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Quality Function Deployment: Application to Chemotherapy Unit Services

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Abstract

Background: Today's healthcare organizations are challenged by pressures to meet growing population demands and enhance community health through improving service quality. Quality function deployment is one of the widely-used customer-driven approaches for health services development. In the current study, quality function deployment is used to improve the quality of chemotherapy unit services.

Methods: First, we identified chemotherapy outpatient unit patients as chemotherapy unit customers. Then, the Delphi technique and component factor analysis with orthogonal rotation was employed to determine their expectations. Thereafter, data envelopment analysis was performed to specify user priorities. We determined the relationships between patients' expectations and service elements through expert group consensus using the Delphi method and the relationships between service elements by Pearson correlation. Finally, simple and compound priorities of the service elements were derived by matrix calculation.

Results: Chemotherapy unit patients had four main expectations: access, suitable hotel services, satisfactory and effective relationships, and clinical services. The chemotherapy unit has six key service elements of equipment, materials, human resources, physical space, basic facilities, and communication and training. There were four-level relationships between the patients' expectations and service elements, with mostly significant correlations between service elements. According to the findings, the functional group of basic facilities was the most critical factor, followed by materials.

Conclusion: The findings of the current study can be a general guideline as well as a scientific, structured framework for chemotherapy unit decision makers in order to improve chemotherapy unit services.

Keywords: Quality function deployment, Chemotherapy unit, Quality improvement, Delphi method, Data envelopment analysis

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Introduction

Today's healthcare organizations are challenged by pressures to meet growing population demands and to enhance the community's health through improving service quality.[1] This cannot be achieved unless customer satisfaction is considered as a permanent goal.[2]

In this regard, quality function deployment (QFD) is one of the widely-used customer-driven approaches for new or improved product/service design and development to fulfill customer requirements (CRs) and maximize customer satisfaction.[3,4] Quality function deployment helps an organization to become proactive to quality problems rather than taking a reactive position by acting on customer complaints. Quality function deployment also makes the organizational shift from inspecting the service's quality to designing quality into the service; that is, QFD can be referred to as designed-in quality rather than traditional inspected-in quality. According to Yang, QFD can reduce the service-development time and cost, improve service quality, increase customer satisfaction, and consequently increase the market share. It can also facilitate continuous service improvement with emphasis on the impact of an organization's learning on innovation.[5,6]

In this regard, there are many QFD studies and applications in different product and service industries. However, few studies have been performed in the health sector. According to the literature these studies are driven by four potentials: better understanding of customers' needs and wants, identification of opportunities for process improvement, effective system thinking approach and better communication, and a more transparent process. There are three antecedents in the studies: understanding the customer, understanding the customer's needs, and finding ways to prioritize and translate those needs of QFD application in healthcare.[7] Based on this, Kuo et al. have applied QFD to improve outpatient services for elderly patients in Taiwan. Their QFD model not only reduced costs but also revealed the crucial outpatient service items that could improve the quality of medical care for elderly people.[8]

Volpato et al. used QFD to verify the possibility of quality planning in family health units. The results of their study showed that QFD was an efficient tool for quality planning in public health services.[9] Lorenzo et al. adopted QFD methodology to identify clients' needs in a hospital. According to the results, QFD methodology was highly useful in allowing complaints to be related to the results of a perceived quality questionnaire. It was also beneficial in identification of the attributes with the greatest influence on patients' satisfaction and identification of areas for improvement according to clients' needs.[10] Kullberg et al. examined QFD in safety promotion in Sweden. As the results of their study showed the QFD technique was suitable for providing residential safety promotion efforts with a quality orientation from the layperson's perspective. QFD could augment the methodological toolbox for safety promotion programs, including interventions in residential areas.[11]

The core concept of QFD is to collect and then translate the customer expectations (CEs) into engineering characteristics (ECs), and subsequently into part characteristics (PCs), process parameters (PPs) and production requirements (PRs). Accordingly, the typical QFD process consists of four phases: product planning [also known as house of quality (HoQ)], parts deployment, process planning, and production planning.[12,13] Among these four phases, the HoQ is the most fundamental and strategically important since it is in this phase that the customer needs for the service are identified and transformed into service characteristics for these needs; it can significantly affect the preciseness of the subsequent deployment phases. There is a lack of specificity in the literature as how to develop downstream QFD phases, partly because of the fact that the structures and analyzing methods of the other three QFD phases are more or less the same as those of the HoQ phase.[4,5,14-17] Hence, HoQ attracts the most attention from both theoretical and practical fields. Many companies have confirmed that a tremendous benefit can be

Table 1. House of quality (HoQ) matrix - relationships between service attributes.

