Original Article

Identification and Prioritization of Green Hospital Criteria in Fars Province with DEMATEL Combined Approach and Analytic Network Process (DANP)

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Abstract

Introduction: Designing and constructing hospitals using a green approach leads to a reduction of energy consumption and carbon emissions, improvement of indoor and outdoor air quality. The purpose of this research is to help hospitals identify and prioritize the factors influencing the establishment of a green hospital to protect the environment. Materials and Methods: In this descriptive-analytical research, the criteria of Green Hospital were first identified by a literature review and were localized and selected by experts using the Delphi method. Then, we applied the DEMATEL method to determine the relationships and effect of factors and analytic network process methods for weighting and prioritizing factors. Results: Findings of the DEMATEL method showed that management, water use, health, treatment, and innovation are effective in establishing green hospitals. The management dimension is of the highest weight (101%) and the greatest influence (1.48) and innovation and the quality of the indoor environment with the weight 83% are in the next rank. Discussion & Conclusion: Management and its sub-criteria are the most important factors in implementing a green hospital in Fars province. As a result, the implementation of the green hospital depends on the managers' efforts. In this regard, the strategic role of managers in today's hospitals affects the environmental resources and reduces the burden of disease on society while reducing costs.

Keywords: Prioritization, Criterion, Establishment, Green Hospital, Fars Province, Network Analysis

INTRODUCTION

Hospitals around the world strive to innovate in patient care by maintaining high standards of quality. In implementing this innovation, hospitals have an impact on the natural environment [1], and by applying the tools and techniques of green productivity, they minimize the environmental pollutants resulting from the service delivery process. For this reason, green productivity methodology has been practiced in hospitals around the world [2].

The Green Hospital sees the environment as part of its service quality processes and seeks to not harm itself and others by employing effective approaches in each of its dimensions including management, water, energy, building, waste, medicine, and shopping [3]. Hospitals consume a large amount of energy and other resources to provide high-quality care. Also, health care institutions can greatly reduce their environment-destroying impacts by using simple, smart and green measures [4].

The first method of environmental assessment (BREEAM) was from the United Kingdom in 1446, which led to the development of green assessment methods in the world [5]. For example, the studies of Nurisyahi Chua Abdullah, Hesam Sadatafafi, and Tanisha Barbara, Mohamed Effendi and Yvonne Ryan-Fogart have used green building assessment models including GBI, LEED, WHO, ISO 14001- HESG, GBRS to build green hospitals [6-11].

For example, the Pittsburgh Children Hospital in the United States has a LEED (Energy Leadership and Environmental Design) license [12]; it has applied energy productivity, leadership, chemicals, waste, energy, water, transportation by applying energy efficiency criteria. Food, Drugs, Building and Shopping [13] and has benefited from the green building

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design impacts by reducing mortality by 19 percent, reducing electricity and water by 50 percent and reducing sewage [14]. Singapore has achieved significant savings of $1872,000 in energy management and hospital waste management [15] using Green Productivity Strategy [15].

In Iran, measures have been taken for a green hospital following the environmental standards. In this regard, the Iranian Green Management Association has adapted the German Green Hospital Pattern and compiled a Checklist for Green Hospital with a validation approach [16, 17]. In a study, Shabani et al. proposed the dimensions of water, management, chemicals, waste, energy, garbage, site sustainability, innovation, indoor quality, environmental preferred purchasing, transportation and noise pollution for Iran [18, 19]. Of the 69 Social Security Hospitals, 19 have been able to implement fully the International Standard on Environmental Management, according to statistics provided by the Department of Health Deputy of Social Security Organization [4, 19].

Since none of the studies studied has used a combined method of DEMATEL and ANP and on the other hand, they are suitable methods for prioritization. Therefore, the purpose of the present research is to use MCDM combined methods to identify and analyze the effective factors in green hospital in Fars province.

Research Methodology

This research is applied and in terms of data collection, it is a descriptive-analytical survey oriented to problem-solving through fuzzy mathematical modeling. In the data collection sequence, qualitative data first and then quantitative data were collected. The main data collection tool in this research is the questionnaire. We have extracted the theoretical issues of criteria and dimensions of Green Hospital through library studies and reference to Persian and Latin articles. We have chosen the Delphi localization method to finalize the model. The Delphi results are shown in Table (1). The content validity and reliability of the questionnaire derived from field studies and the model were confirmed by 5 university experts and 10 hospital managers. Then, the findings of the studies were evaluated by a DAMATEL questionnaire and the causal relations were investigated by the DAMP method.

