Designing a Multi-Criteria Decision-Making Framework to Establish a Value Ranking System for the Quality Evaluation of Long-Term Care Services

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Abstract

Various levels of government across Taiwan are eager to promote the establishment of long-term care residential facilities to meet the significant caregiving needs arising from the wave of population aging. However, the successful establishment of an effective mechanism relies on proper supervision and guidance. Therefore, implementing a value assessment system for long-term care service quality management is of paramount importance. Using multi-criteria decision-making (MCDM) approach can provide effective conditions for the establishment of such system and enable a more comprehensive and objective evaluation of long-term care service quality. Using this system, decision-makers can incorporate different indicators based on various needs and weights to evaluate the quality and performance of long-term care services. This facilitates the determination of priorities and the formulation of improvement strategies, thereby enhancing the quality of long-term care services. This study develops an information-based assessment model for a platform that is win-win for both institutions and individuals. The model incorporates consumer reputation and environmental social governance (ESG) dimensions, in addition to indicators such as operational and management efficiency, professional care quality, safety and environmental facilities, and protection of individual rights and interests. Further, it integrates multiple indicator items and employs the analytic hierarchy process (AHP) to decompose and structure complex multi-dimensional issues, thereby aligning itself with current corporate evaluations. It aims to assist care service agencies in making key service quality decisions across different dimensions, and enhance the overall quality and competitiveness of those agencies, while increasing public trust and recognition in the evaluation of care service quality.

Keywords: Long-term care, Enterprise value, Ranking system, Multi-criteria decision-making, Business sustainability

1 Introduction

The global elderly population is experiencing a rapid growth. According to statistics from the World Health Organization (WHO), the worldwide number of individuals aged 60 and above reached approximately 1 billion in 2019, and this figure is projected to ascend to 1.4 billion by 2030 and further surge to 2.1 billion by 2050 [1]. This demographic pattern manifests across continents, with the Asian region alone anticipated to account for over 60% of the global rise in the elderly population between 2021 and 2050 [2]. Consequently, the rapid expansion of population aging holds profound ramifications for global demographic dynamics. The inescapable caregiving issues arising from the aging phenomenon are of significant global concern, prompting an increasing recognition of the multifaceted long-term care requirements associated with this demographic shift.

Using Taiwan as an example of the Asian region, the proportion of individuals aged 65 and above has been rapidly increasing since Taiwan entered an aging society in 1993. According to the National Development Council, Taiwan's elderly population is projected to surpass 20% by 2025, thereby entering a super-aged society. This issue continues to escalate in Taiwan, leading to an increasing demand for long-term care services. Considering the pressures of declining birth rates and population aging, the professional resources for long-term care and healthcare has proved insufficient to cope with the rapid expansion of the aging population. From the time of entering an aging society until 2020, which was merely a two-year period, the dependency ratio increased by 2.27%, while the old-age dependency ratio rose by 2.46%. This indicates that, on average, every year, one additional elderly person needs to be supported by every 100 working-age individuals. It is projected that by 2025, the elderly dependency ratio will reach 6.87%, with an increasing trend each year. By 2050, the elderly population will reach its peak, with an annual average increase of 15.32% over a span of 25 years. Therefore, the issue of elderly care is a compelling matter that requires immediate attention [3].

To address the substantial demands associated with the aging population, the WHO defines long-term care residential facilities as institutions that provide a range of health and social care services for elderly adults. These services encompass observation, treatment, and support for family members, aiming to effectively manage/address the complex health needs of the elderly [4]. In Taiwan, with the implementation of Long-term Care 2.0, the emphasis is on the realization of the concept of local aging [5]. It involves strengthening services between neighborhoods and homes, integrating professional medical and caregiving personnel, consolidating available resources, and gradually improving the quality of healthcare services. This allows for effective expansion of these resources to the community. Currently, elderly care residential facilities in Taiwan include nursing homes, long-term care residential facilities, rehabilitation centers/convalescent facilities, and assisted living facilities. As of the end of February 2023, there were 1,065 long-term care and assisted living institutions, with a capacity of 60,863 residents. The actual number of residents was 50,037, resulting in an occupancy rate of 82% [6]. With the promotion of relevant policies, the number of care service entities continues to increase.

