The Model of Stroke Rehabilitation Service and User Demand Matching

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***Abstract*—This article focuses on matching stroke rehabilitation services, and patient needs through the interconnection between patient demand and rehabilitation service capabilities. A solution is proposed based on the KJ, fuzzy AHP, and QFD methods to address this problem. Specifically, the KJ method categorizes user needs, and the fuzzy AHP method calculates weights and rankings. Furthermore, rehabilitation service capability indicators are developed, and the QFD method is applied to match customer needs with rehabilitation service capability indicators. The service indicator value is constructed through mapping relationships, and the rehabilitation service capability value is obtained by adding up the results. The best matching scheme is predicted by comparing rehabilitation service capability values of service alternatives. The success of the model has been proven by examining the case. It has helped patients and service organizations find suitable caregivers. The research results illustrate that the proposed model can effectively address the problem of stroke rehabilitation services and patient needs matching and has practical value and potential applications. Therefore, this research is significant in enhancing the quality of stroke rehabilitation services and patient satisfaction and provides a reference value for future studies of similar issues.**

Keywords—Stroke; rehabilitation services; user needs; matching model

I. Introduction

Stroke is a significant public health issue worldwide, significantly burdening patients and society. Early post-stroke rehabilitation is crucial, and studies have shown that inpatient rehabilitation within 14 days after stroke onset could significantly improve daily living activities capabilities [1]. Stroke rehabilitation services accompany the entire rehabilitation process, and effectively meeting patient needs during the rehabilitation service delivery is essential to improve the quality of life and rehabilitation outcomes. Service and demand matching is a critical issue in effectively meeting patient needs.

Researchers have studied user needs matching for the service and demand matching problem. For example, Demain et al. [2] found that understanding and meeting patient needs is vital to alleviating treatment burden, and rehabilitation service providers need to focus on patient's psychological, social, and lifestyle needs. Reichert et al. [3] provided valuable insights into meeting cultural rehabilitation needs and improving the existing rehabilitation services by implementing workplace interventions, specifically through community-driven collaborative needs assessment that facilitated the establishment of responsive rehabilitation institutions. Joshi [4] emphasized the significance of patient-centred care in the success of outpatient surgeries, emphasizing the need for a clear understanding of the diverse needs of different patients. Lu et al. [5] investigated stroke patients' fundamental psychological needs, satisfaction, and influencing factors, focusing on the autonomy, competence, and relatedness aspects of patient needs. The study found that stroke increased patients' satisfaction with their relatedness needs while decreasing their autonomy and competence needs. Saut et al. [6] discussed the mechanisms and structures of patient and family participation in healthcare systems, indicating that reforming open culture and processes may promote service quality. Reforming open culture includes improving service quality through information sharing between patients and professional service providers and achieving a balance of rights between patients and service providers. Trivedi et al. [7], from the perspective of nursing physicians, promoted a smooth transition in post-discharge care by providing nursing education before patient discharge, which helped patients understand their own needs and thus promoted the quality of rehabilitation care.

Therefore, the current ways to match healthcare services with user needs include: providing more appropriate services by understanding factors such as patients' cultural backgrounds, religious beliefs, socioeconomic status, and living environments; continuously optimizing and adapting services through patient feedback and assessment; establishing good communication and trust with family members to better understand patients' needs and provide better services; promoting communication between patients and service providers, educating them about healthcare knowledge, and promoting patients' understanding of their own needs and the positive attitude of service providers. However, there are still many unmet needs in healthcare globally [8]. These unmet needs are because the focus is solely on users' needs in the service-demand relationship, neglecting the service providers' capabilities assessment. The lack of quality in healthcare services is due to insufficient research on user needs and the incorrect evaluation of their service capabilities.

In existing research, the only evaluation of service providers in the context of rehabilitation services is often their caregiving ability. Kardami et al. [9] demonstrated the feasibility and functionality of using a cancer scale to evaluate the caregiving ability of mothers of children with cancer, which can identify the nursing needs of pregnant women. The measurement scale includes five dimensions: effective role-playing, fatigue and subservience, trust, uncertainty, and ignorance of caring for children with cancer. The results showed that the scale had acceptable content, scope, construct

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validity and sufficient reliability. The cancer scale can be used to evaluate the caregiving ability of mothers of children with cancer in Iran. Zhong et al. collected data through the Caregiver Burden Inventory (CBI) and the World Health Organization Quality of Life to construct a caregiver difficulty scale to evaluate the burden on caregivers and the impact on the health of disabled children [10]. O'Malley et al. used the Caregiver Reaction Scale (CRS) to evaluate positive aspects of family caregiving experiences, such as role conflict, challenge, and caregiving, as a multidimensional measure [11].