The research population included 15 health experts, 5 university professors, and 10 hospital managers. Characteristics of the experts were 2 years of work experience related to health care management, postgraduate qualifications related to health care management, availability and willingness to participate in research. The most important point in determining the experts is the presence of academic experts against the professional and empirical experts of hospital management to ensure the comprehensiveness of different perspectives. Since this research uses the expert population, so there is no statistical sample in this research.

Data were analyzed using the combined methods of multi-criteria decision theory including ANP based on DEMATEL (DANP). The ANP method is a mathematical theory proposed by Saati in 1999; it systematically calculates the weight of factors when they are in contact and prioritizes the problems existed among dependency and feedback assessment factors [6]. In this research, we used the DEMATEL method to determine dependency and to determine relationships among factors. The DEMATEL method examines the structure of how agents influence and tries to solve the problem facing organizations and improve it by applying group decision making in context. In this method, the degree of influence of one factor on another is determined by the opinions of the experts and ultimately it determines the priority of the factors influencing a particular system [7].

Table 1: Completing the questionnaire from the five-degree DEMATEL spectrum

Without effect	Very low effect	Low effect	Moderate effect	High effect
0	1	2	3	4

Findings

To identify the effective factors in Green Hospital, we identified by reviewing the articles, criteria and following dimensions for Green Hospital implementation:

Dimensions of sustainable sites, water efficiency, energy and atmosphere, materials and resources, environmental quality, innovation [8-11, 14, 19-36] as well as India's IGBC [10, 35] and Africa's Green GSH [9], the Chinese GBL pattern are an adaptation of the LEED model [10, 11].

UK Environmental Assessment Method BREEAM with Dimensions of Management, Health, Energy, Transport, Water, Materials, Waste, Land Use, and Environment, Pollution, Innovation [10, 11, 14, 25, 34, 35, 37, 38]. The Duurzaamheidsmeter Zorg method is adapted from the English model of hospital green evaluation [39].

Malaysia Green Assessment Method GBIAP with dimensions of Environmental Assessment, Energy productivity, Indoor Environmental Quality, Planning and Management, Materials and Resources, Water Productivity, Innovation [8, 10, 25, 37, 38, 40].

Australian Green Star Method GREEN STAR with dimensions of Management, Environmental Quality, Energy, Transport, Water, Materials, Land Use and Environment, Innovation [8, 10, 25, 35, 37].

German Environmental Assessment Method DGNB with dimensions of Classification of Internal, Economic, Social Environmental Quality, Technology, Process, Site and dimensions of Energy, Management, Chemical, Building, Purchasing, Medication, Waste, Water [4, 41]. Japan

Environmental Assessment Method CASBEE has the following classification: Pre-design, New Construction, Existing Buildings, and Reconstruction and with dimensions of Energy Efficiency, Site Selection, Indoor Environmental Quality, Resources and Materials, Water Conservation [10, 11, 35, 42]. World Health Organization WH0 with model GGHC with dimensions of Energy, Pollution, Environment, Shopping, Green Building Design, Transportation, Food, refuse & Waste, Water, Healthy Environment and Sustainable Health, Focus on Health Promotion and Prevention [8, 28, 30, 35, 39, 43, 44]. Environmental Management System Approach ISO 14001 - Environmental management system with dimensions of management, energy, hazardous and infectious waste management, water, sewage, pollutants, water, environmental preferred purchase [4, 30, 43, 45-47]. The WELL method has used the dimensions of the health of air, water, nutrition, light, fitness, comfort and mind, water, sleep and ergonomic factors of chemical inhibitors [24]

In the following, the Delphi method was used to localize and apply the identified factors to the green hospital under study; the experts reached consensus in two phases. In the second phase in the fuzzy Delphi method, 13 dimensions are assigned to the accepted theory as described in Table (1).