It is natural for individuals to desire proper care during their elderly years owing to the inevitable process of aging. In situations where elderly family members have become disabled and require long-term care while their children are unable to provide companionship owing to work commitments, the intervention of professional caregivers and healthcare resources becomes crucial to maintain their quality of life and stability. However, when selecting a long-term care residential facility, apart from engaging in prior communication and assessment, it is essential to gather resources from various channels to identify the most suitable institution. This involves comparing information from different sources, such as seeking advice from relatives or friends with similar experiences, conducting online searches, or referring to government evaluations of welfare institutions for the elderly conducted every four years. These efforts facilitate an in-depth understanding and evaluation of caregiving facilities.

In Taiwan, the "Evaluating and Rewarding Enforcement for Senior Citizens' Social Welfare Organizations" was promulgated in 2000. This regulation applies to national, provincial public, publicly owned private, and foundation-based senior citizens' welfare organizations. It mandates that these organizations adhere to the evaluation guidelines for senior citizens' welfare institutions and undergo evaluations conducted by the central supervisory authority at least once every four years [7]. This regulation aims to standardize the service quality of institutions, safeguard the residents' rights and well-being, and enhance consumer choices for the general public. The government's evaluation process, encourages institutions to improve their comprehensive services and address any operational issues or challenges through guidance and support [8]. Currently, the institutional evaluation primarily encompasses five dimensions; however, it faces several challenges. These include reliance on paper-based documentation for review (environmental protection and informatization), inflexibility in adjusting review

recommendations to align with the actual circumstances of institutions (adaptive to local conditions), and the four-year evaluation interval that may compromise timeliness [9]. However, the reward and punishment mechanisms of the evaluation system have constrained the survival space of many small-scale eldercare institutions. Some experts and scholars argue for the implementation of a third-party fair evaluation system that emphasizes feedback from service recipients, enabling them to have a sense of satisfaction [10]. Despite the existence of relevant regulations owing to policy implementation, there is a lack of an adaptable evaluation model that can respond to changes. Determining the appropriate standards or criteria to establish and develop service quality that earns customers' trust has become a challenging task for institutional operators.

Based on the above, this study analyzes various evaluation models both across Taiwan and worldwide, and incorporates ESG indicators [11] to construct an innovative evaluation process for care institutions. The focus is on comparing and analyzing similar institutions and providing overall assessment recommendations. The evaluation serves as a basis for predicting and investing in the sustainable operations of institutions and informing management in decision making, by integrating diverse perspectives.

2 Methodology

This chapter comprises three sections. Section one explores the evaluation methods for care residential facilities. Currently, long-term care residential facilities based on established criteria are classified into accommodation-based, home-based, and community-based models. Specifically, accommodation-based models can be further categorized as care facilities and nursing homes. Section two elaborates upon the evaluation model for care residential facilities. Section three outlines the steps of MCDM analysis.

2.1 Exploring the Evaluation Methodology of Care Institutions

The evaluation framework for long-term care service institutions established by the Ministry of Health and Welfare (MOHW) encompasses five major dimensions. These dimensions include operational management efficiency, professional care quality, safety of environmental facilities, protection of individual rights, and innovative initiatives for service enhancement. Within the assessment methodology, a total of 54 items are subjected to document review. Among these, 6 items are categorized as Level 1 essentials, while 3 items are classified as Level 2 enhancements. The following analysis and explanations are provided:

A. Operational Management Efficiency: In Level 1, Essential Criteria A7, it is mentioned that the institution must comply with relevant legal regulations, employ full-time personnel, provide labor and health insurance coverage, and allocate labor retirement funds. The calculation of labor insurance expenses is as follows: labor insurance portion is calculated as insured salary × standard accident rate (10.5%) × 20% + insured salary ×

employment insurance rate (1%) × 20%; health insurance portion is calculated as insured salary × health insurance rate (4.69%) × 30%. For instance, if the base salary is assumed to be 30,300 NTD, the labor insurance cost would be 697 NTD, and the health insurance cost would be 426 NTD. This does not include occupational accident insurance. If a director has received labor insurance elderly benefits and is over 60 years old without participating in labor insurance, but has received retirement benefits from other social insurance, they can enroll in occupational accident insurance if re-employed. In Level 1, Essential Criteria A8, the criteria explain the appointment of full-time and part-time staff. For instance, there should be nursing staff on duty at all times. If foreign caregivers are employed, their number should not exceed half of the total number of caregivers, and at least one Taiwanese caregiver should be on duty at all times. Staff lists and relevant documentation need to be reviewed. Scheduling information for institution staff for the entire month can be reviewed through the information system. In Level 2, Enhanced Criteria A2, regulations for admitting and discharging service recipients are specified. The content should include service recipients, processes and assessment mechanisms, service plans, and fee standards. These should be periodically revised, and records should demonstrate the status and information of service recipients. The assessment involves document review and on-site interviews to verify if the number of on-site service recipients and the types of cases admitted align with the institution's approved registration type and numbers as stipulated by the regulatory authority.

