Middle East J Rehabil Health Stud. 2023 July; 10(3):e133871. https://doi.org/10.5812/mejrh-133871.

Published online 2023 May 28. **Research Article**

Evaluation of Rehabilitation Service Capacity for Mildly Disabled Institutionalized Elderly - An Analysis Based on the Hierarchical Analysis and Entropy Method

Maoqiang Xu [1, *], Asha Hasnimy Mohd Hashim [1] and Zhiwei Chen [1]

[1] Faculty of Social Sciences and Humanities, University of Technology Malaysia, Skudai, Malaysia

[*] *Corresponding author*: Faculty of Social Sciences and Humanities, University of Technology Malaysia, Skudai, Malaysia. Email: xumaoqiang0000@outlook.com

Received 2022 November 30; **Revised** 2023 March 07; **Accepted** 2023 April 08.

Abstract

Background: The quality of rehabilitation services plays an important role in the health and satisfaction of society, but it still has some significant deficiencies in different aspects at the same time. It is one of the main issues in the system of rehabilitation services in all countries.

Objectives: This study aimed to investigate the rehabilitation service capacity for mildly disabled older adults in nursing homes.

Methods: The data were used hierarchically and assigned entropy values, the final level of rehabilitation service capacity of mildly disabled older adults in nursing homes was derived, and hierarchical analysis and entropy power methods were combined.

Results: In evaluating rehabilitation services for older adults with mild disabilities in nursing homes, the weight of the first-level risk indicators was 0.1454 for the rehabilitation environment, 0.3687 for the quality of rehabilitation services, and 0.4859 for the effectiveness of rehabilitation.

Conclusions: Rehabilitation environment indicators for an elderly nursing home on their privacy and anti-slip design were ranked first, rehabilitation service quality indicators on the level of rehabilitation division, respectful treatment, and humanistic care, indicating that older people in nursing homes were more important physiological and psychological rehabilitation effect indicators analysis. Rehabilitation effect indicators, independent laundry, independent toileting, bathing, and independent dressing, are especially important in nursing homes for mildly disabled older adults who prefer the change the healthy physical effects.

Keywords: Rehabilitation, Service Capacity, Mildly Disabled Older Adults, Hierarchical Analysis, Entropy Method

1. Background

Promoting the quality of rehabilitation services is one of the major objectives in the rehabilitation service delivery system in various countries due to its important role in the health and satisfaction of society and the consequences of its deficiencies in different aspects. The rapid population aging will create many challenges for governments and communities as the number of older adults is expected to increase significantly globally due to the aging of the baby boomers (those born between 1946 and 1964) and declining birth rates. One consequence of this demographic shift is a further increase in the demand for long-term rehabilitation care. Between 2006 and 2016, the number of elderly care facilities in China increased from 308,000 to 1.16 million, and elderly beds increased from 1.533 million to 6.272 million (1). The growing number of older adults poses new challenges to satisfaction with rehabilitation services in nursing homes. Service capacity has certain distinctive characteristics: These services must be delivered through highly structured volunteers or stipend roles in "named" programs with an ongoing commitment. Rehabilitation includes various methods rehabilitation professionals can use to improve functions (2). It aims to optimize the functional rehabilitation of individuals in activities that can promote the participation of older people in social activities, promote healthy aging, and improve the quality of life in China. The World Health Group has emphasized the integration of rehabilitation into the health service systems at different levels, the establishment of a special government financial budget system, and the improvement of the capacity and level of rehabilitation services in nursing homes by multi-sectoral cooperation among public organizations, enterprises or nonprofit organizations in families, communities and nursing homes, which affects the daily life of older people (3). Promoting the overall care levels of nursing homes is crucial,

and those with better service capacity can better meet customers' needs for various services (4). In the literature, the need for rehabilitation services for older adults in nursing homes has been discussed extensively. Still, no indicative evaluation of rehabilitation services in nursing homes has been conducted. In this context, this thesis assesses the ability of rehabilitation services for older people with mild disabilities in nursing homes. To our knowledge, no researcher in the field has conducted similar studies in the country. This research can contribute to the establishment of a basis for providing better rehabilitation services in nursing homes in the Region.

2. Objectives

This study aimed to derive the capacity of rehabilitation services for older people with mild disabilities in nursing homes.

3. Methods

3.1. Research Design

This study used a quantitative analysis of 120 older adults with mild disabilities. Using MATLAB software to analyze the data hierarchically and assign entropy values, the rehabilitation service capacity of the mildly disabled elderly in the nursing homes was finally extracted. The combined use of hierarchical analysis and entropy method can, on the one hand, weaken the effects of the subjectivity of hierarchical analysis on the results. On the other hand, it can decrease the possibility of the entropy method deviating from reality and provide a more scientific method for evaluating rehabilitation service levels in nursing homes.