Thus, the current research on evaluating caregivers' abilities is solely based on their reactions to various tasks, ignoring the link between patients' needs and caregivers' abilities. This study aims to develop a stroke rehabilitation service and user needs a matching model that considers the interplay between patients' needs and rehabilitation service capabilities. The aim is to offer more adaptable services for patients and rehabilitation institutions.

Compared to the statistical methods used in existing rehabilitation service research, the novelty of this study lies in constructing a resolution through a computational model, predicting service outcomes to enhance service quality and efficiency:

Firstly, this research employed the KJ method and fuzzy analytic hierarchy process (FAHP) to construct user demand indicators and assign weights to sort their importance.

Secondly, this research constructed service capability indicators.

Thirdly, this research mapped user demands to service capabilities using Quality Function Deployment (QFD) and used the value of the caregivers' comprehensive ability as the metric to evaluate rehabilitation service capabilities, aiding patients and service providers in matching appropriate service plans.

Finally, this research conducted a case analysis to validate the proposed model's feasibility. Through this case study, researchers demonstrated the feasibility of the model. Researchers helped patients and service providers find suitable caregivers that match patients' needs. Through this research, researchers hope to provide theoretical and practical guidance to optimize rehabilitation services for stroke patients and foster the development of the rehabilitation service industry.

In this thesis, Section I introduces the research problem. Section II briefly discusses related work. Section III describes the primary user needs and care service matching model. Section IV applies the model to a case study involving the selection of caregivers for stroke patients and compares its predictions with actual selection outcomes. Finally, Section V discusses the results of the case study, and Section VI concludes the work.

II. Related Work

A. Fuzzy Analytic Hierarchy Process (FAHP)

The Fuzzy Analytic Hierarchy Process (FAHP) is a multi-criteria decision-making method based on fuzzy mathematics theory, initially proposed by Professor Thomas L. Saaty of Northeastern University in 1970 [12]. It builds on the Analytic Hierarchy Process (AHP). It can convert fuzzy and uncertain information into mathematical quantities, facilitating analysis and processing.

Singh and Özşahin developed an interval fuzzy analytic hierarchy process (IFAHP) model to investigate the key factors influencing the selection of wooden outdoor furniture. They subdivided five major factors into sub-factors and conducted pairwise comparisons, using fuzzy numbers to represent the relative importance of each factor. By computing the weights of each factor, the researchers determined their relative importance in the overall hierarchy. Ultimately, they obtained a prioritization of factors to evaluate and prioritize outdoor furniture selection [13].

Xuan et al. developed an expert automatic cutting tool selection system using an integrated fuzzy analytic hierarchy process approach. They conducted a fuzzy hierarchy analysis evaluation of the distinguishing factors of the cutting tools to determine the priority of tool types. Then they selected the optimal tool type through sorting [14].

Wang proposed a feature-driven triangular fuzzy hierarchy process that obtained a support interval-based triangular fuzzy hierarchy process from the fuzzy multiplication preference relations matrix by establishing three positive definite matrices of feature problems and linear programming based on feature vectors. Additionally, a method for acceptability checks was suggested [15].

In summary, the fuzzy analytic hierarchy process is valuable for assigning weights and ranking relevant factors through hierarchical division and fuzzy evaluation of sub-factors in complex and multi-criteria screening problems. The differences between studies lie in the formulation of fuzzy rules. The fuzzy analytic hierarchy process was used to assign weights and rank the relevant factors of user needs and rehabilitation service capabilities for this paper's matching problem discussed of the stroke rehabilitation service and patient needs. This method helped to address the uncertainty and fuzziness problems in the analysis process of user needs and rehabilitation service evaluation factors, resulting in a reliable analysis process.

B. Quality Function Unfolding Method

Quality Function Deployment (QFD) is a method that converts customer requirements into product design specifications, aiming to enhance product quality and customer satisfaction by incorporating customer needs into product design and services. The core of QFD involves constructing and analyzing a series of matrices to transform customer requirements into product design specifications, which are then reflected in various aspects of the product.

Kürüm Varolgüneş et al. utilized QFD and AHP to design a thermal hotel building that meets customer needs and improves the quality of building design. The QFD method was employed to gather customer needs and opinions. In contrast, the AHP method evaluated different design options and selected the best one. Combining these two methods can provide a more comprehensive and accurate understanding of customer needs and improve the satisfaction and practicality of the building [16].

