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Using AHP and ANP approaches for selecting improvement projects of Iranian Excellence Model in healthcare sector

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Healthcare has a long tradition in developed methods and models to assess the quality of work. There have been several models presented for deployment and assessment of quality management which much more attention is paid to organization excellence models due to their being total and complete. The European Foundation for Quality Management (EFQM) excellence model can be used for continuous improvement of activities and performance of organizations from both private and public sector by establishing a Total Quality Management (TQM) philosophy. Iran national productivity and excellence award in collaboration with Azad University – Science and Research campus and ministry of health, treatment and medical training, designed a model for healthcare organizations and this model was used in 23 hospitals. The study was based on experience gained in hospitals, to rank the improvement projects using Analytic Network Process (ANP) and Analytic Hierarchy Process (AHP) methods. The objective of this paper is to present the results of the application of AHP and ANP to select a project within the field of healthcare in Iran. Project number nine "Leadership Development and Succession Planning" got the highest score, and it is the most appropriate choice.

Key words: European Foundation for Quality Management, multi-criteria decision methods, analytic hierarchy process, analytic network process, health sector.

INTRODUCTION

Nowadays many Iranian organizations have realized the need for regular and systematic self-assessment on improving projects. It has realized that on-time detection and management of change is a competitive advantage. Improvement projects help the organization achieve higher level of excellence. A self-assessment process clearly identifies the strength and improvement potentials of the organization (Najmi and Hosseini, 2009). Today, many countries around the world encourage organizations and companies to follow the models of excellence such as EFQM, Deming and Baldrige. They award prizes, such as Human Resource (HR) excellence awards of HR management association of America, standard of investment in Human Resources and developer standard in Singapore, through institutions and professional associations of human resource development and management to companies and organizations that have accomplished significant achievements in the field of

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human resources.

The EFQM model is a generic model for quality management, which is used in all types of organizations as a multidimensional framework. One of the most positive aspects of EFQM is the use of self-assessment (Tutuncu and Kucukusta, 2009). In order to achieve excellence; companies need to be aware of the impact of criteria on each other and also the analysis of relations between enablers and results. Since the EFQM excellence model does not show the relationships clearly, companies are not able to accurately analyze the effects of the projects on the criteria after implementing self-assessment and identifying areas that have to be improved. Understanding the relationships between the criteria makes it possible for companies to analyze the projects' effects on model criteria and to apply appropriate tools for improvement while planning and setting goals for the future direction of organizational excellence. Accordingly, in 2002, following the model of the EFQM Excellence Award (EEA), Iran has lunched Iran National Productivity and Excellence Award (INPE). Also due to the needs of various sectors for an exclusive and customized model, the plan for the recreation of the EFQM excellence model in accordance with the healthcare sector was proposed in 2010.

MCDM applications in healthcare settings have spread into various areas, including allocation of health resource (Earnshaw and Dennett, 2003), health policy (Epstein et al., 2007), medical assessment (Oddoye et al., 2006), medical decision (Liberatore and Nydick, 2008), regional resource (Wilson and Gibbard, 1990), resource allocation (Flessa, 2003), surgical case (Cardoen et al., 2009), and surgical waiting lines (Arenas et al., 2002). AHP has been widely used in the multiple criteria decision making in various fields such as the assessment of medical implementation plan (Dolan, 1989), the planning of healthcare human resources (Kwak et al., 1997), health care assessment and policies (Hannan et al., 1981), the assessment of medical institutions' performance care (Ahsan and Bartema, 2004); healthcare (Javalgi et al., 1991), business process reengineering (Kwak and Lee, 2002), etc. Recently, there has been increased interest in its application for evaluating health care facilities. The analytic hierarchy (AHP) and analytic network process (ANP) are two Multi-Criteria Decision Methods (MCDM), originally developed by Prof. Thomas L. Saaty. ANP is a generalization of the AHP. A hierarchy is comprised of a goal, levels of elements and connections between the elements. These connections are oriented only to elements in lower levels. Many decision regarding problems cannot be structured hierarchically because they involve the interaction and dependence of higher-level elements in a hierarchy on lower-level elements. Not only does the importance of the criteria determine the importance of the alternatives as in a hierarchy, but also the importance of the alternatives themselves determines the importance of the criteria. A network has clusters of elements, with the elements in one cluster being connected to elements in another cluster (outer dependence) or the same cluster (inner dependence). A hierarchy is a special case of a network with connections going only in one direction. An example of the format of a network is shown in Figure 1(b).

Therefore, ANP is represented by a network, rather than a hierarchy. The ANP consist of the clusters, elements, interrelationship between elements in the cluster and interrelationships between clusters, while AHP does not include interrelationship and feedback within the elements in the model.

Mashhad University of medical sciences which, in the form of MUMS[1] Evaluation and Excellence Award (MEEA), uses the EFQM excellence model in order to assess performance of its affiliate branches, in 2011, used the re-conceptualized model for health sector in 23 of hospitals controlled by this university. While using the model, Hospitals noticed a large number of areas for improvement, and in order to grow they had to cover them by implementing improvement projects. But it was not possible to implement the entire project simultaneously and they needed to prioritize and chose the most effective ones. Therefore in this paper ANP and AHP methods will be applied to prioritize 10 improvement projects. The opinions of 15 experts are collected by means of a matrix based questionnaire and the analysis is performed based on the responses.

Beneath there will be a literature review and criteria of healthcare organization excellence model, the process of deploying the excellence model, description of AHP and ANP methods, and a review on background of the study. The research methodology is given in the following section. Also, deployment of these methods in 23 treatment centers (hospitals) in Mashhad is described. And finally, conclusion of the whole discussion is drawn.

LITERATURE REVIEW

In this section, EFQM and AHP, ANP will be described.

EFQM excellence

The European Foundation for Quality Management (EFQM) based in Brussels was founded in 1988 by 14 leading corporations. The aim is to induce and secure a systematic and incremental increase in quality in European organizations in order to strengthen their position in the global market (Herget and Hierl, 2007). There are some researches that have pointed out that the EFQM Excellence Model constitutes an appropriate framework to guide the systematic implementation of Total Quality Management (TQM) (Bou-Llusar et al., 2005; Calvo-Mora et al., 2005; Martinez-Lorente et al., 2009; Vijende and Gonzalez, 2007; Westlund, 2001).

