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Identifying and Prioritizing the Effective Criteria in Selecting Lean Six Sigma Improvement Projects in the Healthcare Sector

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Abstract

The main objective of this study was to identify and prioritize effective criteria in selecting Lean Six Sigma improvement projects in the healthcare and treatment sector in Iran. The present study was an applied research in terms of objective and a descriptive and analytical one according to the research methodology and data collection approach. The research statistical population included experts and managers with experience in the field of implementing the Lean Six Sigma methodology in the field of healthcare and treatment in Iran. We used interviews and questionnaire tools to collect the data. The effective criteria were identified through reviewing previous research, which were then prioritized based on the experts' opinions using the Best Worst Method. According to the results, out of the six main dimensions and 20 criteria identified, the customer development dimension with a weight of 0.387 and the customer satisfaction criterion with a weight of 0.066 were determined as the most effective dimension and the most effective criterion, respectively. Accordingly, the directors of medical centers and organizations affiliated with the healthcare sector are recommended to pay special attention to these defined criteria of the customer development dimension to effectively implement the Lean Six Sigma methodology and managing an effective customer relationship.

Keywords: *Improvement projects, Lean Six Sigma, Healthcare Sector, Best Worst Method.*

Introduction

Lean Six Sigma improvement projects have been always the focus of attention in different industries and sectors, especially the healthcare sector by organizations and managers. Thus, identifying and prioritizing

Lean Six Sigma improvement projects in the healthcare sector appears to be an effective and inevitable issue for all managers involved in this field. For, Lean Six Sigma is recognized as a continuous improvement process that simultaneously increases efficiency and productivity in the organization and reduces costs (Sunder & Kunnath, 2020). In fact, Lean Six Sigma is a process that enables the organization to understand and control changes in the future besides enhancing the quality accompanied by data collection (Bumjaid & Malik, 2019). Organizations, on the other hand, use the lean methodology to reduce and eliminate waste and improve environmentally friendly processes (Sá et al., 2020). the Lean philosophy as a strategy allowing companies in any sector to adapt to rapid changes in the market, in the economy, in technical and social complexity issues, and in the needs of customers as well as for the health sector to adapt (Morell-Santandreu et al,2021). Also, the lean tools can perform usefully in different organizations to improve performance (Gupta et al., 2020). By focusing Lean, we can specify that continuous improvement is achieved by increasing value-added activities or reducing activities with no added value, by reducing the variation in process, and by altering bad working conditions(Morell-Santandreu et al,2020). Given that improvement projects in organizations need to be constantly developed and they are seen as the best approaches to improve operational competitiveness according to the areas of quality, organization costs, reliability, and the speed of performing processes (Lizarelli & Alliprandini, 2020), the "Lean Six Sigma" seems to be one of the best methods to improve processes in all areas of service-providing various sectors (Sunder, 2013). Due to the importance of Six Sigma projects, we sought to identify and prioritize the Lean Six Sigma improvement projects in the healthcare sector among the private sector hospitals in Iran in this research. Lean Six Sigma and Six Sigma are the first methods that are used in healthcare centers to increase quality (Henrique & Godinho Filho, 2020). The leans Six Sigma, as a method to improve quality, can be used in the healthcare sectors to increase the quality standards of the organization and enhance the satisfaction level of all individuals in the organization (Rahul et al., 2020). Moreover, the use of Lean Six Sigma in hospitals minimizes errors, increases safety in patients, and also increases the sense of satisfaction in patients and hospital staff (Trakulsunti et al., 2020). This method increases the efficiency of processes and the overall performance in hospitals as well, and thereby, the healthcare system will improve (Improta et al., 2018). Identifying and selecting Lean Six Sigma projects based on effective and desirable criteria is one of the most important challenges for organizations involved in the implementation of Lean Sigma in the Healthcare Sector. Therefore, the present study aims to identify and prioritize effective criteria in Selection of lean Six Sigma improvement projects was performed.