Baskir proposed a QFD-AHP model for evaluating after-sales services of automobiles based on customer beliefs. This model converts customer feedback into technical features in lean implementation. Managers, employees, and customers can use belief space evaluation to identify their perception mechanisms and experience how the uncertainty of perception mechanisms affects their decision-making. This model provides a more accurate and comprehensive solution by eliminating ambiguity in poor decision-making based on conceptual change [17].

Shan et al. proposed an optimized design framework combining the quantitative Kano model and fuzzy quality function deployment (QFD) model to best match enterprise service elements under uncertain and imprecise judgment information. This approach improves the quality and customer satisfaction of express delivery services [18].

Combining QFD and other methods, such as AHP and Kano model, provides a more comprehensive and accurate product design and service optimization solution. This application effect highlights the practicality of QFD in helping businesses understand customer needs and convert them into specific product design requirements, thus improving product quality and customer satisfaction. Additionally, combining different methods can further enhance the accuracy and comprehensiveness of analysis and decision-making. This study's combination of FAHP and QFD is feasible for matching the needs of stroke patients with rehabilitation services.

C. Health Care Service Capability

Current research on healthcare service capabilities has primarily focused on evaluating the general abilities of caregivers. Factors such as self-pressure, health management, coping strategies, age, financial status, social issues, self-efficacy, and disease severity have been found to affect caregiver ability [19-20]. However, such evaluations need more direct relevance.

Other studies have shown that caregiver participation in patients' rehabilitation exercises benefits their physical and mental health [21]. While existing research helps to diversify methods related to patient rehabilitation and maintaining caregivers' physical and mental health, it does not provide insights into matching patients with convenient care services.

Research on healthcare services from the perspective of patients and therapists includes rehabilitation therapy methods [22], assessment of rehabilitation outcomes and impacts [23], and the duration and contribution of rehabilitation interventions. However, such research weakens caregiver involvement.

Therefore, it is necessary to propose a model for matching stroke rehabilitation services with user needs from the perspective of patient needs and healthcare service capabilities. This model will provide valuable insights into improving the quality and effectiveness of stroke rehabilitation services.

III. Methodology for the Construction of a Matching Model Between User Needs and Health Care Services

A. User Requirements Acquisition

The matching model between user needs and care services is shown in Fig. 1. A combination of questionnaires, observation, and the Delphi method is used to gather demand information to ensure accurate user requirements. The questionnaire survey method often has low user participation and recall rates, but this can be improved by conducting quick surveys under typical situations. However, users' erroneous responses cannot be resolved. The observation method provides first-hand information but is time-consuming. The Delphi method requires achieving a specific consensus rate in each round through expert evaluations and has limited avenues to obtain indicators [24]. Combining these methods reduces their deficiencies. Since most stroke patients have post-stroke sequelae, it is necessary to interview family members and patients and observe their behaviour to obtain primary needs. The most critical demand indicators are screened by requiring the patient's rehabilitation therapist and the primary doctor to act as Delphi method experts.

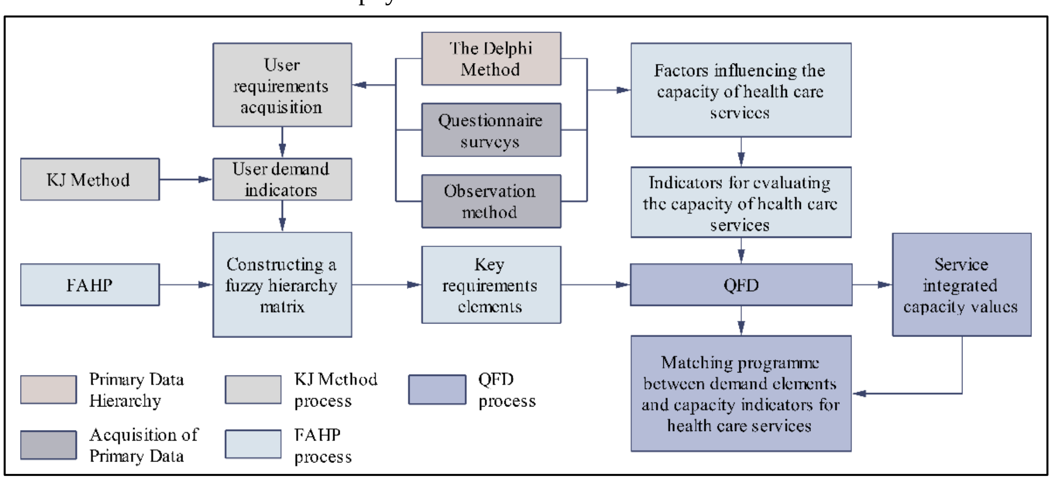

Fig. 1. Matching model of user needs and rehabilitation services.

