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Hospital leanness assessment model: A Fuzzy MULTI-MOORA decision making approach

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Abstract

The aim of this paper is to determine the critical factors in successful implementation of a lean healthcare system in a hospital. Despite the recent developments in lean hospitals, there is a long route to traverse in order to get close to the maturity stage of the leanness. We propose an approach in which the most important leanness criteria are determined and the leanness of a given hospital is measured using ranking of leanness criteria. The uncertainty in the opinion of experts is modelled using fuzzy sets. Fuzzy Delphi method equipped with questionnaire analysis is used to investigate the main criteria affecting leanness in hospital. Fuzzy Multi-Moora technique is used to rank main criteria affecting the leanness of a healthcare system.

Keywords: Leanness criteria, lean measurement, lean hospital, multi-criteria decision analysis, fuzzy MULTI-MOORA, Delphi method.

1-Introduction

Lean is defined as an integrated system consisting of four principles: human development, technical tools, management approaches and the philosophy creating lean organizational culture Convis (2001). Lean production means to diminish all non-value added activities meanwhile producing goods or providing services. The lean concept was first considered in Toyota production System (TPS). In mid-1980s, the positive results of lean implementation in automotive industry motivated other manufacturing industries to apply lean in their processes. The lean paradigm has been widely expanded from production to services. Womack and Jones (2010) demonstrated that the principles of lean manufacturing can be used in any system. Some problems in healthcare systems and hospitals are listed in table 1. These problems force the hospital managers to seek systematic approaches.

Lean thinking is one of these approaches. In recent years, implementing lean paradigm in healthcare has considerably been increased. It seems that lean is an effective approach to improve the performance of the healthcare organizations Brandao de Souza (2009).

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Table 1: Hospitals' Fundamental Problems

Increasing Problems in Hospitals:	• Rising Treatment Costs
	• Poor Quality of Treatments
	• Hurting Patients Through Predictable Errors
	• Heavy Workload of the Staff
	• Shortage of Staff
	• Nurses' Fatigue and the Physical and Mental Damage They Suffer
	• Transfer of Patients to Other Hospitals
	• Delayed Delivery of the Requirements
	• Problem Facing Personnel in Using New Equipment
	• Improper Use of Limited Storage Space
	• Unreported Minor Injuries and Illnesses

Many researchers have been allocated to measure the leanness level in manufacturing industries. Some of these researches suggested a number of metrics to cover the leanness concepts in production. The leanness has also been expressed using some quantitative criteria. Although there are several researches about lean paradigm in production systems, there are few researches about leanness in services including healthcare systems. Due to our best knowledge there is no model to measure leanness level in service industries, particularly in healthcare systems and hospitals. Since the hospitals deal with people's lives, special model is required to measure the leanness level.

In this paper, we present a model which measures the leanness level of the hospitals according to their unique features. In Section 2, the existing literature on leanness is reviewed. Then, in Section 3, the research methodology is described. The proposed model and algorithm are presented in Section 4. Section 5 is dedicated to address the applicability of the proposed model and algorithm in a real case study. The results and conclusions are discussed in Section 6.

2- Literature review

2-1-Lean assessment

The previous researches about measuring the degree of leanness can be categorized in two groups. The first group referred to those that introduce only a series of meters covering lean concepts. In second group, authors developed some models to measure the level of leanness.

In the first group, the following researches have worth to be mentioned here. Waring and Bishop (2010)offered a methodology for implementation of lean service in UK NHH hospital. They found out that implementation of some techniques in the operation department of hospital would cause many changes. Habidin et al., (2014) used supply chain innovation to deploy lean healthcare. Habidin et al., (2014) created four perspectives in order to implement lean healthcare in Malaysian hospitals. These perspectives were leadership, employee evolvement, organizational culture and customer focus. Kinder and Burgoyne (2013) evaluated the way information can affect lean healthcare system. Some of them pointed out that many hospitals could not implement lean healthcare. Kinder and Burgoyne (2013) showed that one of the main reasons for the failure of the lean healthcare is a lack of information. Hayes et al., (2014) have shown the way employees think about lean healthcare. Hayes et al., (2014) figured out many aspects of an employee such as responsibilities of the job and the role of staff has strong effect on the implementation of lean healthcare. Al-Balushi (2014) found out the main factors affecting the lean healthcare in the hospitals of Oman. Al-Balushi (2014) showed that decentralized management style, and end-to-end process view had strong effects on the implementation of lean healthcare.

In the second group, the following researches have worth to be mentioned here. Al-Araidah et al., (2010) used lean tools to reduce lead-time in healthcare systems. Al-Araidah et al., (2010) compared lean tools and used them in the hospital. Some of these tools, including DMAIC and 5S, decreased the lead-time 45%.

Grove, et al., (2010)identified the challenges in the UK hospitals during implementing lean healthcare systems. Grove, et al., (2010)figured out six major challenges in the lean healthcare systems are high process variability, lack of understanding lean concept, weakness in communication, not focusing on targets, not defining waste problem transparency, improper define of customer. Díaz, et al., (2012) attempted to use the process and value stream map analysis for using better lean healthcare. Vinodh and Chintha (2011) designed a leanness evaluation system including 5 lean enablers, 20 criteria and several attributes for an ABS factory. Vinodh and Chintha (2011) used a multi-grade fuzzy approach to measure the leanness level.

As mentioned before, although there is several research of lean paradigm in production system, the researches regarding lean paradigm in services, including healthcare systems and hospitals, are very limited. Moreover, all methods and tolls used in production systems cannot be purely utilized in services while the service systems differ from production systems in many aspects. Other issues in assessment of healthcare systems are as follows. The data collection in such systems is usually done using questionnaires so, a) It is likely that different people have different perceptions and judgments about a single number and, b) Judgments and personal preferences can have a significant effect on these methods and their results.

Robinson, et al., (2012) used simulation approach to implement lean production in health care systems. The approach helped the healthcare system to reduce its cost. Radnor et al., (2012) showed the effects of using lean tools such as improvement process and kaizen in healthcare system. Poksinska (2010) studied about the factors impacting the implementation of the lean healthcare. Kimsey (2010) used lean healthcare to increase the efficiency of the system. The results showed that deployment of the lean healthcare improved efficiency, teamwork, safety, change management, staff empowerment and decreased wastes. Dahlgaard et al., (2011) evaluated healthcare system in Danish healthcare system. Burgess and Radnor (2013) illustrated the way in which lean healthcare can be implemented in UK hospitals.

3- Fuzzy sets and fuzzy MULTI-MOORA approach

There is some uncertainty in the measuring of the leanness criteria. These uncertainties are modeled through fuzzy sets in this paper. Fuzzy sets can model qualitative data in quantitative measurements. The idea of fuzzy logic was first developed by professor Zadeh in 1965 (Zadeh, 1965). Fuzzy sets are the sets whose elements have the index of belonging. Totally not belonging is equal to 0, and the others are given an index between 0 and 1 according to the extent of belonging. This index is called membership degree (μ).