3.2. Participants

The participants were selected among older people with mild disabilities in nursing homes. These mildly disabled older adults were studied using the activities of daily living (ADL) scale questionnaire. A non-probability sampling method was also used to select the patients (5). A total of 120 patients (47 males and 73 females) with a mean age of 69 years were enrolled.

3.3. Construction of Evaluation Index System

Analytical hierarchical analysis (AHP) was first introduced in the early 1970s by Professor T.L. Saaty, an American operations researcher. It divides the elements related to the problem into objective, criterion, and solution levels and analyzes the data according to this model.

The application of hierarchical analysis is divided into four steps: The first step is to investigate and study the decision object (6) and divide the factors in the relevant target system into different levels and establish a hierarchical structure model; the second step is to construct a judgment matrix from top to bottom according to the constructed hierarchical structure model by comparing two by two on a scale of 1 - 10; the third step is to solve the maximum eigenvalue of the judgment matrix (7) and pass consistency check; the fourth step is to rank the hierarchy from top to bottom.

The selection of indicators for the evaluation of the quality of rehabilitation services for older people with mild disabilities in urban nursing homes should follow the following principles: (A) functional principle, the selected indicators need to have descriptive, evaluative, and explanatory functions; (B) accessibility principle, the data of relevant indicators can be obtained from authoritative publications and media; (C) comparability principle, the indicators are comparable in terms of meaning, time and space (8) and statistical caliber; (D) completeness principle; (E) non-overlapping principle; (F) combination of quantitative and qualitative indicators (9). Based on the above principles, 30 sub-indicators in 3 categories were selected for the questionnaire.

3.4. Constructing the Judgment Matrix

The judgment matrix was constructed using the 1 - 9 scale method quoted by Saaty and Tavana to represent the two levels of importance (10). Taking the "rehabilitation environment" criterion layer as an example (11). The eight indicators in this layer are compared and ranked according to their importance. C_{ij} is the ratio of the importance of the i-th indicator to the j-th indicator; the judgment matrix $A = (C_{ij})\ n \times n$ contains nine scales (Table 1).

Table 1. Importance Levels and Their Assigned Values

Scale	Meaning
1	C_i element and C_j element have the same effect
3	Element C_i has a slightly stronger effect than element C_j
5	The effect of element C_i is stronger than that of element C_j
7	The influence of element C_i is significantly stronger than that of element C_j
9	C_i elements are stronger than C_j elements
2, 4, 6, 8	The ratio of the influence of C_i elements over C_j elements is between the two adjacent classes mentioned above
1, 1/2,..., 1/9	The ratio of the influence of element C_i over element C_j is the reciprocal of C_{ij} above

The RI of the judgment matrix of order 1 - 10 is shown in the following table (Table 2):

RI = 0 for n = 1, 2 in the table because the positive reciprocal inverse matrix of order 1, 2 always passes consistency.

Table 2. RI Values for Matrices of Order 1 - 10

Order Number	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49

3.5. Discriminant Matrix Construction and Solution of the Weights

The importance of the indicators was scored according to the index system. Then the scoring results were discussed and summarized internally to obtain a two-by-two discriminant matrix as follows (Table 3):

The maximum characteristic roots of the judgment matrix were calculated using MATLAB software. The consistency test of the judgment matrix is performed $\lambda_{max} = 3.0538$, and the consistency index is calculated as follows (7):

$$CI = \frac{\lambda_{max} - n}{n-1} = \frac{3.0538 - 3}{3-1} = 0.0269 \quad (1)$$

Average random consistency index RI = 0.52. Stochastic consistency ratio:

$$CR = \frac{CI}{RI} = \frac{0.0269}{0.52} = 0.0517 < 0.10 \quad (2)$$

Therefore, the results of the hierarchical analysis are considered to have satisfactory consistency, i.e., the distribution of the weight coefficients is very reasonable. The results of the weights are as follows (Table 4):

3.6. Entropy Method Correction

The calculation principle is:

Step 1: The scale and unit of each indicator are different and cannot be compared and calculated directly; before calculation of each indicator weight, it needs to be standardized:

$$x'_{ij} = \frac{x_{ij} - minx_j}{maxx_j - minx_j} \quad (3)$$

Step 2: To eliminate negative values for panning, some index values may have small or negative values after standardization. Therefore, for the unity and convenience of calculation, the standardized values are planned to eliminate the above situation (12):

$$x'_{ij} = H + x'_{ij} \quad (4)$$

Where H is the magnitude of the indicator panning, generally taken as 1.