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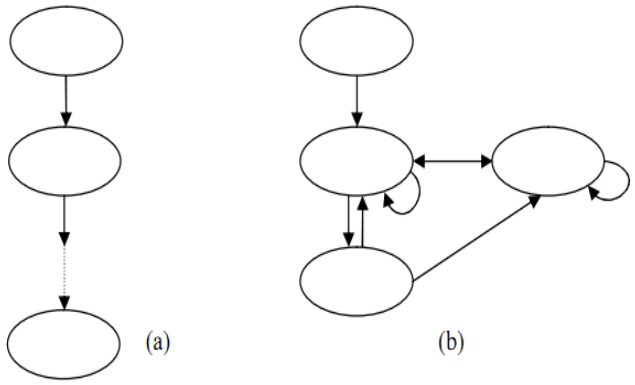

Figure 1. Structural difference between a hierarchy and a network. (a) A Hierarchy (b) a Network.

After reviewing the literature, it turned out that many researchers have considered excellence model as a systematic mechanism to improve organizational performance (Bergquist et al., 2005; Dahlgaard-Park, 2008).

The EFQM excellence model is a non-prescriptive framework that establishes nine criteria, which any organization can use to assess the progress towards excellence. These nine criteria are divided between enablers and results (Calvo-Mora et al., 2006). The model includes five “enabler” criteria: leadership, strategy, people, partnership and resources; and processes, products and services. It also comprises four “results” criteria: customer results, people results, society results, and key results (European Foundation for Quality Management, 2010). The enablers represent the way the organization operates, and the results concentrate on achievements relating to organizational stakeholders (Bou-Llusar et al., 2009). According to EFQM (2010) organizations that aim at achieving excellence focus on improvement in some concepts of TQM theory such as achieving balanced Results, adding value for customers, leading with vision, inspiration and integrity, managing by processes, succeeding through people, nurturing creativity and innovation, building partnerships and taking responsibility for a sustainable future. The specific purpose of the EFQM excellence model is to provide a systems perspective for understanding performance management. With their acceptance nationally and internationally as the model for performance excellence, the criteria represent a common language for communicating and sharing best practices among organizations (Wongrassamee et al., 2003).

EFQM Model has been comprised of two parts: One part entitled "Enablers" while the other part is entitled "Results". Of total nine criteria, five of which have been used as "Enablers" while four of these criteria are related to the "results" part. Leadership, strategy, policy, staff and personnel, trade partners, resources and processes are considered of the criteria which are posed at "Enablers" part. Moreover, results of customers, results of staff and personnel, results of sample society, and key results of performance are of the criteria which are discussed at "results" sector.

The structure of EFQM Model has been shown in Figure 2.

The process of using organizational excellence model in the health sector

Based on the method defined by EFQM, the organizational excellence model is used through an eight-stage process, as shown in Figure 3.

Stage 1 - The first stage of this process is establishing and maintenance of organizational leaders’ commitment to organizational excellence. In this stage, using educational plans and culture building, leaders become familiar with the concepts and models of organizational excellence and the necessity of self-assessment and improvement planning based on excellence model.
Stage 2 - The aim of this stage is establishing organizational excellence relationships. The speeches and messages of the leaders, using panels and newsletters, and creating websites are among tools which are used to implement excellence relationships strategy.
Stage 3 - In the self-assessment planning stage, the manager of organizational excellence is appointed and organizing excellence is performed (appointing excellence teams). Besides, the technique used for self-assessment is specified and a schedule for implementing self-assessment is prepared.
Stage 4 - Implementing self-assessment begins with selecting individuals and appointing them to excellence teams as well as familiarizing them with the model and self-assessment based on excellence model.
Stage 5 - In the self-assessment stage, using techniques selected for self-assessment, excellence team members perform different stages of self-assessment. Self-assessment will have three major results for the organization; strong points, improvable areas, and score. The obtained improvable areas are the input of the sixth stage.
Stage 6 - At this stage, organization leaders discuss the improvements which have priority for the organization and prioritize them and eventually, select some of them.
Stages 7 - For the selected improvable areas, improvement projects are defined, trustees are selected, resources are allocated to them and their implementation begins.
Stage 8 - In the last stage, the progress of improvement projects is periodically monitored and by revising the process of self-assessment in the previous stages, a new self-assessment is performed at the organization. In fact, using excellence model is a continuous improvement cycle which lasts forever.

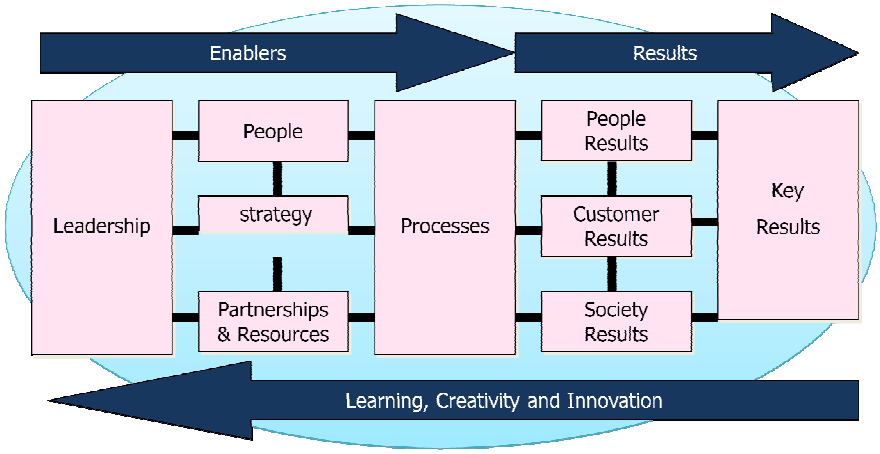

Figure 2. EFQM excellence framework.