A fuzzy number $\tilde{A}$= (a, b, c, d) is called a generalized trapezoidal fuzzy number with membership function μ_A which is a continuous mapping from R to the closed interval [0, 1]. If a=c, then $\tilde{A}$ is called a generalized triangular fuzzy number (Dubois and Prade, 1978).

Fuzzy logic contains varied solutions that are essentially based on four basic concepts: fuzzy sets, linguistic variables, membership functions and if-then rules (Yen and Langari, 1999). Usually a person cannot express his/her judgment with an exact numerical value, so in that type of evaluation the researcher uses linguistic assessment to express the evaluation judgments instead of a numerical value. The fuzzy linguistic approach is a soft computing tool for linguistic information management, which is based on the concept of the linguistic variable(Zadeh, 1976). In several researches, it has been shown that fuzzy membership function can reflect the relative importance of linguistic words (Dyer and Sarin, 1979). Triangular and trapezoidal membership functions seem to be more appropriate to respond ambiguity of human assessments(Delgado et al., 1992).

We use fuzzy logic and linguistic expressions to illustrate ambiguity of data. So experts apply linguistic terms to assess the leanness criteria.

3-1- Fuzzy Multi-MOORA

MOORA model initially appeared by Brauers and Zavadskas (2009). There introduced a developed model in 2012 (Brauers and Zavadskas,2012), called MULTI-MOORA. The term stands for multi-objective optimization by ratio and it's the multiplicative form of MOORA. MULTI-MOORA employs internal

normalization and all objectives are given equal importance there. Every alternative is compared with the objective through the ratio system of this model.

What actually occurring in MOORA is the simultaneous optimizing process of two or more conflicting attributes (objectives) subjected to certain constraints. In problems dealing with decision making, we initially evaluate the values of these objectives for every decision alternatives. So it provides a basis for comparing the choices and consequently facilitates the selection of the best (acceptable) option. Therefore, multi-objective optimization techniques seem to be an suitable tool for ranking or selecting one or more alternatives from a set of feasible options based on multiple, usually conflicting attributes. The minimum math computation and the taking time required for MOORA method, in addition to its convenience, stability and robustness, has enhanced its reputation.

So what actually happening in MOORA method is calculating the overall performance of each alternative using the difference between sums of its normalized performances for beneficial and non-beneficial criteria, as demonstrated in the following expression:

$$y_i = \sum_{j=1}^{g} x_{ij}^* - \sum_{j=g+1}^{n} x_{ij}^* \qquad (1)$$

Where xij* is a dimensionless number belongs to [0,1] representing the normalized performance of i th alternative on j th criterion, g is the number of beneficial criteria, (n – g) is the number of non-beneficial criteria and yi is the overall performance of i th alternative considering all the criteria. Priority weights can also been considered there to give relative importance of one criterion over the other. In this case equation (1) can be reformed as:

$$y_i = \sum_{j=1}^{g} w_j x_{ij}^* - \sum_{j=g+1}^{n} w_j x_{ij}^* \qquad (j = 1,2,\ldots,n) \qquad (2)$$

Knowing that wj is the weight of j th criterion which can be obtained from AHP or entropy method. The highest yi value stands for the best alternative, while the worst one has the lowest yi value.

Thanks to the mathematical framework provided by Fuzzy set theory, it's possible to study obscure abstract phenomena accurately (Zadeh, 1965). It has already been proven as a valuable tool to make the decision-making process more comprehensive and reasonable. It comes to be a significant method when measuring the ambiguity of concepts that are addressed by the decision maker's subjective judgments, including linguistic terms, satisfaction degree and importance degree that are often obscure. A fuzzy set $\tilde{A}$ in a universe of discourse X is characterized by a membership function $\mu_{\tilde{A}}(X)$ which associates each element x in X with a real number in the interval [0,1]. The function value $\mu_{\tilde{A}}(X)$ is called the x's grade of membership in $\tilde{A}$. The most widespread fuzzy numbers are triangular and trapezoidal. Triangular fuzzy numbers are often used in applications owing to the ease of calculation and added features. Triangular fuzzy numbers can be indicated by Ā = (l, m, n) and the membership function of fuzzy number $\tilde{A}$ is defined by the following equation.

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & x<l, \\ \dfrac{x-l}{m-l} & l \le x \le m, \\ \dfrac{n-x}{n-m} & m \le x \le n, \\ 0 & x>n \end{cases} \qquad (3)$$

In this membership function, the triangles are completed with the minimum and maximum points attached to the adjacent center. The distribution function is dependent on the consequent minimum and maximum values of the input data. A new variant of MOORA method, namely fuzzy MOORA, is suggested here to utilize MOORA method in the best way for solving the decision-making problems involving inaccurate and obscure data. This consists of the following steps.

Step 1: develop the fuzzy decision matrix founded on the valued opinions of the decision makers, where each criterion value is calculated using triangular membership function.

$$X = \begin{bmatrix} [x_{11}^l, x_{11}^m, x_{11}^n] & [x_{12}^l, x_{12}^m, x_{12}^n] & \dots & [x_{1n}^l, x_{1n}^m, x_{1n}^n] \\ [x_{21}^l, x_{21}^m, x_{21}^n] & [x_{22}^l, x_{22}^m, x_{22}^n] & \dots & [x_{2n}^l, x_{2n}^m, x_{2n}^n] \\ \dots & \dots & \dots & \dots \\ [x_{m1}^l, x_{m1}^m, x_{m1}^n] & [x_{m2}^l, x_{m2}^m, x_{m2}^n] & \dots & [x_{mn}^l, x_{mn}^m, x_{mn}^n] \end{bmatrix} \quad (4)$$

Where x_{ij}^l , x_{ij}^m and x_{ij}^n respectively indicate the lower, middle and upper values of a triangular membership function for i th alternative according to the j th criterion.

Step 2: Normalize the fuzzy decision matrix by applying the vector normalization procedure. Following equations are employed here.

$$r_{ij}^l = \frac{x_{ij}^l}{\sqrt{\sum_{i=1}^{m} [(x_{ij}^l)^2 + (x_{ij}^m)^2 + (x_{ij}^n)^2]}}$$

$$r_{ij}^m = \frac{x_{ij}^m}{\sqrt{\sum_{i=1}^{m} [(x_{ij}^l)^2 + (x_{ij}^m)^2 + (x_{ij}^n)^2]}}$$

$$r_{ij}^n = \frac{x_{ij}^n}{\sqrt{\sum_{i=1}^{m} [(x_{ij}^l)^2 + (x_{ij}^m)^2 + (x_{ij}^n)^2]}} \quad (5)$$

Step 3: Obtain the weighted normalized fuzzy decision matrix adopting the following equations:

$$v_{ij}^l = w_j r_{ij}^l$$

$$v_{ij}^m = w_j r_{ij}^m$$

$$v_{ij}^n = w_j r_{ij}^n \quad (6)$$

Although Fuzzy criteria weights might also be used, for building up the weighted normalized fuzzy decision matrix, but more sophisticated calculations will be required.

