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Research Article

An Integrated Approach for Prioritizing Key Factors in Improving the Service Quality of Nursing Homes

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This study looks at improving the service quality in nursing homes as well as the intricate relationships between various factors. We use two research models herein. First, Interpretive Structural Modeling (ISM) establishes the criteria for the interrelationship structure, categorized according to their driving power and dependence. This methodology provides a means by which order can be imposed on the complexity of such criteria. Insights from this model can help top managers in strategic planning to improve the service quality in nursing home care. Second, because ISM does not provide any weighting associated with the criteria, we employ the Analytic Network Process (ANP) approach to calculate the weighted importance of the key factors and to identify those factors impacting the service quality of nursing home care.

1. Introduction

Nursing homes are defined as long-term, aged, or skilled-care facilities. For an aging population, nursing homes play an important role in the provision of care for elderly people. In Taiwan, people pay great respect to elderly family members, and so the majority of elderly people are traditionally cared for at home. The percentage of Taiwanese people over 65 years old rose from approximately 7% in 1993 to 10% by 2007 and is expected to increase to about 20% by 2025. In the year 2000, the life expectancy for men and women had increased, respectively, to 73.7 and 79.3 years [1]. This rapid rate of increase has drastically raised healthcare needs and demand for long-term care. Since industrialization and urbanization have changed the structure of many Taiwanese families, placing older family members with impairments in nursing homes has become a new alternative, albeit not a desirable or acceptable one by many [2]. However, there are no active regulations to govern nursing homes and monitor their service quality. As such, the service quality of nursing homes has become a major concern both to customers and the government, with nursing homes devoting more and more effort to improving it. In view of this, we identify and prioritize the key factors in improving the service quality of nursing homes. The results of this study can serve as a good reference for nursing homes striving to improve their service.

Nursing homes are defined as facilities that provide skilled nursing services to patients with chronic conditions. Home care refers to providing needed services and equipment to patients and families at home. The importance of good service quality offered by nursing homes is widely recognized, such as good skilled nursing and good care facilities. Providing appropriate long-term care services and good care facilities for elderly people is important to enhance the safety and quality of life. Therefore, identifying those factors that affect care service utilization and safe facilities has become an important concern. Nursing home care quality is a multidimensional construct that is difficult to define and assess [3]. The literature gives several definitions of quality, including "Quality is the degree of agreement between the reality and previously set criteria" [4] and "Quality should be defined as a continuous effort by all members of an organization to meet the needs and expectations of the clients" [5].

According to Donabedian [4], the assessment of nursing care encompasses three domains: structure, process, and outcome. The structure determines the instrumentalities of care and their organization, including facilities, equipment, manpower, and financing. The process evaluates the quality of the way in which care is given, which involves an assessment of the care itself and an evaluation of the activities of the professional nurses. The outcome refers to the appraisal of the end results of care, usually specified in terms of health, welfare, patient satisfaction, patient stress, and so forth. Within these three domains, this paper employs the multiple criteria decision-making (MCDM) approach to find the evaluation criteria that influence service quality in the nursing home industry based on some studies in the literature [6–8].

The MCDM approach is a well-known branch of decision making and is widely used in ranking one or more alternatives from a set of available alternatives with multiple attributes. The MCDM approach presents an effective framework for decision making based on the evaluation of multiple conflicting criteria. A number of approaches have been proposed for solving MCDM problems, such as Interpretive Structural Modeling (ISM) and Analytical Network Process (ANP). Warfield [9] originally proposed ISM, which transforms the relationship among the criterion matrix into graphics through a two-dimensional matrix and Boolean algebra operations. Saaty [10] offered ANP as an extension of the Analytical Hierarchy Process (AHP), as ANP adds the dependence and feedback relationships to AHP. In practical problems, the internal criteria are interdependent and there is a feedback relationship between the low-stage and high-stage criteria. ANP uses a supermatrix algorithm to identify the priority weights of the goals, criteria, and alternatives. In this paper we first apply ISM to analyze the interactive relationship among the quality care criteria. We then employ ANP to calculate the weighted importance of the criteria and to identify key criteria of care quality in order to improve nursing home quality.

The remainder of this paper is organized as follows. Section 2 reviews the literature with respect to models for measuring care quality. Section 3 introduces research methodologies, including ISM and ANP. Section 4 presents data analysis, applying a case with the proposed approaches to identify the key factors of care quality in order to improve nursing home quality. Section 5 discusses the results and provides suggestions for improving nursing home care. Finally, Section 6 draws the conclusions.

2. Literature Review

Many research studies have recently developed quality models to assess and manage nursing home care quality. Spilsbury et al. [11] employed a systematic review for the relationship between nursing home and nurse staffing and how this affects quality of care for nursing home residents. Owusu-Frimpong et al. [12] implemented qualitative and quantitative methods to determine patients' levels of satisfaction. Goodson and Jang [13] presented a Bayesian network as a tool for assessing the quality of care in nursing homes. Nyman and Bricker [14] used several measures of quality of care in a regression analysis. Monique et al. [15] studied quality systems in northwestern Europe and the USA that improve quality of care. Nakrem et al. [8] reviewed nursing sensitive indicators used for nursing home care across seven nations with similar elderly care (USA, Australia, Norway, New Zealand, England, Sweden, and Denmark). The findings help define sensitive nursing quality indicators for nursing home care, in which the main focuses are use, development, and/or test of quality. Rantz et al. [16] presented the Observable Indicators of Nursing Home Care Quality Instrument (OIQ) to measure a nursing facility's quality during a brief on-site visit to a nursing home. According to scholarly research on the topic of nursing, we find that the literature mainly focuses on qualitative and quantitative methods such as systematic review, statistic analysis, regression analysis, Bayesian network analysis, and so forth. The MCDM approach (ISM and ANP) is almost never applied in the field of nursing home care.