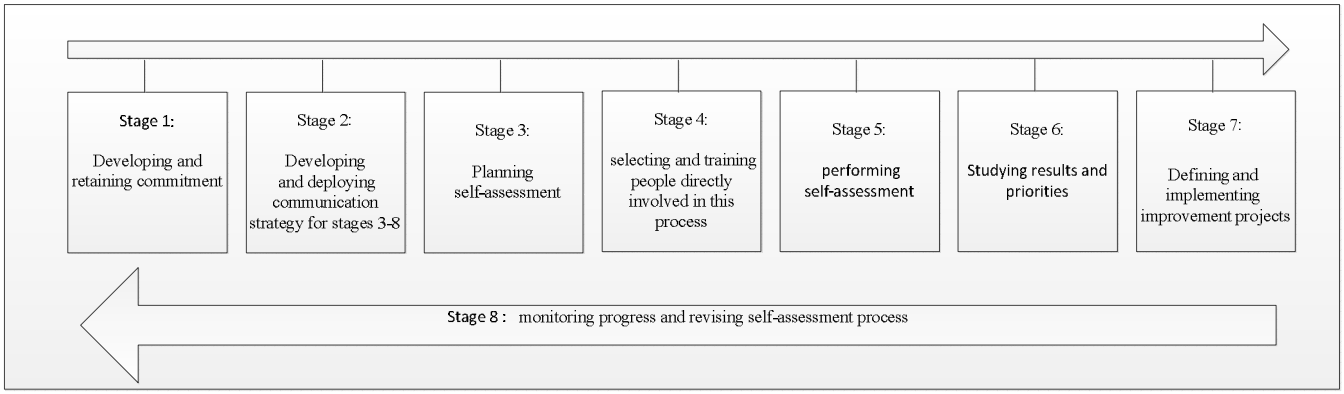

Figure 3. Stages for using organizational excellence model.

AHP technique

The AHP is a structured practice for representing the elements of a problem, hierarchically. The AHP method was developed by Saaty (2005). It can enable decision makers to represent the interaction of multiple factors in complex, unstructured situations. The procedure is based on the pair-wise comparison of decision elements with respect to attributes or alternatives.

Structuring the hierarchy for evaluation

In general, the AHP method divides the problem into three levels:

- Define a goal for resolving the problem
- Define objectives for achieving the goal
- Determine evaluation criteria for each objective.

After structuring a hierarchy, the pair-wise comparison matrix for each level is constructed. During the pair-wise comparison, a nominal scale is used for the evaluation. The scale used in AHP for preparing the pair-wise comparison matrix is a discrete scale from 1 to 9, as presented in Table 1.

A reciprocal value is assigned to the inverse comparison; that is, $a_{ij} = \frac{1}{a_{ji}}$, where a_{ij} (a_{ji}) denotes the importance of the ith (jth) element. The values of pair-wise comparisons are allocated in comparison matrix and local priority vector is obtained from eigenvector which is calculated from this equation:

$$A \times w = \lambda_{max} \times w$$

Where A is the matrix of pair-wise comparison, w is the eigenvector, and λ_{max} is the largest Eigen value of A.

Consistency of pair-wise matrix is checked by consistency index (CI). For accepted consistency, CI must be smaller than 0.10.

$$CI = \frac{\lambda max - n}{n-1} \qquad CR = \frac{CI}{RI}$$

Table 1. Scale of relative importance.

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Essential or strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate value between adjacent scale values

In the equations above, CI, RI and CR represent consistency indicator, random indicator and consistency ratio, respectively.

Analytic Network Process (ANP) method

The ANP, a new theory extending from the AHP, is proposed by Saaty (1996). The ANP is composed of four major steps (Saaty, 1996):

Step 1: Forming the network structure.

The problem should be stated clearly and decomposed into a rational system like a network. The structure can be obtained by the opinion of decision-makers through brainstorming or other appropriate methods. Firstly, criteria, sub criteria and alternatives are defined. Then, the clusters of elements are determined. The network is formed based on relationship among clusters and within elements in each cluster.

Step 2: Forming pair-wise comparison matrices and obtaining priority vector.

Pair-wise comparisons are performed on the elements within the clusters as they influence each cluster and on those that it influences, with respect to that criterion. The pair-wise comparisons are made with respect to a criterion or sub-criterion of the control hierarchy. Thus, importance weight of factors is determined. In pair-wise comparison, decision makers compare two elements.

Then, they determine the contribution of factors to the result (Saaty, 2001). In ANP, like AHP, it is formed pair-wise comparison matrices to use a 1 to 9 scale of relative importance proposed by the Saaty.1 to 9 scale of relative importance is given at Table 1. Using superdecision software the pair-wise comparisons were provided for dependencies among the clusters and decision elements. The superdecision software reports an inconsistency ratio for every pair-wise comparison matrix. A comparison matrix is considered to be consistent when its inconsistency ratio is less than 0.10. Inconsistency ratios of all our comparison matrices turned out to be less than 0.10, therefore, accepted as consistent.

Step 3: Super-matrix formation.

For evaluating the weights of the elements, the AHP uses the principal eigenvector of comparison matrix, while the ANP employs the limiting process method of the powers of the super-matrix. The super-matrix concept is similar to the Markov chain process (Saaty, 2005). To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix. As a result, a super-matrix is actually a partitioned matrix, where each sub-matrix represents a relationship between two nodes (components or clusters) in a system.

Step 4: Selection of best alternatives.

It is able to determine importance weights of alternatives, factors and sub-factors from limited super-matrix. The highest importance weight shows the best alternative.

Research background

Table 2 shows some researches around using AHP and ANP methods in healthcare sector.

METHODOLOGY

The research methodology consisted of three main phases the process is presented in Figure 4.

Phase 1: Defining problem and Theoretical framework of research. Review on fundamental of Organization excellence model and healthcare excellence model and Process of using organization excellence model.

Phase 2: Deployment of AHP and ANP for ranking the projects.

In the final phase AHP and ANP method was used for prioritizing 10 improvement projects.

SOLUTION APPROACH

In this paper, ANP and AHP methods was applied to prioritize 10 improvement projects. The names of these projects are provided in Table 3 (a and b).

Project selection using AHP technique

The application of the AHP to the study case has been performed with reference to the three phases described earlier, the model has been developed through the use of the specific Expert choice software. Figure 5 shows the

Table 2. Some researches around using AHP and ANP methods in healthcare sector.