	EQ	MA	HR	PS	BF	CT
EQ	1					
MA	0.796 (0.0001)***	1				
HR	0.579 (0.001)***	0.670 (0.0001)***	1			
PS	0.332 (0.059)	0.446 (0.014)*	0.428 (0.014)*	1		
BF	0.662 (0.0001)***	0.658 (0.0001)***	0.574 (0.001)**	0.746 (0.0001)***	1	
CT	0.698 (0.0001)***	0.786 (0.0001)***	0.742 (0.0001)***	0.36 (0.055)	0.750 (0.0001)***	1

EQ: Equipment, MA: Materials, HR: Human resources, PS: Physical space, BF: Basic facilities, CT: Communication and training; Pearson correlation coefficient (*P*-value): **P*<0.05, ***P*<0.01, ****P*<0.001.

achieved from just completing the HoQ matrix.[18] For this reason, we mainly focus on the HoQ matrix of the QFD system in this research.

The studied services are chemotherapy unit services because of cancer patients' critical conditions. As different studies show, cancer is a devastating event that causes patients to suffer from a significant amount of psychological and physical distress.[19] Thus, cancer patients are physically and psychosocially vulnerable, and any failure in meeting their expectations in any aspect can disturb their supportive care, causing them harm. Quality function deployment, as a customer-oriented approach for service development, is a useful tool that can improve the quality of chemotherapy unit services based on cancer patients' expectations. The hospital under study is Nemazee Hospital, the main center for cancer patients in Fars and its neighboring provinces.

Materials and Methods

House of quality, as the main matrix of QFD, is a structured and systematic way to translate CEs for a product into prioritized service elements (SEs) that can be further deployed to develop process and service provision plans.[19] House of quality is built upon two principal components: voice of customer (VoC) and voice of engineer (VoE), which are embodied in CEs and SEs, respectively. A matrix, the heart of the HoQ model, is constructed from cause-effect relationships which is best described by a mapping from the VoE (SEs) space into the VoC (CEs) space.

Specifically, HoQ begins with the customer in order to fully identify customers' wants. By operationalizing VoC, one constructs CEs so that the overall customer concern can be clearly and effectively represented. Voice of customer is then translated into corresponding SEs, which represents the means of response to CEs. Those SEs are listed at the top of the framework and each SE may affect one or more CEs. After determining CEs and SEs, the HoQ continues with establishing the relations. The primary outcome of the HoQ is SE priorities, which is to be located at the bottom of the matrix. Important SEs are identified so that effort can be concentrated on them for effective quality improvement. With prioritizing SEs, one is able to be more responsive to customer needs that CEs surrogate. From now on, we will use the terms VoC and CE inter-changeably. The same applies to VoE and SE. The QFD process in the current study has been performed through six

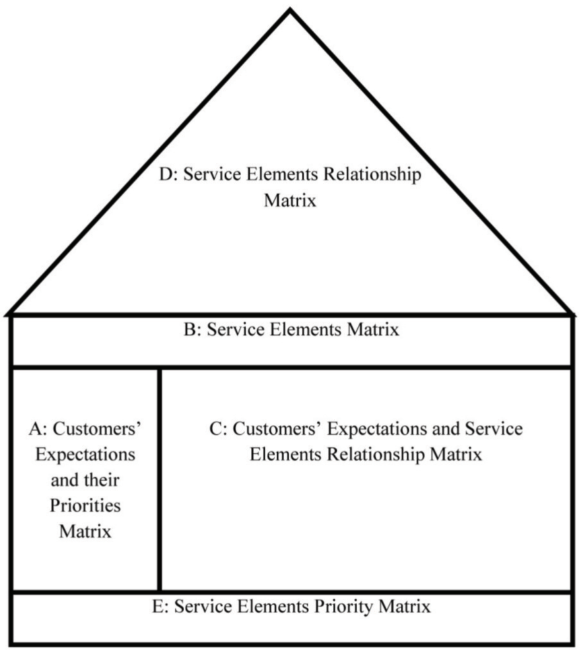


Figure 1. House of quality (HoQ).

stages. During these stages the matrices that formed HoQ were completed separately and in order. Figure 1 shows HoQ and its constituent matrices.[5] The stages of the QFD process, as well as the HoQ constitution are as follows.