ISM is a multicriteria decision-making methodology and an interactive learning process whereby a set of dissimilar directly and indirectly related elements are structured into a completed systemic model [17]. This technique transforms unclear and poorly articulated system models into visible and well-defined models. ISM is an influential approach that can be applied in various fields. Vivek et al. [18] resorted to ISM to establish changing emphases of the specific elements in offshore alliances. Wanga et al. [19] employed ISM to summarize the critical barriers hindering the project of energy savings in China and to explain the interrelationships among them. Luthra et al. [20] identified the contextual relationship among the eleven barriers to implementing green supply chain management in the automobile industry. Govindan et al. [21] used ISM for identifying and summarizing relationships among specific attributes for selecting the best third-party reverse logistics provider among the 3PRLPs.

The ANP is a comparatively simple and systematic mathematical model that can be used in the decision-making process. It incorporates the influences and interactions among the elements of the system as perceived by the decision maker and groups them into clusters. Some of the most recent applications of ANP to decision-making problems have been as follows: logistics service provider [22], supplier selection [23, 24], project selection [25, 26], supply chain management [27], energy policy [28], product mix planning [29], and facility location problem [30, 31]. Some hybrid approaches that combine over two kinds of MCDM methods are applied in the field of alternative selection problems. Kannan et al. [32] integrated ISM and fuzzy TOPSIS for the selection of a reverse logistics provider. Lee et al. [33] employed delphi, ISM, and fuzzy ANP to analyze the relationship among technology transfer, knowledge management, and buyer supplier relationships in the acquisition of new equipment. Lin et al. [34] proposed a hybrid method that combines ISM and fuzzy ANP to cope with the problem of the different dimensions' interdependence and feedback in the vendor selection problem.

According to the literature review, we are finding that the methods of ISM and ANP are useful analytical tools for evaluating complex systems. Integrating ISM and ANP can reduce the questionnaires' process and cope with the problem of different dimensions' interdependence and feedback in the selection problem. Although these approaches are widely applied in numerous fields for research, there are few studies in the literature that apply these approaches in the related nursing issue to investigate the relevant problems. Therefore, we propose the integrated approach to present key factors in improving the service quality of nursing homes.

3. Method

This study employs two research models: ISM and ANP. ISM establishes the criteria for the interrelationship structure, categorized according to their driving power and dependence. This methodology provides a means by which order can be imposed on the complexity of criteria. The insights gained from the model can help top managers perform strategic planning for improving service quality in nursing home care. Since ISM does not give any weighting associated with the criteria, we employ ANP to calculate the importance weights of the key factors and to identify those factors affecting the service quality of nursing home care. Subsequent sections describe the details of the proposed approaches.

3.1. Interpretive Structural Modeling. ISM converts a complex system into a visualized hierarchical structure. It is a method for analyzing and solving complex problems to manage decision making. The method can be adopted to identify and analyze the relationships among specific variables that define a problem or an issue [35, 36] and thereby establish the hierarchical structure. The overall structure is portrayed through a digraph model [37, 38], which is an approach adopted for structuring details related to a problem or activity, such as complex technical problems [33] and competitive analysis [39].

ISM starts with the identification of factors that are relevant to the problem or issue and afterward extends to a group problem-solving technique. A contextual relationship is then chosen. Having decided the factor set and contextual relation, a structural self-interaction matrix (SSIM) is developed based on a pairwise comparison. The SSIM is developed based on the pairwise comparison of variables and can be described as

$$S = \begin{array}{c} \\ e_1 \\ e_2 \\ \vdots \\ e_m \end{array} \begin{array}{c} \begin{matrix} e_1 & e_2 & \cdots & e_n \end{matrix} \\ \begin{bmatrix} 0 & \pi_{12} & \cdots & \pi_{1n} \\ \pi_{21} & 0 & \cdots & \pi_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \pi_{m1} & z_{m2} & \cdots & 0 \end{bmatrix} \end{array}, \quad (1)$$

where e_i represents the ith element and π_{ij} is the interrelationship between the ith and the jth elements. Four symbols are used to denote the type of relation that exists between two factors i and j under consideration. A: factor j leads to factor i. V: factor i leads to factor j. X: factor i leads to factor j, and factor j leads to factor i. O: no relationship exists between factor i and factor j.

The contextual relationship of "leads to" means that one factor leads to another. Based on the relationship between two factors, a SSIM is developed via experts' comments. In this process, the experts discuss the direction of the relationship between key agile factors, clarify the intent of the factors, and ensure that only the key agile factors are included. This process is continued until all the experts agree on the direction of the relationship.

After a SSIM is developed, the binary rules are used to obtain the initial reachability matrix S. The substitution of 1's and 0's is done as follows.

(1) If the (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0.

(2) If the (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.

(3) If the (i, j) entry in the SSIM is X, then the (i, j) entry and the (j, i) entry both become 1.

(4) If the (i, j) entry in the SSIM is 0, then both the (i, j) entry and the (j, i) entry in the reachability matrix become 0.

The reachability matrix is then established by

$$M = S + I, \qquad M_R = M^k = M^{k+1}, \quad k > 1, \quad (2)$$

where I is the identity matrix, k denotes the powers, M_R is the reachability matrix, and M^k denotes the stable reachability matrix. Subsequently, the stable reachability set $R(t_i)$ and the priority set $A(t_i)$ can be calculated based on (3) and (4), respectively. The former includes the element of e_i for all reachable criteria, whereas the latter includes all criteria of the reachable elements of e_i. Consider

$$R(t_i) = \{e_i \mid \pi_{mn'} = 1\}, \quad (3)$$

$$A(t_i) = \{e_i \mid \pi_{m'n} = 1\}. \quad (4)$$

We can determine the hierarchy and relationships among criteria using (3) and (4). Note that the reachability matrix is under the operators of Boolean multiplication and addition. From the final reachability matrix, the reachability set $R(t_i)$, the antecedent set $A(t_i)$, and the intersection set $R(t_i) \cap A(t_i)$ for each factor can be found. Once the top-level factors are found, they should be separated from other factors. After that, the next level of factors is identified by the same processes.

