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Improvement of Cancer Treatment Processes and Reduction of Cost and Patient Length of Stay in Hospital

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Abstract

Background: Reducing patient length of stay (LOS) in hospitals reduces the high cost of chemotherapy and increases patient satisfaction.
Objectives: This study aimed to present a combined model based on value engineering and the house of quality (HOQ) to improve the chemotherapy processes of hospitalized adult patients and reduce LOS and costs.
Methods: In this study, a cost and time model of the functions was drawn for the current chemotherapy process, and as a result, the duration and costs of a chemotherapy course were obtained. A simulation model corresponding to the process map was developed and the output was validated. Afterward, using the HOQ method in the pre-study stage and collecting value engineering information, the real needs and wants of patients were transformed into quality characteristics, and by implementing other value engineering steps, 5 scenarios were presented to improve the process and were tested on the validated simulation model.
Results: The presented scenarios included the process scenario (17.29% time reduction and $ 537,827 cost reduction), medication delivery scenario (7.3% time reduction and $ 268,231 cost reduction), technology scenario (2% time reduction and $ 59,640 cost reduction), end-of-life scenario (20% reduction in time and no cost savings), home care scenario (14% reduction in time and $ 329,020 cost reduction).
Conclusion: By implementing these scenarios and improving the process, the treatment protocol was changed and caused an increase in the value index of the patient's LOS and a decrease in the waiting list for chemotherapy in the above hospital.

Keywords: Cancer, Cost evaluation, House of quality, Length of stay, Simulation, Value engineering

1. Background

Value engineering was developed by Larry Miles during World War II to minimize production costs. This method determines the performance of products and services, monitors the value of each performance, and meets the performance needs of a product at a low cost. Value engineering is a key industrial engineering tool that balances cost and effectiveness in any industry (1). This technique can be an effective industry in hospitals and health centers (2). Value engineering, known in the health care industry as value analysis, has today become a strategic tool for reducing the organization's costs in purchasing and the value cycle of materials. In value engineering studies, efforts are made to identify unnecessary costs of the project, and by encouraging creativity and synergy of experts in value engineering workshops, creative solutions are provided to minimize unnecessary costs and improve the performance of the desired services (3). Health care organizations, such as hospitals, are government agencies with complex business processes. With scarce resources, it is important that services be provided efficiently (4). These organizations are involved in some activities, such as reducing time and cost and improving the service quality. The evaluation activity constitutes an integral part of the management system of the services; therefore, they must use new management techniques to improve their processes. The value engineering technique, which has many applications in manufacturing organizations, has recently been used by a number of institutions to assist health care organizations in managing costs and providing appropriate services to customers. During 7 years of implementing this technique in American medical centers, they were able to save up to 11 times more than previous systems, and the savings in health care projects were from $ 10,000 upwards. The average savings in American projects has been estimated as equal to 6% up to 10% of its executive cost. Table 1 refers to value engineering applications in the United States and the world.

The incidence of cancer is very high and with the spread of this disease in the country, the most important dimension after the loss of death is the economic dimension and the costs that are imposed on individuals and communities. The diagnosis of cancer and the resulting physical and mental burdens are still considered fatal events for many patients, and more than a third of patients experience anxiety and depression, and there will be a state of deep stress for their families.

The results of studies show that cost is associated with improved patient satisfaction, reduced out-of-pocket costs, and a higher likelihood of non-compliance with medication protocol. Both patients

Table 1. Application of value engineering in different fields in the United States

Row	Field	Important points
1	Roads and transportation	Return on investment of $ 113 per dollar invested on average, as well as $ 845 million in cost savings in 1999
2	Health	24% reduction in the cost of health-related projects over six years in New York
3	Construction	Save $ 1 billion in 2000 on U.S. highway construction projects
4	Industry	Cost reduction in the range of 5-100% in different sectors
5	Environment	In environmental projects, due to high costs, they have a lot of potentials to use methodology
6	Government services	Return on investment of $ 20 per dollar invested on average

and physicians are in dire need of accurate, accessible, and transparent information about the cost of cancer care (5).

Due to the high cost of treatment of this disease, it is necessary to review the treatment protocols, both economically and technically, without compromising the quality of treatment to meet all the targeted needs. In this regard, the use of engineering perspectives and approaches, especially industrial engineering, due to their systematic and holistic view, can help the health sector. One of these techniques with a systemic and problem-solving approach is value engineering and the other one is quality function deployment (QFD). Quality function deployment defines service performance based on customer needs (6), and value engineering is a way to help break free of deterrent mental frameworks and models. The key elements of value engineering are the use of human communication, motivated teams, teamwork, and creativity.

Since the output of value engineering increases service value by using key elements, and service value includes reducing service cost and time while maintaining quality and objectives, the results of value engineering are consistent with the objectives achieved.

Since the output of value engineering by using key elements increases the value of service and the value of service includes reducing the cost and time of service while maintaining the quality and objectives, the results obtained from value engineering with objectives. In the study plan, in the above context, reducing the average length of stay (LOS) of the patient, improving the economic index and optimizing the cost of services, and improving the value index were determined.

2. Objectives

Through this study, the researchers proposed redesigning the chemotherapy process using an integrated value engineering model with QFD and brainstorming. The QFD method used in this study focuses on the house of quality (HOQ) matrix and as a tool to support decision-making. In research that has been conducted to reduce the cost or improve the performance of medical centers, including studies in medical centers in the United States and Canada, only one engineering technique, such as value engineering or QFD and simulation, has been done. Such research focuses only on improving one aspect, such as cost, time, or performance (Table 2); however, in this study, by integrating three value engineering techniques and expanding quality performance and simulation, we tried to examine the problem in several ways, identify the real needs of patients, and optimally allocate available resources, while reducing service time and patient LOS in hospital and improving service costs without reducing quality.

Table 2. Thread gap table

Author Name/Project	Year(s)	Location	Problem definition							Solving method			
			Health care	Non-health care	Cancer	Drug	Cost	Time	Quality	VE	QFD	Simulation	Other
Jabal Ameli MS	2014			*						*			
Trujillo	2001	Mexico									*		
Ray B	2011	USA	*				*			*			
Yokl RT	2017	USA	*				*			*			
Stasiak-Betlejewska R	2015	USA	*				*			*			
Stasiak-Betlejewska R	2015	USA		*			*			*			
Angela B et al.	2020	USA	*		*		*						*
Peter B et al.	2012	USA	*		*	*	*						*
Roderick P et al.	2003	UK	*		*		*					*	
Michael P et al.	2002	USA	*		*		*						*
Rossana R et al.	2017	Latin America	*		*	*	*						*
Power J et al.	2016	Poland	*		*				*		*		
Hashemi N et al.	2015	Iran	*		*				*		*		
Hinyard L et al.	2019		*		*		*	*					*
Simon PK	2014	USA	*		*		*	*					*
Chindaprasirt J et al.	2013	Thailand	*		*		*	*					*
Rosa RG et al.	2014	Brazil	*		*			*					*
US 339-bed hospital	2008	USA					*			*			