First stage

The first state consisted of identifying customers, determining and collecting CEs of the desired service, and constructing a matrix of HoQ.

In the current study, we identified chemotherapy outpatient unit patients as chemotherapy unit customers. In order to determine their expectations, we have used the Delphi technique. This technique is a structured process that uses a series of questionnaires or 'rounds' to gather information until consensus in the panels is reached.[20] This technique is useful for situations where individual judgments must be combined in order to address a lack of agreement or incomplete state of knowledge, as the case for this research.[21,22] To form the Delphi team, chemotherapy outpatient unit patients who have received chemotherapy services between July 2013 and September 2013 were considered. After explaining the research goals and inviting these patients to participate in the study, 94 patients (35 women and 59 men) stated their agreement to participate. Therefore, they were selected as Delphi team members. The Delphi rounds were as follows.

The first questionnaire consisted of 33 questions obtained from literature reviews and opinions of an expert group. To allow expression of a wide range of views, the questionnaire comprised open-ended questions.[23] Printed copies of the questionnaire were distributed to Delphi team members. Patients wrote the answers to the instrument questions. If unable to write, they answered verbally. Ideas and suggestions generated from round 1 were combined and similar ideas were clustered into emerging themes. Three of the authors as the Delphi coordinators performed this separately at first, then jointly to discuss different interpretations. The items were used as input for round 2.

In the second round, another questionnaire was given to the same respondents. The items were arranged in main topics that could be derived from round 1, using a thematic analysis. Participants were asked to indicate whether they thought that addressing the items in the chemotherapy unit was extremely important (5), very important (4), moderately important (3), slightly important (2), and not important (1). Space was provided for optional comments at the end of each theme and at the end of instrument. Based on the literature, we defined consensus as at least 80% of the participants in the Delphi team who chose the same answer category (e.g., 5 'extremely important') and no more than 15% who answered two or three categories away (e.g., 2 'slightly important' or 1 'not important').[20] Items on which consensus was reached were removed from the subsequent questionnaire(s).

In the third questionnaire, items on which consensus was not achieved in the previous round were included, together with feedback on the responses of the panel and the participants' own responses. The participants were asked to reconsider their previously given responses in light of the opinions of other panel members. The scoring process was the same as the previous round. At the end of the round, consensus was reached in almost 90% of questionnaire items. Therefore, the Delphi team members reached consensus and Delphi rounds were stopped.

In the next step, principal component factor analysis with orthogonal rotation was employed to construct patients' expectations. At the end of this stage patients' expectations were specified.

Second stage

This stage consisted of prioritizing patients' expectations and construction of a matrix of HoQ. For user priorities in the set of SAs, we performed data envelopment analysis (DEA). Data envelopment analysis has been successfully employed for assessing the relative performance of a set of firms, usually called decision-making units (DMUs), which use a variety of identical inputs to produce a variety of identical outputs.[24]

Data envelopment analysis is concerned with understanding how much each DMU is performing relative to others, the causes of inefficiency and how a DMU can improve its performance to become efficient.

In this regard, in the current study each agreed questionnaire item in the last Delphi round (third round) was regarded as one DMU. According to the expert panel opinion and literature review,[25-27] literacy and citizenship factors were considered as inputs of DMUs in the DEA model and the mean score of each agreed questionnaire item was approached as an output of DMUs. Therefore, the efficiency scores of DMUs were regarded as priorities in patients' expectations. Literacy was scored by a three-point scale (illiterate=1, school graduate=2, university graduate=3) and citizenship was scored by a two-point scale (urban=1 and rural=2). Inputs and outputs were scored by the expert panel.

According to the specified inputs and outputs, the efficiency of DMUs using cross-sectional data and under input minimization and variable returns to scale conditions (BCC Model) was calculated by the following linear programming model with EMS 1.3 software:

$\min_{\theta,\lambda} \theta_0$

$-y_i+Y\lambda\geq 0$

$\theta x_i-X\lambda\geq 0$

$Ni\lambda=1$

$\lambda\geq 0$

where:

y_i is a m×1 vector matrix of output for i^{th} farm,

x_i is a k×1 vector matrix of inputs for i^{th} farm,

Y is a n×m output matrix for 'n' number of farms,

X is a n×k input matrix for 'n' number of farms,

N_i is a n×1 vector matrix of ones,

θ is an efficiency score - it is a scalar whose value would be the efficiency measure for each 'i' farm and it ranges from 0 to 1. If θ=1, then the farm would be efficient; otherwise, the farm would be below the efficient level, and λ is a n×1 vector of matrix which provides the optimum solution. The λ values are used as weights in the linear combination of other efficient farms for an inefficient farm, which influences the projection of the inefficient farms on the calculated frontier.[28]