Let criterion i consist of four criteria e_1, e_2, e_3, and e_4. The values of the adjacency matrix S between the criteria given by evaluator M can be represented as below. We add the adjacency matrix to the identity matrix to form a tentative reachability matrix M at $k = 1$ as follows:

$$S = \begin{array}{c} \\ e_1 \\ e_2 \\ e_3 \\ e_4 \end{array} \begin{array}{c} \begin{matrix} e_1 & e_2 & e_3 & e_4 \end{matrix} \\ \begin{bmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array},$$

$$M = S + I = \begin{array}{c} \\ e_1 \\ e_2 \\ e_3 \\ e_4 \end{array} \begin{array}{c} \begin{matrix} e_1 & e_2 & e_3 & e_4 \end{matrix} \\ \begin{bmatrix} 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \end{array}. \quad (5)$$

Table 1: Reachability of the criteria.

e_n	$R(t_i)$	$A(t_i)$	$R(t_i) \cap A(t_i)$	Level
1	1, 2, 4	1, 2, 3	1, 2	2
2	1, 2, 4	1, 2, 3	1, 2	2
3	1, 2, 3, 4	3	3	3
4	4	1, 2, 3, 4	4	1

We calculate the reachability matrix under the operators of the Boolean multiplication and addition law (i.e., $1 \times 1 = 1$, $1 \times 0 = 0 \times 1 = 0$, $1 + 1 = 1$, $1 + 0 = 1 + 0 = 1$, and $0 + 0 = 0$). Consider

$$M = (S+I)^2 = \begin{matrix} e_1 \\ e_2 \\ e_3 \\ e_4 \end{matrix} \overset{\begin{matrix} e_1 & e_2 & e_3 & e_4 \end{matrix}}{\begin{bmatrix} 1 & 1 & 0 & 1^* \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1^* \\ 0 & 0 & 0 & 1 \end{bmatrix}}, \quad (6)$$

where the asterisk k indicates the derivative relation that does not emerge in the original relation matrix (i.e., $S + I$). According to $R(t_i) \cap A(t_i)$, we determine that the top-level criterion is criterion e_4 in Table 1. We now can delete the row and column corresponding to criterion e_4 from matrix M. Repeating the above step, the second level is determined next.

3.2. Analytic Network Process. ANP is the general form of the analytic hierarchy process [10, 40]. It is used in multiple criteria decision making to release the restriction of a hierarchical structure that integrates linkages and feedbacks into the decision system in order to evaluate the overall cumulative importance of all indicators within an evaluation model. ANP is able to include interdependent relationships among its elements by capturing the composite weights through the development of a supermatrix. The principal concept of ANP is parallel to the Markov chain process with the relative importance weights adjusted by forming a supermatrix from eigenvectors of these weights. The supermatrix is actually a partitioned matrix, where each matrix segment expresses a relationship between two clusters in a system [41]. Assume that a system has K clusters or components. Component p, denoted by C_p, $p = 1, \ldots, K$, has n_p elements, denoted by $e_{p_1}, e_{p_2}, \ldots, e_{p_{np}}$. We formulate a standard form of a supermatrix as follows:

$$W = \begin{matrix} C_1 \begin{matrix} e_{11} \\ e_{12} \\ \vdots \\ e_{1n_1} \end{matrix} \\ C_2 \begin{matrix} e_{21} \\ e_{22} \\ \vdots \\ e_{2n_2} \end{matrix} \\ \vdots \quad \vdots \\ C_K \begin{matrix} e_{K1} \\ e_{K2} \\ \vdots \\ e_{Kn_K} \end{matrix} \end{matrix} \overset{\begin{matrix} C_1 & C_2 & \cdots & C_K \\ e_{11}, e_{12}, \ldots, e_{1n_1} & e_{21}, e_{22}, \ldots, e_{2n_2} & \cdots & e_{K1}, e_{K2}, \ldots, e_{Kn_K} \end{matrix}}{\begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1K} \\ w_{21} & w_{22} & \cdots & w_{2K} \\ \vdots & \vdots & & \vdots \\ w_{K1} & w_{K2} & \cdots & w_{KK} \end{bmatrix}}. \quad (7)$$

A priority vector derived from a pairwise comparison in the usual way represents the impact of a given set of elements in a component on another element in the system. When an element has no influence on another element, its influence priority is assigned to be zero [10]. As an example, we give the matrix representation of a hierarchy with three levels as

$$W = \begin{bmatrix} I & 0 & 0 \\ w_{21} & 0 & 0 \\ 0 & w_{32} & I \end{bmatrix}, \quad (8)$$

where W_{21} is a vector that represents the impact of the goal on the criteria, W_{32} is a vector that represents the impact of the criteria on each of the alternatives, and I is the identity matrix. Here, W is referred to as a supermatrix, because its entries are matrices. For example, if the criteria are interrelated among themselves, then a network replaces the hierarchy. In addition, W_{22} will be nonzero and indicates interdependence. We present this supermatrix as follows:

$$W = \begin{bmatrix} I & 0 & 0 \\ w_{21} & w_{22} & 0 \\ 0 & w_{32} & I \end{bmatrix}. \quad (9)$$