Table 2. Continued

US 158-bed hospital	2008	USA					*			*			
US 158-bed hospital	2008	USA					*			*			
US 339-bed hospital	2008	USA					*			*			
150-bed hospital in the United States	2008	USA					*			*			
158-bed hospital in the United States	2008	USA					*			*			
158-bed hospital in the United States	2008	USA					*			*			
Ardestani T et al.	2008	Iran		*						*			
Darreh Sh et al.	2008			*						*			
Farbod E et al.	2002	Iran	*				*						
Rouhani Z A et al.	2009	Iran	*					*		*			
Jabal Ameli S et al.	2003	Iran		*						*			
LeeaChloe T et al.	2015		*						*		*		
Gremyr I et al.	2013	Sweden	*			*		*	*		*		
Feroz Kh et al.	2021	Pakistan	*						*		*		
Chiou CC et al.	2008	Taiwan	*						*		*		
Dijkstra L et al.	2002	Netherlands	*						*		*		
Camgöz-Akdağ H et al.	2013	Turkey	*						*		*		
Ishak A et al.	2020	Indonesia							*	*	*		
Hatice C et al.	2013	Turkey	*						*		*		
Leonardo Frizziero	2014	Italy							*		*		
Nayra M et al.	2003	Mexico							*	*	*		*
Jariri F et al.	2008	Iran					*		*	*	*		
Feili HR et al.	2012			*						*			*
Farsi JY et al.	2014	Iran		*						*	*		*
Sediq M et al.	2008	Iran		*						*	*		
Yeganegi K	2011	Iran	*				*		*	*	*		
Rajiv P et al.	2014	Singapore							*	*	*		*
Rosnani G et al.	2020	Indonesia							*	*	*	*	
Al Memari et al.	2016	Dubai	*						*		*		
Simon CM et al.	2019	USA	*						*		*		
Hosam E	2020	Egypt		*						*			
Ziyaeidustan S	2017	Iran	*					*	*	*			*
Nuri ÖD et al.	2016	Turkey	*					*	*			*	*
Gavareshki MHK et al.	2017	Iran		*			*			*	*		*
Perdana S et al.	2020	Indonesia		*			*			*	*		
Kumar GK et al.	2018			*			*		*	*			
Eliza JP et al.	2017	UK	*		*		*		*		*		
Adjei Boakye E et al.	2019	USA	*		*		*	*	*				*
Present article		Iran	*		*	*	*	*	*	*	*	*	*

3. Methods

This study was performed in one of the specialized chemotherapy centers affiliated with Shiraz University of Medical Sciences, Shiraz, Iran, in 2017. All of the adult patients (n=3,923) in the mentioned year who were diagnosed with cancers, including blood, colon, stomach, esophagus, pancreas, soft tissue (soft tissue sarcoma), breast, liver, and lymph nodes, and were hospitalized were examined.

These patients underwent treatment with chemotherapy protocols, including FOKFOX, FOLFIRI, FOLFIRINOX, FLOT, MAID, IFEX/ETOPOSIDE, VAD, ICE, IEV, HYPER CYVAD, HIDAC, and DARZALEX.

To determine the indirect costs of treatment and non-treatment according to the statistical population, a sample size of 100 people was determined with a confidence of 95% and a standard deviation of 5%. The data were analyzed using SPSS version 22 software. The data collection tool was the Integrated Health Information System and a questionnaire whose validity and reliability were approved by professors and experts in this field.

In this study, first, the current model of the chemotherapy process was developed, based on which the cost model and the time model of the process were determined. Subsequently, the above models were approved using the opinion of experts. In the pre-study and data collection phase, value engineering must correctly identify the real needs of patients. For this purpose, the QFD technique and the graphic method called "house of quality" were used to relate the needs to the engineering requirements and design based on the needs of patients.

On the other hand, engineering performs the optimal allocation of resources based on the importance of product functions and, using the system performance analysis [FAST(Function Analysis Systems Technique)] method, identifies the relevant dependencies and priorities. Besides, sequentially and logically, it identifies the primary and secondary functions of the service. According to the standard published by the International Association of Value Engineers in Figure 1, the stages of value study are pre-study, value study, and additional study, respectively, which should be examined in this study (7).

According to Figure 2, value engineering studies

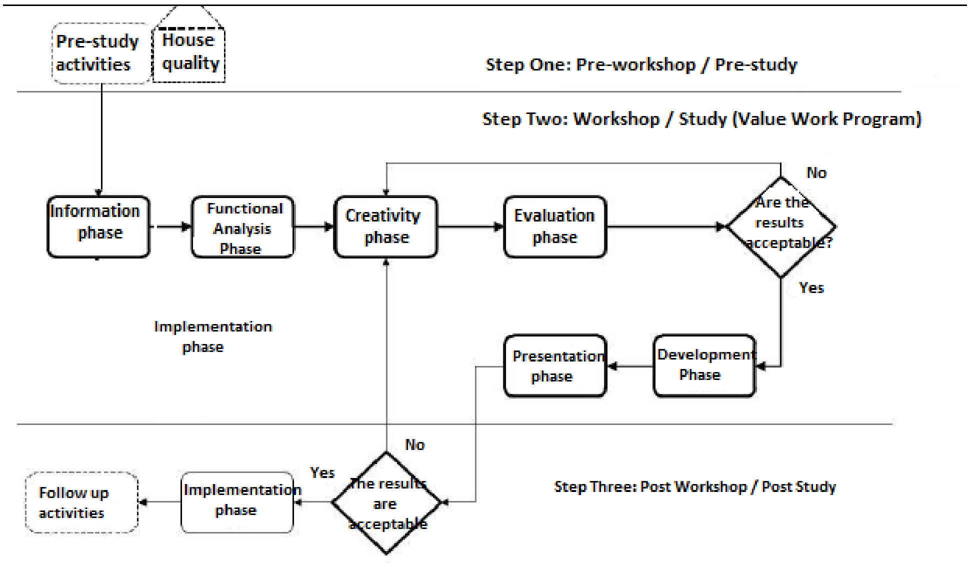

Figure 1. Phases of value engineering implementation

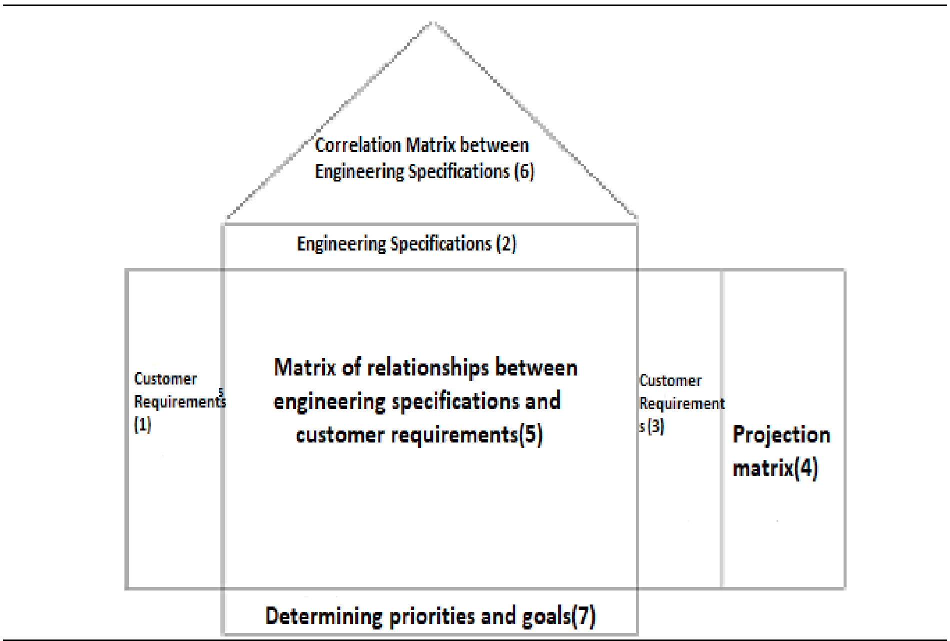

Figure 2. Quality House

include three stages, namely pre-study, study, and post-study (implementation). In the pre-study stage, the HOQ, according to Figure 2, was used to understand the patient's wishes correctly. In the value engineering study, we faced two groups of questions in general. The first group, which included four questions, examined the current situation, and the second group, with four other questions, sought alternative options.

Group 1: Questions related to "What is the current situation? What does this component do, or What should it do? Is it vital? How much does it cost?"