As stated, the efficiency scores estimated for the DEA models are truncated to lie between zero and unity with a higher score for more efficient units. However, in the current study, the efficiency scores of several units have equaled 1. In order to rank these units the super-efficiency ranking method of Anderson and Peterson which ranks only the efficient units has been applied. In other words, the standard DEA model complicates the ranking of the efficient set of units and the Anderson and Peterson method can be considered as a solution of this shortcoming. The larger the super-efficiency value, the higher an observation is ranked among the efficient units.[29]

In order to determine the priority of each patient's expectation, the mean of the questionnaire items efficiency scores which constructed that patient's expectation was calculated. In this regard, the patient's expectation with the highest mean efficiency score had the highest priority among other expectations and was the most important expectation and the priority of expectations decreased in parallel with the reduction of the efficiency score mean.

Third stage

The third stage comprised determining SEs and constructing a B matrix of the HoQ. In order to determine the SEs, we used the Delphi technique. To form the Delphi team, 42 chemotherapy unit doctors, nurses, and hospital directors were identified. We sent 42 letters that included explanations about research rounds and goals along with an invitation to participate in the study to each identified individual. Of these, 35 invitees stated their agreement to participate in the study. Therefore, they were selected as Delphi team members.

The items of the first round questionnaire were extracted from literature reviews and expert group's opinions. The instrument comprised 42 open-ended questions. Printed copies of the instrument were distributed to Delphi team members, and these copies were collated after a specific period of time. The analysis of the response in this round was the same as those of determining patients' expectations. At the end of the analysis 286 items and 6 themes were produced.

In the second round, the participants were presented with the previous round items and themes. The items were scored by a five-point Likert scale (extremely important=5, very important=4, moderately important=3, slightly important=2, not important=1). Space was provided for comments (if any) at the end of each theme and at the end of the questionnaire. The considerations in analyzing the second round responses were the same as those of determining patients' expectations. In this round, the additional comments of respondents were listed as separate items and put into previous themes according to their coordination. Expectations on which consensus was reached were removed from the subsequent questionnaire(s).

In the third round the participants were requested to repeat the points' allocation process after taking the round 2 results into account. If necessary, the provided information was explained to them. Participants were reminded that they were free to change their answers based on the results, or to answer the same way as they did in round 2. Space was again made available at the end of each theme as well as at the end of the instrument for optional comments. After analyzing the gathered data in round 3, consensus was reached in 92% of questionnaire items. Therefore, the Delphi team members reached consensus and Delphi rounds were stopped.

Then, principal component factor analysis with orthogonal rotation was applied in order to construct SEs. At the end of this stage SEs of chemotherapy unit services were determined.

Fourth stage

In this stage, the relationships between patients' expectations and SEs were determined through expert group consensus using the Delphi method. The expert group consisted of nine members that included nurses, doctors, and hospital directors as Delphi team members. The Delphi rounds were conducted by live meetings during which individual survey responses remained anonymous in order to preserve objectivity. In the first round, expert group members were asked to determine the relationships between CEs and SEs in four levels of: no relationship (0), weak relationship (1), medium relationship (3), and strong relationship (9), individually. The responses were collected and analyzed on a group basis. In the next round, the CEs and SEs accompanied with the percentage of respondents that assigned each level of relationship between them in the previous round were given to the Delphi team members. They were told to score the relationships again based on the scoring process in the previous round. At the end of the round, consensus was reached in almost 85% of the relationships. Therefore, the Delphi team members reached consensus and Delphi rounds were stopped.

Fifth stage

This stage determined the relationship between SEs and constructing D matrix of HoQ. In this stage, the relationships between SEs were determined using Pearson correlation between two SEs in each pair.

Sixth stage

This stage consisted of prioritizing SEs and constructing E matrix of HoQ. In this stage, the simple and compound priorities of the service specifications were derived by matrix calculation. At the end of this stage, E matrix of the HoQ was constructed.