Saaty and Vargas [42] captured the overall priorities of elements according to Cesaro Summability to raise the supermatrix to limiting powers. Here, $W^{\infty} = \lim_{k \to \infty} (1/N) W_j^k$, the limit is unique, and there is a column vector W^{∞} for which $W^{\infty} = w^{\infty} \times e^T$. However, if W is reducible, then the multiplicity n_i of the principal eigenvalue has to be considered in order to obtain the limit priorities of a reducible stochastic matrix with the principal eigenvalue being a multiple root. As an illustration, $n_i = 1$, and thus we give W^{∞} for a hierarchy with three levels as follows:

$$W^{\infty} = \lim_{k\to\infty} \begin{pmatrix} 0 & 0 & 0 \\ W_{22}^{k} W_{21} & W_{22}^{k} & 0 \\ W_{32}\left(\sum_{h=0}^{k-2} W_{22}^{h}\right) & W_{32}\left(\sum_{h=0}^{k-1} W_{22}^{h}\right) & I \end{pmatrix}. \tag{10}$$

Now $|W_{22}| < 1$ implies that $(W_{22})^k$ tends to zero as k tends to infinity, and thus we have

$$W^{\infty} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ W_{32}(I - W_{22})^{-1} W_{21} & W_{32}(I - W_{22})^{-1} & I \end{pmatrix}. \tag{11}$$

The impact of the goal for ranking the alternatives is given by the $(3, 1)$ entry of W^{∞}. The matrix can always be made primitive by replacing all zeros by an arbitrarily small positive number, ensuring that the matrix remains column stochastic.

Limit priority values within this supermatrix indicate the flow of influence of an individual element towards the overall goal. Since the decision alternatives are elements of an original cluster of the network, their limit priorities are synonymous with their contributions to the goal and are used for ranking the alternatives, being normalized within the cluster.

4. Case Study

We present a case study conducted in 2011 at registered nursing homes in Taiwan to demonstrate the practicality of the proposed approaches. The main types of nursing homes are private hospital-based and freestanding. Private hospital-based nursing homes are owned privately. The others are freestanding; that is, they are owned and run by individuals or companies. Some experts were selected from these nursing homes to form a committee for conducting our research survey. With a comprehensive literature review [6–8, 15] and consultations with the committee, we determine four dimensions: Patient's Care of Life (D_1), Nursing Staff (D_2), Home Care Environment (D_3), and Home Care Facilities (D_4). Under each of the four dimensions there are several factors, with Table 2 showing a candidate list of 20 factors.

Table 2: Dimensions and factors affecting nursing home quality.

Dimensions	Factors
Patient's Care of Life (D_1)	Emergency Processing Speed (F1)
	Rapid and Appropriate Referral (F2)
	Medical and Therapeutic Care (F3)
	Pain Management (F4)
	Clinical Care (F5)
Nursing Staff (D_2)	Good Service Attitude (F6)
	Specialized Nursing Care (F7)
	Staff Complement (F8)
	Physician Involvement (F9)
	Sufficient and Competent Staff (F10)
Home Care Environment (D_3)	Space Requirements (F11)
	Hygiene and Infection Control (F12)
	Public Area Clean and Neat (F13)
	Health and Safety Management (F14)
	Good Living Environment (F15)
Home Care Facilities (D_4)	Appropriate Bed Distribution (F16)
	Enough Illumination (F17)
	Bathroom and Toilet Facilities (F18)
	Medical Instrument (F19)
	Monitoring Information System (F20)

4.1. Analyzing Care Quality by ISM. ISM is an interactive learning process. A set of different and directly related variables affecting the system under consideration is structured into a comprehensive systemic model. The beauty of the ISM model is that it portrays the structure of a complex issue for the problem under study. The ISM method in the first stage inquires experts' opinions in developing the contextual relationship among all factors. In this study, pairwise comparisons are formed by the experts.

After pairwise comparisons, we construct the structural self-interaction matrix (SSIM) as shown in Table 3. We then transform the SSIM into a binary matrix, called the initial reachability matrix, by substituting V, A, X, and O by 1 and 0 as per the case. The transforming rules for the substitution of 1's and 0's are shown in Section 3.1. The initial reachability matrix in Table 4 is finished based on Table 3. The final reachability matrix in Table 5 can be obtained from transitivity checks that have been carried out to extract a consistent model from the set of factors as enumerated in the ISM approach in Section 3.1. Partitioning the reachability matrix is continuously constructed by assessing the reachability and antecedent sets for each factor. The reachability set encompasses the factors themselves and the other factors that it can reach. The antecedent set contains the factors themselves and the other factors that may help in achieving them. The intersection of these sets is derived for all factors. If the factors fall into the reachability set the same as the intersection sets, then the factors can be given the first-level factors in the ISM hierarchy, which does not help achieve any other factors above their own level. The same process is repeated to find the next level of factors. In the present case, Table 6 shows the factors along with their reachability set, antecedent set, intersection set, and levels.

After the reachability matrix is partitioned, we construct the driver power and dependence for each factor. The driver power and dependence in this study are used to identify and to analyze the factors. Summations of the row show the driver power of the factor and summations of the column indicate dependence in Table 5—for example, factor 7 has

Table 3: Structural self-interaction matrix (SSIM).

Factors	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	O	O	O	O	O	O	X	O	O	O	A	A	O	A	O	O	O	O	V	—
2	O	O	O	O	O	O	V	O	V	O	O	O	O	O	O	V	O	O	—	
3	O	O	O	O	O	O	V	O	V	O	O	O	O	O	O	V	V	—		
4	O	O	O	O	O	O	V	O	O	O	O	A	O	O	O	O	—			
5	O	O	O	O	O	O	V	O	V	O	O	X	O	X	O	—				
6	O	O	O	O	O	O	O	O	O	O	O	O	O	O	—					
7	O	O	O	O	O	O	O	O	V	O	O	O	O	—						
8	O	O	O	O	O	O	O	O	O	O	A	O	—							
9	O	O	O	O	O	O	V	O	V	O	O	—								
10	O	O	O	O	O	O	O	O	O	O	—									
11	O	O	V	O	O	O	O	O	O	—										
12	O	O	O	O	O	A	X	O	—											
13	O	O	O	O	O	X	O	—												
14	O	O	O	O	O	O	—													
15	O	O	X	X	O	—														
16	O	O	O	O	—															
17	O	O	O	—																
18	O	O	—																	
19	O	—																		
20	—																			

Table 4: Initial reachability matrix.

Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
2	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
3	0	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
5	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
10	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
14	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

a driving power of 8 and a dependence of 15. The driver power and dependence can be grouped into four clusters, as shown in Figure 1. The first cluster encompasses the autonomous factors that have weak driver power and weak dependence. All factors in this area express a relative disconnection from the system, in which they have only a few links and may be strong. The second cluster consists of the dependent factors that have weak driver power but strong dependence. The third cluster includes factors that have strong driver power and strong dependence. These factors are unstable. It is easy to influence the others when taking any action on these factors, and there is also a feedback on themselves.

Table 5: Final reachability matrix.

Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Driver power
1	1	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	8
2	1	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	8
3	1	1	1	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	9
4	1	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	8
5	1	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	8
6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7	1	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	8
8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
9	1	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	8
10	1	1	0	1	1	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0	10
11	1	1	0	1	1	0	1	0	1	0	1	1	1	1	1	0	1	1	0	0	13
12	1	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	8
13	1	1	0	1	1	0	1	0	1	0	0	1	1	1	1	0	1	1	0	0	12
14	1	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	8
15	1	1	0	1	1	0	1	0	1	0	0	1	1	1	1	0	1	1	0	0	12
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
17	1	1	0	1	1	0	1	0	1	0	0	1	1	1	1	0	1	1	0	0	12
18	1	1	0	1	1	0	1	0	1	0	0	1	1	1	1	0	1	1	0	0	12
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Dependence power	15	15	1	15	15	1	15	2	15	1	1	15	5	15	5	1	5	5	1	1	

Table 6: Level partitions for factors' iteration.

Factors	Reachability set	Antecedent set	Intersection set	Level
1	1, 2, 4, 5, 7, 9, 12, 14	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18	1, 2, 4, 5, 7, 9, 12, 14	II
2	1, 2, 4, 5, 7, 9, 12, 14	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18	1, 2, 4, 5, 7, 9, 12, 14	II
3	1, 2, 3, 4, 5, 7, 9, 12, 14	3	3	III
4	1, 2, 4, 5, 7, 9, 12, 14	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18	1, 2, 4, 5, 7, 9, 12, 14	II
5	1, 2, 4, 5, 7, 9, 12, 14	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18	1, 2, 4, 5, 7, 9, 12, 14	II
6	6	6	6	I
7	1, 2, 4, 5, 7, 9, 12, 14	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18	1, 2, 4, 5, 7, 9, 12, 14	II
8	8	8, 10	8	II
9	1, 2, 4, 5, 7, 9, 12, 14	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18	1, 2, 4, 5, 7, 9, 12, 14	II
10	1, 2, 4, 5, 7, 8, 9, 10, 12, 14	10	10	III
11	1, 2, 4, 5, 7, 9, 11, 12, 13, 14, 15, 17, 18	11	11	V
12	1, 2, 4, 5, 7, 9, 12, 14	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18	1, 2, 4, 5, 7, 9, 12, 14	II
13	1, 2, 4, 5, 7, 9, 12, 13, 14, 15, 17, 18	11, 13, 15, 17, 18	13, 15, 17, 18	IV
14	1, 2, 4, 5, 7, 9, 12, 14	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18	1, 2, 4, 5, 7, 9, 12, 14	II
15	1, 2, 4, 5, 7, 9, 12, 13, 14, 15, 17, 18	11, 13, 15, 17, 18	13, 15, 17, 18	IV
16	16	16	16	I
17	1, 2, 4, 5, 7, 9, 12, 13, 14, 15, 17, 18	11, 13, 15, 17, 18	13, 15, 17, 18	IV
18	1, 2, 4, 5, 7, 9, 12, 13, 14, 15, 17, 18	11, 13, 15, 17, 18	13, 15, 17, 18	IV
19	19	19	19	I
20	20	20	20	I

The fourth cluster includes the independent factors having a strong driver power but weak dependence. The driver power-dependence matrix reveals the following results.

(1) Autonomous. In this case, F6 (Good Service Attitude), F8 (Staff Complement), F16 (Appropriate Bed Distribution), F19 (Medical Instrument), and F20 (Monitoring Information System) are categorized as autonomous. These barriers have less influence on the overall system and in many ways can be handled independently during the intervention. This indicates that these factors have few direct linkages throughout the system.

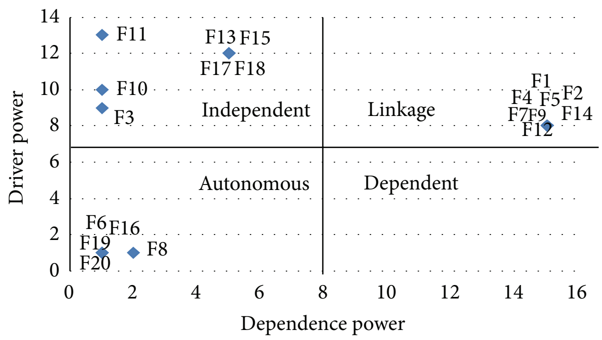

FIGURE 1: Driver power and dependence power diagram.

(2) Dependent. The dependent factor has weak driving power but strong dependence. Since factors in this area are the weak drivers, any action on such factors should usually wait until their driving variables have been addressed. No such factors are found in the dependent factor.