Table 2: Final Criteria for Designing the Green Hospital Establishment Pattern in Fars Province

Criterion	Sub-criterion	Criterion	Sub-criterion
Sustainability	Sustainability	Preferred purchase	Food
	Planning	Energy consumption	Economy
	Location		Natural light
Construction	Orientation	Water consumption	Drop irrigation
	Resistant structure		Water-efficient equipment
Indoor environment	Toxic substances		Energy evaluation
	Weather		Evaluating water Consumption
	Noise	Wastewater	Wastewater purification
Management	Guideline	Waste and recycling	Waste separation
	Green management		Waste
	Wastage reduction		Education
	requests		Disinfection
	Safety		Materials control
Resources	Recycle	Health & treatment	Education
	Shopping		Disinfection
	Electronic services	Innovation	Electronic innovations
Transport	Electronic transport		Innovation in each criterion

F DEMATEL method was used to investigate the inter-relationships between factors. Experts determined the extent to which each of the factors influenced each other, and after aggregating the opinions of 15 experts, the matrix table of the aggregated opinions relations for dimensions and criteria was formed. We formed the normalized matrix of direct relations and then obtained the matrix (T).

Table 3: Complete Relationship Matrix (T) of Principal Factors (Source: Research Data)

Dimensions	Innovation	Health & treatment	Transportation	Waste	Sewage	Water	Energy	Preferred	Resources	Management	Quality	Construction	Sustainability
A	0.050	0.044	0.039	0.050	0.059	0.048	0.057	0.034	0.049	0.061	0.057	0.060	0.052
B	0.045	0.039	0.034	0.041	0.042	0.040	0.055	0.027	0.042	0.053	0.045	0.038	0.053
C	0.044	0.045	0.039	0.047	0.043	0.035	0.041	0.031	0.040	0.054	0.040	0.047	0.046
D	0.060	0.060	0.050	0.060	0.056	0.050	0.057	0.041	0.055	0.066	0.062	0.057	0.053
E	0.052	0.045	0.039	0.044	0.041	0.040	0.047	0.031	0.038	0.059	0.046	0.049	0.045
F	0.026	0.025	0.021	0.025	0.026	0.022	0.027	0.011	0.025	0.035	0.026	0.025	0.028
G	0.052	0.044	0.038	0.044	0.047	0.047	0.046	0.036	0.047	0.060	0.046	0.059	0.051
H	0.045	0.036	0.032	0.035	0.042	0.038	0.043	0.025	0.037	0.050	0.037	0.040	0.040
I	0.054	0.049	0.040	0.052	0.030	0.041	0.045	0.033	0.045	0.062	0.053	0.050	0.050
J	0.052	0.057	0.048	0.052	0.048	0.038	0.043	0.031	0.047	0.066	0.054	0.050	0.045
K	0.039	0.044	0.021	0.042	0.032	0.028	0.032	0.024	0.033	0.053	0.042	0.029	0.030
L	0.051	0.042	0.040	0.053	0.044	0.037	0.041	0.030	0.045	0.063	0.050	0.040	0.037
M	0.055	0.062	0.056	0.060	0.019	0.056	0.063	0.044	0.063	0.076	0.065	0.060	0.059

In this study, the threshold value is 0.044. So the pattern of meaningful relationships is as follows. The result of the calculations is given in Table 4.

Table 4: Causal Relations Pattern of Research Main Dimensions

Dimensions	D	R	D+R	D-R
Sustainability	0.5876	0.6610	1.2486	-0.0733
Construction	0.6037	0.5533	1.1570	0.0504
Quality	0.6212	0.5511	1.1723	0.0700
Management	0.7577	0.7266	1.4842	0.0311
Sources	0.5663	0.5760	1.1422	-0.0097
Preferred purchase	0.4000	0.3211	0.7211	0.0789
energy productivity	0.5980	0.6173	1.2153	-0.0193
Water	0.5200	0.4994	1.0194	0.0206
Sewage	0.5283	0.6040	1.1323	-0.0757
Waste and recycling	0.6056	0.6319	1.2375	-0.0263
Health & treatment	0.4982	0.4494	0.9476	0.0488
Transportation	0.5895	0.5727	1.1622	0.0169
Innovation	0.6248	0.7372	1.3621	-0.1124

The sum of the elements of the columns and rows of the T matrix is computed for the main factors and their sub-factors and in the form of D vectors, in which management has the most influence. Quality, waste, and recycling are also next in effectivity.

R was named impressionable. In the present study, management is highly impressionable. The criterion of health and treatment is the least impressionable among criteria.

-Horizontal vector (D + R) is the amount of influence and impression of the factor in the system. In other words, the higher the D + R factor, the more it interacts with other system factors. Therefore, management has the most interaction with the other criteria under study. Transport has the least interaction with other variables.