B. Fuzzy Hierarchical Analysis Deals with Demand Indicators

1) KJ Method stratified user requirements indicators: Clustering analysis and the KJ method are commonly used for hierarchical requirement analysis. While clustering analysis has the advantage of concise and intuitive data processing, it requires a large sample size [25]. On the other hand, the KJ method is not limited to numbers and is also suitable for text descriptions [26]. Therefore, in this study, researchers opted for the KJ method to classify user requirements hierarchically.

The KJ method is typically conducted in the form of cards. However, researchers encoded the indicators in this study instead of distributing cards. We asked the respondents to use the same code for similar information. Participants, including rehabilitation teachers, nurses, and some patients, were invited to participate in a group study using the KJ method. Researchers finally divided 24 indicators into 3 levels and 4 modules, as shown in Fig. 2.

2) Fuzzy hierarchical analysis (FAHP) quantitative steps

a) Defining fuzzy rules: To achieve precise and accurate outcomes with minimal requirements for periodic modifications to data consistency, we defined a fuzzy scoring interval of [0,1], with adjacent score differences of 0.1. The final score was then selected from the three available values {0,0.5,1} (referred to as "three values" in this study). Specifically, the initial score was compared with {0,0.5,1}, and the value in the three values closest to the actual value was chosen as the final score, resulting in a new fuzzy rule.

b) Demand stratification: Using the KJ method, the research team obtained the target layer G, the quasi-measurement layer Z, and the indicator layer E, forming a three-level fuzzy analytic hierarchy. Researchers first used the three values to construct a fuzzy priority consensus matrix. Then researchers generated a fuzzy judgment consensus matrix using an improved fuzzy analytic hierarchy process [27].

To avoid the need for further consistency evaluations, we took the following measures:

Firstly, to establish the consistency matrix for constructing the fuzzy priority relationship, we used the three values $\{0,0.5,1\}$, which facilitated explicit judgments and avoided confusion. First, we constructed a fuzzy priority relationship matrix a_{ij}, with each position labelled by i and j, where i represents the row number and j represents the column number. In the three values, 0 indicates that j is more critical than i, 0.5 indicates that i and j are equally important, and 1 indicates that i is more critical than j. The consistent matrix factor for the fuzzy priority relationship is obtained by summing the rows to obtain r_i and the columns to obtain r_j, where $i = \{1, \cdots, s\}$ and $j = \{1, \cdots, n\}$, with s representing the number of rows in the matrix and n representing the number of columns. The relationship between the factors in the matrix can be expressed as:

$$a_{ij} + a_{ji} = 1 \tag{1}$$

Secondly, we converted the fuzzy priority relationship consensus matrix into a fuzzy judgment consensus matrix. The formula for constructing the factor b_{ij} in the fuzzy judgment consistency matrix is:

$$b_{ij} = \frac{r_i - r_j}{2s} + 0.5 \tag{2}$$

Thirdly, we calculated and ranked the weights.

The first step was to calculate the product of the elements in each row of the judgment matrix and then calculate the s-th root of the product. Next, we normalized the eigenvector to obtain the weight vector W_Z. The weight vector W_E represents the relative importance weight of each indicator for the upper quasi-criterion factor, and W is the integral vector. Finally, the ranking was based on the integral weight, and the formula is as follows:

$$M_i = \prod_{j=1}^{n} b_{ij} \tag{3}$$

$$\overline{W_i} = \sqrt[s]{M_i} \tag{4}$$

$$W_i = \frac{\overline{W_i}}{\sum_{i=1}^{s} \overline{W_i}} \tag{5}$$

$$W = W_Z * W_E \tag{6}$$

Tier 1 Demand G(target level)	User needs			
Secondary demand Z(guideline level)	Life Care A	Treatment Care B	Evaluation Observation C	Consumables supplied D
Tier 3 Demand E(indicator layer)	A8 Consumables selection A7 Fall and bed fall prevention A6 Drug feeding A5 Urinary catheterization A4 Cleanliness A3 Body Massages A2 Pneumotomy care A1 Food and Drink	B5 Positive Psychological Intervention B4 Assistance in the use of equipment B3 Assistance with training B2 Assistance with treatment B1 Transporting patients for treatment	C5 Observation of psychological dynamics C4 Mental state C3 Functional impairment assessment C2 Self-care assessment C1 Physical Indicator Testing	D6 Fogging Kits D5 Diaper pads D4 Disinfectant D3 Suction tube D2 Urine bags D1 Air cutting kit

Fig. 2. KJ affinity diagram.

c) Fuzzy Analytic Hierarchy Process (FAHP) was used to calculate weights and rankings.

