

# Factors affecting the effectiveness of quality control circles in a hospital using a combination of fuzzy VIKOR and Grey Relational Analysis

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## Abstract

**Background:** One of the techniques used to achieve productivity, employees' job satisfaction and higher quality goods and services, as well as to solve the problems by using a team, is the formation of quality control circles. Quality control circles enable managers to meet the organization's and employees' needs through making effective use of resources and facilities. On the other hand, the quality of services is always affected by uncertainty and ambiguous and implicit judgments, which make its measurement uncertain.

**Aim:** The present study aimed to identify important factors affecting the effectiveness of quality control circles in a hospital, as well as rank them using a combination of fuzzy VIKOR and Grey Relational Analysis (GRA).

**Methodology:** This was an applied, cross-sectional and descriptive–analytical study conducted in 2016. The study population consisted of five academic members and five experts in the field of nursing working in a hospital, who were selected using a purposive sampling method. Also, a sample of 107 nurses was selected through a simple random sampling method using their employee codes and the random-number table. The required data were collected using a researcher-made questionnaire which consisted of 12 factors. The validity of this questionnaire was confirmed through giving the opinions of experts and academic members who participated in the present study, as well as performing confirmatory factor analysis. Its reliability also was verified ( $\alpha=0.796$ ). The collected data were analyzed using SPSS 22.0 and LISREL 8.8, as well as VIKOR–GRA and IPA methods.

**Results:** The results of ranking the factors affecting the effectiveness of quality control circles showed that the highest and lowest ranks were related to 'Managers' and supervisors' support' ( $\bar{S} = 6.80$ ,  $\bar{R} = 0.36$ ) and 'Group leadership' ( $\bar{S} = 2.63$ ,  $\bar{R} = 0.98$ ). Also, the highest hospital performance was for factors such as 'Clear goals and objectives' and 'Group cohesiveness and homogeneity', and the lowest for 'Reward system' and 'Feedback system', respectively.

**Conclusion:** The results showed that although 'Training the members', 'Using the right tools' and 'Reward system' were factors that were of great importance, the organization's performance for these factors was poor. Therefore, these factors should be paid more attention by the studied hospital managers and should be improved as soon as possible. Applying quality control circles in any organization is very helpful and provides opportunities for maximum use of employees' creativity, initiative and skills in reaching their and their organization's goals and objectives, and prepares favorable working conditions for the employees' optimal performance through increasing the managers' sense of responsibility and commitment.

## Keywords

Quality control circles, fuzzy VIKOR, Grey Relational Analysis, Importance–Performance Analysis

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## Introduction

The health system is one of the most important sectors in each country; it affects other related areas, has medical, social, political, moral, business and financial implications and outcomes<sup>1,2</sup> and is constantly growing in the developed and developing countries. In the healthcare systems, the quality of care and services provided to patients is an issue which is at the forefront of attention, is a tool for judging the health systems and achieving patient loyalty and is a competitive advantage.<sup>3</sup> Also, the quality of healthcare is considered as a reliable tool for attracting customers.<sup>4</sup> In this regard, Otani et al. have introduced 'quality' as the main driving force of healthcare organizations to make efforts to respond to the competitive challenges of such organizations.<sup>5</sup> The UK health system has defined service quality as the provision of appropriate services for the right person, at the right time, in the right and correct way, and by taking into account the patient's financial circumstances.<sup>6</sup> This has led to considering improved quality as a strategy to achieve a competitive advantage and to improve the reputation and profitability of a healthcare organization over time.<sup>7</sup> Because the healthcare organizations are directly responsible for maintaining people's health, providing high quality services is of particular importance in the prevention of death and injuries.<sup>8</sup> Therefore, healthcare managers need a thorough understanding of the ways to increase the quality of care in the operational conditions.<sup>9</sup> To achieve effective operational performance, familiarity with and use of service quality improvement techniques is essential, and also it is necessary to gain sufficient understanding of cause and effect relationships among service quality indicators, quality structures, customer satisfaction, and continuous measurement of service quality, because the improved quality of services provided is considered the most important step in increasing consumer satisfaction. In conclusion, service quality is an important factor in increasing consumer satisfaction and significantly affects profitability, productivity, market share, return on investment and cost reduction.<sup>10</sup>