- Vertical vector (D - R) shows the power of the effectivity of each factor. Generally, if D - R is positive, the variable is causal, and if negative, it is a cause. In this model, the construction stage, environmental quality, management, environmental preferred purchasing, water use, transportation, and health are the effects and site sustainability, resources, sewage, and innovation are the causes.

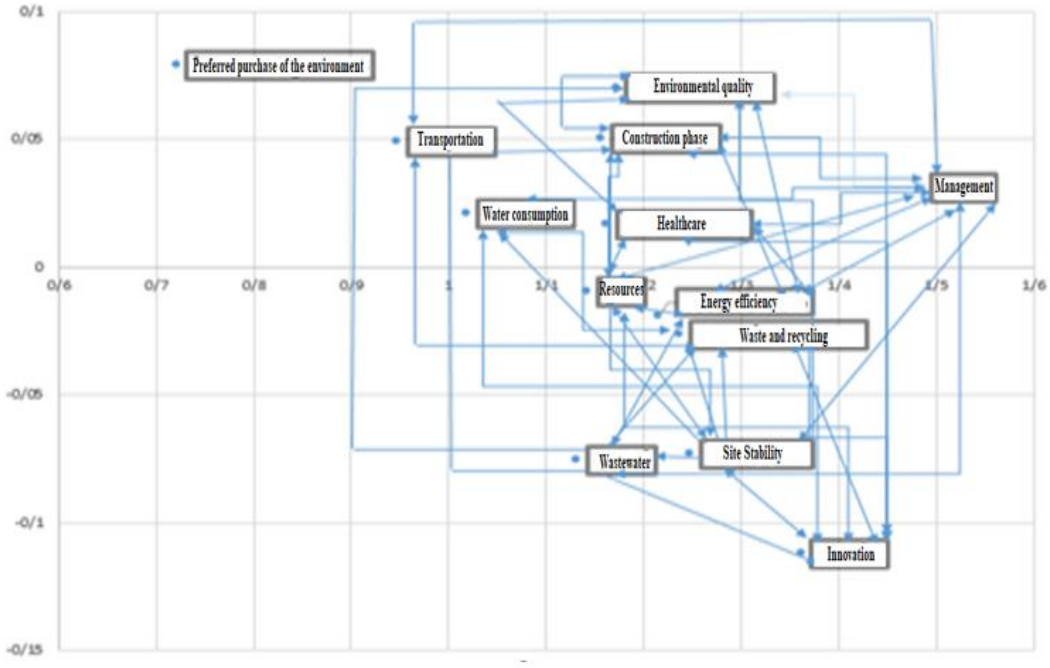

Diagram 1: Cartesian coordinate diagram of DEMATEL output for the main factors (source: research data)

The horizontal axis of the diagram shows the importance of D + R factors and the vertical axis the net action/reaction of D-R factors and the direction of the arrow show the effectivity. The map of relations network has been shown in Diagram (1).

Table 5: Dimensions weight and design criteria for a green hospital establishment pattern in Fars province

Criterion	Sub-criterion	Weight of sub-criterion	Weight of dimensions	Criterion	Sub-criterion	Weight of sub-criterion	Weight of dimensions
Sustainability	Sustainability	0.25	0.78	Preferred purchase	Food	0.53	0.53
	Planning	0.25		Energy	energy consumption	0.43	0.80
	Location	0.29			natural light	0.37	
Construction	Orientation	0.43	0.83	Water consumption	drop irrigation	0.16	0.69
	Resistant structure	0.37			Water-efficient equipment	0.17	
Indoor environment	Toxic substances	0.29	0.83		Energy Consumables	0.19	
	Weather	0.29			Consumption of water equipment	0.18	
	Noise	0.25		Wastewater	Wastewater purification	0.71	0.71
Management	Guideline	0.24	0.101	Waste and recycling	Waste separation	0.17	0.81
	Green management	0.24			Waste	0.16	
	wastage	0.19			Education	0.17	
	requests	0.17			Disinfection	0.16	
	Safety	0.17			Materials	0.16	
Resources	Recycle	0.23	0.75	Health & treatment	Education	0.39	0.79
	Shopping	0.33			Disinfection	0.39	
	Electronic services	0.20		Innovation	Electronic innovations	0.32	0.83
Transport	Electronic transport	0.66	0.66		Innovation	0.52	

Then, the ANP method was used for weighting the factors. Initially, the model was drawn with the research grid structure the figure (2) shows it. At this stage, the normalized weight was obtained for the DEMATEL general relations matrix factors; an unbalanced supermatrix was formed and then the balanced supermatrix was obtained. Finally, the weighted super-matrix was converged and the limit matrix was formed and the weight of the factors were obtained. Table 5 shows the results. The results of Table (5) show that the most weight is related to the dimension of management with 101 weight; it gained the priority and later gained the dimensions of innovation and quality of the interior environment obtained the subsequent priorities. This is due to the importance of these factors among the other factors.