(3) Linkage. The factors falling into this area have strong driver power and strong dependence, including F1 (Emergency Processing Speed), F2 (Rapid and Appropriate Referral), F4 (Pain Management), F5 (Clinical Care), F7 (Specialized Nursing Care), F9 (Physician Involvement), F12 (Hygiene and Infection Control), and F14 (Health and Safety Management). These factors are unstable, which means that any action on these criteria has an effect on the others and also a feedback effect on themselves. Therefore, improving its service quality must be considered as a top priority.

(4) Independent. We observe that F3 (Medical and Therapeutic Care), F10 (Sufficient and Competent Staff), F11 (Space Requirements), F13 (Public Area Clean and Neat), F15 (Good Living Environment), F17 (Enough Illumination), and F18 (Bathroom and Toilet Facilities) are in the third quadrant. These are independent factors that have a significant influence on the system and drive the factors above them. Because of their high driver power and low dependence, addressing these factors early in the intervention will help establish a solid foundation for the intervention and improve the service quality in nursing care as it tackles the remaining factors.

4.2. Ranking Key Factors by the ANP Method. We have applied the ISM method to analyze all factors, aiming to facilitate the interrelationships of each factor with the other factors. The factors can be classified into four clusters to realize the driver power and dependence of all factors. However, even though the interrelationship of all factors can be classified using the ISM method, the importance of the factors is difficult to be presented by using the same approach. Therefore, we implement the ANP method to rank the importance of all factors in this section.

Figure 2 constructs the complete network hierarchy. Satty's nine-point scale pairwise comparison was prepared to set up a questionnaire, and five experts in nursing care from an anonymous nursing home in Taiwan were asked to fill out the questionnaire. The consistency property of each matrix from each expert was checked first to ensure the consistency of judgments in the pairwise comparison. The pairwise comparisons were entered into the $(2, 1)$, $(2, 2)$, $(3, 2)$, and $(3, 3)$ blocks' super-matrix before convergence in Table 7.

The results of pairwise comparisons W_{21} and W_{32} show the priorities of dimensions and factors with respect to dimensions when the interrelationship among factors was not considered. The interrelationships among dimension (W_{22}) are depicted in the $(2, 2)$ block. In addition, the interrelationships among factors (W_{33}) are developed based on Table 5 in the $(3, 3)$ block. For example, column four has two rows to show that the value is one. That means factors 3 and 9 must complete a pairwise comparison to find out the interrelationships among these factors. Table 7 shows the total final values of W_{21}, W_{22}, W_{32}, and W_{33}. For example, the priorities of the dimensions (D_1 to D_4) with respect to the goal are 0.318, 0.248, 0.252, and 0.181, respectively.

We weight the unweighted supermatrix first. We then raise the weighted supermatrix to limiting powers in order to capture all the interactions and to obtain a convergence outcome. After the weighted supermatrix, we present the priorities in Table 8.

According to the results of Table 8, the order of importance for the dimensions is Patient's Care of Life (D_1) = 0.3128, Nursing Staff (D_2) = 0.2858, Home Care Environment (D_3) = 0.2383, and Home Care Facilities (D_4) = 0.1632. Patient's Care of Life (D_1) is the key dimension that affects the quality of improvement in a nursing home. From the experts' viewpoint and experience in nursing care, Patient's Care of Life is more important than the other dimensions. Because a patient's daily care impacts the health and safety of the people who live in nursing homes, the patients themselves as well as their family look for good care of life in a nursing home.

Looking at the results of the global weights, the top ten priorities of factors are Rapid and Appropriate Referral (F2) > Specialized Nursing Care (F7) > Pain Management (F4) > Health and Safety Management (F14) > Emergency Processing Speed (F1) > Good Service Attitude (F6) > Sufficient and Competent Staff (F10) > Physician Involvement (F9) > Hygiene and Infection Control (F12) > Public Area Clean and Neat (F13). In order to effectively improve the quality of nursing care, those quality elements with a higher global weight should receive greater emphasis regarding improvement.

5. Discussion

As current generations get older and enter retirement, the thought of entering a nursing home can leave many with unsettled, mixed emotions. News stories frequently highlight poor treatment in senior living homes. Thus it is important for nursing homes to focus more on the treatment of residents. With proper customer service, a nursing home can be a pleasant place for all residents. In this study, we find some factors that improve service quality, which must be considered as a top priority.

Rapid and Appropriate Referral (0.0902) and Specialized Nursing Care (0.0769) are the respective first and second

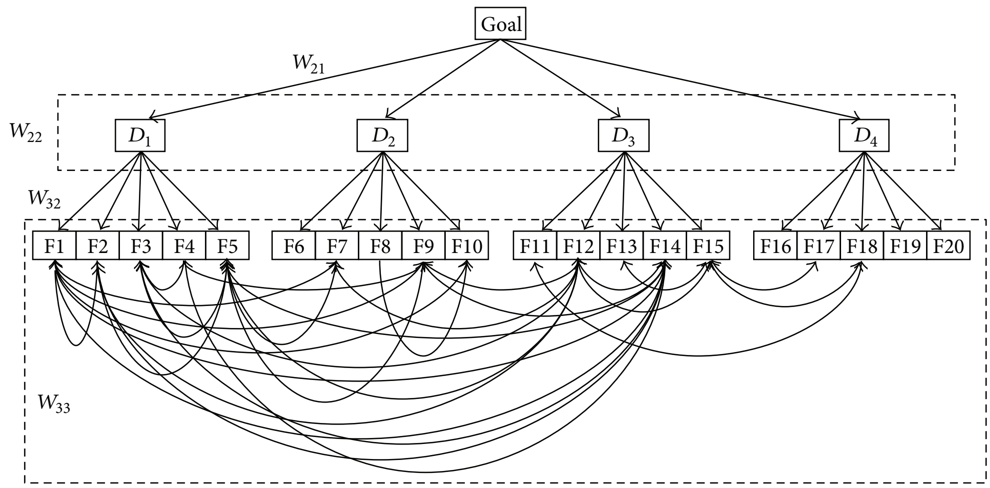

Figure 2: The ANP hierarchy.

priorities that require improvement. Older people in nursing homes are vulnerable to conditions causing disability. In Taiwan, at least 70% of older people suffer from one or more chronic illnesses, such as cancer, cerebral vascular disease, hypertension, heart disease, diabetes, and arthritis [43]. The demand for Rapid and Appropriate Referral and Specialized Nursing Care for disabled and chronically ill older people is very important in Taiwan. Therefore, we suggest increasing the number of professional nursing staffs engaged in nursing care and constructing a nursing care team for monitoring older people who need medical treatment as well as directing patients to a medical specialist.