Review of literature

Lean Six Sigma

The development of the Six Sigma method was initially made at Motorola Company aimed at reducing diversity in the manufacturing sections. Afterward, many organizations employed this method for different purposes such as improving work processes (Antony et al., 2016). In fact, Six Sigma enables the organization to identify the root causes of mistakes and work to correct them. As a result, defects and changes reduce to 3.4 cases per million (Mason et al., 2015). The processes are improved in these areas by eliminating and reducing existing waste and recognizable changes using the Six Sigma method (Wang & Chen, 2010). In

fact, Six Sigma enables the organization to detect and minimize changes, and hence, create value consistent with the process output (Erdil et al., 2018). It is a method to improve all business processes by eliminating mistakes and defects, which focuses on outputs that highly matter to customers (Laureani & Anthony, 2017). On the other hand, the "Lean" method is one of the most important ideas for management that is fit to all organizations and departments (McCann et al., 2015). Lean thinking has originated from Toyota's production system, which emphasizes the optimal use of all available resources associated with proper timing (Shenshinov & Abdulsattar Al-Ali, 2020). It is a system relying on learning in the organization with the help of continuous improvement to eliminate unnecessary processes and all actions that do not create value (Aramoon et al., 2020). Lean is very different from mass production and is actually another type of production system design, seeking to meet customer needs ideally (Kadarova & Demecko, 2016). The Lean approach indeed generates more value for customers with fewer resources and less waste (Mrugalska & Wyrwicka, 2017). Here, waste refers to motion over production, defects, inventory, transportation, waiting time, and processing time (Marodin et al., 2016). Five different principles need to be specifically considered to implement the Lean method, including value, value flow, flow, pool, and perfection (Naumovich, 2020). Many organizations and companies have used the "Lean" method so far to gain competitive advantages and have adjusted their performance based on this methodology (Okpala et al., 2020). The Lean Six Sigma approach can be also used in healthcare organizations to reduce the cost of healthcare measures, increase the quality of treatment of patients, enhance the patients' safety, and in general, providing better healthcare measures for patients (Bhat et al., 2019). Conducting a study in 2018, Trakulsunti and Antony looked for answering the question that "Can Lean Six Sigma be useful in healthcare units to reduce medication errors?" They found that Lean Six Sigma can be used as a powerful method to improve processes aimed at reducing medication errors and operating costs and increasing the patients' safety. Ahmed et al. also performed a study in 2018 to examine the impact of Lean Six Sigma on the quality performance in Malaysian hospitals and realized that the Lean Six Sigma method and labor management have a great impact on the quality performance of hospitals in Malaysia. They also found that the CEO's commitment has a significant relationship with quality performance through the mediating effects of Lean Six Sigma and workforce management.

The selection criteria for Lean Six Sigma improvement projects

Lean Six Sigma is actually a combination of principles that exist in lean production, which main focus is on facilitating process flows and Six Sigma. It is a set of different tools and techniques designed to reduce existing errors (Vinodh & Swarnakar, 2015). Implementing Lean Six Sigma improves the processes that create value. Selecting Lean Six Sigma improvement projects will be successful if the criteria capable of influencing or limiting the project are identified and considered. By studying the existing literature on the criteria affecting the success of Lean Six Sigma projects, we find that the importance of different criteria is significant.In the car segments, Swarnakar and Vinodh used criteria such as cycle time reduction and pull production along with 12 other criteria in 2014 and calculated the weight of these criteria for selecting Lean Six Sigma projects. In 2017, Yadav and Desai evaluated the factors affecting the Lean Six Sigma such as interaction in the management department, the culture of organizational quality, and the training required for the lean six sigma. Moreover, many researchers such as de Miranda Lammoglia et al. (2020), Swarnakar

and Vinodh (2014), and Vinodh and Swarnakar (2015) have examined the existing financial impacts on projects, costs optimization, and the return to investing on Lean Six Sigma implementation projects. Thus, the list of necessary criteria is identified by reviewing the relevant literature and these criteria are classified into different categories in various dimensions such as project feasibility, development of the organization's customers, the financial condition of the organization, and other criteria. In this study, following the review of previous studies and after consulting with experts, 20 criteria in 6 different categories were identified, which had been obtained from the review of the literature concerning the selection of Lean Six Sigma projects in the field of healthcare and treatment. Table 1 introduces these criteria.