Step 3: Dimensionless data reduction using the specific gravity method:

$$y_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{n} x'_{ij}} \quad (5)$$

Step 4: Calculate the entropy value of the first indicator:

$$e_j = -\frac{1}{lnn} \sum_{i=1}^{n} y_{ij} lny_{ij} \quad (6)$$

Step 5: The coefficient of variation of the first indicator is:

$$g_j = 1 - e_j \quad (7)$$

Among them, j = 1, 2, ….p

Step 6: The j weights of the first indicator are:

$$\omega_j = \frac{g_j}{\sum_{j=1}^{p} g_j} \quad (8)$$

Among them, find the combination weights:

$$\lambda_j = \frac{w_j v_j}{\sum_{j=1}^{n} w_j v_j} \quad (9)$$

(Where w_j is the weight of the hierarchical analysis method, and v_j is the weight of the entropy value method) (Table 5).

4. Results

Based on the weight calculation results above (Table 5), the weight of the primary risk indicators was 0.1454 for the indicator of rehabilitation environment (13), 0.3687 for the indicator of rehabilitation service quality, and 0.4859 for the indicator of rehabilitation effect.

Analyzing and comparing the weighting results of the primary risk indicators demonstrated that the weighting results, in descending order, were: Rehabilitation effect, rehabilitation service quality, and rehabilitation environment. Among them, the rehabilitation effect had the largest weight.

Analysis and comparison of the results of the weights of the secondary indicators revealed that the highest privacy weight in the rehabilitation environment was 0.2315, followed by anti-slip facilities, with a weight of 0.1875. The third was seating comfort, with a weight of 0.1313, and the least was related to rehabilitation room design, with a weight of 0.032. The highest weight of rehabilitation service quality was the level of rehabilitation teachers, with a weight of 0.2076, followed by respectful treatment, with a weight of 0.1883. The third was humanistic care, with a weight of 0.1861, and the least was the health work system, with a weight of 0.0395. The highest weight of rehabilitation service quality was rehabilitation teacher level, with

Table 3. Importance of Indicators and Experts' Scores

Indicators	Rehabilitation Environment	Quality of Rehabilitation Services	Rehabilitation Results
Rehabilitation environment	1	1/3	1/3
Quality of rehabilitation services	3	1	2
Rehabilitation results	3	1/2	1

Table 4. Indicator Layers and Weights Calculation Results

Indicators	Weights
Rehabilitation environment	0.1416
Quality of rehabilitation services	0.5247
Rehabilitation results	0.3338

a weight of 0.2076, followed by respectful treatment, with a weight of 0.1883. The third was humanistic care, with a weight of 0.1861, and the least was regarding the wellness work system, with a weight of 0.0395.

5. Discussion

This paper proposes a model for evaluating the level of rehabilitation services for mildly disabled older adults in nursing homes based on an AHP and entropy power method. In this research, the following results were obtained. On the one hand, the target level weights were ranked as rehabilitation quality, rehabilitation effect, and rehabilitation environment according to the expert scoring. On the other hand, the overall satisfaction index of the rehabilitation service of the nursing homes based on 30 indicators was not quite satisfactory. For improvement and enhancement of the service levels, the conclusions of the analysis are discussed as follows.

In the analysis of rehabilitation environment indicators (Table 5), the eight indicators of rehabilitation environment, privacy, and anti-slip design were ranked first. This can be because older people are more concerned about privacy and safety. Moreover, older adults had the lowest requirement coefficients for the rehabilitation room design and the rehabilitation teachers' dress code, indicating that older people with mild disabilities did not care about the outside environment and paid more attention to their own needs.

The analysis of rehabilitation service quality indicators (Table 5) demonstrated that among the ten indicators of rehabilitation service quality, the level of three indicators of rehabilitation teachers, respectful treatment, and humanistic care had the highest weight. This indicates that the physical and psychological aspects of these older adults are more important. Moreover, the older adults paid more attention to their needs and received respectful services. In the overall service system evaluation, for the mildly disabled elderly in the provision of rehabilitation services, the most important element was humanistic care, which includes communication and conversation with the rehabilitators during the service project. This can be attributed to the fact that the disabled elderly living in nursing homes tend to be more depressed and have a lower quality of life than those living at home, and they need a companion. Existing quality indicators emphasize physical and psychological care, environmental safety, and administration. However, these issues are demonstrated to be insufficient to meet the requirements and expectations of older adults in nursing homes. Research on how to change long-term care has demonstrated that nursing homes may provide person-centered care (such as creating a home-like environment, encouraging older adults to participate, and providing more alternative options), and the concept of emphasizing the humanistic aspects of the care delivery process could complement existing quality indicators for rehabilitation services (14).