Group 2: Questions related to the alternative design as "What else can do the same? How much does the alternative cost? Is this new solution practical? What is the possibility of accepting and implementing it?" (7)

These eight questions included the value engineering team's issues to reach a clear answer and thus develop scenarios to replace the status quo with lower costs and higher quality. In general, quality performance enhancement ensures that "appropriate product/service service" is designed, and value engineering ensures that "appropriate product/service design" is best done.

By combining these two methods, product functions and patients' needs were identified, and their importance was found. By using working groups that had different specializations in the field of service, engineering demands related to process functions and patients' needs were determined; afterward, the relationship between markets was discovered. After reviewing engineering requirements, costs related to service performance and customer needs and costs associated with engineering requirements were obtained in the final stage. For each phase in Figure 2, the key questions would be answered according to Table 3 of the scheme through the use of special techniques.

In general, the goal of the VEHOQ method is to meet the needs of patients and the optimal allocation of resources and appropriately save time so that the desired value of patients is increased and the cost of production is reduced to increase profitability and improve performance. The final model, like the original model, was approved in various meetings with experts. Since any change in the treatment process directly impacts the disease recovery process, to ensure the implementation of the recommendations, "Visual.Paradigm.For.UML. Enterprise.Edition.v10" simulator software was utilized, the process was modeled in the above software, and different scenarios were simulated.

According to the rate announced by the Central Bank in 2017, the average exchange rate of the rial against the dollar was 34,880 per US dollar.

Table 3. Model implementation process

Phase	Target	Key questions	Techniques
Pre-study	Preparation for study	What is being studied? What information is needed to start the study? What do people need to study? When and where to study What are the red lines and the purpose of the study? Determine real patient needs	Get management support Working with specialists Gather information from the best sources Teamwork Planning QFD
Study information	Project analysis	What are the project and problem? What are the costs and time? What has been or should be done?	Exchange of information Explore all locations
Study - functional analysis	Functional analysis	What is the cost and time of the primary and secondary operation? Where are the costly and low-cost intersections and time? Can a function be deleted?	Evaluation or comparison Valuation on a key standard
Study - creativity	Idea of options	What else does this function do? Where else is this function fulfilled? In what other ways is this function fulfilled?	Imagination creativity methods Suspend judgment Divergent thinking
Study - evaluation	Options evaluation	How can any idea work? How much does it cost and how long does it take? Do all the ideas fulfill the original function?	Weighting options Modify ideas Estimated spending on ideas
Study - development	Develop options options Option	How does the new idea work? How are its disadvantages remedied? How much does it cost and how long does it take?	Describe the standard Use new information Describe the total costs
Study - presentation	Provide options	What are resources and savings? What is necessary to implement the proposal?	Obtain an approval Create an operational plan
Post-study - implementati on	Run options	Who is responsible for implementing the option? Are the resources needed? Did the new method work?	Transfer plan to action Project supervision Determine the adequacy of implementation
Post-study - documentation	Document the results	How much does it cost and how much money is saved? Did the changes meet the expectations?	Report to management Report to management

4. Results

There are several methods for treating cancer patients, including chemotherapy, radiotherapy, and surgery. The understudy hospital provides chemotherapy services to cancer patients subspecialty with a bed occupancy rate of 98.5%.

Each year, about 4,000 adult patients are referred to the above center for chemotherapy and treatment of cancer-related diseases. Due to the limited number of beds, 75% of them face a shortage of beds at the time of referral. Patients are referred to the above hospital at least four or more times during the treatment process. The average monthly income of 75% of patients is less than 15 million rials ($ 429) per month, and 95% of patients are covered by basic insurance. Since 2014, with the implementation of the health system evolution program patients have received health subsidies. The purpose of this program is to improve Iran's health systems with three approaches to protect people against the people, create equality in access to health services, and enhance the quality of service. As a result, it reduces out-of-pocket payments for hospitalized patients (10% in urban insurance patients and 5% in rural insurance patients). Other demographic information is presented in Table 4.

Table 4. Demographic characteristics of the patients

Variable	Categories	
Gender	Men	1,503 (38.5)
	Women	2,420 (61.7)
Faced with a lack of beds in the center	Yes	2,730 (69.6)
	No	1,193 (30.4)
Education	Uneducated	1,232 (31.4)
	Reading and writing	1,577 (40.2)
	High school	879 (22.4)
	College	235 (6)
Job	Unemployed	369 (9.4)
	Worker	157 (4)
	Employed	565 (14.4)
	Self-employed	961 (24.5)
	Housewife	1,695 (43.2)
	Farmer	43 (1.1)
	Retired	133 (3.4)
Location	Shiraz	1,901 (48.47)
	Out of Shiraz	1,228 (31.3)
	Out of the province	791 (20.16)
Percentage of education with the patient	Reading and writing	3,087 (78.7)
	Diploma	636 (16.2)
	College	200 (5.1)
Distance from the residence to the hospital in percentage	>100 Km	1,844 (47)
	100-300 Km	1,059 (27)
	<300 Km	1,020 (26)
Type of insurance	Social security	2,024 (51.6)
	Health Service	945 (24.1)
	Armed forces	279 (7.1)
	Health insurance	596 (15.2)
	None	78 (2)

In the study year, the average annual cost of an urban household was $ 8,684. The average yearly income of an urban household was $ 9,736. Of the total gross household expenditure, 5.7% is allocated to the health and treatment group (Statistical Center of Iran). The average annual income of 75% of patients referred to the above center was less than $ 4,737 per year. Only 1% of the patients had more than $ 11,953 per year. Therefore, economic investigation and reduction of the LOS were necessary considering the low income of hospitalized patients compared to the average income of the family of the year under study.

Cancer is a significant public health problem worldwide and the second leading cause of death in the United States. In 2019, there were 1,762,450 new cancer cases and 606,880 deaths due to cancer in the United States (Rebecca, 2019). Cancer and its treatment lead to the loss of economic resources and opportunities for patients, families, employers, and society as a whole. These losses include financial losses, mortality, reduced quality of life, and premature death (8). Cancer typically incurs high costs inside and outside of the health care system, and these costs vary from country to country (9). Member states of the European Union, for example, spent around € 126 billion on cancer treatment in 2009 (8) and up to € 199 billion in 2018 (9). Cancer treatment in the United States cost $ 124.5 billion (10), which increased by 27% to $ 157.8 billion in 2020.

The total cost of cancer and its progression over time is a function of the size of the disease burden (cancer incidence, prevalence, and mortality) and advances in technology. The introduction of new technologies can reduce the cost of treatment; however, if these technologies are used as an adjunct to treatment, they will increase the costs imposed on the patient. Using a nuclear biopsy for open surgery instead of NLB (Nucleolus-Like Body), for example, can reduce the cost of screening by up to 50%, and over-the-counter percutaneous biopsy can decrease the marginal costs by up to $ 200,000. (11)

4.1. Introduction to chemotherapy

Before starting chemotherapy, the doctor will do tests to ensure that the side effects of the previous session vanish and the patient is ready for the new session. In most cases, chemotherapy is not a one-time treatment, but a series of treatments over time. A period usually lasts between 3 and 6 months, and sometimes more or less. Each session is between 4 and 8 sessions, and each session can last from one day to one week, followed by a break until the start of the next session. Cancer treatment usually includes frequent hospitalizations following the treatment protocol, surgical protocol, radiotherapy protocol, outpatient visits by physicians, laboratory services and pathology results, chemotherapy, and expensive medications and medical supplies (12).

4.2. Execution of value engineering in the hospital

4.2.1. Pre-study phase

Case studies on value engineering were carried out by 15 experts, including managers, professors, specialists in the medical field, physicians, and nurses, as well as a management team consisting of value engineering specialists playing the role of facilitators in the understudy hospital.