B. Quality of Professional Care: In the enhanced Level 2, Criterion B2 explanation, it is stipulated that newly admitted service recipients should receive individualized care within 72 hours of admission. This includes assessments of physical, psychological, and social needs, establishing a profile for each service recipient. This profile should encompass vital signs, language, vision, hearing, health cognitive processing, cardiorespiratory function, skin condition, nutritional status, pain, excretory functions, activity status, fall occurrences, leisure, sleep, and emotional well-being. At least every 3 months, or as per the needs of the service recipients, evaluations of their physical (including nutritional), psychological, social, cognitive, and functional activities should be conducted. In the enhanced Level 2, Criterion B9 explanation, it is mandated that staff measure the body temperature of service recipients at least once daily and their own body temperature at least once weekly. Comprehensive records should be maintained, documenting the daily temperature measurements for all service recipients.

C. Safety Environment Equipment: In Level 1, Item C9 of the required criteria, it is specified that norms should include self-inspection records of daily use of fire, electricity, fire safety equipment, and fire evacuation facilities within the past year. Long-term care facilities should conduct monthly self-inspections of internal electrical equipment safety and maintain records accordingly.

D. Case Rights Protection: Level two reinforcement. In the explanation for criterion D1, it specifies the circumstances for ensuring the confidentiality of service recipient data through the regulation of system user permissions. Additionally, it involves the statistical analysis of service recipient's daily life activities and functionalities within the management system, in accordance with the MOHW's policy of uploading care service data. The analytical results are then utilized to formulate specific responses or improvement measures, serving as references for internal quality enhancement.

E. Service Improvement and Innovation: Provide innovative measures or initiatives that align with policy implementation, such as (1) ensuring the safety of service recipients, (2) developing innovative care service models for special groups, (3) participating in policy-related projects or pilot programs. At least one of these initiatives should be implemented, and a consensus decision should be reached by the evaluation committee. A maximum of 2 points can be awarded. Deductions will be made for violations and confirmed significant negative incidents during the evaluation period. Violations may include instances of overcharging and concealing residents, improper treatment of service recipients, and other violations confirmed by regulatory authorities. Significant negative incidents could encompass cases of internal abuse within the organization, staff violence towards service recipients, public safety accidents, or other negative incidents determined by regulatory authorities.

The above are partial evaluation items, with each evaluation criterion having a maximum score of 4 points. An A grade earns 4 points, and so on, with an E grade earning 0 points. A total score of ≥ 90 is considered excellent. In addition, there are 9 mandatory first-level criteria. If C9 does not reach an A grade and C10 does not reach a B grade, it will not be classified as excellent or first class. Furthermore, if fewer than 3 criteria are at an A grade, it cannot be classified as excellent. If there are 4 or more criteria below an A grade, it cannot be classified as first class. There are also 9 enhanced second-level criteria. If fewer than 3 criteria are at an A grade, it cannot be classified as excellent. The evaluation process consists of 6 steps: 1. Preparation Meeting (5 minutes) → 2. Introduction of relevant personnel, evaluation committee, and accompanying evaluators (5 minutes) → 3. Organization presentation (10 minutes) → 4. On-site inspection and review of written materials (120 minutes) → 5. Evaluation team discussion (15 minutes) → 6. Comprehensive discussion (25 minutes). The entire process takes 3 hours, which can be cumbersome and time-consuming for long-term care institutions.

2.2 Expanding the Evaluation Model for Care Institutions

Drawing inspiration from the evaluation practices in Japan, this study references the third-party evaluation framework and the concept of ESG to align the Taiwanese evaluation methods for care residential facilities with global trends. Currently, third-party evaluation is applied to professional medical institutions and comprises the following four elements [12]: (1) guided questioning as a means to facilitate institutional reflection, (2) emphasis on the self-growth and expectations of institutional personnel, (3) survey-based understanding of users' thoughts and expectations regarding services, and (4) observation of the interaction between users and institutional personnel in a contextualized manner. Shifting from traditional passive evaluation methods to proactive evaluation approaches that focus on service delivery can help users and institutional staff members create a more comfortable care environment.

As care residential facilities are the core providers of care services to the public, ensuring a healthy work environment for their service personnel staff is a crucial management indicator. ESG factors, which include considerations related to the environment, society, and corporate governance, can be leveraged to sustain employees' physical and mental well-being in the workplace through initiatives such as arranging employee health check-ups, implementing health management and maintenance programs, and organizing recreational activities in daily life.