	Year	Authors	Methodology and Results
AHP and Healthcare	2006	Chan	This paper proposes to apply the AHP to hospital scorecards in performance assessment. Although AHP could be a time-consuming exercise, it allows participative input in determining a comprehensive measure for comparing performance of healthcare organizations. The objective of this paper is to examine the value of balanced scorecard in the management of healthcare organizations and to describe an analytic hierarchy framework that can be used to evaluate scorecards of departments and programs within healthcare organizations and the performance of healthcare organizations as a whole.
	2007	Brent et al.	This paper focuses on the application of the AHP technique in the context of sustainable development to establish and optimize health care waste management (HCWM) systems in rural areas of developing countries. This is achieved by evaluating the way in which the AHP can best be combined with a life cycle management (LCM) approach, and addressing a main objective of HCWM systems, that is to minimize infection of patients and workers within the system. The modified approach was applied to two case studies: the sub-Saharan African countries of South Africa and Lesotho. Quantitative weightings from the AHP are used to identify alternative systems that have similar outcomes in meeting the systems objective, but may have different cost structures and infection risks. The two case studies illustrate how the AHP can be used (with strengths and weaknesses) in environmental engineering decision support in developing countries.
	2010	Chung-Hsiung et al.	This study conducts AHP method to develop a managerial competency framework for middle managers in the medical industry. The data collection is from nursing supervisors and top-level executives in medical institutions. Participants are required to make a comparison in importance between two competencies and then comparison results are processed and analyzed. Factors at the first level for selecting middle managers in the medical industry are sorted by importance as follows: personality, plan, manage, professional ability and interpersonal ability, indicating that experts believe that personality and plan are very important to middle managers in the medical industry, most of which are responsible for administrative management. We establish a core competency model for reserve middle-level managers in the medical industry. Reserve cadres can take training courses for administrative management arranged by the Nursing Department and the hospital, in which they can establish their career plans and improve their abilities and the human resource department can also find and train excellent talents.
	1997	Hokey et al.	This paper proposes an AHP that can help medical clinics formulate viable service improvement strategies in the increasingly competitive healthcare industry. This paper also illustrates the usefulness of the proposed health care quality measures using the case of prominent Korean cancer clinics.
	2011	Hummel et al.	The objective of this study is to review the past applications of the AHP in supporting health care decision making, and to make recommendations for its future use. We conducted a systematic review of AHP applications in health care, as described in the relevant medical, health-economical, psycho-sociological, managerial, and applied mathematical literature. They found 62 distinctive AHP applications in health care. Of the retrieved applications, 13% focus on shared decision-making between patient and clinician, 27% on the development of clinical practice guidelines, 5% on the development of medical devices and pharmaceuticals, 40% on management decisions in health care organizations, and 15% on the development of national health care policy. From the review it is concluded that the AHP is suitable to apply in case of complex health care decision problems, a need to improve decision making instead of explain decision outcomes, a need to share information among experts or between clinicians and patients, and in case of a limited availability of informed respondents.

Table 2. Cond.

ANP and Healthcare	2009	Liao et al.	This study describes the use of ANP in Taiwanese hospital public relations personnel selection process. In this article, they interview 48 practitioners and executives to collect the selecting criteria. Then, they retained the 12 critical criteria that was mentioned 40 times by theses respondents, including: interpersonal skill, experience, negotiation, language, ability to follow orders, cognitive ability, adaptation to environment, adaptation to company, emotion, loyalty, attitude, and response. Following a discussion with 20 executives, we took 12 criteria into account in three perspectives to construct the hierarchy. In another research, they found that most of the contributors applied AHP concept to facilitate the personnel selection process. Because of the interrelated relation among the selecting criteria, they apply a more accurate approach, ANP, to solve this selection problem.
EFQM and AHP	2010	Iranzadeh et al.	Designing and formulating a comprehensive organization performance evaluation model based on EFQM in AHP method is the main aim of the present research study. Evaluation is considered as one of the most important activities in each organization in a way that reformation of processes and procedures of doing activity without evaluation of results will be impossible. At the present research activity, AHP has been used as one of MADM (Multi-Attribute Decision Making) methods for the evaluation of performance of organizations through the application of EFQM excellence model criteria. Also, Municipality of City of Tabriz has been selected as subjects for testing the presented model. In the same direction, seven districts of this municipality were selected as sample model. Necessary and required information were accumulated through questionnaire, interview and also taking advantage of data and library resources, details of which were analyzed and studied through the application of advanced Excel and Expert Choice 11.5 software package system.

Table 3a. Comparisons of AHP and ANP.

Projects	Ranking by ANP	Ranking by AHP
1	7	6
2	3	3
3	9	9
4	10	10
5	4	4
6	5	7
7	8	8
8	2	2
9	1	1
10	6	5

hierarchical structure which could correctly represent the decision-making problem. During the analysis, the elements at each level of the hierarchy have been compared pair-wise with respect to the upper-level element. Mention should be made to fact that the judgments that have been used to fill the comparison matrixes have been derived from expert opinions. Both AHP and ANP derive ratio scale priorities by generating pair-wise comparisons of elements based on a common property or criterion. Table 4 presents an example pair-wise comparison. A final ranking of the projects is presented in Figure 6.

It can be clearly seen that project number nine “Leadership Development and Succession Planning” has the best score and can be said that it is most suitable project and followed by projects 8,2,5,10,1,6,7,3,4.

Project selection using ANP technique

The ANP method allows dependence relations between elements and clusters. Such relations are represented by arrows, when the dependence occurs between a cluster over another cluster, or through a loop, when there is dependence among elements of a same cluster. In order to exist an arrow from a cluster to another, it is enough that at least one element of the original cluster is connected to an element of the destination cluster (Saaty, 2005).

This way, with the possibility to analyze dependences among criteria and influences among alternatives, ANP method was applied to rank the improvement projects with the help of the superdecisions software. Priorities obtained from the pair-wise comparison matrix (Table 4), as the shown in Figure 8.

The un-weighted super-matrix is constructed after weighting that matrix with the component matrix, and finally, we obtain the limit super-matrix, represented as follows: The un-weighted, weighted and limit super-matrix for this model is shown in Tables 5, 6 and 7 respectively.

Table 3b. Name of alternatives (Projects).