The expert group was asked to make critical judgments and calculate the average value. Based on the fuzzy rules of this study, the most suitable value was selected from the three values, and the fuzzy priority relationship consistency matrix was constructed and converted into a fuzzy judgment consistency matrix. The fuzzy consistency matrices for the goal layer G, quasi-measurement layer A, quasi-measurement layer B, quasi-measurement layer C, and quasi-measurement layer D are shown in Tables I to V. The indicator layer weight W_E and criterion layer weight W_Z were calculated using formulas (4) - (6). The total weight W was obtained by multiplying the indicator and criterion layer weights, as shown in TableVI.

C. Construction of Indicators for the Evaluation of Health Care Services

After four months of in-depth research in a rehabilitation hospital in Shenzhen, China, semi-structured interviews were conducted with 25 nursing staff and 51 patients and their family members. The results were analyzed, summarized, and organized. Focus group discussions were also held with several frontline rehabilitation therapists. The results showed that the duration of the patient's illness, cultural level, and cooperation level can affect the rehabilitation outcomes. The cultural level, body weight, lifestyle habits, health philosophy, coping skills, time management skills, psychological quality, professional spirit, and caregivers' communication skills can also affect the rehabilitation results.

Compared with existing studies on the comprehensive ability factors of family caregivers, disease-related knowledge, daily and disease-related care skills, coping strategies, self-stress, and health management are used as standards. Some scholars have also added hope level [28] and readiness level [29]. Some scholars aim to improve the effectiveness of rehabilitation nursing interventions by focusing on the sense of interest of caregivers [30]. Understanding disease, daily and disease-related care skills belong to professional abilities; coping strategies are problem-solving skills; self-stress is a psychological quality, and health management is a health concept and lifestyle habit. Hope level and readiness levels are professional ability and time management skills, and the interest of caregivers is a psychological quality. High-quality nursing and efficient care are preparations for good quality of life for patients after discharge.

In contrast, nursing staff can improve the cooperation level of patients through psychological intervention. The key to joint efforts by nursing staff and patients is setting realistic rehabilitation expectations [31]. Patients understand their disease correctly and actively cooperate, leading to a healthy life. Patients and caregivers need to create reasonable rehabilitation expectations. Caregivers should keep in mind the patient's rehabilitation goals. In order to clarify the influencing factors, nursing staff, work, patients and diseases should be studied separately. The patient's cooperation level can represent the caregiver's communication and coping abilities. The indicators of the final rehabilitation serviceability are physical health (I1), lifestyle habits (I2), health philosophy (I3), coping skills (I4), time management skills (I5), psychological quality (I6), professionalism (I7), and communication skills (I8), as shown in Fig. 3.

D. Mapping of User Needs and Wellness Service Capabilities

QFD is often used in product design to convert user needs into technical product characteristics [32]. The user mapping relationship determines the technical importance of needs indicators and technical features. In this study, a scoring method was used to evaluate the rehabilitation service capability under different user needs indicators, and then the weight of user needs indicators was multiplied by the score of rehabilitation service capability indicators. The scoring uses three values $\{0,0.5,1\}$, where 0 represents a low service capability match, 0.5 represents a moderate service capability match, and 1 represents a high service capability match.

A correlation was established between user needs indicators and rehabilitation service capability indicators based on the significance score of the latter. The rehabilitation service capability is measured by the total ability value VA of the caregiver, and the caregiver with the highest VA value can be regarded as the best match. The scoring of the caregiver's ability indicators is evaluated by the hospital or caregiver service institution based on the matching ability of the user needs indicators, forming a fuzzy matrix J. W_n is the weight of user needs indicators, where n is the number of demand indicators and $\in \mathrm{R}^+$. The caregiver's ability indicator is P_k, where k is the number of comprehensive ability indicators of caregivers, and $k \in \mathrm{R}^+$. The matrix J represents the mapping of user needs and caregiver's ability indicators:

$$J = \begin{matrix} W_1 \\ \vdots \\ W_n \end{matrix} \begin{bmatrix} P_{11} & \cdots & P_{1k} \\ \vdots & \ddots & \vdots \\ P_{n1} & \cdots & P_{nk} \end{bmatrix} \quad (7)$$

The calculation method of the total ability value VA of the caregiver based on the fuzzy matrix J is as follows:

$$VA = \sum_{K=1}^{k} \sum_{N=1}^{n} W_n * P_{nk} \quad (8)$$

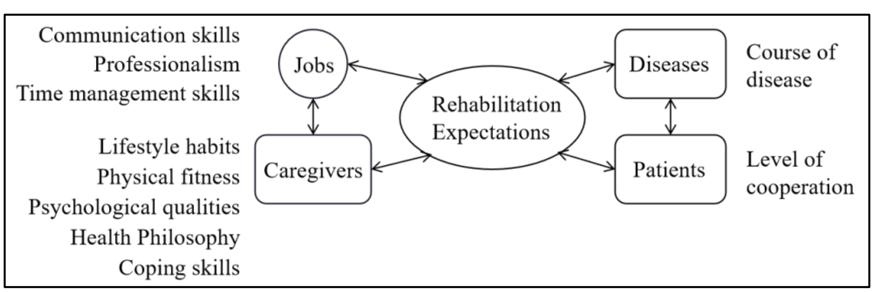

Fig. 3. Caregiver capacity indicators.