During the studies for implementing different phases of value engineering (pre-study, analysis, and post-study) and the HOQ, while creating an interdisciplinary team without considering the position and organizational structure, the success of studies in the framework of value engineering was considered.

In the pre-study stage, presenting all elements of the project and proficient specialists (including faculty members of the Department of Internal Medicine, Hematology, and Pathology), the project's information and knowledge were received, and then, various aspects of the project were examined using the Six Thinking Hats Technique, which in practice gives thought to the structure.

Information was received using the white hat technique, and the project was recognized by the experts and representatives of the above medical center. Taking advantage of the yellow and black hats, the team members presented their positive and negative points of view without judgment. According to the complication detection performed using the Six Thinking Hats Technique (which gives structure to thinking), this technique clarified all aspects of the problem. Using the hats, which can also be virtual, performs the act of thinking, and people are forced to think with the Six Thinking Hats Technique and present their thoughts (13). Subsequently, the initial version of goals, criteria, and constraints will be developed to be finalized in the information phase.

Using the HOQ technique (according to Figure 3), it was found that for patients, the following factors were of great importance: shortening the duration of chemotherapy, reducing the length of stay in the hospital, reducing treatment costs, the presence of medications in the hospital pharmacy at the time of hospitalization, and decreasing discharge time.

4.2.2. Study phase

The management team examines some items in this phase, such as work plan description, value engineering, risk literature, and opportunity identification. Besides, general information about the

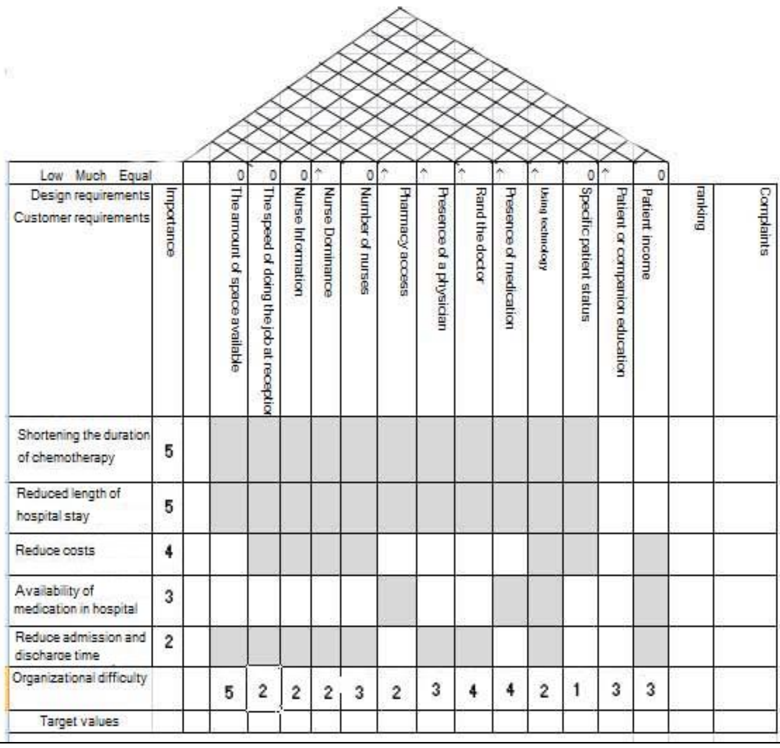

Figure 3. House of quality

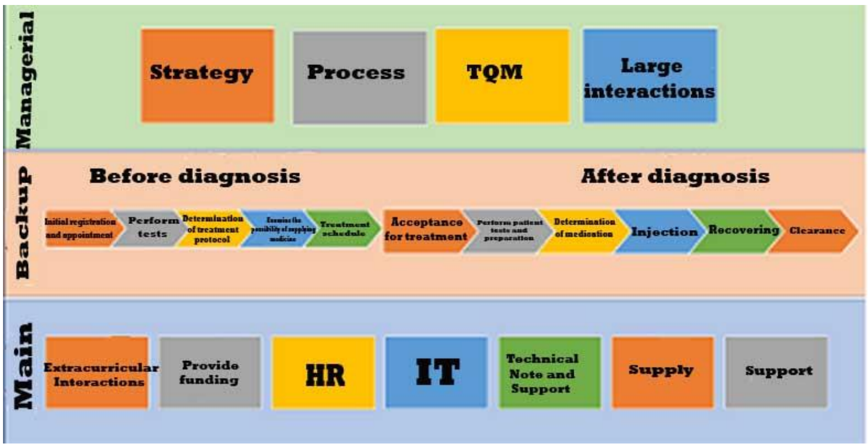

Figure 4. Value process diagram

hospital, including bed occupancy rate, patient accommodation, chemotherapy process flowchart for adult patients for various cancers, various chemotherapeutic drugs, drug supply, and distribution process, effective parameters in selecting the best option, cost model, time model, finalization of criteria and weighting, scoring of the existing plan, problems related to patients and hospital, and the patient's fundamental needs for treatment were examined. Furthermore, the value process diagram was developed according to Figure 4 in the managerial, principal, and support dimensions and the initial model of chemotherapy.

By recognizing the initial model according to Figure 5, and designing the time and cost model, while recognizing the high costs of the initial model, it was determined that each adult patient stayed in the hospital for an average of 4 days for each course of chemotherapy according to the type of cancer and chemotherapy protocol. During this period, he paid an average of $ 1,239.4 for direct and indirect medical expenses (including hospitalization, medicine, paraclinical, food, accommodation, and travel).

Moreover, due to the spread of cancer in recent years and the increase in the number of patients referred to the hospital, patients cannot receive timely chemotherapy services, and sometimes an average of about 60 adult patients are on the waiting list to receive chemotherapy services (albeit not for all oncology wards and not for all times, just in some times of the same year of the study period). A delay of about 9 days compared to their protocol just in exceptional overcrowded times during the study period, they received benefits, which caused numerous problems in their treatment. The value index of the patient's stay is 4 days, and the value index of the waiting list of 60 patients is 9 days late.

In the function analysis phase, the members of the value engineering team, by identifying, defining the functions, and specifying the primary and secondary parts of the process, explained the function analysis as a group and validated the previous experiences. In the next step, using the QFD HOQ results, the goal of the project or, in other words, the function with the highest rank (value index) in the project was described as "reducing the chemotherapy waiting list" and "reducing the duration of the chemotherapy process for adult patients."

By identifying and categorizing the results of functions, including major, minor, and non-essential functions, team members focused on improving the