One of the techniques used to achieve such goals is quality control circles (QCCs). By creating these circles organizations try to meet many objectives, such as productivity, employees' job satisfaction, producing and providing higher quality goods and services and solving problems by using a team. QCCs enable managers to satisfy the organization's and employees' needs through making effective use of resources and facilities.<sup>11</sup> The importance of QCCs is that the employees and the circle members are more familiar with the workplace problems than others and can solve them more effectively because of their thorough understanding of the problems and issues.<sup>12</sup> Each circle consists of members and non-members, a leader, a circle guide and the organization's senior manager, who encourages employees to participate in matters and issues that affect their working lives.<sup>13</sup> Although the use of QCCs initially started in business management, today they are used in the fields of medicine and healthcare around the world. The main goals of QCCs are to increase healthcare employees' morale, improve the working environment, increase the quality of medical care, decrease medical management costs and improve the efficiency of medical services.<sup>13</sup> The results of some quality studies in the health sector and in the fields of

Nursing and Management, Pharmaceutical Management, Quality Management, Operating Room Management, et cetera have shown that quality control has reduced the number of clinical errors and the rate of complications caused by invasive procedures, and has improved the quality of operating room nurses' work and activities.<sup>14,15</sup>

On the other hand, the quality of services is always affected by uncertainty and ambiguous and implicit judgments.<sup>16</sup> To resolve the ambiguities related to human judgment, multi-criteria decision-making models and the fuzzy theory have been introduced and used for performance evaluation.<sup>17,18</sup> Grey System Theory and fuzzy VIKOR are two multi-criteria decision-making methods that have attracted researchers' attention in recent years. Grey System Theory was first introduced and proposed by Deng in 1982. This method has already been used extensively in various fields and its advantages in the face of uncertain, incomplete and poor information have been verified. Grey Relational Analysis (GRA) is a part of Grey System Theory and is appropriate for resolving issues with complex interrelations. One of the advantages of using GRA in identifying relationships, compared with statistical methods, is to specify the quantitative and qualitative relationships among complex factors with incomplete information.<sup>19</sup> Fuzzy VIKOR also is a logical and systematic process to achieve the best solution, and is used for solving fuzzy multi-criteria decision making issues and problems.<sup>16,20</sup>

Many studies have been conducted using fuzzy VIKOR, including studies on performance management in healthcare,<sup>21</sup> the effects of education on housing choice,<sup>22</sup> supplier selection,<sup>23</sup> material selection<sup>24</sup> and improvement of domestic airlines' service quality.<sup>25</sup> Moreover, some studies have been conducted using the combination of fuzzy VIKOR and GRA, including studies on the failure mode and effects analysis<sup>26</sup> and evaluation of airport service quality.<sup>27</sup> Although numerous studies have been conducted on QCCs, the current researchers did not find any study on ranking factors affecting the effectiveness of QCCs in their searches. Therefore, the present study aimed to identify important factors affecting the effectiveness of QCCs, as well as rank them using a combination of fuzzy VIKOR and GRA. Also, using Importance-Performance Analysis (IPA) and based on the importance of each factor determined by the fuzzy VIKOR-GRA method and the overall performance of a Tehran hospital for each factor, practical recommendations were made for increasing its success in forming the QCCs more effectively.

## Methods

This was an applied, cross-sectional and descriptive-analytical study conducted in a Tehran hospital in 2016. The studied hospital is educational teaching hospital with 600 available beds and has received grade I excellent in the accreditation program implemented by Iran's Ministry of Health and Medical Education in 2015. The study population consisted of five academic members and five experts in the field of nursing working in this hospital, who were selected using a purposive sampling method. The nurses involved in the current study were nurses and head nurses who had bachelor's, master's or PhD degrees and were working in different shifts of the selected hospital wards of the studied hospital (N=147).