In Table 5, among the 12 rehabilitation effectiveness indicators, the four indicators of independent laundry, independent toileting, bathing, and independent dressing are important, with "dressing" and "bathing" in the instrumental activities of daily living scale (IADL) domain, which seems to be due to the relatively low physical demands of the tasks associated with these activities. Similarly, three of the six programs identified as IADL domains - "caring for family members," "participating in community activities," and "doing light housework" - cross-loaded on the mobility domain, as the decision to place any individual program in a particular domain was based on empirical and conceptual theoretical foundations. This suggests that older adults prefer rehabilitation services that can lead to tangible changes assisting them in coping with their life difficulties and yield practical rehabilitation outcomes (15).

5.1. Limitations

Based on the quantitative studies, it may be argued that the major limitation of this study was related to cognitive bias due to sedative medication in mildly disabled older adults, and this needs to be studied in more depth.

Table 5. Combined Weights of Each Indicator Under the Entropy Weighting Method Correction

Indicator Layer	AHP Analysis Weights	Entropy Value	Coefficient of Variation	Entropy Method Weights	Combined Weights
Rehabilitation environment	0.1416	0.9821	0.0179	0.3224	0.1454
Quality of rehabilitation services	0.5247	0.9878	0.0122	0.2206	0.3687
Rehabilitation results	0.3338	0.9747	0.0253	0.4569	0.4859
Rehabilitation room design	0.0351	0.9924	0.0076	0.1103	0.0320
Ventilation, lighting, and air conditioning facilities	0.1072	0.9901	0.0099	0.1432	0.1270
Health status	0.0822	0.9889	0.0111	0.1614	0.1098
Seat comfort	0.1243	0.9912	0.0088	0.1277	0.1313
Anti-slip facilities	0.2225	0.9930	0.0070	0.1018	0.1875
Privacy	0.2466	0.9922	0.0078	0.1134	0.2315
Quiet level	0.1223	0.9919	0.0081	0.1181	0.1195
Dress code	0.0597	0.9914	0.0086	0.1241	0.0613
Financial input	0.0168	0.9925	0.0075	0.0872	0.0149
Rehabilitator level	0.1767	0.9901	0.0099	0.1153	0.2076
Treatment time	0.0568	0.9900	0.0100	0.1165	0.0675
Respectful treatment	0.1901	0.9917	0.0083	0.0972	0.1883
Treatment	0.0636	0.9903	0.0097	0.1130	0.0732
Human care	0.2255	0.9931	0.0069	0.0810	0.1861
Rehabilitation normalization	0.1038	0.9924	0.0076	0.0884	0.0935
Work system	0.0375	0.9911	0.0089	0.1034	0.0395
Employee input	0.0394	0.9914	0.0086	0.1009	0.0405
Management level	0.0897	0.9917	0.0083	0.0972	0.0888
Blood pressure indicators	0.1015	0.9886	0.0114	0.0941	0.1166
Muscle strength	0.0257	0.9903	0.0097	0.0796	0.0250
Coordination ability	0.0158	0.9934	0.0066	0.0543	0.0105
Body mass index	0.0184	0.9919	0.0081	0.0667	0.0150
Body weight	0.0995	0.9890	0.0110	0.0904	0.1098
Self-washing	0.1939	0.9915	0.0085	0.0702	0.1663
Self-directed toileting and bathing	0.1958	0.9909	0.0091	0.0747	0.1787
Outbound activities	0.0582	0.9879	0.0121	0.0996	0.0708
Self-dressing	0.1676	0.9907	0.0093	0.0765	0.1566
Bed and chair mobility	0.0296	0.9897	0.0103	0.0847	0.0306
Flatland movement	0.0316	0.9874	0.0126	0.1038	0.0401
Solitude relief	0.0622	0.9872	0.0128	0.1053	0.0800

Abbreviation: AHP, analytical hierarchical analysis.

5.2. Conclusions

The findings suggest that older adults with mild disabilities are less concerned with the outside world and more focused on their own needs. Focusing on their emotional adjustment and psychological behavior can effectively improve interpersonal problems in nursing home residents. The perceived importance of humanistic care in the care process suggests that older adults prefer rehabilitation services that can significantly affect their life difficulties and actual rehabilitation outcomes.

Footnotes

Authors' Contribution: Maoqiang Xu conceived and designed the assessment and drafted and revised the manuscript. Asha Hasnimy Mohd Hashim reevaluated the paper, supervised its revision, and proposed suggestions for its improvement. Zhiwei Chen performed the statistical analysis of the data. All authors read and approved the final manuscript.