Projects	Name of alternative
1	Design and implementation of employee performance management system
2	Design and implementation of macro-level performance management system
3	Design and implementation of mechanisms for periodic monitoring of aberrations to improve its budgeting and planning
4	Design and implementation of systems and equipment maintenance and calibration of measuring instruments
5	Designing and implementing a patient relationship management System
6	Designing and implementing a process management system (identification, formulation, implementation, measuring, improve)
7	Designing and Implementing a promotion and marketing system to increase bed occupancy rate
8	Formulation, implementation and evaluation of current strategies
9	Leadership Development and Succession Planning
10	Staff surveys and improvement planning in human resources

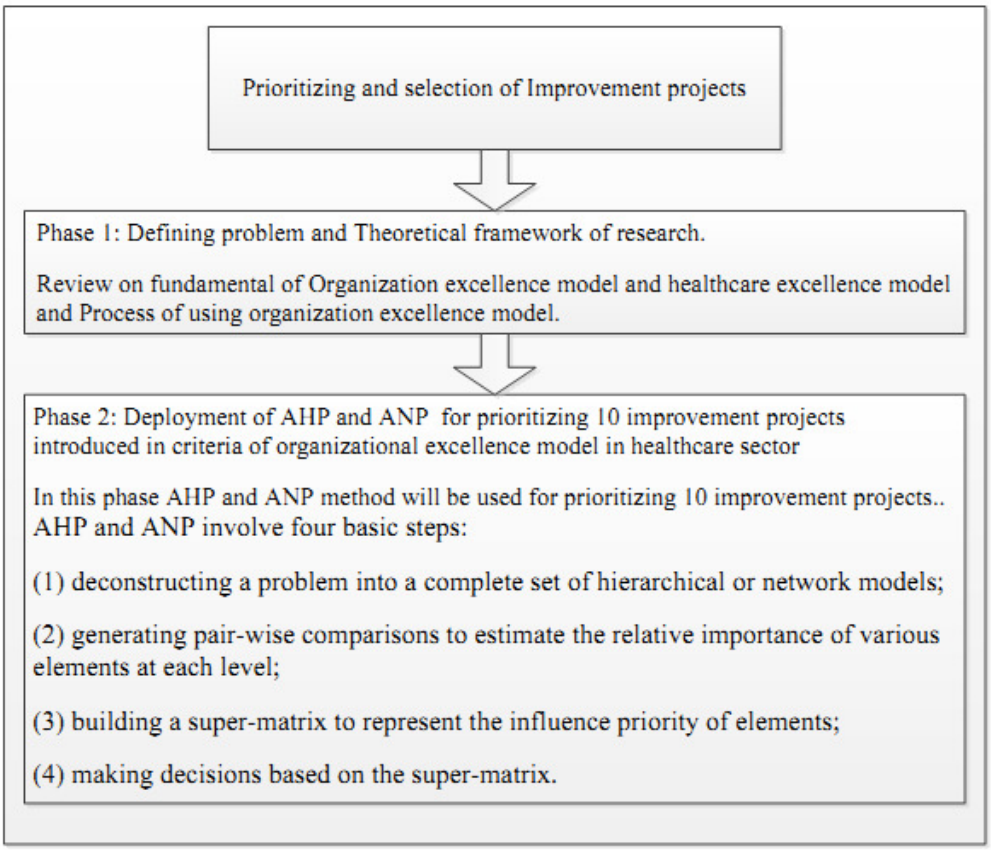

Figure 4. Research methodology.

Limit super matrix shown in Table 7 is obtained from the weighted super matrix by raising it to power until it converges and shows the importance weights of sub-factors, factors and alternatives. All columns in this limiting super matrix are identical.

Finally, we obtained scores of projects, which are represented by raw values, from limit super-matrix table. To get normal values, raw values are summed up and every row in the raw column is divided by the sum. To obtain ideal values, every value in raw values column is divided by the greatest value of the column. The final ranking of the projects is presented in Figure 9.

It can be clearly seen that project number nine “Leadership Development and Succession Planning” has

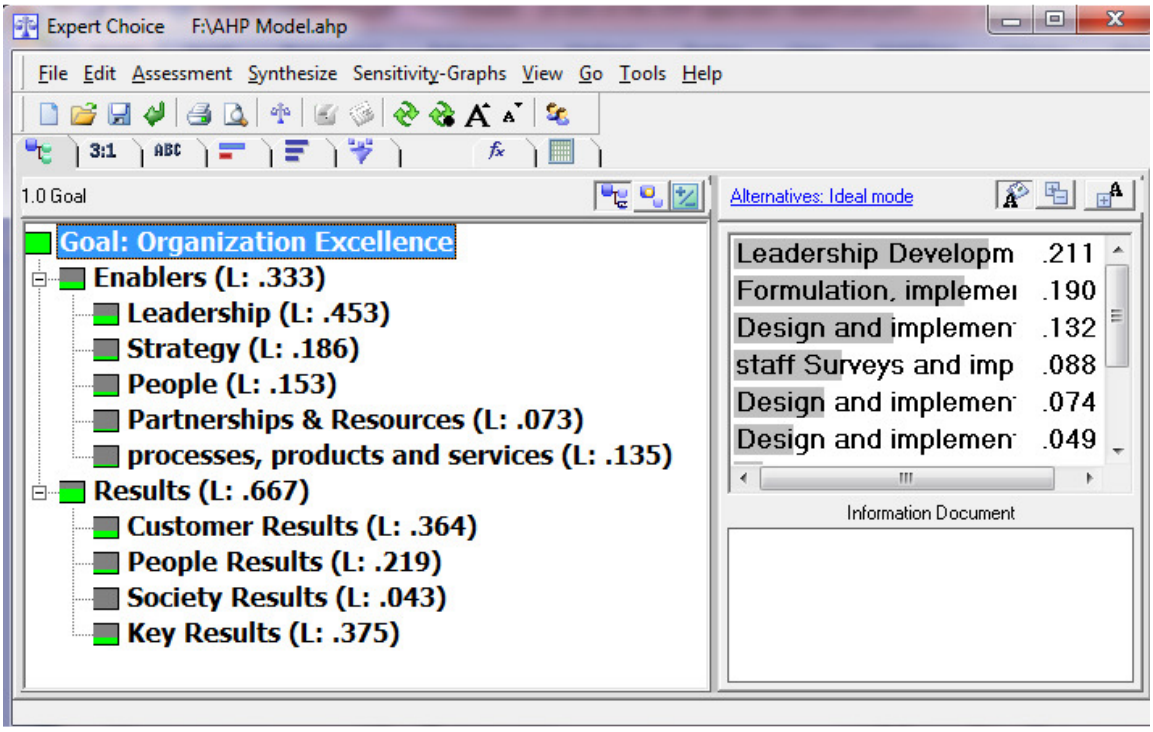

Figure 5. Hierarchical approach of the problem in expert choice.