A sample of 107 nurses was determined using the following formula, assuming  $\alpha=0.05$ ,  $p=q=0.5$  and  $\varepsilon=0.05$ . However, because of the probability of dropping out, 115 employees were selected through a simple random sampling method using their employee codes and the random-number table. It should be noted that the response rate was 94%.

$$n = \frac{147 * 1.96^2 * 0.5 * 0.5}{146 * 0.05^2 + 1.96^2 * 0.5 * 0.5} = \frac{141.1788}{1.3254} = 107$$

The required data were collected using a researcher-made questionnaire. The validity of this questionnaire was confirmed through the opinions of experts and academic members who participated in the present study, as well as performing confirmatory factor analysis. Its reliability also was verified ( $\alpha=0.796$ ). To identify factors affecting the effectiveness of QCCs, a literature review was carried out and 45 factors were determined, which were categorized into the following 12 categories using the experts' opinions.

1. Managers' and supervisors' support.
2. Training the members.
3. Clear goals and objectives.
4. Voluntary membership.
5. Using the right tools.
6. Group cohesiveness and homogeneity.
7. Reward system.
8. Feedback system.
9. Organizational culture.
10. Management style.
11. Regularly holding meetings.
12. Group leadership.

The collected data were analyzed using SPSS 22.0 (to analyze the studied participants' demographic characteristics), LISREL 8.8 (to perform confirmatory factor analysis), as well as VIKOR–GRA and IPA methods (to rank factors affecting the effectiveness of quality control circles and identify the critical points and provide the required strategies and recommendations).

Written informed consent was obtained from all participants in this study and all of them were assured of the confidentiality of their responses. This research project was approved by the Ethical Committee of Baqiyatallah University of Medical Sciences (ethical code: CH/7020/96).

Some explanations of the VIKOR–GRA steps and IPA have been provided in the next section.

### The VIKOR–GRA method

The comprehensive and critical review of the results of studies conducted on identifying factors affecting the effectiveness of QCCs using multi-criteria decision-making methods shows that it seems that such studies have not considered two points. First, in these studies the evaluation has been carried out without considering the uncertain conditions. Second, the methods that have been employed are not able to identify weak factors. Therefore, in the current study, the fuzzy approach was used to deal with the uncertainties, and a combination of VIKOR and GRA methods was used to evaluate effective factors.

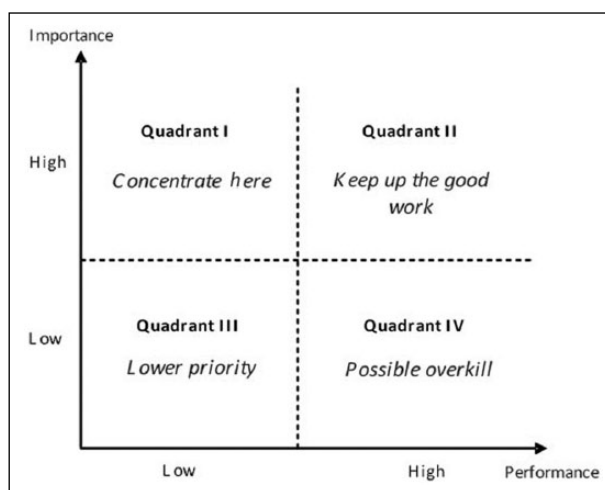


Figure 1. The Importance–Performance Analysis framework.

Table 1. Linguistic terms used for fuzzy ranking.<sup>32</sup>

Very low	(0, 0, 1)
Low	(0, 1, 3)
Average	(3, 5, 7)
High	(7, 9, 10)
Very high	(9, 10, 10)