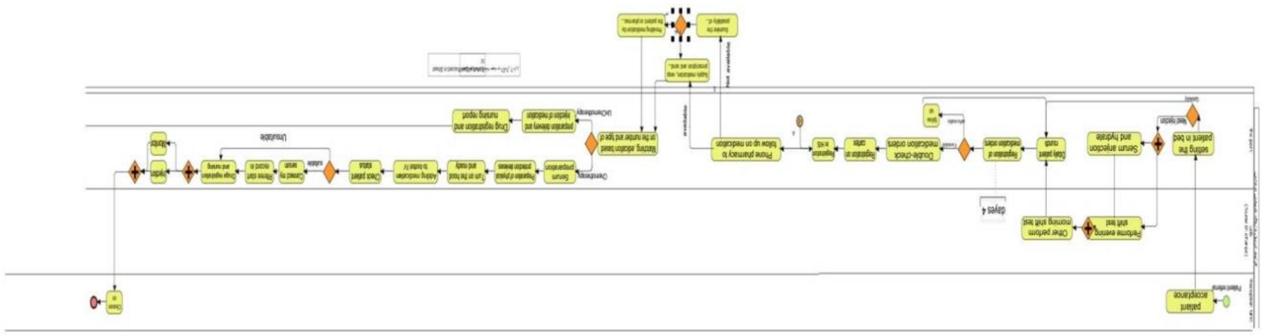

Figure 5. Current model of chemotherapy process implementation

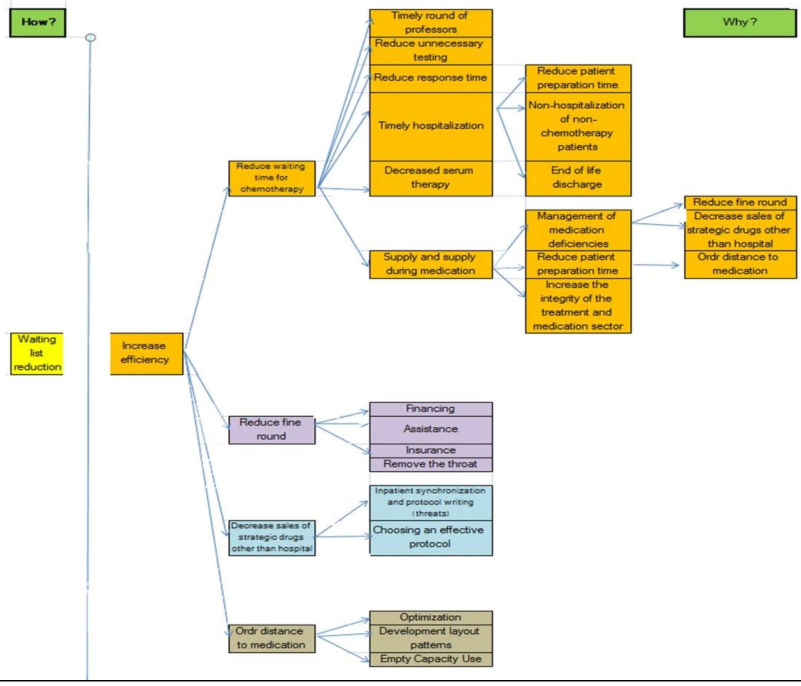

Figure 6. Function analysis systems technique diagram

design of the design functions and eliminating unnecessary functions. The members of the value engineering team then tried to depict the value map of this project. After selecting the function with the highest rank in this method, the team members expressed the part with the lowest rank using the brainstorming method. Afterward, in this way, the primary process, backup functions, permanent functions, one-time functions, and design requirements were examined, and the results were summarized in Figure 6 (FAST).

In the creative phase, a careful study was performed on the functions of each department in terms of cost, time, and risk. To select the desired tasks of this phase, cost-effective, high-opportunity, and high-risk functions were identified by team consensus. After passing through the stages of pre-study and function analysis and reviewing specialized areas with particular emphasis on function and process risks, the value engineering team produced 85 ideas (in four areas based on initial complication detection) using the SCAMPER technique and brainstorming. Subsequently, after evaluation, they were summarized in specialized working groups. In the evaluation phase, the ideas were screened and evaluated with a standard weighting matrix (scale pairwise comparison) according to Figure 7 with the criteria of time reduction, cost reduction, risk reduction, idea pervasiveness, and ease of implementation. The remaining ideas were evaluated according to the intended function in specialized divisions and assessed for further examination by expert judgment.

In the idea development phase, the ideas were divided into four categories according to the type of technical knowledge required to evaluate the views, the closeness of the presented concepts, the ability of the experts of the value engineering team to develop the ideas, and the judgment by the experts. Group A included ideas that had developmental implications. Group B contained statements related to outsourcing activities, and Group C separately examined the modification of the current treatment process. Group D explored ideas for using information technology, public participation, and cross-sectoral activities.

By controlling the process of developing the ideas, the control team tried to create an interactive and persuasive atmosphere, reviewing the ideas in different stages and finalizing the best suggestions. According to the approach of the management team and information about the HOQ, the results and achievements of each specialized group in the joint meetings of invited experts and team members, as

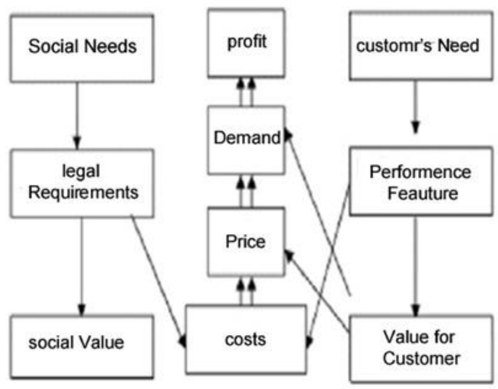

Figure 7. Relationship between quality function deployment and value engineering designed by Alan Lebak

Table 6. Summary of scenario results

Benefits and consequences/scenarios	Scenario1	Scenario2	Scenario3	Scenario4	Scenario5
Reducing occupancy coefficient					
Transferring patients to other medical centers or other non-chemotherapy departments					
Reducing costs					
Reducing waiting list					
Increased satisfaction of patients and their companions					
Reduced length of hospital stay					
Reducing the risk of nosocomial infection					
Reducing patient length of stay					
Converting and shifting a percentage of appropriate and justified inpatient chemotherapy to a non-hospitalized form					
Deleting or reducing queuing systems					
Reducing the side effects and consequences of failure to perform chemotherapy in a timely manner					
Decreasing the mental health status of cancer patients after leaving the hospital and hospital wards to continue treatment					
Improving patient-hospital communication					
Improved communication between different hospital units					
Communication between Professors-Nursing System-Management					
Increasing the admission capacity of an adult patient for chemotherapy					

well as statements and points related to each scenario, were discussed and summarized in these meetings.

Finally, it seemed necessary to make changes and implement the achievements of value studies after careful consideration. The results of each working group's studies were presented in detail in the development section to overview valued engineering achievements.

Proposals in different areas that received the highest score in the evaluation stage and were identified as initial ideas for expansion development were divided in the different scenarios into two categories of process and non-process changes. These scenarios included:

A: Process change scenarios: 1- Accepting patients in the morning shift (as soon as hospitalization), 2- Predicting and supplying the required drugs, and 3- Preparing a management dashboard to add proper (time) adjustment of admissions management of the center.

B: Scenarios of non-process ideas: 1- Setting up a new department (setting up a new mandatory system known as oncology palliative supportive care system for caring the cancer patients throughout their life, including their ending period of life) and 2- Outsourcing activities (performing chemotherapy on an outpatient basis or home care).

In different sessions for each scenario, the current situation was first described; afterward, according to Table 6, the proposal included quality benefits and consequences, disadvantages and risks of implementation, forecast of implementation time, activities needed to implement ideas, impact on financial leverage (income/cost), and time levers for each scenario were identified and developed.

Given that any change in the treatment process directly impacts the disease recovery process, to ensure the results of the implementation of the recommendations that were effective in the treatment process from the simulator software Visual.Paradigm.For.UML.Enterprise, we used "Edition.v10" and modeled the initial process in the above software. The initial model was designed in the simulator software and approved by experts. According to Figure 8, the simulation results of the initial model were consistent with the results in reality. After that, process scenarios 1 to 3 were simulated in the software, and experts approved non-process scenarios 4 and 5.

4.3. Execution of process change scenarios in the software

In process scenario (1), potassium, sodium, cratonium, and LFT (Liver Function Test) tests were excluded for on-admission chemotherapy patients from available hospital services. The patient had to have these tests performed in approved laboratories no later than 48 h before admission and included the answer in the management dashboard (patient section). If the doctor diagnosed that there was no need to hydrate, the patient would have started chemotherapy immediately.