We provide some aspects for improving Pain Management (0.0765). A nursing home may designate responsibility and accountability to specific staff positions for the screening of pain at admission and they can do so periodically thereafter as part of their routine interaction with residents. They can also educate all the staff members about pain symptoms in elderly people to address preexisting attitudes about such pain or knowledge deficits about pain manifestations in cognitively impaired individuals. They can use standardized evaluation tools, including pain-rating scales, to evaluate residents' complaints of pain found during screening and to train nursing staff about effective communication with physicians about pain management.

Health and Safety Management (0.0710) is also a key aspect of nursing care. We suggest concrete efforts be made to establish a systematic, standardized health and safety management system and mechanism. To achieve this, a nursing home has to set up its own health and safety management system to ensure the safety of all patients and nursing staffs through continuous improvement in the management system. This system covers education, training, consultation, prevention, and risk monitoring of serious diseases for patients, nursing staffs, and their families.

Emergency Processing Speed (0.0666) should be improved so as to enhance the quality of nursing care. We suggest that a nursing home develop a workable emergency evacuation plan. This plan has to provide guidance in the development of an evacuation plan containing detailed information, instructions, and procedures that can be executed under any emergency situation necessitating either a full or partial evacuation of the nursing home or assisted care facility. This plan must incorporate staff roles and responsibilities essential to this process. Staff must be educated in their role. These factors indicate that nursing home residents are concerned about their health and safety. If a nursing home can make residents feel confident regarding its ability to deal with emergencies and health and safety, then residents' satisfaction will increase.

6. Conclusions

This research has employed the ISM and ANP methods to prioritize key factors for improving the service quality of nursing homes in Taiwan's nursing home industry. First, we use ISM to systematically explore the causal relationships among various factors. Second, we implement ANP to identify the importance weights of the factors in improving the service quality of nursing homes. The findings show that the ISM technique can only help to prioritize the strategic issues during an assessment of the quality of nursing care, in the sense that it explores the influences and dependences between factors that affect the quality of nursing care and classifies them into independent, linkage, dependent, and autonomous clusters. It appears that ISM does not fully present the ability to depict what the key factors are. However, ISM can assist ANP in generating a quantifiable discussion, which appears more reasonable when presenting the identification of the key factors for improving the service quality of nursing homes.

The use of the ISM-ANP model in decision making is extremely useful, because both visualized analysis and quantified priorities can be obtained to assist management in decision making. According to the results herein, we are able to determine not only the rank order of all factors that affect the quality improvement of nursing care but also the assessment status of all possible causal relationships among

Table 7: Supermatrix before convergence.

		Goal	Dimensions				Factors																			
		G	D_1	D_2	D_3	D_4	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
Goal	G																									
Dimensions	D_1	0.318	0	0.323	0.261	0.403																				
	D_2	0.248	0.624	0	0.345	0.239																				
	D_3	0.252	0.334	0.255	0	0.358																				
	D_4	0.181	0.041	0.422	0.394	0																				
Factors	F1		0.216				0	0	0	0	0	0	0	0	0	0	0	0	0	0.095	0	0	0	0	0	0
	F2		0.289				0	0	0	0	0.284	0	0	0	0	0	0	0.051	0	0.065	0	0	0	0	0	0
	F3		0.136				0	0	0	0.645	0.367	0	0	0	0	0	0	0.118	0	0.145	0	0	0	0	0	0
	F4		0.246				0	0	0	0	0	0	0	0	0	0	0	0	0	0.242	0	0	0	0	0	0
	F5		0.112				0	0	0	0	0	0	0	0	0	0	0	0.148	0	0.222	0	0	0	0	0	0
	F6			0.237			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F7			0.267			0.21	0	0	0	0.189	0	0	0	0	0	0	0.159	0	0	0	0	0	0	0	0
	F8			0.126			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F9			0.165			0.29	0	0	0.355	0.159	0	0	0	0	0	0	0.207	0	0.159	0	0	0	0	0	0
	F10			0.204			0.3590	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F11				0.193			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.453	0	0
	F12				0.205		0	0	0	0	0	0	0	0	0	0	0	0	0	0.073	0	0	0	0	0	0
	F13				0.197		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.32	0	0	0	0	0
	F14				0.299		0.141	0	0	0	0	0	0	0	0	0	0	0.124	0	0	0	0	0	0	0	0
	F15				0.107		0	0	0	0	0	0	0	0	0	0	0	0.192	0	0	0	0	0	0.547	0	0
	F16					0.287	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F17					0.242	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.285	0	0	0	0	0
	F18					0.262	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.396	0	0	0	0	0
	F19					0.020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F20					0.189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8: Priorities of dimensions and factors.