IV. Case Study: Choice of Carer for a Stroke Patient

A. Description of the Problem

The feasibility of the matching model proposed in this study was demonstrated using the example of a patient in a rehabilitation hospital in Shenzhen, China, who needed to select a caregiver. The patient was paralyzed due to a stroke and required bedridden care, feeding, urinary catheterization, and other rehabilitation services. As the patient's family members were busy with work, they needed to hire a caregiver with a high degree of matching ability to provide the necessary care. The rehabilitation hospital collaborated with several caregiving service institutions and provided six caregivers for selection. The patient's family members could use the matching model proposed in this study to select the best caregiver based on the patient's demand indicators and the caregiver's ability indicators.

B. Test Rules

This model selects the most suitable caregiver by calculating the comprehensive ability value of six caregivers based on the patient's demand indicators. Then, the six selected caregivers provided one week of rehabilitation services based on their numbers. The patient or their family can evaluate the caregivers' performance during the week and select the most suitable caregiver to continue service. The model's feasibility is determined by comparing the results obtained from the model calculation and essential service. The matching model can be feasible if the caregiver number matches between the two. If the number does not match, an error analysis is conducted using the caregiver's comprehensive ability value. If the error is small, the model can be revised and used; if the error is too large, the model needs to be modified to meet the actual needs better, or it will not meet the actual requirements.

C. Test Method

According to the architecture of the model shown in Fig. 1 and the framework of user demand indicators and caregiving ability indicators built in Section III, six nurses and four rehabilitation therapists were invited as evaluation experts and were evenly divided into two groups: a model group and an experimental group. The model group mainly participated in asking about user requirements, scoring user demand indicators, and scoring the caregiving ability indicators of the six caregivers provided by the rehabilitation institution to provide input for the model calculation. The experimental group mainly discussed and selected a suitable caregiver based on the effectiveness of the caregiver's services and the feelings of the patient and family members. The two groups of experts are not allowed to discuss with each other. The experimental process is shown in Fig. 4.

D. Calculation Results

User demand and caregiving service indicators were constructed, and demand weights and caregiving ability values were calculated based on formulas (1) to (8), as shown in Tables I to VII and Fig. 5. Table I to Table V represents pairwise comparison matrices and their respective weight values for user requirement factors. Table VI represents the comprehensive weight and ranking of user requirement factors. Table VII represents the scores for healthcare service indicators corresponding to user requirements and the total ability value of the caregiver. Fig. 5 represents the comprehensive capability values of different caregivers. Finally, caregiver No. 1 had the highest matching degree, with a comprehensive ability value of 3.320. After the six caregivers provided caregiving services for one week each, the experimental group and the patient's family discussed and decided to keep caregiver No. 1, consistent with the model's prediction.

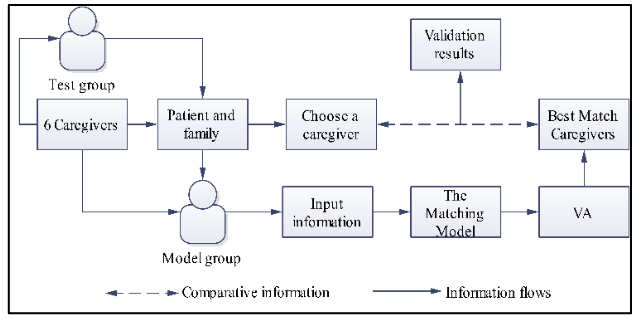

Fig. 4. Test process.

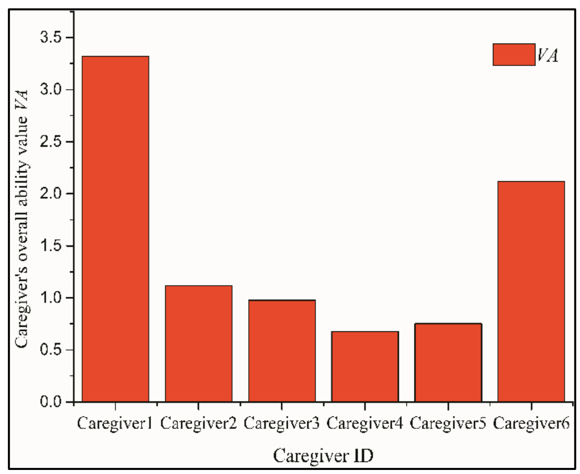

Fig. 5. Results of the capacity matching model for rehabilitation services.