By implementing this scenario, according to the time model of the baseline plan (taking into account the need of 20% of patients to serve HYDRATE) and based on the simulated results, the patient's stay time was reduced by 17.29% (equivalent to 16 h and 36 min). The risk of nosocomial infections was diminished due to reduced patient stay. The admission capacity of a new patient for chemotherapy increased by about 17%, equivalent to about 2,734 beds per day in a year.

With this reduction in accommodation, 683

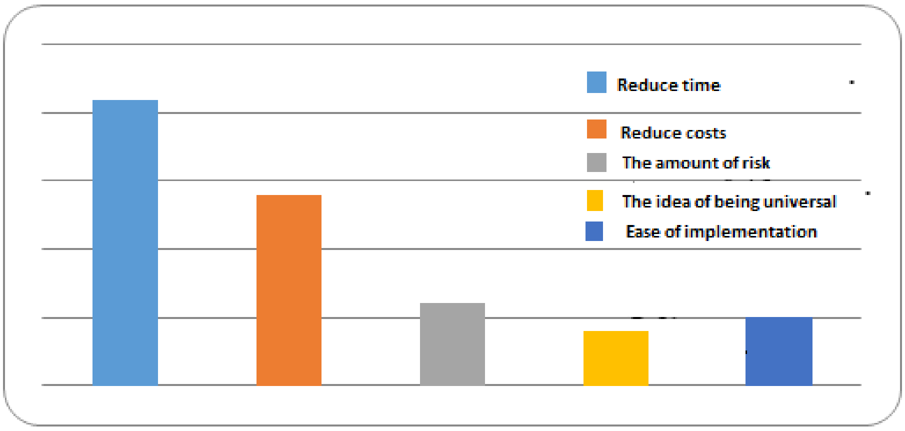

Figure 8. Weight of evaluation criteria

patients (56 patients per month) would receive more services during the year; therefore, there would be a reduction in the waiting list and the complications and consequences of not performing chemotherapy on time.

The simulation results of Figure 9 also showed that with the elimination of inpatient tests and HYDRATE service for patients who do not need this service, the patient's stay value index and the patient waiting list for hospitalization improved by about 17.7%

Considering hospital costs for each hour of hoteling and according to the cost model of the baseline plan, this time reduction led to a savings of 10.35% of the direct cost for each chemotherapy period. In this scenario, reducing the length of the patient's stay in the hospital did not affect the use of chemotherapy drugs; in this regard, the cost of the drug was not calculated in this scenario.

In drug scenario (2), based on information from the pre-study phase, in case of a lack of medicine in the pharmacy and its non-timely supply, at least 7 to 36 h would be spent to supply the drug. Sometimes, 40% of patients experienced a medication shortage in the hospital pharmacy during hospitalization, which increased the patient's stay (about 10% of the patients and just for sometimes during the study period).

In this scenario, the patient's treatment protocol, and consequently, the type of medication required by the patient before admission were determined by the physician in the management dashboard. The oncologist also determined for each patient between 1 or 2 alternative treatment protocols based on priority. The hospital pharmacy could prepare the medicine before the patient was admitted and then the patient was admitted. Suppose there was no medicine in the pharmacy or it was not possible for the hospital to provide medicine due to national or provincial shortages for the prescribed protocols. In that case, the patient would be hospitalized or the patient's lack of medicine would be provided and then hospitalized.

Execution of this scenario according to the time model of the base design could save at least 7.3% of the time. By implementing this scenario, the patient's

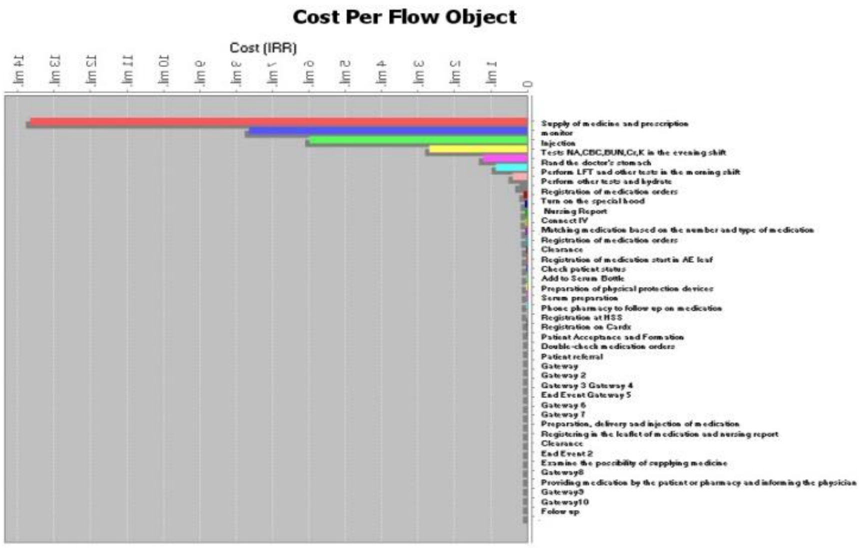

Figure 9. Primary model results including direct medical costs for a patient in the software

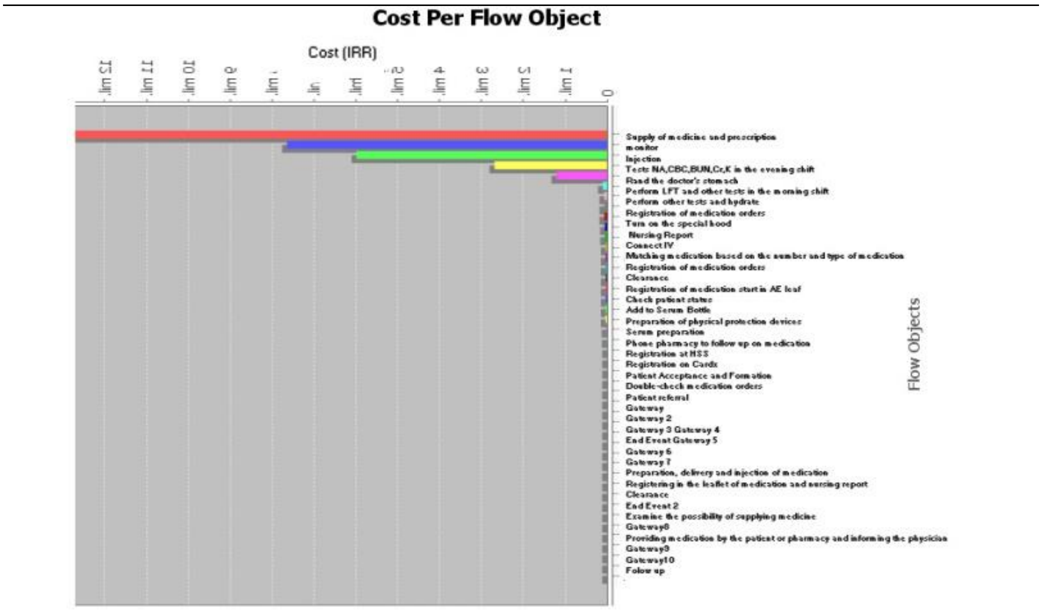

Figure 10. Scenario 2 admission in the morning shift with direct treatment costs for one patient

stay was reduced, and as a result, the risk of nosocomial infections and complications due to chemotherapy was diminished. According to Figure 10, execution of this scenario in the simulator software showed that the value index of patient LOS and reduction of the waiting list improves by about 7.3%. Hence, considering the hospital costs for each hour of hoteling, this reduction in time according to the cost model of the baseline plan led to a 7.3% direct cost savings for each period of chemotherapy.