The demand for long-term care in an aging society continues to rise with the rapidly transforming social structure. Care residential facilities, in addition to providing care services, strive to optimize service quality and implement sustainable business practices. As discussed in previous chapters, sustainability has emerged as an international trend across various domains, such as university rankings, hospital performance, and corporate evaluations. Examining the limitations of conventional evaluation methodologies allows us to explore avenues for developing a more appropriate and socially responsible approach to service evaluation. However, the inclusion of a broader range of indicators may introduce complexity into the evaluation process, leading to an elaborate evaluation model. Therefore, this study draws upon the decision support system framework proposed by Turban et al. [13] and incorporates the concept of third-party evaluation [12], along with the integration of ESG principles, to construct an innovative evaluation approach for care residential facilities and aligns with the core principles of sustainable development outlined by the United Nations.

In summary, the evaluation of care residential facilities has not achieved the expected objectives and benefits over the years. Moreover, it has imposed additional administrative burdens on institutional personnel and lacked objective indicators. Therefore, this study aims to address these issues by constructing a self-evaluation model for value assessment, incorporating innovative evaluation methodologies and utilizing information and communication technologies, as illustrated in Figure 1. Decision-makers can input relevant information into the self-assessment system to rapidly understand the operational and service conditions of the institution. This provides them with a more objective basis for managing the institution, thereby effectively adjusting service processes, work environments, and personnel management.
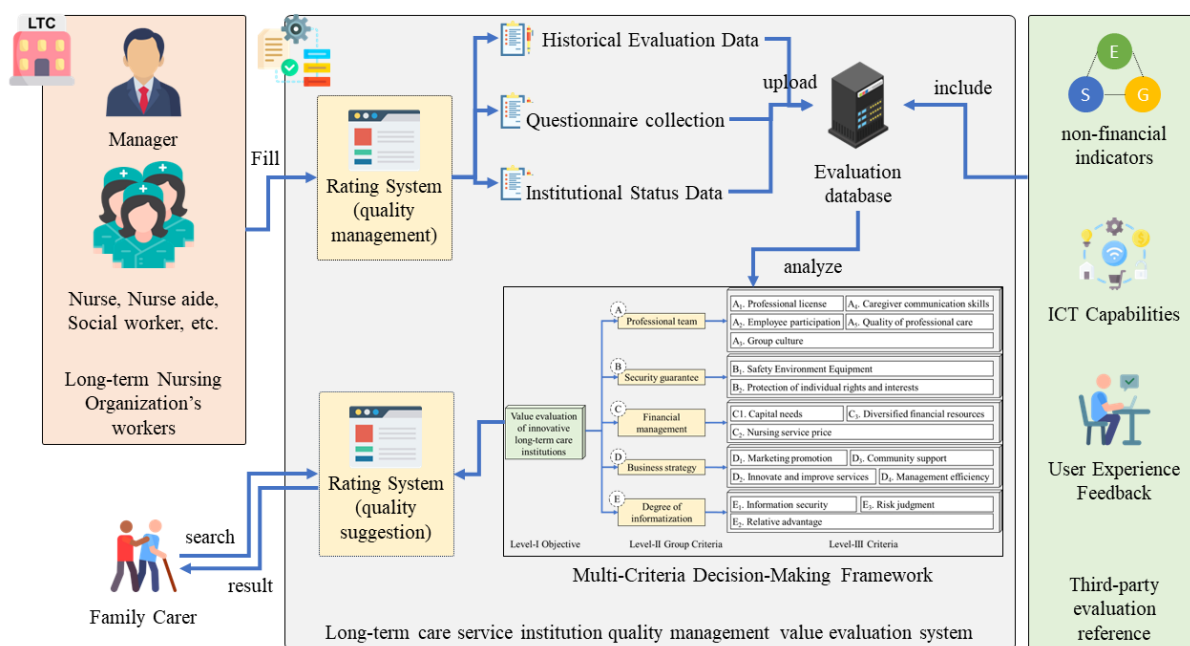

Figure 1. Innovative long-term care institution service quality management value assessment concept diagram

2.3 Multi-criteria Decision Analysis for Organizational Contexts

This study collected data on indicator weight evaluations related to the considered factors using literature review and expert interviews to assess the influence of indicator weights in the institution's value assessment scheme. Three hierarchical levels were defined: the first level being the institution's value assessment, the second level representing decision making criteria, and the third level comprising decision making factors. AHP was employed for indicator analysis, which involved five steps as outlined below:

2.3.1 Identifying the Research Question

The present study aims to provide decision-makers with a score or rating for innovative evaluation. To achieve this, a framework was established wherein inputting various parameters and applying mathematical formulas results in a single outcome.