Step 4: Obtain the overall ratings of beneficial and non-beneficial criteria for each alternative. The overall ratings of an alternative for lower, middle and upper values of the triangular membership function are computed as follows, for beneficial criteria:

$s_i^{+l} = \sum_{j=1}^{n} v_{ij}^{l} \mid j \in J^{max}$	(7)
$s_i^{+m} = \sum_{j=1}^{n} v_{ij}^{m} \mid j \in J^{max}$	(8)
$s_i^{+n} = \sum_{j=1}^{n} v_{ij}^{n} \mid j \in J^{max}$	(9)

In case of non-beneficial criteria, the overall ratings of an alternative are calculated as follows:

$s_i^{-l} = \sum_{j=1}^{n} v_{ij}^{l} \mid j \in J^{min}$ $s_i^{-m} = \sum_{j=1}^{n} v_{ij}^{m} \mid j \in J^{min}$ $s_i^{-n} = \sum_{j=1}^{n} v_{ij}^{n} \mid j \in J^{min}$	(10)

Step 5: Calculate the overall performance index (Si) for all alternatives. In this regard, the defuzzified values of the overall ratings are calculated for beneficial and non-beneficial criteria for all alternatives using the vertex method, as follows,

$S_i(s_i^{+}, s_i^{-}) = \sqrt{\frac{1}{3}\left[(s_i^{+l} - s_i^{-l})^2 + (s_i^{+m} - s_i^{-m})^2 + (s_i^{+n} - s_i^{-n})^2\right]}$	(11)

Step 6: Rank the alternatives from the best to the worst, Based on the descending values of overall performance index. Now, to spot our most acceptable choice we look for the alternative with the highest overall performance index.

4-Research methodology

4-1- Research question

One of the aims of this study is to prioritizing factors for the implementation of lean healthcare in the hospital. The main research questions are as follows:

- *Which factors impact on implementation of lean healthcare in hospitals?*
- *What is the priority of these factors?*

4-2- Sample of experts

In this research, top managers of hospitals were asked to answer the questionnaires. The experts are 10 top managers who involve in implementing the lean healthcare systems in their hospitals. All these managers have passed several courses about lean healthcare systems. Hence, they are suitable persons to ask questions about lean healthcare. The managers work both in governmental and non-profit hospitals.

4-3- Data collection process

The influencing factors of lean health care are extracted from the literature review and interview. The 32 selected factors are as the following: ***smoothness of information flow, adaption to team management, personnel ability, goal clarity, management involvement, information transparency, culture improvement, suitable staff, flexibility of staff, improvement process, pull treatment system, treatment process, optimal treatment process, availability of hospital services, number of skilled personnel, patients' waiting time, value stream mapping, finding seven MUDA, using advanced technology, multi task staff, job rotation, staff morality, changing devices as soon as possible, strategic healthcare, performance trust, service quality, medium-term and long-term objective, job security, type of communication, incentive system, hospital areal and financial resource availability.***

The questionnaire used for ranking the factors is based on 5-point Likert-type scale (Likert, 1932).Based on the received questionnaires; the factors are examined using Delphi method. Delphi method is based on the aggregation of all opinions for decision making (Dalkey and Helmer, 1963; Linstone and Turoff, 1975). If the average of scores is equal to 4 or higher in the 5-point Likert-type scale, those factors will be selected. If the average is less than 4, the associated factor will be eliminated. Table 2 and table 3 show the calculation process using Delphi method.

Table 2. Expert opinions using 5-point Likert scale

Factors	Experts									
	1	2	3	4	5	6	7	8	9	10
Smoothness of information Flow	3	4	3	4	4	4	4	3	3	4
Adaption to team management	4	4	4	5	4	5	4	5	3	5
Personnel ability	4	4	4	4	4	3	4	5	4	5
Goal clarity	4	4	4	4	3	3	4	5	5	5
Management involvement	5	5	5	5	4	5	3	4	5	5
Information transparency	3	3	4	5	4	5	3	4	3	4
Culture improvement	5	5	4	5	4	4	5	3	5	5
Suitable staff	4	4	4	4	3	5	5	4	5	4
Flexibility of staff	5	5	5	5	4	4	5	3	4	5
Improvement process	4	4	4	4	5	5	5	3	4	5
Pull treatment system	3	3	3	4	5	3	4	5	4	3
Treatment process	4	4	4	5	5	5	4	5	3	4
Optimal treatment process	5	5	5	4	4	4	4	5	3	5
Availability of hospital services	5	5	5	5	4	4	5	3	4	5
Number of skilled personnel	4	4	4	4	5	5	5	3	4	5
Patients' waiting time	5	5	5	5	5	4	4	5	4	3
Value stream mapping	5	5	5	5	5	4	4	4	3	4
Finding seven MUDA	5	5	5	5	5	4	4	5	4	3
Using advanced technology	5	5	5	5	4	4	3	5	4	5
Multi task staff	4	4	4	4	3	3	4	5	5	5
Job rotation	3	3	3	4	5	4	3	4	3	4
Staff morality	3	3	3	4	5	4	3	3	4	5
Changing devices as soon as possible	4	4	4	5	5	5	5	4	5	3
Strategic healthcare	4	4	4	4	5	3	4	5	3	4
Performance trust	5	5	5	4	4	5	3	5	4	4
Service quality	4	4	4	4	5	5	3	5	4	5
Medium-term and long-term objective	4	4	4	3	5	3	4	5	5	3
Job security	3	3	3	3	4	3	5	3	4	3
Type of communication	3	3	4	5	3	4	5	3	3	3
Incentive system	5	5	5	5	4	4	5	3	5	4
Hospital area	5	5	5	4	5	3	4	5	5	3
Financial resource availability	4	4	4	4	5	5	4	3	5	4

Table 3. Average Score of Leanness Criteria

Factors	Average	Accept/Reject
Smoothness of information flow	3.6	Reject
Adaption to team management	4.3	Accept
Personnel ability	4.1	Accept
Goal clarity	4.1	Accept
Management involvement	4.6	Accept
Information transparency	3.8	Reject
Culture improvement	4.5	Accept
Suitable staff	4.2	Accept
Flexibility of staff	4.5	Accept
Improvement process	4.3	Accept
Pull treatment system	3.7	Reject
Treatment process	4.3	Accept
Optimal treatment process	4.4	Accept
Availability of hospital services	4.5	Accept
Number of skilled personnel	4.3	Accept
Patients' waiting time	4.5	Accept
Value stream mapping	4.4	Accept
Finding seven MUDA	4.5	Accept
Using advanced technology	4.5	Accept
Multi task staff	4.1	Accept
Job rotation	3.6	Reject
Staff morality	3.7	Reject
Changing devices as soon as possible	4.4	Accept
Strategic healthcare	4	Accept
Performance trust	4.4	Accept
Service quality	4.3	Accept
Medium-term and long-term objective	4	Accept
Job security	3.4	Reject
Type of communication	3.6	Reject
Incentive system	4.5	Accept
Hospital area	4.4	Accept
Financial resource availability	4.2	Accept

Seven leanness criteria are deleted. In the next step, the remaining 25 criteria are considered further analysis. Figures 1and 2 show the research methodology.