Dimensions	Local weight	Factors	Local weight	Global weight	Priorities
Patient's Care of Life (D_1)	0.3128	Emergency Processing Speed (F1)	0.2130	0.0666	5
		Rapid and Appropriate Referral (F2)	0.2885	0.0902	1
		Medical and Therapeutic Care (F3)	0.1416	0.0443	13
		Pain Management (F4)	0.2446	0.0765	3
		Clinical Care (F5)	0.1123	0.0351	17
Nursing Staff (D_2)	0.2858	Good Service Attitude (F6)	0.2324	0.0664	6
		Specialized Nursing Care (F7)	0.2691	0.0769	2
		Staff Complement (F8)	0.1237	0.0354	16
		Physician Involvement (F9)	0.1711	0.0489	8
		Sufficient and Competent Staff (F10)	0.2037	0.0582	7
Home Care Environment (D_3)	0.2383	Space Requirements (F11)	0.1938	0.0462	12
		Hygiene and Infection Control (F12)	0.2023	0.0482	9
		Public Area Clean and Neat (F13)	0.1962	0.0468	10
		Health and Safety Management (F14)	0.2980	0.0710	4
		Good Living Environment (F15)	0.1097	0.0261	19
Home Care Facilities (D_4)	0.1632	Appropriate Bed Distribution (F16)	0.2843	0.0464	11
		Enough Illumination (F17)	0.2430	0.0397	15
		Bathroom and Toilet Facilities (F18)	0.2653	0.0433	14
		Medical Instrument (F19)	0.0201	0.0033	20
		Monitoring Information System (F20)	0.1873	0.0306	18

all factors. Significantly, the proposed method provides objective information to identify and evaluate the key factors for improving the quality of nursing care.

There are two noteworthy limitations to this study: generalizability and experts' judgments. First, the generalizability of these research findings is limited, because they are generated from a specific nursing home industry. The research design was not intended to produce results that account for or predict the decision-making problem in all industries. To apply the proposed methodology to other industries, an adjustment to the dimensions and factors may be needed. Second, in the theory of multiple criteria decision making, real-world decision-making problems are usually complex and ill-structured. Each decision making is based on a decision maker's preferences, experiences, judgments, and organizational policy. Therefore, one decision maker's judgment is expected to differ from another's, because the results reflect only the opinions of the experts who took part in this research. Therefore, invited experts should have sufficiently wide experience in the research industry and be truly representative in providing data that could be applied to top management in the research's targeted industry.

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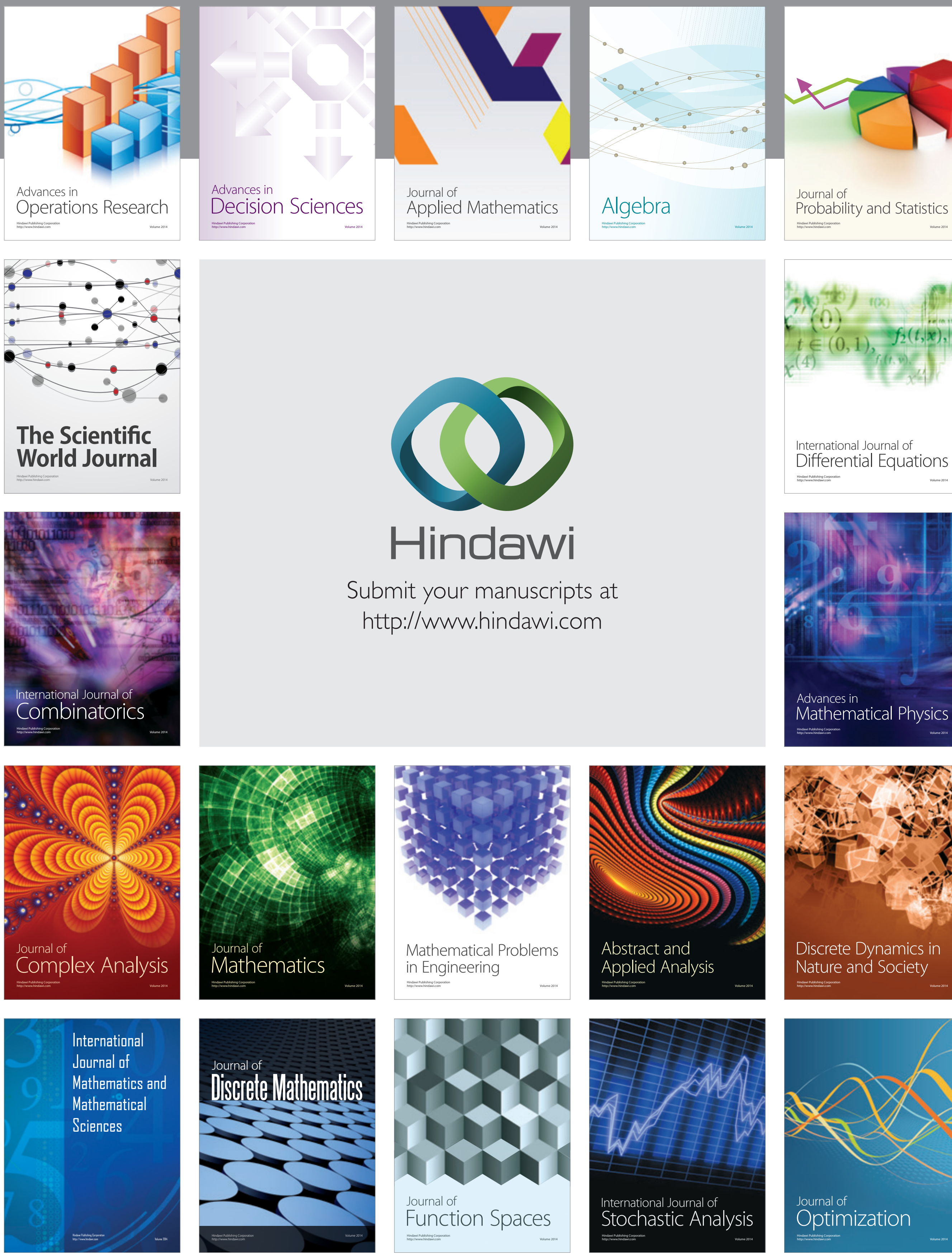
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