Table 1.The criteria for selecting the Lean Six Sigma projects

Categories	Criteria	References
Customer Development (D1): Necessary measures in order to attract new customers, maintain and respond to existing customers in order to develop the market for the company's products.	Business Opportunities (C1): Opportunities to participate in the business environment.	(Yadav & Desai., 2017a) (Swarnakar & Vinodh ., 2014) (Vinodh & Swarnakar., 2015)
	Customer Complaint (C2): Complaints received from customers regarding products and services.	(de Miranda Lammoglia et al., 2020) (Swarnakar & Vinodh ., 2014) (Vinodh & Swarnakar., 2015)
	Customer Satisfaction (C3): Customer satisfaction with receiving the company's products and services.	(Assarlind & Aaboen., 2014) (Singh et al ., 2021)
Financial status (D2): Effective measures to optimize the budget and manage project costs according to the rate of return on investment.	Project budget (C4): Estimated cost for project implementation improvement.	(de Miranda Lammoglia et al., 2020) (Swarnakar & Vinodh ., 2014)
	Return on Investment (C5): The rate of return on investment spent on the project.	(Yadav & Desai., 2017a) (Vinodh & Swarnakar., 2015) (Singh et al ., 2021) (de Miranda Lammoglia et al., 2020)
	Reducing the project cost (C6): The rate of return on investment spent on the project.	(de Miranda Lammoglia et al., 2020) (Swarnakar & Vinodh ., 2014)
Management Commitment & Participation (D3): Necessary measures to strengthen the spirit of employee participation and enhance the commitment of senior management of the organization in order to develop intra-organizational cooperation	Senior Management Commitment & Employees' Involvement (C7): the level of loyalty and participation of managers and employees in the implementation of the project.	(Yadav & Desai., 2017a) (Swarnakar & Vinodh ., 2014) (Yadav & Desai., 2017b)
	Strong spirit & cooperation (C8) Level of motivation of employees involved in project implementation.	(Pakdil et al., 2020) (Swarnakar & Vinodh ., 2014)
	Staff Improvement (C9): Improving staff performance in order to implement project actions	(Yadav & Desai., 2017b) (Swarnakar & Vinodh ., 2014)

Growth potential (D4): Define and implement effective measures to turn potential into actual actions through training and clear sharing of knowledge information	Education (C10): Necessary training in order to implement project actions	(Yadav & Desai., 2017a) (Vinodh & Swarnakar., 2015) (Yadav & Desai., 2017a)
	Improvement capability (C11) Potential to improve the performance of the organization according to the existing capabilities	(Pakdil et al., 2020) (Yadav & Desai., 2017b)
	Transparent information sharing (C12): Transparency level of information shared in the project	(Yadav & Desai., 2017b) (Vinodh & Swarnakar., 2015)
Business Performance (D5): Define and implement all strategic measures that seek to achieve sustainable competitive advantage by improving organizational processes with the help of a flexible workforce.	Process Improvement (C13) Improving the level of performance of organizational processes according to project implementation.	(Yadav & Desai., 2017b) (Vinodh & Swarnakar., 2015) (Swarnakar & Vinodh ., 2014)
	Flexible workforce (C14): The degree of flexibility of employees in implementing project actions	(Yadav & Desai., 2017a) (Swarnakar & Vinodh ., 2014)
	Projects with critical quality (C15) Acceptable level of sensitivity in the quality implementation of project actions.	(Yadav & Desai., 2017a) (Vinodh & Swarnakar., 2015) (Yadav & Desai., 2017b)
	Business Strategy (C16) Organizational business strategies related to project actions.	(Vinodh & Swarnalkar,2015)
	Competitive Advantage (C17): The advantage that the organization gets as a result of the correct implementation of the project actions	(Vinodh & Swarnalkar,2015)
Process Management (D6): Implementing the necessary measures in the field of organizational process management with the aim of reducing the time to perform Lean Six Sigma projects by reducing time wastes in the project process cycle	Reducing the process cycle time (C18) Appropriate reduction of time in the implementation of organizational processes	(Swarnakar & Vinodh.,2014)
	Project duration (C19): The time required to execute the project actions	(Bazrkar & Iranzade,2017)
	Project sigma level (C20): Increase or decrease the sigma level of the organization's processes as a result of implementing the Six Sigma improvement project	(Bazrkar & Iranzade,2017)