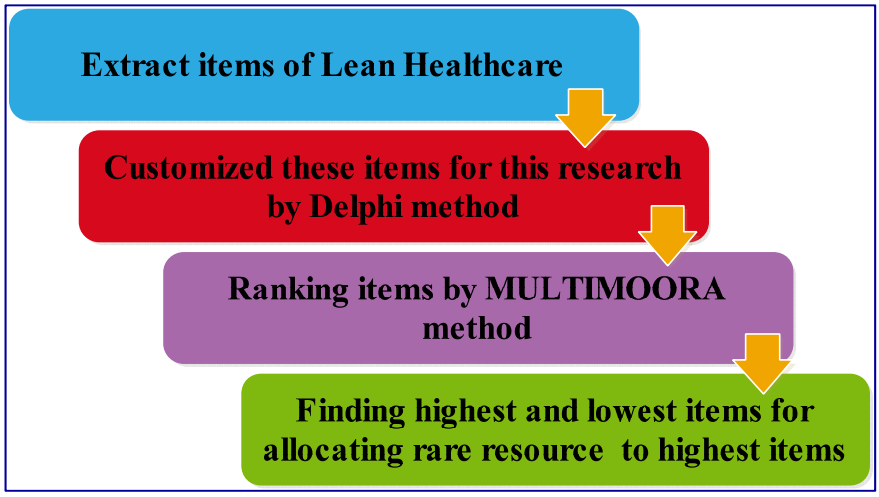

Fig 1. Research Methodology Steps

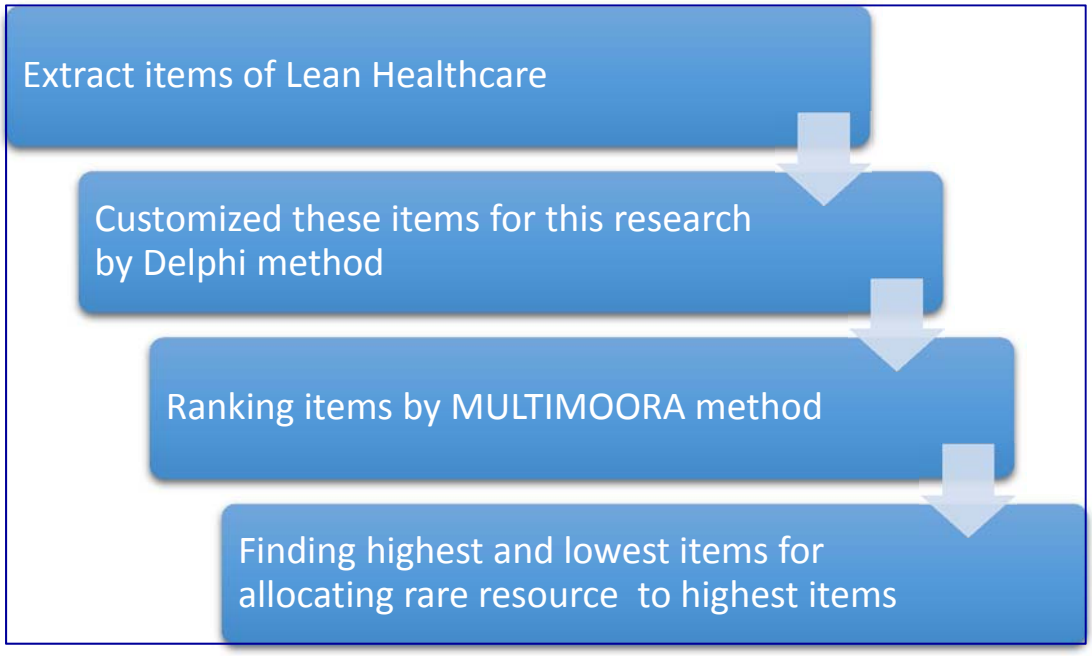

Fig 2. Research Methodology Steps

5-Data analysis

Applying leanness to healthcare systems brings several benefits such as less cost for either hospitals or patients and more patients 'satisfaction and loyalty; though implementing a lean healthcare system is not so simple. Thus, hospitals must take account of more important factors in order to apply an effective lean process. So, it will make possible to allocate the limited resources to high priority factors to obtain the best possible result. The introduced model is employed in a hospital with 240 beds.

After evaluating the leanness criteria, the remaining criteria are evaluated by MULTIMOORA method to find out the high-priority ones and low-priority ones. The experts are asked to score all 25 remaining criteria using fuzzy numbers in table 4.

Table 4. Fuzzy triangular numbers

$\widetilde{\mathbf{1}}$	(0,0.2,0.4)
$\widetilde{\mathbf{2}}$	(0.2,0.4,0.6)
$\widetilde{\mathbf{3}}$	(0.4,0.6,0.8)
$\widetilde{\mathbf{4}}$	(0.6,0.8,1)
$\widetilde{\mathbf{5}}$	(0.8,1,1)

The resultant fuzzy decision matrix presented in table 5.

Table 5. Fuzzy decision matrix

	expert1			**expert2**			**expert3**			**expert4**			**expert5**			**expert6**			**expert7**			**expert8**			**expert9**			**expert10**		
Smoothness of information Flow	0.4	0.6	0.8	0.6	0.8	1	0.4	0.6	0.8	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.4	0.6	0.8	0.4	0.6	0.8	0.6	0.8	1
Adaption to team management	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.8	1	1
Personnel ability	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.8	1	1
Goal clarity	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.4	0.6	0.8	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.8	1	1	0.8	1	1
Management involvement	0.4	0.6	0.8	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1	0.4	0.6	0.8	0.6	0.8	1
Information transparency	0.8	1	1	0.8	1	1	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.8	1	1	0.8	1	1
Culture improvement	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.4	0.6	0.8	0.8	1	1	0.8	1	1	0.6	0.8	1	0.8	1	1	0.6	0.8	1
Suitable staff	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1
Flexibility of staff	0.4	0.6	0.8	0.4	0.6	0.8	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.4	0.6	0.8
Improvement process	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1
Pull treatment system	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.8	1	1
Treatment process	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1
Optimal treatment process	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.8	1	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1
Availability of hospital services	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.4	0.6	0.8
Number of skilled personnel	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.4	0.6	0.8	0.6	0.8	1
Patients' waiting time	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.4	0.6	0.8
Value stream mapping	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.4	0.6	0.8	0.8	1	1	0.6	0.8	1	0.8	1	1
Finding seven MUDA	0.4	0.6	0.8	0.4	0.6	0.8	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.4	0.6	0.8	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1
Using advanced technology	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8
Multi task staff	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1
Job rotation	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.8	1	1	0.6	0.8	1	0.6	0.8	1
Staff morality	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.8	1	1	0.4	0.6	0.8	0.8	1	1	0.6	0.8	1	0.8	1	1
Changing devicesas soon as possible	0.4	0.6	0.8	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.4	0.6	0.8	0.4	0.6	0.8
Strategic healthcare	0.8	1	1	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.8	1	1	0.6	0.8	1
Performance trust	0.8	1	1	0.8	1	1	0.8	1	1	0.6	0.8	1	0.8	1	1	0.4	0.6	0.8	0.6	0.8	1	0.8	1	1	0.8	1	1	0.4	0.6	0.8

Fuzzy decision matrix is normalized as using equation (1).