Discussion and Conclusion

In the present research, we have presented a combined multi-criteria system of ANP (DANP) and DEMATEL (DANP) for implementing the green hospital criteria that can be used in similar hospitals.

We have selected the criteria affecting green hospital including 13 dimensions and 34 criteria (Table 2). These dimensions and criteria indicated the importance of establishing a green hospital in Fars province. Dimensions of management, waste, innovation, and quality of the indoor environment influenced green hospital implementation, respectively. The management dimension is most effective in the green hospital. In other words, the dimension of management is the bottleneck of hospital operation that is resolved by influential dimensions. This result indicates that the dimension of management becomes a measure of health. The dimension of Management is also the most influential aspect and should be prioritized by policymakers. Therefore, to use the green hospital benefits, hospital managers and health policymakers must adequately support it. Therefore, it is clear that considering the novelty of the green hospital model in Fars province, paying attention to proper management and consulting with experienced specialists is of great importance.

According to the results of Table (4), the most important factor calculated by DANP in executing the green hospital was the management dimension, which gained the priority with a weight gain of 0.101. Among the following sub-criteria, the criterion with the weight of treatment Guideline and Green Management Executive Programs achieved priority. It indicates that any hospital design and project requires proper planning, clear objectives, proper implementation, and supervision, all of which are defined in the management framework.

On the other hand, the dimensions of innovation and quality of the internal environment, with a weight of 83%, came in second priority. It is clear that using innovative methods and creativity is valuable in all criteria of a green hospital is valuable. The environmental management system enables the centers to achieve their environmental goals. As it is clear, using innovative methods and creativity is valuable in all Green Hospital criteria.

Finally, the waste and recycling criterion with the weight 0.81 achieved the third priority. This result showed that in the present research, waste and recycling are also in the next degrees of effectivity. Waste disposal, energy consumption, and sewage are major hospital costs that have potential environmental implications. Most health care centers are unaware of the effects they may have on the environment. Lack of optimal utilization of facilities, lack of oversight and inadequate planning and mismanagement of hospitals and inappropriate separation of hospital wastes produce high volumes of diverse wastes whose control imposes a high cost on each society from the production to final disposal. Among the available waste, hospital waste was classified as the most hazardous type of waste and considered as one of the major environmental pollutants.

In research, Ryan Fogarty et al. have dealt with the importance of management, supervision, and innovation [48]. Also, in research, Sahamir & Zakaria discussed the obligation to implement green management, green hospital standards and the establishment of an environmental management system (green management systems) without formal procedures for obtaining voluntary standards [21, 37]. BREEAM, LEED, SBTool, and CASBEE patterns have dealt with innovation [49, 50].

Ali Taleshi et al. believe that sound management and planning are of paramount importance in green hospital standards. Management approaches in today's hospitals have severely depressed the environment and have had a serious impact on the increase in society's health while increasing hospital costs. In other words, hospitals were captured by a managerial paradox.

According to researches, all researches, both internal and external, point to the importance of environmental quality [37, 51]. In the study, Ridolfia, Andreisb, Panzieric et al. concluded that indirect aspects are mainly related to land supervision and planning. Indicators based on the classical pressure-state approach as well as based on CO2 equilibrium, sustainable analysis exposed to the environment have been used to evaluate EMS environmental performance [52].

In research, Van Demark et al. showed that health services in the United States produce 4 billion pounds of waste annually, with 70% directly generated by operating rooms. Waste disposal accounts for up to 20% of the hospital's annual environmental budget; the use of green management systems leads to reduce waste disposal in the operating room and reduce health care costs and potential environmental hazards [53]. Research by Unger et al. suggests that re-optimizing medical product reuse reduces the use of custom-packaged products and evaluates the energy recovery potential of the

products used [54]. The findings are consistent with the present study.

Comparing the results of the present research with those of previous studies, we can say that the results of this research are in line with previous researches as above mentioned.

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