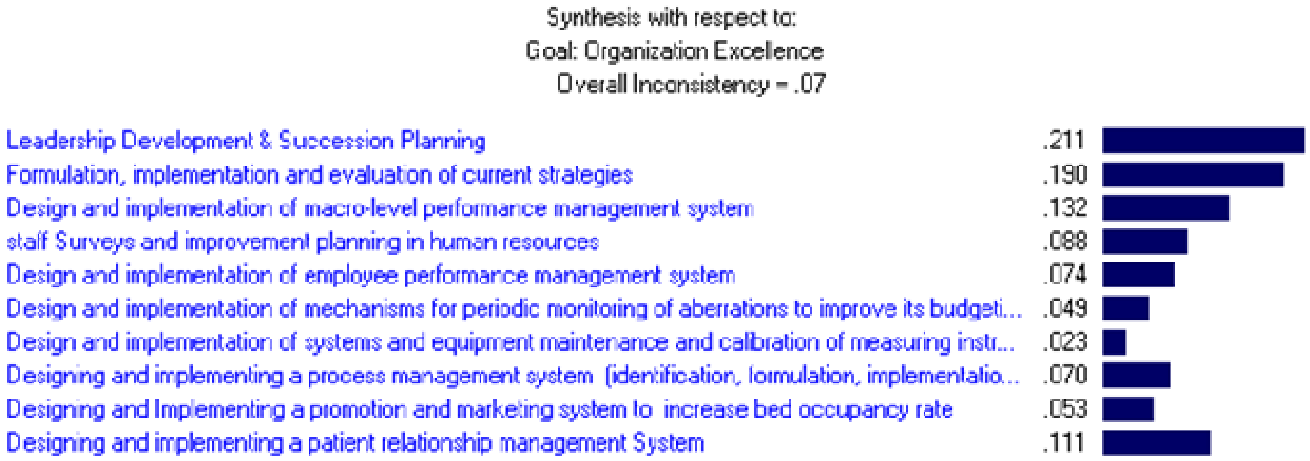

Figure 6. AHP results and ranking.

the best score and can be said that it is the most suitable project and followed by projects 8,2,5,6,10,1,7,3,4.

Conclusion

The analysis of selecting improvement projects was carried out by comparison of two methods, AHP and ANP. The definition of network structure is based on the inter- dependencies between elements or sub criteria and the criteria themselves. ANP is characterized for including qualitative and quantitative criteria, structured in a network, where the dependence relations among elements are allowed. Calculating the super-matrix and limit matrix shows that the priorities in ANP technique are different with AHP. Both decision metrics ANP and AHP, for the 10 improvement project alternatives evaluated.

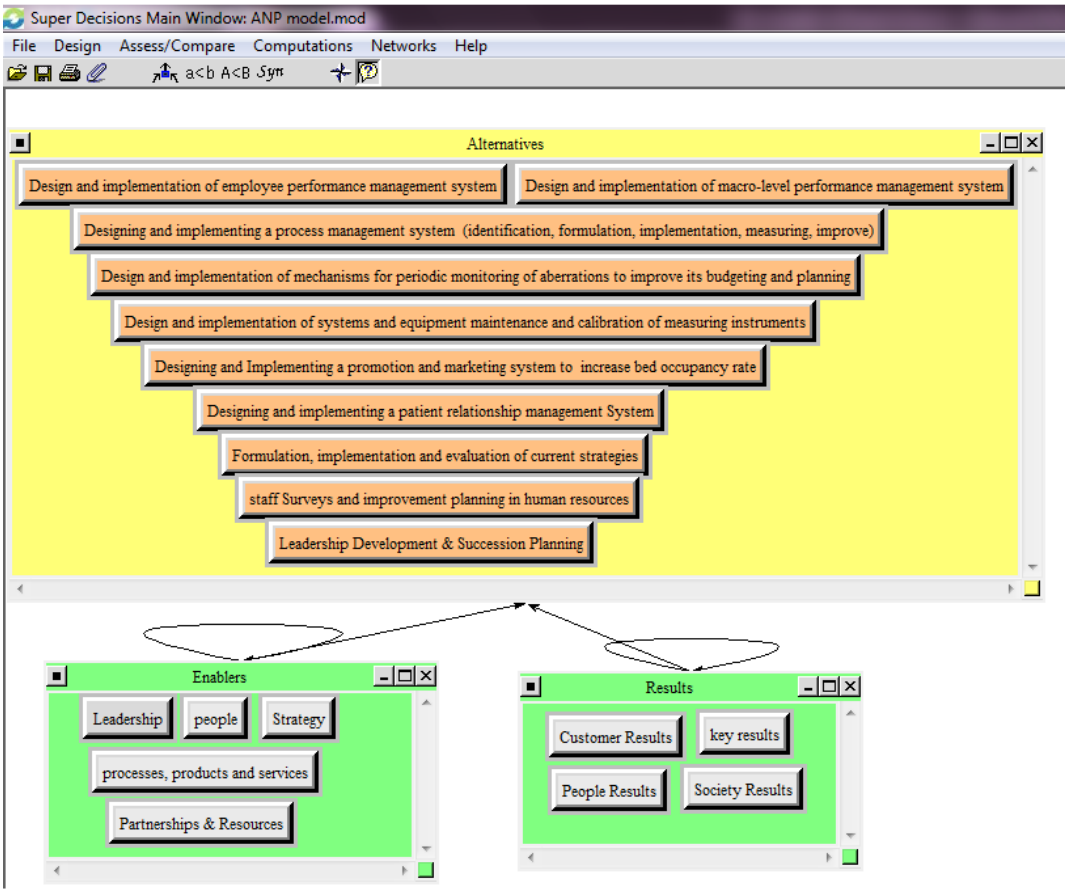

Figure 7. The network structure of the proposed model.