Table 6. Normalized Fuzzy Decision Matrix

	expert1			expert2			expert3			expert4			expert5		
adaption of team	0.120168354	0.139271504	0.16609096	0.1786474	0.184310271	0.206021411	0.119522861	0.138527129	0.163572164	0.168763185	0.175919799	0.2	0.177084401	0.182955741	0.204465205
personnel ability	0.18025253	0.185695338	0.2076137	0.1786474	0.184310271	0.206021411	0.179284291	0.184702839	0.204465205	0.22501758	0.219899749	0.2	0.177084401	0.182955741	0.204465205
clear of goal	0.18025253	0.185695338	0.2076137	0.1786474	0.184310271	0.206021411	0.179284291	0.184702839	0.204465205	0.168763185	0.175919799	0.2	0.177084401	0.182955741	0.204465205
management involvement	0.18025253	0.185695338	0.2076137	0.1786474	0.184310271	0.206021411	0.179284291	0.184702839	0.204465205	0.168763185	0.175919799	0.2	0.118056267	0.137216806	0.163572164
culture improvement	0.120168354	0.139271504	0.16609096	0.119098267	0.138232703	0.164817129	0.179284291	0.184702839	0.204465205	0.22501758	0.219899749	0.2	0.177084401	0.182955741	0.204465205
suitable staff	0.240336707	0.232119173	0.2076137	0.238196534	0.230387839	0.206021411	0.179284291	0.184702839	0.204465205	0.22501758	0.219899749	0.2	0.177084401	0.182955741	0.204465205
flexibility of staffs	0.18025253	0.185695338	0.2076137	0.1786474	0.184310271	0.206021411	0.179284291	0.184702839	0.204465205	0.168763185	0.175919799	0.2	0.118056267	0.137216806	0.163572164

	expert6			expert7			expert8			expert9			expert10		
adaption of team	0.1875	0.191345949	0.2076137	0.1875	0.191345949	0.2076137	0.120385853	0.13972393	0.170097302	0.132744662	0.150376412	0.170097302	0.181901719	0.187112108	0.209243488
personnel ability	0.25	0.239182437	0.2076137	0.1875	0.191345949	0.2076137	0.240771706	0.232873216	0.212621628	0.132744662	0.150376412	0.170097302	0.242535625	0.233890135	0.209243488
clear of goal	0.125	0.143509462	0.16609096	0.1875	0.191345949	0.2076137	0.240771706	0.232873216	0.212621628	0.199116993	0.200501883	0.212621628	0.242535625	0.233890135	0.209243488
management involvement	0.125	0.143509462	0.16609096	0.1875	0.191345949	0.2076137	0.240771706	0.232873216	0.212621628	0.265489325	0.250627354	0.212621628	0.242535625	0.233890135	0.209243488
culture improvement	0.25	0.239182437	0.2076137	0.125	0.143509462	0.16609096	0.18057878	0.186298573	0.212621628	0.132744662	0.150376412	0.170097302	0.181901719	0.187112108	0.209243488
suitable staff	0.1875	0.191345949	0.2076137	0.25	0.239182437	0.2076137	0.120385853	0.13972393	0.170097302	0.265489325	0.250627354	0.212621628	0.242535625	0.233890135	0.209243488
flexibility of staffs	0.25	0.239182437	0.2076137	0.25	0.239182437	0.2076137	0.18057878	0.186298573	0.212621628	0.265489325	0.250627354	0.212621628	0.181901719	0.187112108	0.209243488

Table 6. Continued

	expert1			expert2			expert3			expert4			expert5			expert6			expert7			expert8			expert9			expert10		
improvement process	0.240336707	0.232119173	0.2076137	0.238196534	0.230387839	0.206021411	0.239045722	0.230878548	0.204465205	0.22501758	0.219899749	0.2	0.177084401	0.182955741	0.204465205	0.1875	0.191345949	0.2076137	0.25	0.239182437	0.2076137	0.120385853	0.13972393	0.170097302	0.199116993	0.200501883	0.212621628	0.242535625	0.233890135	0.209243488
treatment process	0.120168354	0.139271504	0.16609096	0.119098267	0.138232703	0.164817129	0.119522861	0.138527129	0.163572164	0.168763185	0.175919799	0.2	0.236112534	0.228694677	0.204465205	0.125	0.143509462	0.16609096	0.1875	0.191345949	0.2076137	0.240771706	0.232873216	0.212621628	0.199116993	0.200501883	0.212621628	0.121267813	0.140334081	0.16739479
optimal treatment	0.18025253	0.185695338	0.2076137	0.1786474	0.184310271	0.206021411	0.179284291	0.184702839	0.204465205	0.22501758	0.219899749	0.2	0.236112534	0.228694677	0.204465205	0.25	0.239182437	0.2076137	0.1875	0.191345949	0.2076137	0.240771706	0.232873216	0.212621628	0.132744662	0.150376412	0.170097302	0.181901719	0.187112108	0.209243488
availability of hospital	0.240336707	0.232119173	0.2076137	0.238196534	0.230387839	0.206021411	0.239045722	0.230878548	0.204465205	0.168763185	0.175919799	0.2	0.177084401	0.182955741	0.204465205	0.1875	0.191345949	0.2076137	0.1875	0.191345949	0.2076137	0.240771706	0.232873216	0.212621628	0.132744662	0.150376412	0.170097302	0.242535625	0.233890135	0.209243488
number of skilled	0.240336707	0.232119173	0.2076137	0.238196534	0.230387839	0.206021411	0.239045722	0.230878548	0.204465205	0.22501758	0.219899749	0.2	0.177084401	0.182955741	0.204465205	0.1875	0.191345949	0.2076137	0.25	0.239182437	0.2076137	0.120385853	0.13972393	0.170097302	0.199116993	0.200501883	0.212621628	0.242535625	0.233890135	0.209243488
time of waiting of patient	0.18025253	0.185695338	0.2076137	0.1786474	0.184310271	0.206021411	0.179284291	0.184702839	0.204465205	0.168763185	0.175919799	0.2	0.236112534	0.228694677	0.204465205	0.25	0.239182437	0.2076137	0.25	0.239182437	0.2076137	0.120385853	0.13972393	0.170097302	0.199116993	0.200501883	0.212621628	0.242535625	0.233890135	0.209243488
value stream mapping	0.240336707	0.232119173	0.2076137	0.238196534	0.230387839	0.206021411	0.239045722	0.230878548	0.204465205	0.22501758	0.219899749	0.2	0.236112534	0.228694677	0.204465205	0.1875	0.191345949	0.2076137	0.1875	0.191345949	0.2076137	0.240771706	0.232873216	0.212621628	0.199116993	0.200501883	0.212621628	0.121267813	0.140334081	0.16739479