The Best Worst Method

BWM (Best Worst Method**)** is a multi-criteria decision-making technique, which works by weighting the available criteria based on making pairwise comparisons between the worst and best features (Maghsoodi et al., 2019). This method relies on pairwise comparisons and using a linear programming model. In this method, instead of performing pairwise comparisons for all indicators (criteria and sub-criteria) with each other, which is done in the hierarchical analysis approach, the best and worst indices are selected and other indices are compared with these two indicators. Finally, the weights related to each index are determined using a mathematical model (Rezaei, 2015). This method has features such as reducing the number of pairwise comparisons and the possibility of more confidence in the results obtained (Guo & Zhao,2017). This technique is a good alternative to techniques such as AHP and ANP to reduce the number of pairwise comparisons and increase the consistency of opinions (Rezaei et al,2018).In fact, in the BWM method, pairwise comparisons are made between the best and worst weight vectors after identifying these vectors to ultimately identify the optimal weight vectors (Li et al., 2019). The formulation used in this method, which operates based on the minimum and maximum in the comparisons, guarantees the stability of comparisons (Mi et al., 2019). Fewer comparisons are made in this method than other multi-criteria decision-making comparisons need to be done in the hierarchical analysis method, while the BWM method requires 2n-3 comparisons (Pamučar et al., 2018). Consequently, this method saves time for both decision-makers and researchers (Gupta et al., 2017). Whilst most other methods and techniques have some kind of instability in pairwise comparisons, the BWM method can be very efficient (Gupta & Barua, 2016). Thus, the BWM method has been used in different fields with consistent results(Malek & Desai, 2019).

Methodology

The present study was an applied research in terms of objective and a descriptive and analytical one according to the research methodology and data collection approach. The research statistical population included experts and managers with experience in the field of implementing the Lean Six Sigma methodology in the area of healthcare and treatment in Iran. The statistical sample of this study consisted of 28 experts of Lean Six Sigma in the field of healthcare who had experience in implementing the Lean Six Sigma methodology in the hospital. The opinions of these experts were used to prioritize the effective criteria in selecting the six-sigma projects. The specifications of the experts are presented in Table 2.

Table 2. The research experts

Experts		Minimum Experience (Years)
Expert 1 to 15	Manager	10
Expert 15 to 28	Lean Six Sigma Expert	8

After identifying the criteria by studying the research literature and selecting the research experts, we used the tools of questionnaires and interviews to collect data. The interviews were conducted in a regular and structured manner. Given the objective of the study to prioritize the criteria for selecting Lean Six Sigma projects by the BWM method, we defined the following steps to apply this method:

1. The decision-maker must first provide the criteria as the set $C = \{c_1,c_2,\ldots,c_n\}$. If the number of criteria is high, the criteria need to be classified into appropriate categories with proper dimensions.
2. The worst and the best criteria should be determined among each category according to their importance and priority. The best and worst criteria are actually selected based on an intuitive understanding of the relative importance of the set criteria.
3. The numbers from 1 to 9 must be assigned to the paired comparisons made between the best available criterion (C_B) and other criteria in the set. The basis of this allocation is in fact the same importance and priority of the best criterion over other criteria in the set to finally form an A_B vector, called Best-to-Others, which is as follows: $A_B = (a_{b1}, a_{b2,}..., a_{bn})$
4. In this step, the pairwise comparisons are made between the worst criterion of the or C_w with other criteria in the set by assigning numbers between 1 and 9. The basis of this allocation is the same importance and priority of the criteria over the worst available criterion to eventually form an A_W vector, called Best-to-Others, which is as follows: $A_W = (a_{1W}, a_{2W,}..., a_{nW})^T$
5. The optimal weights ($w_1, w_2,...,w_n$) should be now determined. In this step, the following minimization problem should be solved for all the js in the set:
   $\min \xi$
   $|(W\ B/W\ j) - aBj| \leq \xi$ For all j
   $|(W\ j/W\ W) - ajW| \leq \xi$ For all j
   $\sum j\ Wj = 1$
   $Wj \geq 0$ For all j

Where,

the function ξ is the same optimal target function.

6. At this stage, we need to determine the compatibility ratio or the **"Ksi"** to specify the reliability control. The value to be obtained is between 0 and 1. The closer values of this rate to zero suggest that the comparisons made are highly stable and consistent, while the values closer to 1 indicate less stable comparisons. The calculation formula of this method is as follows:
   $Ksi = \xi / CI$.