2.3.2 Considering all Evaluation Factors

All indicators and factors related to the innovative model for evaluating care residential facilities were compiled, excluding any associations or sequence considerations, by collecting and analyzing literature, conducting expert discussions (Delphi method), and using other methods.

2.3.3 Constructing Innovative Evaluation Hierarchy Structure

It is essential to establish natural relationships between the upper and lower hierarchical levels, without any inherent order within each level, to effectively evaluate the various indicators. The top level represents the overarching objective, and the hierarchy is designed to cascade downwards in a sequential manner. Each level can include multiple indicators. Furthermore, based on the assumption that humans are unable to simultaneously compare more than seven items, it is recommended to limit the number of elements within each level to seven [14]. Therefore, the number of levels can be estimated as n/7, ensuring that the constructed framework adheres to the aforementioned rules. This approach facilitates efficient pairwise comparisons and improves overall consistency.

2.3.4 Designing Indicator Surveys

Each level is evaluated based on the indicators of the higher level as the reference for pairwise comparison. The evaluation is conducted using a scale ranging from 1 to 9, representing values from equal importance to absolute importance. Participants are requested to indicate their preference within each pair of elements by marking the appropriate comparison scale [14]. Clear instructions should be provided for each pairwise comparison matrix in the questionnaire.

2.3.5 Establishing Model Framework

Based on the aforementioned steps 1 to 4, and considering the research questions and experiences in exploring value assessment of care residential facilities, this study ultimately includes 5 decision making criteria and 17 decision making factors, as illustrated in Table 1. The model is structured into three levels. The top-level (ultimate goal) focuses on the long-term care service quality value assessment. The second-level (criterion items) comprises five major evaluation dimensions: professional team, safety assurance, financial management, operational strategy, and level of informatization. The third-level (sub-criterion items) represents the specific decision-making sub-factors corresponding to each dimension. Notably, the five sub-indicators from the existing care facility evaluation are retained and indicated with an asterisk (*) in a light orange rounded rectangle, as illustrated in Figure 2.

Table 1. Compilation table of decision criteria and decision factors

Criteria	Factors	Type	Sources
A. Professional team	A1. Professional license	①	(Safari et al. 2016) [15]
	A2. Employee participation	①	(Song et al. 2016) [16]
	A3. Group culture		
	A4. Caregiver communication skills	①	(Arumugam et al. 2011) [17]
	A5. Quality of professional care	②	(MOHW) [18]
B. Safety guarantee	B1. Safety Environment Equipment		
	B2. Protection of individual rights and interests		
C. Financial management	C1. Capital needs	①	(Dyer et al. 2011) [19]
	C2. Nursing service price	①	(Darroch et al. 2016) [20]
	C3. Diversified financial resources	①	(Song et al. 2016) [16]
D. Business strategy	D1. Marketing promotion	①	(Pulizzi 2013) [21]
	D2. Innovate and improve services	②	(MOHW) [18]
	D3. Community support	①	(Song et al. 2016) [16]
	D4. Management efficiency	②	(MOHW) [18]
E. Degree of informatization	E1. Information security		
	E2. Relative advantage	①	(Muhammad et al. 2021) [22]
	E3. Risk judgment		

① . Literature collection
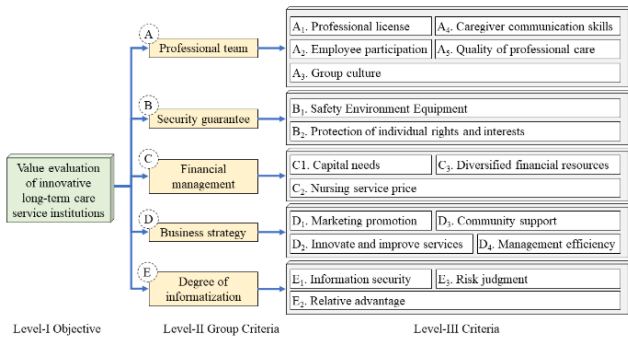② . Traditional evaluation benchmarks

Figure 2. Hybrid hierarchical analysis framework diagram

2.4 Application of the Analytic Hierarchy Process (AHP) for Evaluation

This study referenced the hierarchical framework and operational steps proposed by scholar Saaty [14]. First, a pairwise comparison matrix is established, with the numerical values derived from the survey results of Step 4. The matrix is constructed by applying the geometric mean of individual judgment values. Subsequently, the vector values of the matrix are calculated to obtain the weightings. Prior to constructing the pairwise comparison matrix, the relationship between eigenvalues and eigenvectors is explained. The eigenvector W of matrix A corresponds to its eigenvalue λ, and W is the unique nonzero vector.