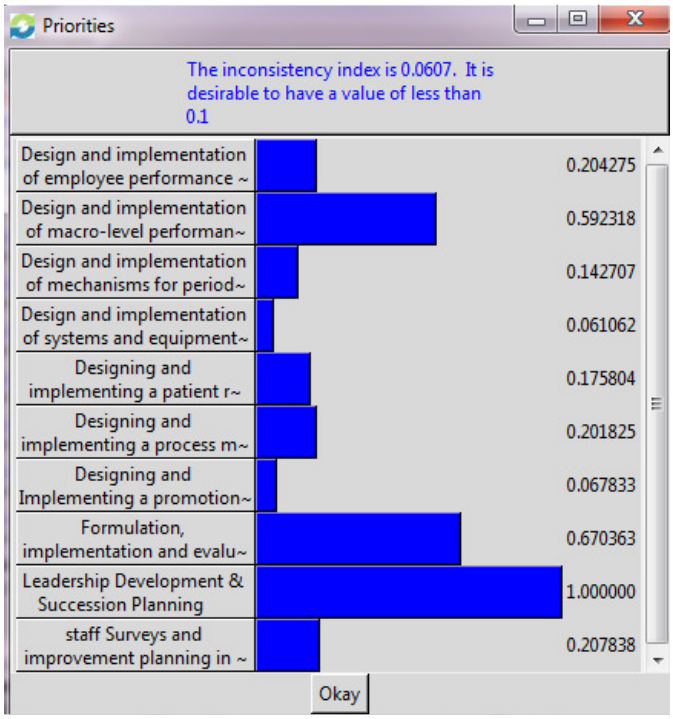

Figure 8. Leadership's priorities relative to alternatives.

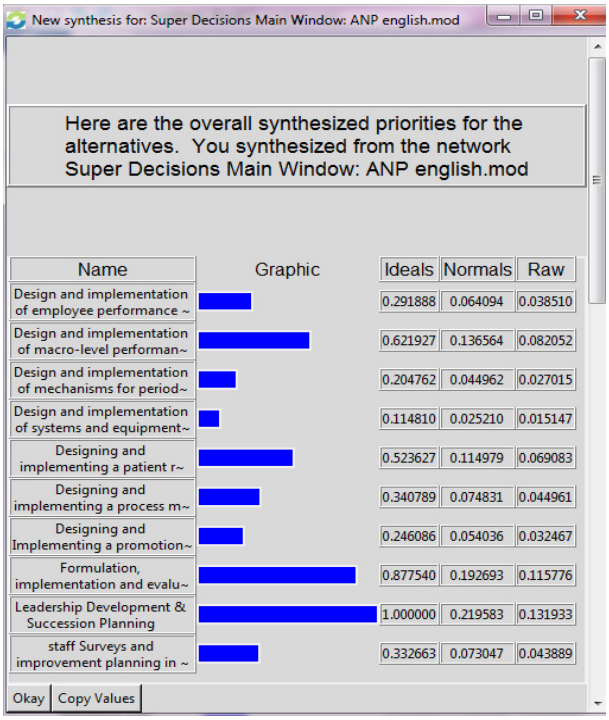

Figure 9. The results of the proposed model.

Table 4. Pair-wise comparison matrix improvement projects respect to the leadership.

Leadership	1	2	3	4	5	6	7	8	9	10
1		1/5	2	4	1	2	5	1/5	1/5	1/2
2			5	7	3	3	7	1	1/3	5
3				3	1	1/2	5	1/5	1/7	1/2
4					1/5	1/5	1/2	1/6	1/7	1/4
5						1	3	1/7	1/6	1
6							5	1/4	1/5	1
7								1/7	1/7	1/4
8									1/3	5
9										5
10										

Table 5. Un-weighted super-matrix.

	Design~	Design~	Design~	Design~	Designi~	Designi~	Designi~	Formula~	Leaders~	StaffS~	Leaders~	Partner~	People	Process~	Strategy	Custome~	Key res~	People~	Society~
Design~	0	0	0	0	0	0	0	0	0	0	0.06145	0.10655	0.1991	0.02515	0.04104	0.04317	0.07515	0.13639	0.04142
Design~	0	0	0	0	0	0	0	0	0	0	0.17819	0.18338	0.09396	0.11483	0.21853	0.08772	0.16692	0.07383	0.10002
Design~	0	0	0	0	0	0	0	0	0	0	0.04293	0.06759	0.03767	0.02464	0.07935	0.03146	0.07493	0.02764	0.02471
Design~	0	0	0	0	0	0	0	0	0	0	0.01837	0.05341	0.01748	0.05169	0.02126	0.02708	0.01529	0.01799	0.01785
Designi~	0	0	0	0	0	0	0	0	0	0	0.05289	0.02379	0.02447	0.15351	0.04287	0.20239	0.11438	0.03226	0.13108
Designi~	0	0	0	0	0	0	0	0	0	0	0.06072	0.06449	0.06637	0.10855	0.09001	0.10405	0.03618	0.05663	0.07125
Designi~	0	0	0	0	0	0	0	0	0	0	0.02041	0.03089	0.01957	0.09617	0.03136	0.07683	0.05747	0.02119	0.09359
Formula~	0	0	0	0	0	0	0	0	0	0	0.20167	0.2116	0.11822	0.19888	0.21853	0.19839	0.18183	0.18079	0.20397
Leaders~	0	0	0	0	0	0	0	0	0	0	0.30084	0.1718	0.15009	0.19911	0.20637	0.18524	0.194	0.25285	0.25085
Staff S~	0	0	0	0	0	0	0	0	0	0	0.06253	0.0865	0.27308	0.02748	0.05068	0.04368	0.08387	0.20043	0.06525
Leaders~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partner~	0	0	0	0	0	0	0	0	0	0	0.09821	0	0.25	0	0.14286	0	0	0	0
People	0	0	0	0	0	0	0	0	0	0	0.29464	0	0	0	0.42857	0	0	0	0
Process~	0	0	0	0	0	0	0	0	0	0	0.25075	1	0.75	0	0.42857	0	0	0	0
Strategy	0	0	0	0	0	0	0	0	0	0	0.3564	0	0	0	0	0	0	0	0
Custome~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Key res~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.58608	0	0.88889	1
People~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35313	0	0	0
Society~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.06079	0	0.11111	0

As shown in Table 3a, projects number 2, 3, 4, 5, 7, 8, 9 have the same ranking by AHP and ANP methods and these are different only in the ranking of 3 projects. Finally, ANP method resulted more suitable than the AHP method because it enhances the function of the AHP to develop a complete model that can incorporate interdependent relationships between elements from different levels or within levels, which are

Table 6. Weighted super-matrix.