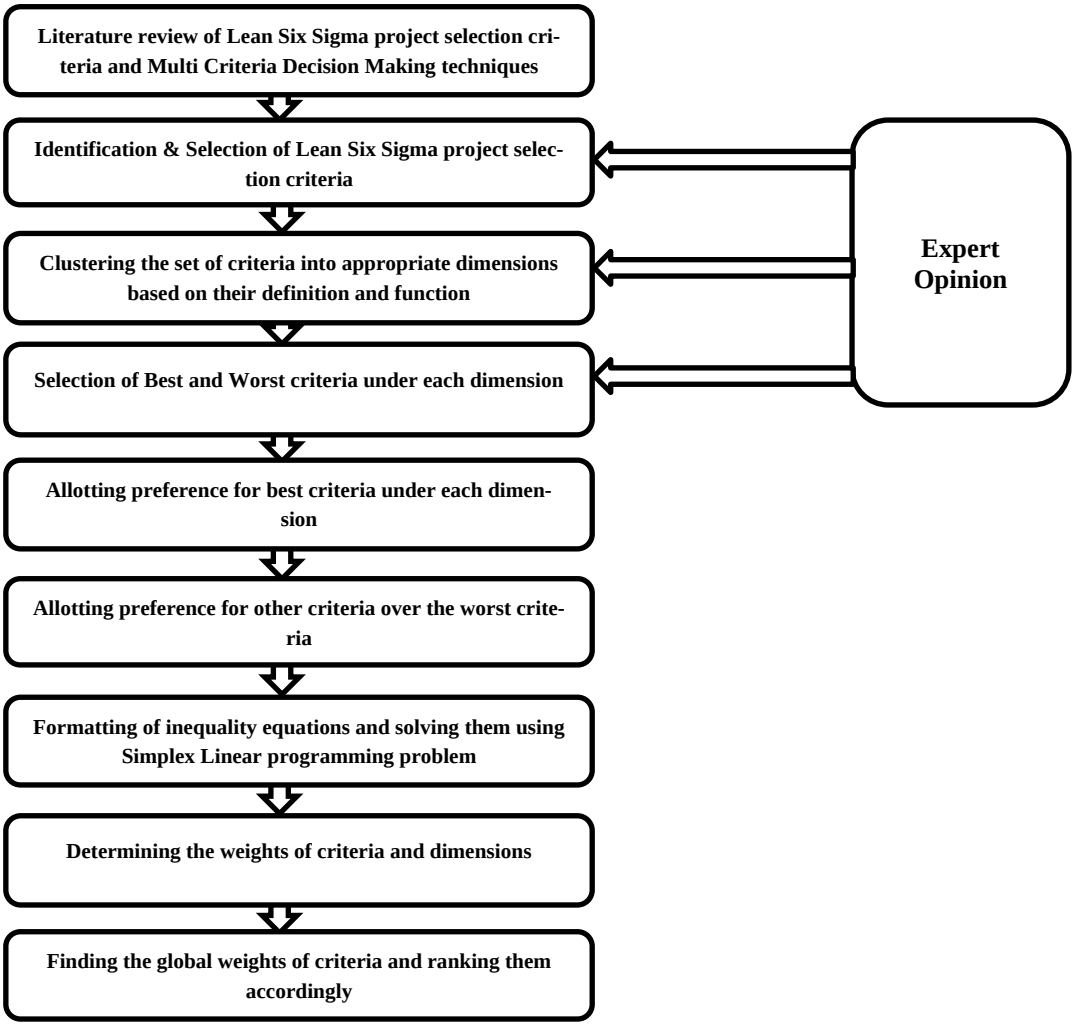
The compatibility index values for different criteria are shown in Table 3:

Table 3. The compatibility index values

a_{BW}	1	2	3	4	5	6	7	8	9
CI	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.00

Accordingly, the steps of implementing the method related to prioritizing the criteria for choosing the Lean Six Sigma project in the healthcare and treatment sector in this research are depicted as a flowchart in Figure 1.

Figure 1. The prioritization steps of Lean Six Sigma projects with a BWM approach



Results

Due to the use of the BWM technique to prioritize the identified criteria, the six steps of the BWM technique were performed after collecting the necessary data through the questionnaires distributed among the research experts. The results are presented in Table 4. It should be noted that the incompatibility ratio obtained is equal to 0.0486. Since the value is close to zero, it indicates that comparisons are highly stable and consistent.

