.*

## I. INTRODUCTION

At present, relevant foreign studies have conducted extensive and in-depth research and detailed specification on the job evaluation system of hospitals [1], which has laid a solid foundation for hospital human resource management and even strategic management. Domestic research mainly focuses on job analysis, but there is less research on job evaluation in hospitals [2]. It can be said that China's hospital job evaluation model is still in the preliminary stage of theoretical exploration and practice. Through literature search, it is found that some hospitals or scholars have designed hospital job evaluation models through professional management consulting companies or on their own, and have carried out relevant practices on job evaluation [3]. The existing practice of job evaluation system in China mainly includes two parts, one part is the existing job evaluation system in China's hospitals, which mainly adopts the job classification

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method to classify and grade the jobs in medical institutions according to the job content, titles and administrative positions [4]. The other part is the exploration of the job evaluation model based on the elemental point method carried out by some hospitals in China, mainly by following the mature model, improving the applied model, and developing the model by themselves.

In this paper, we analyzed the development status and problems of comprehensive cost performance evaluation of a hospital's primary department using fuzzy comprehensive evaluation method, starting from improving the current target management appraisal system of the hospital's primary department [5], dividing the primary department into five levels of indicators according to the needs of appraisal: productivity indicators, quality indicators, operation indicators, social benefit indicators, and development indicators for weight analysis, and using multi-level fuzzy comprehensive evaluation The method of multi-level fuzzy evaluation was used to construct a scientific and fair evaluation model [6], and was applied in a hospital.

1 Basic principle of fuzzy comprehensive evaluation method

There are three elements to the comprehensive evaluation:

The set of factors has $U=\{u_1,\cdots,u_n\}$ , the set of factors of the object being judged.

The set of judgments $V=\{v_1,\cdots,v_m\}$ , the set consisting of rubrics.

Single-factor judgment, i.e., the judgment of a single factor $u_i(\mathrm{i}=1,\cdots,\mathrm{n})$ , yields a fuzzy set on $V$ ( $r_{i1,}r_{i2},\cdots,r_{im}$ ) , so it is a fuzzy mapping from $U$ to $V$ [2]

$$f:U\to F(V)$$

$$u_i\mid\to(r_{i1},r_{i2},\cdots,r_{im})$$

Let $f$ be the judging function, then

(1) $f(x_1,x_2,\cdots x_n)=\sum_{i=1}^{n}a_ix_i$

(2) $\sum_{i=1}^{n}a_i=1\ a_i\geq 0$

The fuzzy mapping $f$ can determine a fuzzy relation $R\in\mu_{n\times m}$, called the judgment matrix.

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$$R=\begin{Bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{Bmatrix}$$

It is composed of the set of all F's judged on a single factor.

Since the factors may not have equal status, the factors need to be weighted. $A=(a_1,a_2,\cdots,a_n)$ The set of $F$ on $U$ is used to denote the weight assignment of each factor, and it is synthesized with the judgment matrix R, which is the combined judgment of each factor.

Thus, a comprehensive evaluation model has to be

$$A\circ R=B=(b_1,b_2,\cdots,b_n)$$

Among them

$$A=(a_1,\cdots,a_n)\quad,\sum_{i=1}^{n}a_i=1\quad,a_i\geq 0$$
$$R=(r_{ij})_{m\times n}\quad,,,r_{ij}\in[0,1]$$
$$b_j=\sum_{i=1}^{n}a_i r_{ij}\quad,\quad j=1,\cdots,m$$

Here $b_j$ is a function of $r_{1j},r_{2j},\cdots,r_{nj}$ , which is the evaluation function. This model uses the addition and multiplication of real numbers, which is finer than using "$\wedge$ ,$\vee$ " operations.

## II. METHOD OF ESTABLISHING EVALUATION INDEX SYSTEM

In determining the hospital job performance evaluation tools, the different weight allocation of each evaluation element of job performance evaluation will also directly affect the accuracy of the job performance evaluation results, which in turn affects the rationality of the pay scheme design [7-8]. Thus, how to scientifically, objectively and accurately allocate the weights of each job performance evaluation element is very important to achieve pay equity within the hospital.

In this paper, we study the screening of hospital job performance evaluation elements mainly through two rounds of screening by Delphi expert consultation method and hospital job evaluation elements questionnaire method, and finally determine the evaluation elements of hospital job performance evaluation model [9]. Meanwhile, the following principles are mainly grasped in the process of screening

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job evaluation elements.

One of them is the principle of completeness. The selected evaluation elements must be common to all the positions to be evaluated [10], and not only those that are applicable to only a small number of positions can be selected.

Second, the principle of scientificity. Evaluation elements must be able to be clearly defined and measured [11], can truly reflect the value of the evaluated position, and have operability.

Third, the principle of independence. As far as possible, there should be no crossover and overlap between the selected evaluation elements [12]. Instead, it will lead to certain evaluation indexes being double-counted and the problem of unscientific and unreasonable scoring.