TABLE I. G-RELATIONSHIP MATRIX - FUZZY MATRIX AND ITS WEIGHTS W_Z

G	A	B	C	D	W_Z
A	1.500	1.500	0.500	0.500	0.350
B	1.000	1.000	0.500	0.500	0.311
C	0.500	0.500	0.167	0.167	0.119
D	0.500	0.500	0.250	0.250	0.220

TABLE II. B-RELATIONSHIP MATRIX - FUZZY MATRIX AND ITS WEIGHTS W_{EB}

B	B1	B2	B3	B4	B5	W_{EB}
B1	0.000	0.500	1.000	0.500	-0.750	0.000
B2	0.500	0.750	1.000	0.750	0.125	0.125
B3	0.667	0.833	1.000	0.833	0.417	0.386
B4	0.500	0.625	0.750	0.625	0.313	0.309
B5	0.250	0.350	0.450	0.350	0.100	0.179
		D6	0.249	0.055		9

TABLE III. C-RELATIONSHIP MATRIX - FUZZY MATRIX AND ITS WEIGHTS W_{EC}

C	**C1**	**C2**	**C3**	**C4**	**C5**	W_{EC}
C1	1.500	1.750	0.250	0.750	0.750	0.209
C2	1.125	1.250	0.500	0.750	0.750	0.356
C3	0.417	0.500	0.000	0.167	0.167	0.000
C4	0.563	0.625	0.250	0.375	0.375	0.189
C5	0.550	0.600	0.300	0.400	0.400	0.247

TABLE IV. D-RELATIONSHIP MATRIX - FUZZY MATRIX AND ITS WEIGHTS W_{ED}

D	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	W_{ED}
D1	0.000	0.250	1.000	0.750	-0.500	0.000	0.000
D2	0.375	0.500	0.875	0.750	0.125	0.375	0.042
D3	0.667	0.750	1.000	0.917	0.500	0.667	0.295
D4	0.563	0.625	0.813	0.750	0.438	0.563	0.265
D5	0.300	0.350	0.500	0.450	0.200	0.300	0.149
D6	0.417	0.458	0.583	0.542	0.333	0.417	0.249

TABLE V. A-RELATIONSHIP MATRIX - FUZZY MATRIX AND ITS WEIGHTS W_{EA}

A	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	W_{EA}
A1	0.500	1.000	0.500	-0.750	0.500	1.500	1.250	-0.500	0.041
A2	0.750	1.000	0.750	0.125	0.750	1.250	1.125	0.250	0.064
A3	0.500	0.667	0.500	0.083	0.500	0.833	0.750	0.167	0.042
A4	0.188	0.313	0.188	-0.125	0.188	0.438	0.375	-0.063	0.019
A5	0.500	0.600	0.500	0.250	0.500	0.700	0.650	0.300	0.141
A6	0.667	0.750	0.667	0.458	0.667	0.833	0.792	0.500	0.265
A7	0.607	0.679	0.607	0.429	0.607	0.750	0.714	0.464	0.259
A8	0.375	0.438	0.375	0.219	0.375	0.500	0.469	0.250	0.169

TABLE VI. WEIGHTING AND RANKING OF REHABILITATION CARE USER NEEDS

Criteria layer (weights)	**Indicator layer**	**Weights**	**Combined weights**	**Combined ranking**
Life Care A（0.35）	A1	0.041	0.014	19
	A2	0.064	0.022	17
	A3	0.042	0.015	18
	A4	0.019	0.007	21
	A5	0.141	0.050	10
	A6	0.265	0.093	3
	A7	0.259	0.091	4
	A8	0.169	0.059	6
Treatment Care B（0.31）	B1	0.000	0.000	22
	B2	0.125	0.039	12
	B3	0.386	0.120	1
	B4	0.309	0.096	2
	B5	0.179	0.056	8
Evaluation Observation C（0.12）	C1	0.209	0.025	15
	C2	0.356	0.042	11
	C3	0.000	0.000	23
	C4	0.189	0.022	16
	C5	0.247	0.029	14
Consumables Supplied D（0.22）	D1	0.000	0.000	24
	D2	0.042	0.009	20
	D3	0.295	0.065	5
	D4	0.265	0.058	7
	D5	0.149	0.033	13