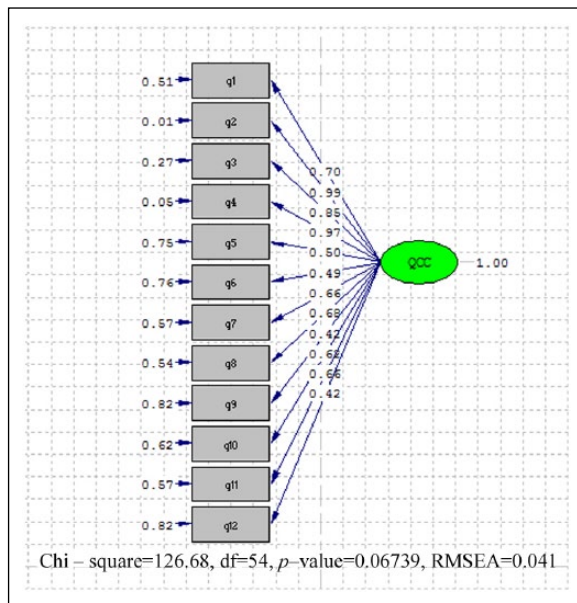
Table 2. The results of ranking factors affecting the effectiveness of quality control circles in the studied hospital.

	$\check{S}$	$\check{R}$	$\check{Q} (\vartheta = 0.5)$	Ranks
Managers' and supervisors' support	6.80	0.36	0	1
Training the members	6.12	0.43	0.321	2
Clear goals and objectives	5.79	0.57	0.329	3
Voluntary membership	5.16	0.62	0.351	4
Using the right tools	4.73	0.76	0.49	6
Group cohesiveness and homogeneity	4.71	0.77	0.51	7
Reward system	4.93	0.71	0.427	5
Feedback system	3.72	0.84	0.591	10
Organizational culture	4.37	0.83	0.56	8
Management style	4.16	0.81	0.58	9
Regularly holding meetings	3.06	0.85	0.8	11
Group leadership	2.63	0.98	1	12

As mentioned above, GRA and VIKOR are two multi-criteria decision-making methods that have attracted researchers' attention in recent years. GRA was first introduced and proposed by Deng and is able to specify the level of similarities or differences between two data series based on their relationship.<sup>28</sup> VIKOR also defines the positive and negative ideal solutions and was first introduced by Tzeng.<sup>29</sup>

### The IPA matrix

IPA was first introduced by Martilla and James in the field of marketing<sup>30</sup> and is used for assessing and evaluating an organization's competitive position in the market, identifying



**Figure 2.** The first-order standard estimation model of quality control circles measurement.  
QCC: quality control circle; RMSEA: root mean square error of approximation.

**Table 3.** The fit indexes of the first-order factor analysis of the quality control circles.

Chi-square	df	p-value	RMSEA	GFI	AGFI
126.68	54	0.067	0.041	0.92	0.90

RMSEA: root mean square error of approximation; GFI: goodness of fit index; AGFI: adjusted GFI

opportunities for improvement and determining appropriate strategies.<sup>28</sup> In IPA, the x-axis represents 'performance' and the y-axis shows 'importance'; thus, a framework of four quadrants is formed, which is shown in Figure 1.<sup>31</sup>

Quadrant I is an important area, and factors which are in this quadrant should be improved as soon as possible.

The decision matrix was formed using Table 1.<sup>32</sup>

Factors in Quadrant II are the important and key organizational ones which the organization should try to maintain.

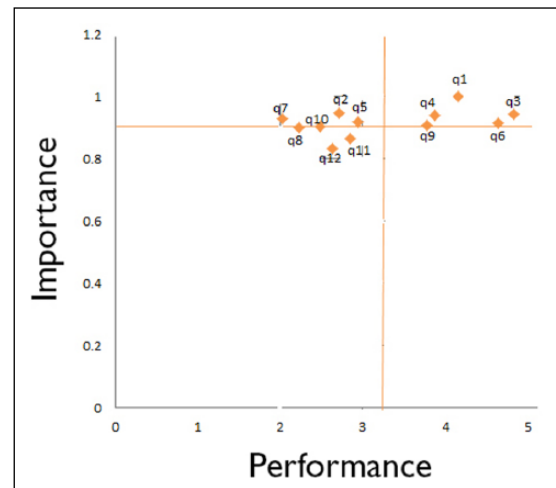
Factors in Quadrant III do not have much importance and do not endanger the organization. Therefore, managers do not care about such factors and allocate limited resources to them.