$$AW = \lambda W. \tag{1}$$

An illustrative example of a pairwise comparison matrix is as follows:

$$A = \begin{bmatrix} 3 & 1 \\ 1 & 2 \end{bmatrix}, W = \begin{bmatrix} 0 \\ 1 \end{bmatrix}. \ AW = \begin{bmatrix} 3 & 1 \\ 1 & 2 \end{bmatrix} \times \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 3 \end{bmatrix} = 3W.$$

The eigenvalue λ of matrix A is determined to be 3.

When the number of criteria items exceeds 3, various approaches can be adopted to calculate the eigenvalue (λ) of matrix A. After constructing the pairwise matrices, the geometric mean values of the row criteria are first calculated and summed. Thereafter, the geometric mean values of the column criteria items are normalized, and the eigenvectors of the matrix are obtained. Finally, the concept of AW = λW is applied to derive the eigenvalue (λ). Saaty proposed four approximation methods to calculate the eigenvector values of the matrix, as presented in Formulas 1 to 4:

1. Formula (2) for normalizing the geometric mean of the row criteria items:

$$W_i^{'} = \frac{1}{n} \sum_{j=1}^{n} \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, \ i, j = 1, 2, 3, ..., n. \tag{2}$$

2. Formula (3) for normalizing the geometric mean of the column criteria items:

$$W_i^{'} = \frac{\sum_{j=1}^{n} a_{ij}}{\sum_{i=1}^{n} \sum_{i=1}^{n} a_{ij}}, \ i, j = 1, 2, 3, ..., n. \tag{3}$$

3. Formula (4) for normalizing the reciprocal of the vector sum of the row criteria items:

$$W_i^{'} = \frac{1 / \sum_{j=1}^{n} a_{ij}}{\sum_{i=1}^{n} \left(1 / \sum_{j=1}^{n} a_{ij} \right)}, \ i, j = 1, 2, 3, ..., n. \tag{4}$$

4. Formula (5) for normalizing the geometric mean of the column criteria items:

$$W_i^{'} = \frac{\left(\prod_{j=1}^{n} a_{ij} \right)^{\frac{1}{n}}}{\sum_{i=1}^{n} \left(\prod_{j=1}^{n} a_{ij} \right)^{\frac{1}{n}}}, \ i, j = 1, 2, 3, ..., n. \tag{5}$$

During the pairwise comparisons, the weights vary and can be influenced. To ensure the attainment of optimal decision-making results, a consistency check is conducted to examine whether there are any inconsistencies in the calculation process. Therefore, after calculating the matrix eigenvectors, the Consistency Index (C.I.) is computed to assess the differences between elements. By calculating the maximum eigenvalue λ_{max}, the final C.I. value is obtained. The maximum eigenvalue is calculated using the following formula (6):

$$\lambda_{\max} = \frac{1}{n} \left(\frac{W_1}{W_1} + \frac{W_2}{W_2} + \frac{W_3}{W_3} + ... + \frac{W_n}{W_n} \right). \tag{6}$$

Formula (7) for calculating the C.I. value:

$$C.I. = \frac{\lambda_{\max} - n}{n - 1}. \tag{7}$$

The Random Index (R.I.) corresponds to the number of characteristics in each hierarchy level, as presented in Table 2. The R.I. values are associated with each hierarchy level and result in different C.I. values for each level of the hierarchy. The Consistency Ratio (C.R.) is the ratio between the C.I. value and the R.I. value. A C.R. value smaller than 0.1 indicates a high level of consistency in the matrix.

Table 2. Random index mapping table

Hierarchy level	1	2	3	4	5
R.I.	0.00	0.00	0.58	0.09	1.12
Hierarchy level	6	7	8	9	10
R.I.	1.24	1.32	1.41	1.45	1.49
Hierarchy level	11	12	13	14	15
R.I.	1.51	1.48	1.56	1.57	1.59

Formula (8) for calculating the Consistency Ratio:

$$C.R. = \frac{C.I.}{C.R.}. \qquad (8)$$

A consistency test is conducted using the Consistency Index, Random Index, and Consistency Ratio. If the consistency test does not pass, the pairwise comparison matrix needs to be revised. In contrast, if the test passes, it indicates that the obtained eigenvector represents the weight vector of the matrix. Here is an example for illustration, as shown in Table 3:

Table 3. X matrix data sheet

Criteria	X_1	X_2	X_3
X_1	1.00	3.00	2.00
X_2	0.33	1.00	2.50
X_3	0.50	0.40	1.00

After performing the matrix calculations, the geometric mean and sum are applied to the column vectors, and the geometric mean of the row vectors is normalized.

$$\left(\prod_{i=1}^{3} X_i\right)^{\frac{1}{3}} + \left(\prod_{i=2}^{3} X_i\right)^{\frac{1}{3}} + \left(\prod_{i=3}^{3} X_i\right)^{\frac{1}{3}} = 29.41$$

Sum $-$ normalized geometric mean of row vectors

$$= \begin{bmatrix} 24.00 \div 29.41 \\ 5.21 \div 29.41 \\ 0.20 \div 29.41 \end{bmatrix} = \begin{bmatrix} 0.816 \\ 0.177 \\ 0.007 \end{bmatrix}$$

$$AW = \begin{bmatrix} 1.00 & 3.00 & 2.00 \\ 0.33 & 1.00 & 2.50 \\ 0.50 & 0.40 & 1.00 \end{bmatrix} \begin{bmatrix} 0.816 \\ 0.177 \\ 0.007 \end{bmatrix} = \begin{bmatrix} 4.897 \\ 0.679 \\ 0.013 \end{bmatrix} =$$

$$\lambda W = \lambda \begin{bmatrix} 0.816 \\ 0.177 \\ 0.007 \end{bmatrix} = \begin{bmatrix} \lambda \times 0.816 \\ \lambda \times 0.177 \\ \lambda \times 0.007 \end{bmatrix}.$$

Finally, the eigenvalue (λ) of matrix A is determined to be $\begin{bmatrix} 6.000 \\ 3.833 \\ 1.900 \end{bmatrix}$. Thereafter, the evaluation results are integrated to generate a final comprehensive ranking. The evaluation findings, along with the research process and expert discussions, lead to the conclusions of this innovative study on long-term care service quality value assessment.

3 Simulation Results

3.1 Results of Decision-Making Criteria

The proposed innovative model for assessing the value of long-term care residential facilities' service quality establishes five major decision making criteria and 17 decision making factors. Following the decision making analysis steps outlined in the previous chapter's research methodology, the weights of each criterion item are calculated as parameters for the value assessment model. The decision making factors correspond to different dimensions of the decision making criteria. Based on the survey results garnered from experts, the weights of the factors influencing business decision making and the criteria are computed using the AHP model simulation. Table 4 illustrates the obtained weights. In the "A. Professional Team" category, the weights of each decision making factor and the criterion are as follows: A1. Obtaining professional certifications: 0.1689; A2. Employee participation: 0.1426; A3. Organizational culture: 0.1369; A4. Employee communication skills: 0.2791; A5. Professional care quality: 0.2696, and so on in a similar manner.

3.2 Experimental Simulation and Evaluation Results

We conducted three rounds of self-assessment with the assistance of a care residential facility in Taipei City. The first self-assessment was completed in December 2021, followed by assessments in February and June 2022. The calculated scores were 3.12, 3.21, and 3.64 for the first, second, and third assessments, respectively. The system allows decision-makers in the institution to integrate and analyze the value assessment results from different quarters using a radar chart, which highlights operational weaknesses/shortcomings among the five criteria. This visualization enables decision-makers to acquire a more intuitive understanding of the service performance, as depicted in Figure 3.
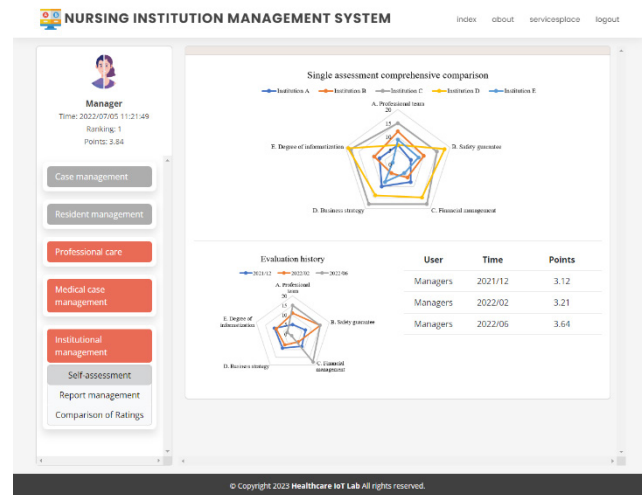

Figure 3. Value evaluation result system interface

This study selected five long-term care residential facilities in Taipei City as examples, to assess the overall effectiveness of the innovative decision-making evaluation. The testing period occurred from June to July 2022, lasting for a month. Decision-makers were provided with the opportunity to conduct self-assessments using the system at any time during this period. The participants, who were the decision-makers of the institutions, were briefed and provided with instructions before beginning the assessment, to ensure the validity of the innovative evaluation system.