service quality	trust performance	strategy healthcare	changing device in	multi task staff	using advanced technology	finding seven MUDA	
0.240336707	0.18025253	0.18025253	0.120168354	0.240336707	0.240336707	0.240336707	expert1
0.232119173	0.185695338	0.185695338	0.139271504	0.232119173	0.232119173	0.232119173	
0.2076137	0.2076137	0.2076137	0.16609096	0.2076137	0.2076137	0.2076137	
0.238196534	0.1786474	0.1786474	0.119098267	0.238196534	0.238196534	0.238196534	expert2
0.230387839	0.184310271	0.184310271	0.138232703	0.230387839	0.230387839	0.230387839	
0.206021411	0.206021411	0.206021411	0.164817129	0.206021411	0.206021411	0.206021411	
0.239045722	0.179284291	0.179284291	0.119522861	0.239045722	0.239045722	0.239045722	expert3
0.230878548	0.184702839	0.184702839	0.138527129	0.230878548	0.230878548	0.230878548	
0.204465205	0.204465205	0.204465205	0.163572164	0.204465205	0.204465205	0.204465205	
0.168763185	0.168763185	0.22501758	0.168763185	0.22501758	0.22501758	0.22501758	expert4
0.175919799	0.175919799	0.219899749	0.175919799	0.219899749	0.219899749	0.219899749	
0.2	0.2	0.2	0.2	0.2	0.2	0.2	
0.177084401	0.236112534	0.236112534	0.236112534	0.177084401	0.236112534	0.236112534	expert5
0.182955741	0.228694677	0.228694677	0.228694677	0.182955741	0.228694677	0.228694677	
0.204465205	0.204465205	0.204465205	0.204465205	0.204465205	0.204465205	0.204465205	
0.25	0.125	0.25	0.1875	0.1875	0.1875	0.1875	expert6
0.239182437	0.143509462	0.239182437	0.191345949	0.191345949	0.191345949	0.191345949	
0.2076137	0.16609096	0.2076137	0.2076137	0.2076137	0.2076137	0.2076137	
0.125	0.1875	0.25	0.125	0.125	0.1875	0.1875	expert7
0.143509462	0.191345949	0.239182437	0.143509462	0.143509462	0.191345949	0.191345949	
0.16609096	0.2076137	0.2076137	0.16609096	0.16609096	0.2076137	0.2076137	
0.240771706	0.240771706	0.18057878	0.120385853	0.240771706	0.240771706	0.18057878	expert8
0.232873216	0.232873216	0.186298573	0.13972393	0.232873216	0.232873216	0.186298573	
0.212621628	0.212621628	0.212621628	0.170097302	0.212621628	0.212621628	0.212621628	
0.199116993	0.132744662	0.265489325	0.199116993	0.199116993	0.199116993	0.132744662	expert9
0.200501883	0.150376412	0.250627354	0.200501883	0.200501883	0.200501883	0.150376412	
0.212621628	0.170097302	0.212621628	0.212621628	0.212621628	0.212621628	0.170097302	
0.181901719	0.181901719	0.121267813	0.242535625	0.242535625	0.121267813	0.181901719	expert10
0.187112108	0.187112108	0.140334081	0.233890135	0.233890135	0.140334081	0.187112108	
0.209243488	0.209243488	0.16739479	0.209243488	0.209243488	0.16739479	0.209243488	

Table 6. Continued

Table 6. Continued

	expert1			expert2			expert3			expert4			expert5			expert6			expert7			expert8			expert9			expert10		
medium and long term	0.18025253	0.18569338	0.2076137	0.1786474	0.184310271	0.206021411	0.179284291	0.184702839	0.204465205	0.168763185	0.175919799	0.2	0.236112534	0.228694677	0.204465205	0.25	0.239182437	0.2076137	0.125	0.143509462	0.16609096	0.240771706	0.232873216	0.212621628	0.199116993	0.200501883	0.212621628	0.242535625	0.233890135	0.209243488
incentive system	0.120168354	0.139271504	0.16609096	0.119098267	0.138232703	0.164817129	0.179284291	0.184702839	0.204465205	0.22501758	0.219899749	0.2	0.118056267	0.137216806	0.163572164	0.1875	0.191345949	0.2076137	0.25	0.239182437	0.2076137	0.120385853	0.13972393	0.170097302	0.132744662	0.150376412	0.170097302	0.121267813	0.140334081	0.167394479
size of hospital	0.240336707	0.232119173	0.2076137	0.238196534	0.230387839	0.206021411	0.239045722	0.230878548	0.204465205	0.22501758	0.219899749	0.2	0.177084401	0.182955741	0.204465205	0.1875	0.191345949	0.2076137	0.25	0.239182437	0.2076137	0.120385853	0.13972393	0.170097302	0.265489325	0.250627354	0.212621628	0.181901719	0.187112108	0.209243488
availability of financial	0.240336707	0.232119173	0.2076137	0.238196534	0.230387839	0.206021411	0.239045722	0.230878548	0.204465205	0.168763185	0.175919799	0.2	0.236112534	0.228694677	0.204465205	0.125	0.143509462	0.16609096	0.1875	0.191345949	0.2076137	0.240771706	0.232873216	0.212621628	0.265489325	0.250627354	0.212621628	0.121267813	0.140334081	0.16739479

The weighted normalized fuzzy decision matrix is calculated by multiplying weights of each criterion.

Table 7. Weighted Normalized Fuzzy Decision Matrix

	expert1			expert2			expert3			expert4			expert5		
adaption of team	0.012016835	0.01392715	0.016609096	0.01786474	0.018431027	0.020602141	0.011952286	0.013852713	0.016357216	0.016876319	0.01759198	0.02	0.01770844	0.018295574	0.020446521
personnel ability	0.018025253	0.018569534	0.02076137	0.01786474	0.018431027	0.020602141	0.017928429	0.018470284	0.020446521	0.022501758	0.021989975	0.02	0.01770844	0.018295574	0.020446521
clear of goal	0.018025253	0.018569534	0.02076137	0.01786474	0.018431027	0.020602141	0.017928429	0.018470284	0.020446521	0.016876319	0.01759198	0.02	0.01770844	0.018295574	0.020446521
management involvement	0.018025253	0.018569534	0.02076137	0.01786474	0.018431027	0.020602141	0.017928429	0.018470284	0.020446521	0.016876319	0.01759198	0.02	0.011805627	0.013721681	0.016357216
culture improvement	0.012016835	0.01392715	0.016609096	0.011909827	0.01382327	0.016481713	0.017928429	0.018470284	0.020446521	0.022501758	0.021989975	0.02	0.01770844	0.018295574	0.020446521
suitable staff	0.024033671	0.023211917	0.02076137	0.023819653	0.023038784	0.020602141	0.017928429	0.018470284	0.020446521	0.022501758	0.021989975	0.02	0.01770844	0.018295574	0.020446521
flexibility of staff	0.018025253	0.018569534	0.02076137	0.01786474	0.018431027	0.020602141	0.017928429	0.018470284	0.020446521	0.016876319	0.01759198	0.02	0.011805627	0.013721681	0.016357216