Factors that fall into Quadrant IV are those which the organization emphasizes and which have good performance, although they are of low importance. Therefore, managers should allocate more resources to the improvement of factors in Quadrant I than to Quadrant IV.

## Results

According to the results, most of the participants were female (69.4%), aged between 30 and 40 years old (41.7%), had 11–15 years of work experience (33.3%) and bachelor's degrees (84.3%).

Figures 2 and Table 3 represent the standard estimation and the significant level models of QCC measurement, as



**Figure 3.** The Importance–Performance Analysis matrix.

well as the fitting indexes of the first-order factor analysis of the QCC. The results showed that the studied model had a good fit.

The results of ranking factors affecting the effectiveness of QCCs in the studied hospital are presented in Table 2. The results showed that the highest and lowest ranks were related to 'Managers' and supervisors' support' ( $\bar{S} = 6.80$ ,  $\bar{R} = 0.36$ ) and 'Group leadership' ( $\bar{S} = 2.63$ ,  $\bar{R} = 0.98$ ), respectively.

After ranking the factors, IPA was used. In the present study, a five-point Likert scale was used to measure the 'performance' whereby 1 corresponds to very low and 5 to very high. To measure the 'performance', the means of answers given by the studied nurses to the questions about the organization's performance for the factors affecting the effectiveness of QCCs were calculated. The values of  $\tilde{Q}$  ( $\vartheta = 0.5$ ) obtained from the fuzzy VIKOR–GRA method were used to determine the 'importance'. Finally, through this matrix, the factors which required improvement and the necessary measures hospital managers should take to improve them were identified (Figure 3). It should be noted that those factors which had lower  $\tilde{Q}$  ( $\vartheta = 0.5$ ) values were more important. In the present study, because of using the IPA matrix, the importance of studied factors was determined on the basis of their  $\tilde{Q}$  ( $\vartheta = 0.5$ ) values.

The results of the IPA matrix showed that 'Training the members' (q2), 'Using the right tools' (q5) and 'Reward system' (q7) were factors that were of great importance; however, the organization's performance for these factors was poor. Therefore, these factors should be improved as soon as possible. Also, the organization's performance for 'Group cohesiveness and homogeneity' (q6) and 'Organizational culture' (q9) was very good. However, these factors were less important. On the other hand, the matrix showed that 'Managers' and supervisors' support' (q1), 'Clear goals and objectives' (q3) and 'Voluntary membership' (q4) were of high importance and the organization's performance for them was high. 'Feedback system' (q8), 'Management style' (q10), 'Regularly holding meetings' (q11) and 'Group leadership' (q12) were of low importance and the organization's performance for them was poor.

## Discussion

In healthcare organizations, quality measurement is the first and most important factor in improving care and monitoring the quality of health services has become crucial because of the increases in the complexity of healthcare and demand for improving patient safety.<sup>33</sup>

Therefore, the analysis of service quality enables managers to allocate financial resources to performance improvement in areas that have greater effects on the customers' perception of service quality.<sup>34</sup>