Fourth, the principle of importance. The number of selected evaluation elements should be appropriate [13], with the aim of facilitating the calculation and management of evaluation results. Too many evaluation elements will increase the burden of the job evaluator and make it easy to score unobjectively; on the contrary, too few evaluation elements [14] cannot cover all factors related to the organizational goals of each job in the organization, and likewise cannot objectively reflect the evaluated job.

Fifth, the principle of differentiation. Different positions have different knowledge and ability requirements, responsibilities, and job characteristics, etc. Different positions should be clearly distinguished [15], and the importance of evaluation elements should be significantly different among different positions.

Sixth, the principle of high acceptability. As an important tool for hospitals to guarantee the internal fairness of remuneration and the basis of hospital human resource management [16], the evaluation elements of job performance evaluation must be widely accepted.

2.1 Setting of Evaluation Indexes

2.1.1 Determine the first-level indicators.

The name and number of first-level indicators were determined according to the balanced scorecard principle, i.e., several main objectives were identified. Five first-level indicators were determined following the requirement that the established indicator system reflects performance.

2.1.2 Screening of secondary indicators.

The indicators contained in the domestic and foreign literature and related to the first-level indicators of the subject design were compiled to constitute a total of 246 selected indicators. On this basis, we analyzed and studied the indicators, clarified the connotation of each evaluation indicator, tried to use

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composite indicators, and reduced the indicators with strong correlation, and screened out 51 indicators. Using the expert panel method, 14 secondary indicators were obtained (as shown in Fig 1).

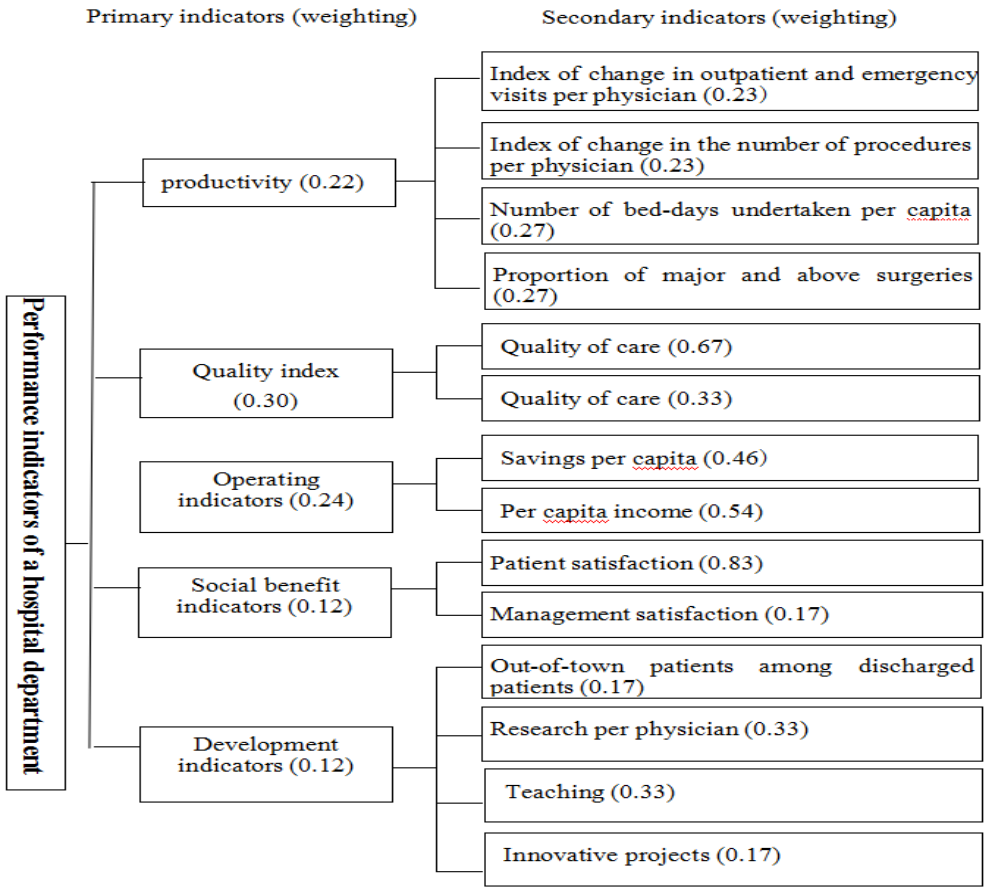


Fig 1: Performance evaluation index and weight assignment of a hospital's primary department based on balanced scorecard