	expert6			expert7			expert8			expert9			expert10		
adaption of team	0.01875	0.019134595	0.02076137	0.01875	0.019134595	0.02076137	0.012038585	0.013972393	0.01700973	0.013274466	0.015037641	0.01700973	0.018190172	0.018711211	0.020924349
personnel ability	0.025	0.023918244	0.02076137	0.01875	0.019134595	0.02076137	0.024077171	0.023287322	0.021262163	0.013274466	0.015037641	0.01700973	0.024253563	0.023389013	0.020924349
clear of goal	0.0125	0.014350946	0.016609096	0.01875	0.019134595	0.02076137	0.024077171	0.023287322	0.021262163	0.019911699	0.020050188	0.021262163	0.024253563	0.023389013	0.020924349
management involvement	0.0125	0.014350946	0.016609096	0.01875	0.019134595	0.02076137	0.024077171	0.023287322	0.021262163	0.026548932	0.025062735	0.021262163	0.024253563	0.023389013	0.020924349
culture improvement	0.025	0.023918244	0.02076137	0.0125	0.014350946	0.016609096	0.018057878	0.018629857	0.021262163	0.013274466	0.015037641	0.01700973	0.018190172	0.018711211	0.020924349
suitable staff	0.01875	0.019134595	0.02076137	0.025	0.023918244	0.02076137	0.012038585	0.013972393	0.01700973	0.026548932	0.025062735	0.021262163	0.024253563	0.023389013	0.020924349
flexibility of staff	0.025	0.023918244	0.02076137	0.025	0.023918244	0.02076137	0.018057878	0.018629857	0.021262163	0.026548932	0.025062735	0.021262163	0.018190172	0.018711211	0.020924349

Table 7. Continued

value stream mapping	time of waiting of	number of skilled	availability of hospital	optimal treatment	treatment process	improvement process	
0.024033671	0.018025253	0.024033671	0.024033671	0.018025253	0.012016835	0.024033671	expert1
0.023211917	0.018569534	0.023211917	0.023211917	0.018569534	0.01392715	0.023211917	
0.02076137	0.02076137	0.02076137	0.02076137	0.02076137	0.016609096	0.02076137	
0.023819653	0.01786474	0.023819653	0.023819653	0.01786474	0.011909827	0.023819653	expert2
0.023038784	0.018431027	0.023038784	0.023038784	0.018431027	0.01382327	0.023038784	
0.020602141	0.020602141	0.020602141	0.020602141	0.020602141	0.016481713	0.020602141	
0.023904572	0.017928429	0.023904572	0.023904572	0.017928429	0.011952286	0.023904572	expert3
0.023087855	0.018470284	0.023087855	0.023087855	0.018470284	0.013852713	0.023087855	
0.020446521	0.020446521	0.020446521	0.020446521	0.020446521	0.016357216	0.020446521	
0.022501758	0.016876319	0.022501758	0.016876319	0.022501758	0.016876319	0.022501758	expert4
0.021989975	0.01759198	0.021989975	0.01759198	0.021989975	0.01759198	0.021989975	
0.02	0.02	0.02	0.02	0.02	0.02	0.02	
0.023611253	0.023611253	0.01770844	0.01770844	0.023611253	0.023611253	0.01770844	expert5
0.022869468	0.022869468	0.018295574	0.018295574	0.022869468	0.022869468	0.018295574	
0.020446521	0.020446521	0.020446521	0.020446521	0.020446521	0.020446521	0.020446521	
0.01875	0.025	0.01875	0.01875	0.025	0.0125	0.01875	expert6
0.019134595	0.023918244	0.019134595	0.019134595	0.023918244	0.014350946	0.019134595	
0.02076137	0.02076137	0.02076137	0.02076137	0.02076137	0.016609096	0.02076137	
0.01875	0.025	0.025	0.01875	0.01875	0.01875	0.025	expert7
0.019134595	0.023918244	0.023918244	0.019134595	0.019134595	0.019134595	0.023918244	
0.02076137	0.02076137	0.02076137	0.02076137	0.02076137	0.02076137	0.02076137	
0.024077171	0.012038585	0.012038585	0.024077171	0.024077171	0.024077171	0.012038585	expert8
0.023287322	0.013972393	0.013972393	0.023287322	0.023287322	0.023287322	0.013972393	
0.021262163	0.01700973	0.01700973	0.021262163	0.021262163	0.021262163	0.01700973	
0.019911699	0.019911699	0.019911699	0.013274466	0.013274466	0.019911699	0.019911699	expert9
0.020050188	0.020050188	0.020050188	0.015037641	0.015037641	0.020050188	0.020050188	
0.021262163	0.021262163	0.021262163	0.01700973	0.01700973	0.021262163	0.021262163	
0.012126781	0.024253563	0.024253563	0.024253563	0.018190172	0.012126781	0.024253563	expert10
0.014033408	0.023389013	0.023389013	0.023389013	0.018711211	0.014033408	0.023389013	
0.016739479	0.020924349	0.020924349	0.020924349	0.020924349	0.016739479	0.020924349	

Table 7. Continued

service quality	trust performance	strategy healthcare	changing device in	multi task staff	using advanced	finding seven MUDA	
0.024033671	0.018025253	0.018025253	0.012016835	0.024033671	0.024033671	0.024033671	expert1
0.023211917	0.018569534	0.018569534	0.01392715	0.023211917	0.023211917	0.023211917	
0.02076137	0.02076137	0.02076137	0.016609096	0.02076137	0.02076137	0.02076137	
0.023819653	0.01786474	0.01786474	0.011909827	0.023819653	0.023819653	0.023819653	expert2
0.023038784	0.018431027	0.018431027	0.01382327	0.023038784	0.023038784	0.023038784	
0.020602141	0.020602141	0.020602141	0.016481713	0.020602141	0.020602141	0.020602141	
0.023904572	0.017928429	0.017928429	0.011952286	0.023904572	0.023904572	0.023904572	expert3
0.023087855	0.018470284	0.018470284	0.013852713	0.023087855	0.023087855	0.023087855	
0.020446521	0.020446521	0.020446521	0.016357216	0.020446521	0.020446521	0.020446521	
0.016876319	0.016876319	0.022501758	0.016876319	0.022501758	0.022501758	0.022501758	expert4
0.01759198	0.01759198	0.021989975	0.01759198	0.021989975	0.021989975	0.021989975	
0.02	0.02	0.02	0.02	0.02	0.02	0.02	
0.01770844	0.023611253	0.023611253	0.023611253	0.01770844	0.023611253	0.023611253	expert5
0.018295574	0.022869468	0.022869468	0.022869468	0.018295574	0.022869468	0.022869468	
0.020446521	0.020446521	0.020446521	0.020446521	0.020446521	0.020446521	0.020446521	
0.025	0.0125	0.025	0.01875	0.01875	0.01875	0.01875	expert6
0.023918244	0.014350946	0.023918244	0.019134595	0.019134595	0.019134595	0.019134595	
0.02076137	0.016609096	0.02076137	0.02076137	0.02076137	0.02076137	0.02076137	
0.0125	0.01875	0.025	0.0125	0.0125	0.01875	0.01875	expert7
0.014350946	0.019134595	0.023918244	0.014350946	0.014350946	0.019134595	0.019134595	
0.016609096	0.02076137	0.02076137	0.016609096	0.016609096	0.02076137	0.02076137	
0.024077171	0.024077171	0.018057878	0.012038585	0.024077171	0.024077171	0.018057878	expert8
0.023287322	0.023287322	0.018629857	0.013972393	0.023287322	0.023287322	0.018629857	
0.021262163	0.021262163	0.021262163	0.01700973	0.021262163	0.021262163	0.021262163	
0.019911699	0.013274466	0.026548932	0.019911699	0.019911699	0.019911699	0.013274466	expert9
0.020050188	0.015037641	0.025062735	0.020050188	0.020050188	0.020050188	0.015037641	
0.021262163	0.01700973	0.021262163	0.021262163	0.021262163	0.021262163	0.01700973	
0.018190172	0.018190172	0.012126781	0.024253563	0.024253563	0.012126781	0.018190172	expert10
0.018711211	0.018711211	0.014033408	0.023389013	0.023389013	0.014033408	0.018711211	
0.020924349	0.020924349	0.016739479	0.020924349	0.020924349	0.016739479	0.020924349	