Table 4. The results of ranking criteria using the BWM method

Dimensions	Dimension weight	Criteria	Local weight	Rank	Global weight	Total Rank
Customer Development (D1)	0.387	C1	0.165	3	0.032	7
		C2	0.263	2	0.051	3
		C3	0.320	1	0.066	1
Financial status (D2)	0.052	C4	0.345	1	0.014	16
		C5	0.160	3	0.007	19
		C6	0.287	2	0.012	17
Management Commitment & Participation (D3)	0.162	C7	0.317	1	0.050	4
		C8	0.196	2	0.031	8
		C9	0.097	3	0.017	13
Growth potential (D4)	0.088	C10	0.157	2	0.006	20
		C11	0.068	3	0.015	15
		C12	0.211	1	0.046	6
Business Performance (D5)	0.199	C13	0.267	2	0.049	5
		C14	0.339	1	0.058	2
		C15	0.123	3	0.022	10
		C16	0.096	5	0.016	14
		C17	0.115	4	0.018	12
Process Management (D6)	0.112	C18	0.159	1	0.020	11
		C19	0.183	2	0.024	9
		C20	0.087	3	0.011	18

The results obtained from Table 4 show that among the twenty criteria affecting the selection of Six Sigma projects in the treatment sector, the customer satisfaction criterion with a global weight of 0.066 is in the first rank and Flexible workforce criteria and customer complaint with global weights of 0.058 and 0.051 are also in the second and third ranks.. Examining the other global weights obtained, it was found that the training criterion with a global weight of 0.006 is in the last rank. Also, by examining the weights obtained for the six dimensions, it was found that the customer development dimension with a weight of 0.387 has the greatest impact on the selection of six-sigma pure improvement projects in the field of treatment. The results of ranking the identified main dimensions and criteria are displayed in the form of Figures 2 and 3:

Figure 2. The ranking of the main dimensions affecting the selection of the Lean Six Sigma projects

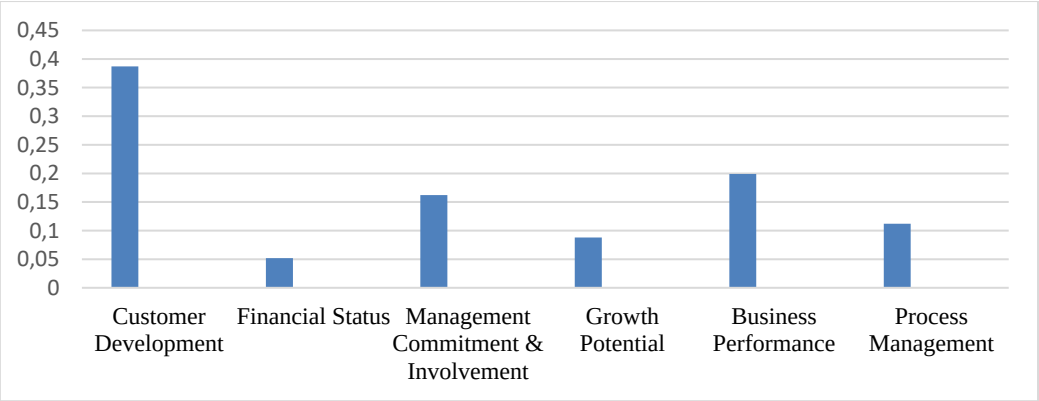
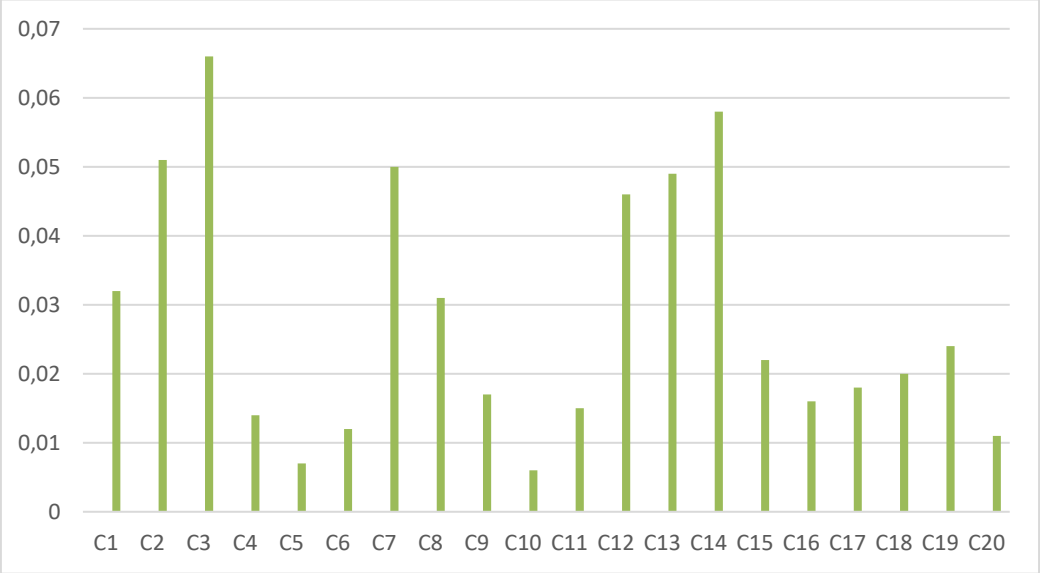