Table 4. Decision criteria and factors AHP weight table

Criteria	Weight	Factors	Weight	Criteria rank	Total rank
A. Professional team	.2574	A1. Professional license	.1689	3	10
		A2. Employee participation	.1426	4	14
		A3. Group culture	.1369	5	15
		A4. Caregiver communication skills	.2791	**1**	**4**
		A5. Quality of professional care	.2696	2	**5**
B. Safety guarantee	.2587	B1. Safety Environment Equipment	.4536	2	**2**
		B2. Protection of individual rights and interests	.5464	**1**	**1**
C. Financial management	.1672	C1. Capital needs	.3637	2	7
		C2. Nursing service price	.3784	**1**	6
		C3. Diversified financial resources	.2579	3	11
D. Business strategy	.1637	D1. Marketing promotion	.2797	2	9
		D2. Innovate and improve services	.3059	**1**	8
		D3. Community support	.2535	3	13
		D4. Management efficiency	.1609	4	17
E. Degree of informatization	.1531	E1. Information security	.2269	3	16
		E2. Relative advantage	.2748	2	12
		E3. Risk judgment	.4983	**1**	**3**

The innovative evaluation model was used to calculate the assessment results, providing comparative analysis for the participating institutions. Additionally, a collective evaluation was conducted among the participating institutions, the results of which are summarized in Table 5. Among the five institutions, Institution C achieved the highest score, with a final score of 3.84 points. The ranking is as follows: Institution C (3.84 points), Institution A (3.64 points), Institution D (3.31 points), Institution B (3.21 points), and Institution E (3.18 points). The results indicate that Institution C displayed the best overall performance in self-assessment during this testing period.

Table 5. Comparative evaluation results table

Subjects	Same-season evaluation results	Ranking
Institution A	3.64 points	2
Institution B	3.21 points	4
Institution C	3.84 points	1
Institution D	3.31 points	3
Institution E	3.18 points	5

4 Conclusion

The innovative framework proposed for evaluating the value of long-term care residential facilities enhances the conventional evaluation. This study incorporated the concept of third-party evaluation and adopted a hierarchical multi-criteria approach as the fundamental framework, to synthesize expert interviews and relevant literature to propose indicators in five key dimensions suitable for assessing the quality and value of long-term care residential facilities. This framework aims to establish more objective standards and guidelines for assessing long-term care services.

The AHP approach was employed to address the complexity of the research problem. A multi-criteria approach was applied to decompose and structure the complex issues using expert interviews and a comprehensive review of the literature. Aligning with existing corporate evaluation methods, this approach assists long-term care residential facilities in identifying key factors across various dimensions. Concerning operational management, the system provides decision-makers with insights into the dimensions of enterprise management, which can serve as a basis for planning the goals of long-term care institutions. Additionally, regarding ensuring personal safety and safeguarding individual rights, practical adjustments were made based on recommendations from professionals to align with the actual clinical application and meet the needs of real-world clinical settings.

This study constructs a comprehensive evaluation system for long-term care institutions using a systematic management framework. The system incorporates multiple key decision indicators to provide care managers with a comprehensive assessment of long-term care service quality. Care institutions can formulate corresponding improvement strategies by understanding their strengths and areas for improvement. Moreover, the evaluation system allows for objective comparisons among different service providers. Using its multi-weight settings and indicator evaluation

models, institutions can compare themselves with similar organizations, serving as a basis for user selection. The detailed analysis results of the evaluation system help institutions establish priority areas for improvement and identify the most important indicators related to core values and goals. This allows institutions to concentrate their efforts and resources on addressing critical issues, thereby enhancing service quality. Furthermore, the evaluation system provides transparency and fairness in assessment standards. It avoids subjective biases from evaluators and ensures the credibility and fairness of the evaluation results by using objective indicators and weight settings. This instills confidence in potential users regarding the quality of institutional services. Finally, as a tool for continuous improvement, the evaluation system enables regular assessments and comparisons to monitor the strengths and weaknesses of institutions. It allows institutions to retain their distinctive features while continuously improving areas that require enhancement, thereby tracking the effectiveness of service improvements.

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