Table 7. Continued

	expert1			expert2			expert3			expert4			expert5			expert6			expert7			expert8			expert9			expert10		
medium and long term	0.018025253	0.018569534	0.02076137	0.01786474	0.018431027	0.020602141	0.017928429	0.018470284	0.020446521	0.016876319	0.01759198	0.02	0.023611253	0.022869468	0.020446521	0.025	0.023918244	0.02076137	0.0125	0.014350946	0.016609096	0.024077171	0.023287322	0.021262163	0.019911699	0.020050188	0.021262163	0.024253563	0.023389013	0.020924349
incentive system	0.012016835	0.01392715	0.016609096	0.011909827	0.01382327	0.016481713	0.017928429	0.018470284	0.020446521	0.022501758	0.021989975	0.02	0.011805627	0.013721681	0.016357216	0.01875	0.019134595	0.02076137	0.025	0.023918244	0.02076137	0.012038585	0.013972393	0.01700973	0.013274466	0.015037641	0.01700973	0.012126781	0.014033408	0.016739479
size of hospital	0.024033671	0.023211917	0.02076137	0.023819653	0.023038784	0.020602141	0.023904572	0.023087855	0.020446521	0.022501758	0.021989975	0.02	0.01770844	0.018295574	0.020446521	0.01875	0.019134595	0.02076137	0.025	0.023918244	0.02076137	0.012038585	0.013972393	0.01700973	0.026548932	0.025062735	0.021262163	0.018190172	0.018711211	0.020924349
availability of financial	0.024033671	0.023211917	0.02076137	0.023819653	0.023038784	0.020602141	0.023904572	0.023087855	0.020446521	0.016876319	0.01759198	0.02	0.023611253	0.022869468	0.020446521	0.0125	0.014350946	0.016609096	0.01875	0.019134595	0.02076137	0.024077171	0.023287322	0.021262163	0.026548932	0.025062735	0.021262163	0.012126781	0.014033408	0.016739479

The weight of each criterion is calculated by the average score of each factor.

Table 8. Weight of criteria

Factors	Fuzzy weights			Un fuzzy weight	Rank
Adaption to team management	0.015742184	0.016808888	0.019048152	0.017199742	22
Personnel ability	0.019938382	0.020052321	0.020297553	0.020096085	4
patients' waiting time	0.018789561	0.019157046	0.020307569	0.019418059	5
Management involvement	0.018863003	0.019200912	0.019898639	0.019320851	18
Culture improvement	0.016908781	0.017715415	0.019055056	0.017893084	11
Suitable staff	0.021258303	0.021048351	0.020297553	0.020868069	13
Flexibility of staff	0.019529735	0.01970248	0.020313866	0.019848694	20
Improvement process	0.021192194	0.021008854	0.020297553	0.020832867	17
Treatment process	0.016373217	0.017292104	0.018652882	0.017439401	2
Optimal treatment process	0.019922324	0.02004193	0.020297553	0.020087269	4
Availability of hospital services	0.020544785	0.020520928	0.020297553	0.020454422	7
Number of skilled personnel	0.021192194	0.021008854	0.020297553	0.020832867	19
Patients' waiting time	0.020050984	0.020118037	0.020297553	0.020155525	4
Value stream mapping	0.021148656	0.020983811	0.02030431	0.020812259	15
Finding seven MUDA	0.020489342	0.02048459	0.020297553	0.020423829	3
Using advanced technology	0.021148656	0.020983811	0.02030431	0.020812259	3
Multi task staff	0.021146053	0.020983617	0.020307569	0.020812413	1
Changing devicesas soon as possible	0.016382037	0.017296172	0.018646125	0.017441445	23
Strategic healthcare	0.020666503	0.020589278	0.02030431	0.02052003	21
Performancetrust	0.01810978	0.018645401	0.019882326	0.018879169	6
Service quality	0.02060217	0.020554402	0.020307569	0.020488047	14
Medium-term and long-term objective	0.020004843	0.020092801	0.020307569	0.020135071	8
Incentive system	0.015735231	0.016802864	0.018217623	0.016918572	9
Hospital area	0.021249578	0.021042328	0.020297553	0.020863153	16
availability of financial resource	0.020624835	0.020566901	0.019889082	0.020360273	10

6-Conclusion

Leanness in healthcare systems causes several advantages such as decreasing cost for both hospital and patient and increasing the satisfaction and loyalty of patient. The implementation of lean healthcare system is not a trivial task. Therefore, hospitals must understand which factors are more important in order to increase the effectiveness of the lean process. Hence, it is possible to allocate limited resources to high priority factors for best implementation. The introduced model was conducted in a 240-bed hospital, and the result indicated that the hospital was in good condition regarding lean approach. Since hospital's specification indicates its good performance. Despite the good performance of the hospital, it is still in the beginning of this path and there are so many progress passes on the way. Here are some potential improvement areas such as personnel ability, goal clarity, treatment process, optimal treatment process,

patients' waiting time, finding seven wastes, using advanced technology, multi task staff and performance trust.

Despite the widespread development of lean hospital in recent years, there are many steps left to be taken to reach maturity stage. The purpose of the present article was to answer some of these questions. In the first step, we studied the details of previous researches about lean assessment. We selected an appropriate method for lean hospital assessment. Ambiguity and uncertainty in human evaluation were modeled using fuzzy sets. So we used fuzzy MULTI-MOORA and linguistic variables in our assessment.

Regarding the fact that the researches done in lean hospitals were mostly limited to advertising lean hospital and stating the practical experiences, there are many potential areas for future researches. In addition, we suggest that the developed model will be implemented in other hospitals, so its ability is proved in different practical fields.

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