TABLE VII. MAPPING OF USER NEEDS AND REHABILITATION SERVICE CAPABILITIES

Needs indicators	**Needs weights**	**Indicators of the capacity of rehabilitation services**								**Service capability values VA**
		I1	I2	I3	I4	I5	I6	I7	I8	
A1	0.014	0.000	0.000	0.007	0.007	0.000	0.000	0.007	0.014	Caregiver 1 : VA =3.320
A2	0.022	0.011	0.000	0.000	0.000	0.000	0.022	0.000	0.000	
⋮	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋮	
D6	0.055	0.027	0.000	0.027	0.000	0.027	0.000	0.000	0.000	
Service indicator values		0.330	0.264	0.334	0.087	0.204	0.186	0.256	1.660	
A1	0.014	0.014	0.014	0.000	0.000	0.007	0.000	0.007	0.007	Caregiver 2 : VA =1.117
A2	0.022	0.000	0.011	0.000	0.000	0.000	0.000	0.011	0.011	
⋮	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋮	
D6	0.055	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Service indicator values		0.169	0.117	0.137	0.087	0.067	0.094	0.236	0.210	
A1	0.014	0.007	0.007	0.000	0.000	0.014	0.000	0.007	0.000	Caregiver 3 : VA =0.977
A2	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
⋮	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋮	
D6	0.055	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Service indicator values		0.078	0.094	0.153	0.050	0.127	0.133	0.179	0.163	
A1	0.014	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	Caregiver 4 : VA =0.679
A2	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
⋮	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋮	
D6	0.055	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Service indicator values		0.053	0.000	0.091	0.046	0.060	0.098	0.218	0.113	
A1	0.014	0.007	0.000	0.007	0.000	0.000	0.000	0.007	0.007	Caregiver 5 : VA =0.752
A2	0.022	0.000	0.011	0.000	0.011	0.000	0.022	0.011	0.000	
⋮	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋮	
D6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Service indicator values		0.060	0.048	0.083	0.046	0.107	0.082	0.138	0.189	
A1	0.014	0.014	0.000	0.014	0.007	0.014	0.007	0.014	0.007	Caregiver 6 : VA =2.118
A2	0.022	0.011	0.011	0.011	0.011	0.000	0.011	0.011	0.011	
⋮	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋮	
D6	0.055	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	
Service indicator values		0.317	0.156	0.269	0.167	0.379	0.193	0.361	0.275	

V. DISCUSSION

In this discussion, researchers try to explore the advancements and significance of our research. The experimental results indicate that the actual selection results are consistent with the predicted results, suggesting the feasibility of the model.

From the calculation data, the patient's demand weight ranking shows that due to being bedridden from paralysis, the patient has a higher demand for living care and rehabilitation training. Therefore, the requirements for service focused on strengthening communication skills, health concepts, caregiver physical fitness, and living habits. The model has performed well in caregiving services, especially caring for patients, through the joint efforts of nurses, rehabilitation therapists, family members, and researchers.

Compared to existing research [6 - 7], the advanced nature of this study lies in its innovative approach, which evaluates and matches user needs and service capabilities from the perspective of the linkage between the two. This mould is done through various methods to meet patients' needs better and improve the quality and efficiency of care services.

In contrast to existing research on demand and capability matching, which uses patient rehabilitation needs quantification [33] and mainly relies on physician experience to predict individual patient discharge pathways, this study stratifies user demand factors, assigns weights, and maps them to service factors. It calculates the degree of match between predicted user needs and services and involves doctors, patients, and third-party service providers in the prediction process. The model developed in this study is more comprehensive in considering the matching relationship and is, therefore, more advanced than existing research.

Moreover, this model has demonstrated practicality in the case study, and we believe it provides more flexible service guidance for patients and rehabilitation institutions. However, the current limitation of this model lies in the fact that its accuracy and reliability depend on the reliability and precision of the data samples. To further improve the model's adaptability, it is necessary to attempt more data analysis.

VI. CONCLUSION

The stroke caregiving service and user demand matching model proposed in this study constructed user demand indicators using the KJ method and fuzzy analytic hierarchy process. They constructed caregiving ability indicators from a service perspective. The model mapped the matching relationship between user demand and caregiving ability indicators using QFD and used the caregiver comprehensive ability value to measure caregiving serviceability evaluation to match suitable caregivers for patients and service institutions and improve the quality and efficiency of caregiving services.

Future research can further optimize the evaluation indicators and parameters of the model to improve its accuracy and reliability. Secondly, this research only focused on stroke caregiving services, and future research can apply this model to other rehabilitation service fields to further verify its practicability and feasibility.

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