In this study, 12 factors affected the effectiveness of QCCs: Managers' and supervisors' support, Training the members, Clear goals and objectives, Voluntary membership, Using the right tools, Group cohesiveness and homogeneity, Reward system, Feedback system, Organizational culture, Management style, Regularly holding meetings, and Group leadership. The results showed that the model proposed and studied in the current study had a good fit in the standard estimation. Similar factors affecting the effectiveness of QCCs have been studied in different studies. The results of Robinson and Malhotra's study showed that factors such as partnership of and communication with customers and suppliers, process integration and management, management and leadership, strategy and best practices had been effective.<sup>35</sup> Flynn and Flynn also, in their study, found that some factors affecting the QCCs were customer and market focus, leadership, information and analysis, human resource development and management, process management and strategic planning, and the studied organization could achieve competitive advantage through improving these factors.<sup>36</sup> Among the factors studied in the present study, 'Managers' and supervisors' support' obtained the highest rank and was known as the most effective factor on the QCCs. Manghani's study also concluded that managers' support was the most important factor affecting quality assurance and quality control.<sup>37</sup> The results of Yavas and Babakus's<sup>38</sup> study also indicated that managers' support of employees had an important role in improving quality. According to Hee Yoon et al., if employees feel the managers' support in the organization, they will perform their tasks more accurately and make greater efforts to increase employee performance and job satisfaction, as well as improve quality and customer orientation.<sup>39</sup> 'Training the members' in the present study was introduced as the second factor, which is similar to the results of the Bellou,<sup>40</sup> Yavas and Babakus<sup>38</sup> and Zumrah<sup>41</sup> studies. Given that patients' needs are constantly changing in healthcare organizations, employees need to update their knowledge to accommodate these changes; in this, employee training can play an important role. In the current study, 'Clear goals and objectives' was found to be the third factor influencing the effectiveness of QCCs, which is confirmed by the results of the studies by Wang et al.<sup>13</sup> and Welekar.<sup>42</sup> Also, 'Voluntary membership', 'Using the right tools', 'Group cohesiveness and homogeneity', 'Reward system', 'Feedback system', 'Organizational culture', 'Management style', 'Regularly holding meetings' and 'Group leadership' were other effective factors, which is consistent with the results of Jiang et al.<sup>43</sup> and Mahlknecht et al.<sup>44</sup> Sharif and Irani<sup>45</sup> have also considered 'Group leadership' as a crucial factor for focusing on creating and maintaining the internal environment, and believe that paying more attention to the

development of appropriate leadership styles in the organization can lead to the survival and improvement of the supply chains and performance management.<sup>45</sup> In the present study, the results of IPA showed that the highest hospital performance was for factors 'Clear goals and objectives' and 'Group cohesiveness and homogeneity', and the lowest for 'Reward system' and 'Feedback system'. The high performance indicates that the studied hospital has had good performance for considered factors, and the low performance shows the lack of hospital managers' attention to the important factors having a significant role in forming the QCCs. The results of the present study agree with those of the Yin et al. study.<sup>46</sup> Therefore, hospital managers should pay special attention to the reward and feedback systems. Although the activities of QCCs are voluntary, the managers' and supervisors' support and employee training can play a key role in forming such circles. In other words, the managers can create opportunities for forming QCCs through supporting the establishment of such circles and training those employees interested in participating in the activities of these circles. Applying QCCs yields important results, such as increases in employee job satisfaction, effective communication, improvement of manufactured products or services provided, and increased organizational productivity, efficiency and effectiveness. The QCCs provide opportunities for maximum use of employees' creativity, initiative and skills in reaching their and their organization's goals and objectives, and prepare favorable working conditions for optimal employee performance through increasing the managers' sense of responsibility and commitment.

The present study had some limitations. In the present study, factors affecting the effectiveness of QCCs have been studied only from the nurses' perspective; it is also necessary to investigate such factors from other stakeholders' viewpoints. Also, the studied framework in the current study has investigated quality subjectively and based on the study population's perspective, while measuring quality based on evidence-based indicators can be more accurate.

## Conclusion

In the present study, the results of IPA showed that the highest hospital performance was for factors 'Clear goals and objectives' and 'Group cohesiveness and homogeneity' and the lowest was for 'Reward system' and 'Feedback system'. The high performance indicates that the studied hospital has had good performance for the considered factors, and the low performance shows the lack of hospital managers' attention to the important factors having a significant role in forming the QCCs. The QCC is a very effective tool which helps to solve problems, make appropriate decisions, manage effectively, et cetera. For the effective use of QCCs, the organization's senior manager should provide adequate training for their employees. This study tried to determine the main factors which help to apply QCCs in a hospital. These factors will enable the organizations to develop appropriate strategies for successful formation and use of QCCs. Also, the use of a combination of fuzzy VIKOR and GRA to identify important factors affecting an issue and rank them can help managers and health policy makers to make the right decisions. In future

studies, researchers should determine factors affecting the effectiveness of QCCs from the viewpoints of other stockholders, such as physicians, patients, and managers.

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The authors declare that there is no conflict of interest.

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