	Design~	Design~	Design~	Design~	Designi~	Designi~	Designi~	Formula~	Leaders~	StaffS~	Leaders~	Partner~	People	Process~	Strategy	Custome~	Key res~	People~	Society~
Design~	0	0	0	0	0	0	0	0	0	0	0.03073	0.05327	0.09955	0.02515	0.02052	0.02159	0.07515	0.06820	0.02071
Design~	0	0	0	0	0	0	0	0	0	0	0.08910	0.09169	0.04698	0.11483	0.10926	0.04386	0.16692	0.03692	0.05001
Design~	0	0	0	0	0	0	0	0	0	0	0.02147	0.03380	0.01884	0.02464	0.03968	0.01573	0.07493	0.01382	0.01236
Design~	0	0	0	0	0	0	0	0	0	0	0.00919	0.02670	0.00874	0.05169	0.01063	0.01354	0.01529	0.00899	0.00893
Designi~	0	0	0	0	0	0	0	0	0	0	0.02645	0.01189	0.01223	0.15351	0.02144	0.10119	0.11438	0.01613	0.06554
Designi~	0	0	0	0	0	0	0	0	0	0	0.03036	0.03225	0.03319	0.10855	0.045	0.05202	0.03618	0.02831	0.03563
Designi~	0	0	0	0	0	0	0	0	0	0	0.01020	0.01545	0.00979	0.09617	0.01568	0.03841	0.05747	0.01060	0.04679
Formula~	0	0	0	0	0	0	0	0	0	0	0.10084	0.10580	0.05911	0.19888	0.10926	0.09919	0.18183	0.09039	0.10198
Leaders~	0	0	0	0	0	0	0	0	0	0	0.15042	0.08590	0.07504	0.19911	0.10319	0.09262	0.194	0.12643	0.12543
Staff S~	0	0	0	0	0	0	0	0	0	0	0.03126	0.04325	0.13654	0.02748	0.02534	0.02184	0.08387	0.10022	0.03263
Leaders~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partner~	0	0	0	0	0	0	0	0	0	0	0.04911	0	0.125	0	0.07143	0	0	0	0
People	0	0	0	0	0	0	0	0	0	0	0.14732	0	0	0	0.21429	0	0	0	0
Process~	0	0	0	0	0	0	0	0	0	0	0.12538	0.5	0.375	0	0.21429	0	0	0	0
Strategy	0	0	0	0	0	0	0	0	0	0	0.17820	0	0	0	0	0	0	0	0
Custome~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Key res~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.29304	0	0.44444	0.5
People~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17657	0	0	0
Society~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03040	0	0.05556	0

Table 7. Limit super-matrix.

	Design~	Design~	Design~	Design~	Designi~	Designi~	Designi~	Formula~	Leaders~	StaffS~	Leaders~	Partner~	People	Process~	Strategy	Custome~	Key res~	People~	Society~
Design~	0	0	0	0	0	0	0	0	0	0	0.03730	0.04390	0.07501	0.02515	0.03365	0.03972	0.07515	0.06862	0.03886
Design~	0	0	0	0	0	0	0	0	0	0	0.09089	0.09940	0.06955	0.11483	0.10132	0.07321	0.16692	0.07758	0.08898
Design~	0	0	0	0	0	0	0	0	0	0	0.02418	0.03074	0.02166	0.02464	0.03351	0.02985	0.07493	0.03265	0.03321
Design~	0	0	0	0	0	0	0	0	0	0	0.01694	0.03503	0.02220	0.05169	0.01986	0.01335	0.01529	0.01094	0.01105
Designi~	0	0	0	0	0	0	0	0	0	0	0.04399	0.05910	0.05176	0.15351	0.04709	0.09418	0.11438	0.04829	0.08182
Designi~	0	0	0	0	0	0	0	0	0	0	0.04477	0.05768	0.05421	0.10855	0.05591	0.04515	0.03618	0.03101	0.03581
Designi~	0	0	0	0	0	0	0	0	0	0	0.02473	0.04235	0.03443	0.09617	0.03161	0.04021	0.05747	0.02640	0.05035
Formula~	0	0	0	0	0	0	0	0	0	0	0.11314	0.13683	0.10198	0.19888	0.12117	0.11842	0.18183	0.11908	0.12860
Leaders~	0	0	0	0	0	0	0	0	0	0	0.14203	0.12364	0.11065	0.19911	0.11843	0.12183	0.194	0.14727	0.14828
Staff S~	0	0	0	0	0	0	0	0	0	0	0.04196	0.03799	0.09854	0.02748	0.04123	0.04582	0.08387	0.09271	0.04971
Leaders~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partner~	0	0	0	0	0	0	0	0	0	0	0.04931	0	0.08	0	0.05930	0	0	0	0
People	0	0	0	0	0	0	0	0	0	0	0.10758	0	0	0	0.12938	0	0	0	0
Process~	0	0	0	0	0	0	0	0	0	0	0.15985	0.33333	0.28	0	0.20755	0	0	0	0
Strategy	0	0	0	0	0	0	0	0	0	0	0.10334	0	0	0	0	0	0	0	0
Custome~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Key res~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.24348	0	0.30909	0.33333
People~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10978	0	0	0
Society~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.025	0	0.03636	0

assumed to be uncorrelated in AHP. Liao and Chang (2009) research showed similar results.

There were some limitations in this research project. For example, Iranian Excellence Model in healthcare Sector has been implemented in 23 hospitals and therefore the number of Improvement Projects was limited. If the model were implemented in most hospitals, the results were probably more accurate. Another limitation was Pair-wise comparison matrix improvement projects respect to the Criteria built based on the thoughts, comments, and suggestions of 15 experts. If these matrixes were built using more experts, the results were probably more accurate.

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