Figure 3. The ranking of criteria affecting the selection of the Lean Six Sigma projects



Discussion & Conclusion

The healthcare system in hospitals is one of the most important factors to increase the quality of services and patient satisfaction and to ensure the implementation of the treatment process. The Lean Six Sigma methodology is a set of tools and principles designed and implemented to meet the customers' needs. Since

the ultimate goal of any improvement is to provide high-quality products and services to customers, thus, paying attention to the selection of Lean Six Sigma improvement projects is one of the major concerns of organizations that use the Lean Six Sigma methodology aimed at improving the quality of their services. Given the sensitivities in the area of treatment and healthcare, choosing these projects in this sector appears to be highly important and vital. Hence, identifying effective and decisive criteria in selecting Lean Six Sigma improvement projects can contribute to the effectiveness of the selected improvement project. This study was performed to identify and prioritize the criteria affecting the selection of Lean Six Sigma projects in the treatment and healthcare sector of Iran. To this end, after identifying effective criteria through the study of previous research, the identified criteria were prioritized using the opinions of the research experts by the BWM method. According to the results, 20 criteria in the form of six main dimensions are influential in the selection of Lean Six Sigma improvement projects in the health and treatment sector. Following the implementation of the BWM method, it was found that the customer development dimension out of the six main dimensions and the customer satisfaction criterion out of the 20 effective criteria can be respectively introduced as the most effective dimension and the most effective criterion in selecting the Lean Six Sigma improvement projects from the perspective of experts. Hence, the high performance of the multi-criteria the best - the worst decision-making method, which is one of the newest multi-criteria decision-making methods, which provides more favorable compatibility comparisons came to the focus of attention. Due to the sensitivity of organizations and companies working in the area of healthcare sector and the growing attention of these organizations to the issue of improving the quality of services and the need to make the right decision regarding the selection of Lean Six Sigma improvement projects to increase customer satisfaction and continuously improve the performance of medical staff, the approach used in this study can help managers and decision-makers in this regard. According to the results of prioritizing the identified criteria and the ranking of two criteria of customer satisfaction and customer complaint after the customer development in the first and third priorities, the managers of medical centers and organizations affiliated with the healthcare sector are recommended to pay special attention to these two criteria when choosing the Lean Six Sigma projects to effectively implement the Lean Six Sigma methodology, reduce the costs, reduce waste, and achieve the goals of the organization in order to effectively manage the customer relationship.

Limitations and suggestions for future research

Like any other research, the present study faced some limitations in the process. Since the present study is an exploratory study, the research findings are limited to the sample size (experts), and if the number of experts changes, the results may change. Also, the existence of different opinions on the subject of research among the research experts can somehow affect the results. The study population in this study consisted of medical centers and hospitals in Iran. Accordingly, the results are specific to these medical centers and cannot be generalized to all organizations and companies. It is suggested that researchers perform this study in other organizations and manufacturing and service companies in future research. According to the research literature review, one can assume that criteria such as cost due to the low quality of services, the level of organizational knowledge, and resilience may be effective in selecting Lean Six Sigma improvement projects. Therefore, it is suggested that the researchers will consider these criteria as effective criteria

and compare the obtained results with the results of this study in future research. Since the use of the BWM technique in this study to prioritize the criteria, it is suggested that researchers will employ other decision-making techniques such as hierarchical analysis and data envelopment analysis with definite and fuzzy data in future research**.**

Conflicting Interests Declaration

This research article's authors declared no potential conflicts of interest in line with the research, authorship, and publication.

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