Conflict of Interests: The authors declare no conflict of interests.

Funding/Support: This article didn't receive any financial support.

References

1. Bhatia V, Sharma S, Bhatia R. Investment decisions and project management over Indian railways: a case of freight corridors. *Meas Bus Excell*. 2022;**27**(2):173–92. https://doi.org/10.1108/mbe-08-2021-0106.
2. Xiong J, Liu H, Jin B, Li Q, Yao Z. A lightweight privacy protection scheme based on user preference in mobile crowdsensing. *Trans Emerg Telecommun Technol*. 2021;**32**(5):e4000. https://doi.org/10.1002/ett.4000.
3. Coote A. Universal basic services and sustainable consumption. *Sustain Sci Pract Policy*. 2021;**17**(1):32–46. https://doi.org/10.1080/15487733.2020.1843854.
4. Bleibtreu E, von Ahlen C, Geissler A. Service-, needs-, and quality-based hospital capacity planning - The evolution of a revolution in Switzerland. *Health Policy*. 2022;**126**(12):1277–82. [PubMed ID: 36229281]. https://doi.org/10.1016/j.healthpol.2022.09.011.
5. Liang X, Huang S, Li S, Gong Q, Guo G. Business Environment Evaluation Based on Entropy-Topsis Model: Evidence from China. *2021 7th Annual International Conference on Network and Information Systems for Computers (ICNISC)*. 23-25 July 2021; Guiyang, China. 2021. p. 397–402.
6. Sugumaran V, Sreedevi AG, Xu Z. *Application of Intelligent Systems in Multi-modal Information Analytics: The 4th International Conference on Multi-modal Information Analytics (ICMMIA 2022), Volume 1. Lecture Notes on Data Engineering and Communications Technologies*. Cham: Springer; 2022. https://doi.org/10.1007/978-3-031-05237-8.
7. Lin Y, Wang X. Port selection based on customer questionnaire: a case study of German port selection. *Eur Transp Res Rev*. 2019;**11**(1):48. https://doi.org/10.1186/s12544-019-0385-1.
8. Zumrut IB, Baran HB, Ozbalta TG. Multi-criteria decision-making approach for selecting a structural system of an industrial facility. *Organization, Technology and Management in Construction: an International Journal*. 2022;**14**(1):2656–65. https://doi.org/10.2478/otmcj-2022-0010.
9. Liu L, Liu H, Xiang M, Guo H, Sun Z, Wu T. Prevalence and Associated Factors of Physical Activity Among Older Adults Living in Nursing Homes: A Cross-Sectional Study. *J Gerontol Nurs*. 2020;**46**(10):19–26. [PubMed ID: 32640032]. https://doi.org/10.3928/00989134-20200706-01.
10. Saaty TL, Tavana M. *The Encyclicon-Volume 4: A Dictionary of Complex Decisions Using the Analytic Network Process*. Pittsburgh, PA: RWS Publications; 2021.
11. Tao X. Modeling of land ecological safety evaluation based on attribute recognition theory: A case study on Henan Province. *2010 2nd IEEE International Conference on Information Management and Engineering*. 16-18 April 2010; Chengdu, China. 2010. p. 518–22.
12. Catz A, Itzkovich M, Elkayam K, Michaeli D, Gelernter I, Benjamini Y, et al. Reliability Validity and Responsiveness of the Spinal Cord Independence Measure 4th Version in a Multicultural Setup. *Arch Phys Med Rehabil*. 2022;**103**(3):430–40-e1. [PubMed ID: 34687675]. https://doi.org/10.1016/j.apmr.2021.07.811.
13. Ma J, Lu S, Wang S. Research on GSEC's Restructuring Financial Risk. *Int J Front Sociol*. 2021;**3**(11):72–7. https://doi.org/10.25236/ijfs.2021.031112.
14. Lee I, Wang HH. Preliminary development of humanistic care indicators for residents in nursing homes: a Delphi technique. *Asian Nurs Res (Korean Soc Nurs Sci)*. 2014;**8**(1):75–81. [PubMed ID: 25030496]. https://doi.org/10.1016/j.anr.2014.03.001.
15. Rejeski WJ, Ip EH, Marsh AP, Miller ME, Farmer DF. Measuring disability in older adults: the International Classification System of Functioning, Disability and Health (ICF) framework. *Geriatr Gerontol Int*. 2008;**8**(1):48–54. [PubMed ID: 18713189]. [PubMed Central ID: PMC5118869]. https://doi.org/10.1111/j.1447-0594.2008.00446.x.