Results

Patients' expectations

After this filtering process, four key factors in patients' expectations were identified with the principal component analysis based on the survey outcome of 48 agreed questionnaire items. According to common, representative features of the question items assigned to a group, we named these four patients' expectations as: quality assurance of clinical services (CS), suitable hotel services (HS), satisfactory and effective relationships (ER) and access (AC).

Patients' expectations priorities

To determine the priority ranks of CEs in terms of user satisfaction, we conducted DEA. According to the results, priorities of chemotherapy unit patients' expectations were scored from 1 (highest) to 0.61(lowest).

Service elements (SEs) of chemotherapy unit services

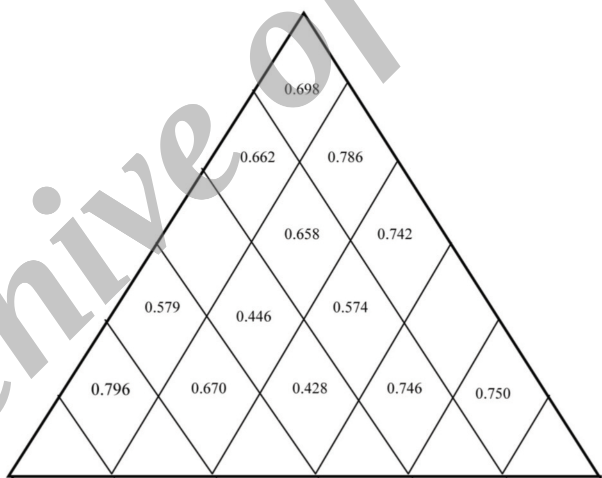
We identified 6 key factors in SEs with the principal component analysis based on the survey outcome on 35 questions. They included: equipment (EQ), materials (MA), human resources (HR), physical space (PS), basic facilities (BF) and communication and training (CT).

Relationship between patients' expectations and service elements (SEs)

Presented in Figure 2 are the relationships between CEs and SEs, which constitute the main body of the HoQ model. All the columns are dense. In particular, the column corresponding to CT shows the greatest density, which implies that this SE is highly correlated with all or most CEs. The overall effects of this matrix structure on the SE priorities will be discussed in the following sections.

Relationship between service elements (SEs)

Table 1 presents the Pearson correlation coefficients between two SEs in each pair, which constituted the roof of the HoQ model. All significant correlations have been highlighted in Table 1; otherwise, they were abandoned in the final HoQ matrix in Figure 2. Although the SE construction procedure through the principal component method resulted in mutually orthogonal SEs, the interdependencies among the SEs could not be completely eliminated.



CE	CE Priority	EQ	MA	HR	PS	BF	CT
CS	0.610	3	3	9	1	1	1
HS	0.813	9	3	1	9	3	1
ER	0.699	0	0	3	1	0	9
AC	1	0	0	1	3	0	9
	Simple SE Priority	9.147	4.269	9.4	11.626	3.049	16.714
	Compound SE Priority	31.673	38.177	36.684	19.828	43.395	35.716

CS: Clinical Services, HS: Suitable Hotel Services, ER: Satisfactory and Effective Relationships, AC: Access

EQ: Equipments, MA: Materials, HR: Human Resources, PS: Physical Space, BF: Basic Facilities and CT: Communication and Training

0: no relationship, 1: weak relationship, 3: medium relationship, 9: strong relationship

Figure 2. HoQ Model for chemotherapy unit services.

Service elements (SEs) priorities

Two rows at the bottom in Figure 2 present the key outcomes of the HoQ model in this study. In terms of the simple priority, the functional group of CT was identified as the most critical factor, followed by PS, EQ and HR, which showed almost similar magnitude of importance. On the other hand, BF seemed to be negligible for the purpose of enhancing user satisfaction. In general, CT dominated the other SEs, and in particular, outweighed BF by approximately 5.5-fold.

Some changes in the pattern of the SE priorities were observed when we took the interrelationships among SEs into account. The priority order of SEs changed and BF and MA obtained the highest compound priority followed by HR, CT, EQ and PS. The priority of BF was 1.2 times greater than CT and MA as the one of the least important SEs considering simple priority became the second most important SE. In contrast, CT priority reduced significantly and became a low compound priority among SEs. The priority of PS regarding the roof data diminished considerably and it became the least important SE.