In technology scenario (3), a management dashboard with patient accessibility, nursing system, physicians, paraclinical units, and hospital management system was designed as a mobile app and webpage for proper management of the center. This dashboard improved the communication between the patient and the hospital, and subsequently, led to the elimination of telephone calls between the patient and the hospital to make an appointment, enhancement of communication between different hospital units (e.g., nursing, pharmacy, and laboratory), better supervision of professors on how to treat patients, better management of hospital beds, reduction of the patient and hospital costs, reduction of waiting and admission times, and reduction of patients' discharge time.

Execution of this scenario, which was a supported scenario in the simulation program, as shown in Figure 11, demonstrated that the value of the

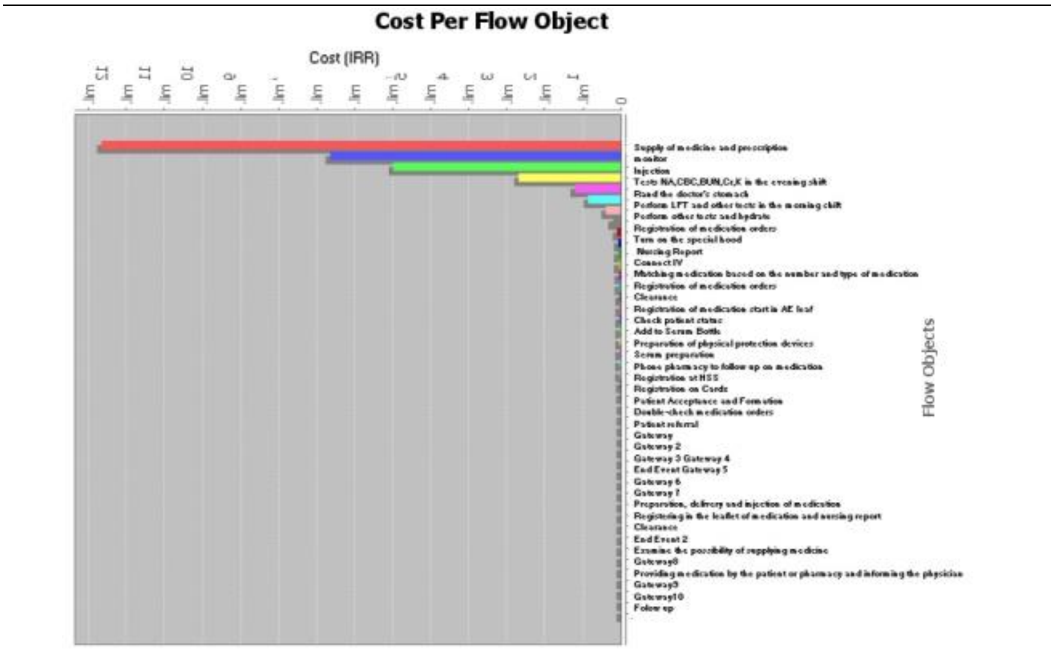

Figure 11. Scenario 3 providing a management dashboard for proper center management

patient's LOS improved by 2%.

4.4. Execution of non-process change scenarios

According to the fast chart in value engineering workshops, one of the things that caused patients to be admitted on time was the end-of-life discharge and non-hospitalization of non-chemotherapy patients.

According to the statistics, in 2017, about 10% of patients were hospitalized for supportive end-of-life care on average for 20 days. This group of patients practically lost hope for their treatment, and their hospitalization was only to reduce pain and provide supportive end-of-life care. The LOS of this number of patients was equivalent to 7,900 days of hospitalization per year.

In scenario 4, it was suggested to activate the end-of-life supportive care unit. With the entire establishment of the above department and considering the average stay of 4 days of hospitalization in 2017, it is possible to provide chemotherapy services to 1,975 new patients, improving the value index of "increasing the capacity of chemotherapy" by more than 50%.

To implement this scenario, it is necessary to formulate new rules and regulations specific to these patients, physical space, human resources, and medical equipment. Due to the limited budget and facilities and the physical structure of the hospital, it is not possible to fully set up the above department and remove this number of patients from the hospital wards for a limited time. Therefore, it was suggested that this scenario be implemented in several phases.

First, as a pilot, space outside the hospital environment with at least seven beds was allocated for this purpose. Considering the average 4 days of the patient's stay, it added about 20% (639 patients) to the inpatient capacity to receive chemotherapy services. This scenario did not affect the current treatment process, yet increased the patient's admission capacity for chemotherapy.

The development of new rules and regulations specific to these patients was outside the scope of the hospital's authority. It required the attention of out-of-university units; therefore, the necessary measures were taken in this regard.

According to the fast chart and in value engineering workshops, one of the things that reduced the waiting list of patients was the conversion and shift of inpatient chemotherapy to non-hospital care (home care); in this respect, the purpose of scenario 5 was the transformation and shift of a percentage of inpatient chemotherapy, which could be done in the outpatient form.

By implementing this scenario, treatment would continue at home and in the family, reducing the unnecessary burden on the hospital system and possibly improving the patients' mental condition. The implementation of this scenario required out-of-hospital and even out-of-university coordination and coordination with insurance companies; as a result, it was much more challenging to be implemented than in other scenarios.

Implementation of this scenario required a team consisting of relevant experts, including general practitioners, nurses, paraclinical services, insurance and management, and legal levels to overcome the many opportunities and consequences of creating and operating this interface system (total hospitalization).

According to information in the pre-study phase in 2017, about 45% of adult patients referred to the above hospital suffering from various types of cancers, including colon, stomach, esophagus, pancreas, soft tissue (soft tissue sarcoma), cases of Ewing sarcoma cancer in selected patients. The treatment of these patients is appropriate to implement this idea. Oncologists in value engineering meetings stated that at least 30% of this number of patients could be treated as home care. The implementation of this scenario would reduce at least 14% of adult patients. In other words, the waiting list reduction index would be improved by 14%.

Given the hospital costs per hour of accommodation, this reduction in time leads to a 38% cost savings per course of chemotherapy according to the cost model. In this scenario, reducing the length of the patient's stay in the hospital does not affect chemotherapy drugs, because must attendant patient to the hospital to receive the medicines needed in chemotherapy pumps. Therefore, the cost of pharmaceuticals and transportation is not calculated in this scenario.

4.5. Value and performance index

As stated in Section 3-2, the value index of the patient's stay in the initial model was 4 days and the waiting list index was about 60 adult patients with a 9-day delay in starting treatment. To improve the value index of the patient's stay and reduce the waiting list due to time constraints and the difficulty of each scenario, as well as its effect on improving the value engineering index, it is suggested that the priority of scenarios be implemented according to the above and according to Figure 12.

Execution of some scenarios, including process scenarios, is completely within the authority of the hospital, and with a few coordination sessions between the nursing and medical system, it can be easily implemented and there is no need for external coordination. Execution of technology scenario (3) After obtaining permission from the university to design and launch the application, it will be possible to implement it in several phases. Some cases require the development of new rules and regulations (by the Ministry of Health and other legal channels), the implementation of which may be more time-consuming than other scenarios.

Execution of some scenarios, such as scenario 1

Figure 12. Scenario implementation steps

Table 7. Summary of priority in cost saving

	Saved time	Patient residence reduction value index	One-year cost savings	Increase in the annual admission capacity	Scenario implementation requirements	Reduction in hospital stay
First priority	17.29% equal to 2,734 inpatient beds 547 hours + facilitating inter-hospital communication 330 days bed hospitalization caused by 2 h decreases in discharge time	+19.37%	$ 775,534	683	In-hospital coordination	Reduction in hospitalization time from 96 h to 79.4 h
Second priority	14% equal to 2,216 hospitalized day beds	+14%	$ 438,693	554	Formulating laws and regulations, out-of-university coordination	Reduction in hospitalization time from 96 h to 82.56 h
Third priority (Phase I)	About 20%	-20%	-	639	Inter-university coordination	Patient not admitted to chemotherapy ward
Third priority (complete)	7,900 hospitalized day beds	+100%	-	1,975	Inter-university coordination	Patient not admitted to chemotherapy ward
Fourth priority	7.3%	+7.3%	$ 357,641	115	In-hospital and in-university coordination	Reduction in hospitalization time from 96 h to 93 h

(admission of patients in the morning shift and start of chemotherapy as soon as hospitalization), requires the necessary infrastructure, including a management dashboard to send and receive test results and bed management, which must be performed simultaneously to achieve the desired result. Some scenarios, including the technology scenario end-of-life, can be implemented in different phases.