2.2 Fuzzy Comprehensive Evaluation of a Section's Overall Performance

Determine the decision set, i.e., the evaluation rating set v = {good, fair, poor} and the evaluation index of a rating dimension as $U=\{u_1,u_2,\cdots,u_p\}$ , and the hospital managers and relevant experts who are familiar with each dimension of the hospital fill out the relevant survey form (e.g., TABLE I), and after calculating the fuzzy affiliation of the evaluation object on each index regarding the evaluation rating, these fuzzy affiliations constitute the fuzzy relationship matrix:

$$R=\begin{Bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{Bmatrix}$$

**TABLE I. Performance evaluation survey of a section**

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| TIER 1 INDICATORS | SECONDARY INDICATORS | Good | General | Difference |
|---|---|---|---|---|
| PRODUCTIVITY INDICATORS | Index of change in the number of outpatient and emergency visits per physician | 64 | 21 | 15 |
| | Index of change in the number of procedures per physician | 22 | 55 | 23 |
| | Number of bed days per capita | 67 | 21 | 12 |
| | The proportion of major surgery and above | 13 | 72 | 15 |
| QUALITY INDICATORS | Quality of care | 47 | 36 | 17 |
| | Quality of care | 52 | 29 | 19 |
| BUSINESS INDICATORS | Savings per capita | 31 | 47 | 22 |
| | Per capita income | 37 | 39 | 24 |
| SOCIAL BENEFIT INDICATORS | Patient Satisfaction | 84 | 11 | 5 |
| | Management Satisfaction | 79 | 12 | 9 |
| DEVELOPMENT INDICATORS | Out-of-town patients among discharged patients | 31 | 40 | 29 |
| | Research per physician | 44 | 37 | 19 |
| | Teaching | 51 | 27 | 22 |
| | Innovative Projects | 22 | 36 | 42 |

Where p is the number of elements in the evaluation index set u and m is the number of elements in the evaluation rating set v. Determine the weight vector of the evaluation index u as $A=(a_1,a_2,a_3\cdots,a_p)$ , then the fuzzy affiliation degree of this rating dimension is

$$B_i = A_i \circ R = (a_1,a_2,a_3\cdots,a_p)\begin{Bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{Bmatrix}, (i=1,\cdots,s)$$

The single-factor evaluation fuzzy matrix for each dimension is.

$$R_{\text{Productivity indicators}} = \begin{Bmatrix} 0.64 & 0.21 & 0.15 \\ 0.22 & 0.55 & 0.23 \\ 0.67 & 0.21 & 0.12 \\ 0.13 & 0.72 & 0.15 \end{Bmatrix}$$

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$$R_{\text{Quality Indicators}} = \begin{Bmatrix} 0.47 & 0.36 & 0.17 \\ 0.52 & 0.29 & 0.19 \end{Bmatrix}$$

$$R_{\text{Business Indicators}} = \begin{Bmatrix} 0.31 & 0.47 & 0.22 \\ 0.37 & 0.39 & 0.24 \end{Bmatrix}$$

$$R_{\text{Social Benefit Indicators}} = \begin{Bmatrix} 0.84 & 0.11 & 0.05 \\ 0.79 & 0.12 & 0.09 \end{Bmatrix}$$

$$R_{\text{Development Indicators}} = \begin{Bmatrix} 0.31 & 0.40 & 0.29 \\ 0.44 & 0.37 & 0.19 \\ 0.51 & 0.27 & 0.22 \\ 0.22 & 0.36 & 0.42 \end{Bmatrix}$$

Experts give the weights of the secondary evaluation indicators for each dimension as

$$A_{\text{Productivity indicators}} = (0.23, 0.23, 0.27, 0.27)$$

$$A_{\text{Quality Indicators}} = (0.67, 0.33)$$

$$A_{\text{Business Indicators}} = (0.46, 0.54)$$

$$A_{\text{Social Benefit Indicators}} = (0.83, 0.17)$$

$$A_{\text{Development Indicators}} = (0.17, 0.33, 0.33, 0.17)$$

A comprehensive evaluation matrix based on the set of evaluation factors $U = \{U1, U2, U3, U4\}$ was constructed using the single-factor comprehensive evaluation matrix $B_1, B_2, B_3, B_4, B_5$ , and C is the comprehensive evaluation result.

$$A = (0.22, 0.30, 0.24, 0.12, 0.12)$$

$$C = A \circ \begin{Bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \end{Bmatrix} = (0.22, 0.30, 0.24, 0.12, 0.12) \circ \begin{Bmatrix} 0.42 & 0.43 & 0.15 \\ 0.49 & 0.34 & 0.17 \\ 0.34 & 0.43 & 0.23 \\ 0.83 & 0.11 & 0.06 \\ 0.41 & 0.34 & 0.25 \end{Bmatrix}$$

$$= (0.47, 0.35, 0.18)$$

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2.3 Correspondence Analysis of Fuzzy Comprehensive Evaluation Results

Using the fuzzy synthesis of R overall performance calculation, the overall performance of a department of the hospital can be evaluated: the proportion of affiliation to "good" is 47%, and the proportion of "average" is 35%. The proportion of "poor" is 18%, and the overall performance of a department in the hospital is rated as "good" according to the principle of maximum affiliation.

## III. CONCLUSION

In this paper, according to the nature of each primary department of the hospital and the difference of its main functions, a department performance evaluation index system is established accordingly, the index weights are determined through the principle of balanced scorecard combined with expert consultation method, and a multi-level fuzzy comprehensive evaluation model is established to make a comprehensive evaluation of the performance of each department, which solves the comprehensive problem of multiple indicators relatively well and is continuously improved in the operation process. Combined with the development goals of the hospital, strong measures are taken to improve hospital performance and enhance the core competitiveness of the hospital.

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