Discussion

Quality function deployment is a planning methodology to improve products, services and their associated processes by ensuring that the voice of the customer has been effectively deployed through specified and prioritized products or SEs. It is also "a flexible tool that can be fashioned to be effective in a wide range of applications and for many types of organizations" with many commonly known benefits. This study has applied QFD in improving chemotherapy unit services of Nemazee Hospital.[6,30]

Accordingly, chemotherapy unit patients at Nemazee Hospital have four main expectations: AC, suitable HS, ER, and CS. In another study, Dawn et al. who reviewed the literature on patients' expectations for medical and surgical care identified the ten most commonly addressed categories of expectations in these studies. Categories comprised medical information, medication/prescription, counseling/psychosocial support, diagnostic testing, referral, physical examination, health advice, outcome of surgery or treatment, therapeutic listening, and wait time.[31] Bostan et al. conducted a survey that measured patients' expectations based on patient's rights. As the survey showed, patients' expectations reached a high expectation level in the factor of receiving information.[27] The comparison between the results of these studies showed discrepancies in patients' expectations. In Dawn and Bostan studies, access to clinical information was the most important patients' expectation.[27, 31] While, in the current study, we determined AC to be the highest priority among other expectations. Patients' expectations were influenced by a range of factors. It could be said that in our study patients' past experiences affected their attitudes towards needs and expectations. To illustrate, in the chemotherapy unit most patients expressed dissatisfaction with access to physicians after hospitalization and nurses during hospitalization. They also complained about the financial burden of cancer care and inadequate communication with their companions during the hospital stay. These factors caused chemotherapy unit patients to express the high expectation of access from chemotherapy unit providers.

According to the results, the chemotherapy unit had six SEs: EQ, MA, HR, PS, BF, and CT. Moores determined seven SEs for radiation safety management. Among the SEs, EQ and training as a sub-item of CT expectation was similar in both studies. The difference between studies of other SEs would be the diversity between radiology and chemotherapy unit services.[32]

The HoQ analysis has shown that to develop quality of chemotherapy unit services the most important issue to be considered is the chemotherapy unit BF. Nemazee hospital has a time worn infrastructure due to the old hospital building, established in 1951. The chemotherapy unit is located in the hospital basement and the location of this unit is not compatible with its function, which reinforces this problem. The ventilation, heating and cooling systems of the chemotherapy unit are old, which cause distress for patients and employees. Most employees have expressed dissatisfaction with the fire-control and electrical systems of the unit - an issue frequently highlighted during the Delphi rounds. However, the space of chemotherapy unit is large enough as PS took the lowest priority score among other SEs.

The second and third most important issues were chemotherapy unit MA and HR. As many chemotherapy unit nurses and specialists indicated, chemotherapy medicines were not sufficient and the existent medicines not distributed in a timely manner. These issues could be the main factors that caused MA to be one of the main SEs in the chemotherapy unit. The number of chemotherapy unit nurses was not enough - most have a few years of work experience in chemotherapy unit. Therefore, there was an urgent need for employing more experienced nurses. Moreover, cleaning services for the spacious chemotherapy unit was provided by a few cleaning workers which has caused contamination of the unit that might pose a serious health risk to patients. In addition, the high working pressure on cleaning workers was one of the most frequent complaints.

As displayed in the Figure 2, CT and PS have the highest simple priorities among other SEs. When the correlations between SEs in the roof matrix of HoQ were considered in the compound priority of SEs, the priority order of SEs changed with BF and MA at the highest priorities. The main reason for this change was the strong relationships of both BF and MA with the other SEs. These relationships indicated the effect of these SEs on others and vice versa. If these SEs improved, other SEs would improve automatically or the improvement of other SEs could significantly enhance the quality of BF and MA. This factor caused the superiority of these SEs. On the contrary, the SEs of CT, and PS showed no relationship with at least one other SE.

In summary, QFD is a service development and improvement support method, which provides a structured way for service providers to assure quality and customer satisfaction.[33] In the current study, QFD has been used to improve hospital chemotherapy unit services according to patients' expectations. Accordingly, six SEs and their priorities, were determined based on four patients' expectations. This information accompanied by the relationships represented in the roof matrix of HOQ could be a general guideline, as well as a scientific and structured framework for chemotherapy unit decision makers in order to improve chemotherapy unit services. In this regard, the results of the study were conveyed to Nemazee Hospital administrators where the actions to enhance the quality of chemotherapy unit services has begun.

Conflict of Interest

No conflict of interest is declared.

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