The amount of time and cost savings that lead to the improvement of the turnover value index are given in Table 7 for each priority.

5. Conclusion

5.1. Conclusions and future suggestions

According to the results of descriptive statistics, 75% of patients evaluated during the study had a monthly income of less than 15 million rials, which highlights the importance of examining the various components of the costs of these patients more than ever. Cancer reduces the level of household income; as a result, a middle-income family with a high income also loses a large amount of income with this disease and becomes a family with a lower income level. The various dimensions of cancer treatment costs include direct costs, indirect costs incurred by the patient, other indirect costs incurred by the patient's family and friends, and intangible costs that are consistent with the study conducted by Cakir Edis (14) in Turkey. The main part of direct treatment costs is related to medications and chemotherapy services. Medicines and consumables, hospitality, and chemotherapy impose higher costs on patients.

The results of this study indicated that in 2017, the total direct and indirect costs of treatment for a course of chemotherapy (regardless of the type of cancer) for an adult patient with an average of 4 days stay in the above center was $ 1,239, which compared with other studies, it showed different results. For example, Farrokhi et al. (2012) estimated the total cost of cancer treatment at $ 920 and

Haririchi et al. at $ 815 (15), while in terms of length of stay, it contradicted the results of a study by Askarzadeh et al. (16). This increase in costs can be justified by the following reasons: the application of tariffs for the Health Transformation Plan in 2014, the import of most of the medications and consumables of patients, and the increase in inflation and the exchange rate. In this study, hospitalization costs with 44% and medications and consumables costs with 41% accounted for the largest shares of total direct medical costs of the patient. These results were consistent with those of a study by Baroun et al. in the United States, where medication costs were the costliest part of treatment overall. It was also in line with the findings of the study by Askarzade et al. (16), which stated that the cost of medicines and consumables accounted for the biggest part of treatment with 24%. Moreover, it was in agreement with the results of a study by Bahmani et al. (2013) in Namazi Hospital in Shiraz, Iran, which had the highest costs of medicine and treatment in all direct medical expenses. Based on the results of a study conducted by Dahlberga et al. (17) on patients with breast cancer in Sweden, hospitalization costs and medicines were responsible for the largest source of total costs, which was somewhat consistent with the findings of a study by Farokhi et al. (18) conducted in 2011 in Kerman, Iran, on cancer patients. According to the different phases of value engineering and QFD, and limitations, criteria, and ideas obtained from creativity, the value engineering team was presented with various options that with comparison and technical studies and considering their value index, the best options in the form of 5 scenarios to implement were introduced.

In the first step of this project, two scenarios were performed, consisting of accepting patients in the morning shift (process) and designing a management dashboard (technology) for the correct management of the center. By simulating the scenario in Visual.Paradigm.For.UML.Enterprise. Edition.v1 software and implementing the first phase of the technology scenario, while facilitating communication between hospital units, patient with hospital, and physician with hospital, the patient residence time index decreased by 17.29%. This reduction led to the addition of 2,734 inpatient beds to the patient admission capacity, which, considering the average stay of 4 days, could provide services to about 683 new patients.

In terms of cost index, according to the initial cost model and medication cost deduction, this scenario reduced treatment costs by 10.35%, equal to $ 775,543. These reductions in cost and time were consistent with value studies conducted by Yukel (19) in hospitals and health care networks in the United States over a seven-year period that resulted in savings of 3.7-11%.

The purpose of the second step was to outsource activities, converting and shifting a percentage of chemotherapy for certain types of cancer, including colon and stomach, under appropriate hospitalization than could be performed in the non-hospitalized form of home care. Time perspective resulted in a 14% reduction in adult patients. From the point of view of the cost index, according to the cost model of the base plan and deduction of the cost of medicine and transportation, it led to annual savings and 438,693$ direct costs. This decrease was consistent with value studies conducted by Yukel in hospitals and health care networks in the United States over 7 years, which resulted in savings of 3.7-11%.

The purpose of the third step was to activate the palliative care (supportive care) unit at the end of life, to separate end-of-life patients from other patients, and provide services to patients who were going through the last days of their lives, their treatment was completed medically, and no medical interventions were possible for them.

About 10% of patients referred for supportive care were admitted at the end of life, and considering the average length of 20 days in the hospital, their removal from the ward could add about 50% to the patient's capacity. In terms of cost, because services to them were no different whether in the hospital or out of the hospital, there was no difference in cost.

The purpose of the fourth step was to prevent the patient from staying longer in the hospital due to the lack of medication and consumables. By running this scenario in Visual.Paradigm.For.UML.Enterprise. Edition.v1 emulator software and depending on the time and cost model, 7.3% ($ 357,641) was saved. These savings were close to those reported in the studies conducted by the SVAH Association according to Table 8.

With the full implementation of 5 scenarios in the form of 4 proposed steps, 41.59% would be saved in terms of time and 32% in terms of cost, and a total of 38.9% would be added to the patient admission capacity. Is consistent with the studies carried out by the SVAH Institute and Santibáñez, P. et al. (20).

Table 8. Results of SVAH savings in different wards of 3 hospitals and one IDN (Integrated Delivery Network) studied

158-bed hospital	400-bed hospital	339-bed hospital	4 IDN hospitals
$ 922,000 in surgical surgery resources	$ 3 million in contract savings	$ 1.6 million in medical surgery resources	$ 1.3 million in improper consumption
$ 102,000 in diet sources	$ 990,000 in consumption	$ 850,000 in savings	$ 361,000 in standardization
$ 127,000 in purchasing medicine	$ 300,000 in buying groceries	$ 500,000 in buying groceries	$ 377,000 Gpo(Group Policy Object)
$ 91,000 in the landing process	$ 133,000 in the best price selection process	$ 345,000 in administrative resources	$ 466,000 in value mismatches

Table 9. SVAH 339-bed hospital savings by state

State	Number of beds	Saving
Connecticut	300	673,000
Ohio	150	258,000
Florida	2000	3,200,000
Connecticut	350	408,000
Indiana	100	275,000
Pennsylvania	123	173,000
California	90	356,000
California	400	4,000,000

Due to the success of the combined model of value engineering and HOQ in a case study in improving the chemotherapy process, the implementation of this model is recommended in other hospital areas, such as outpatient operations, preoperative laboratory, patient registration management, and documenting medical records. Research has shown that cancer patients incur direct and indirect costs during treatment. Therefore, new policies are needed to reduce costs in these cases.

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Footnotes

Conflicts of Interest: The authors declare that there is no conflict of interest regarding the publication of the present study.
Authors' Contributions: Z. R. and H. K. contributed to the conceptualization and design of the article. Z. R, A. R. M. S, H. K., and M. F. contributed to the analysis and interpretation of the data. Z. R. and H. K. conducted the statistical analysis. Z. R. and H. K. wrote and revised the manuscript. Z. R. and H. K. gave the final approval for this article. All authors are accountable for all aspects of the work.
Ethical Considerations: The study protocol was approved by the Committee of Human Experiments of Shiraz University Of Medical Sciences, Shiraz (IR.SUMS.REC). Informed consent was obtained from the participants at the beginning of the study.
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