JOURNAL OF COMPLEMENTARY MEDICINE RESEARCH

RESEARCH ARTICLE

Factors Affecting Lean Management: Designing a Model for Teaching Hospitals

SARA SAFAVI[1], SEYED JAMALEDIN TABIBI[2*], LEILA RIAHI[3], MAHMOOD MAHMOODI MAJDABADI FARAHANI [4]

[1]*Ph.D. Candidate, Department of Health Services Administration, Science and Research Branch, Islamic Azad University, Tehran, Iran, https://orcid.org/0000-0003-1113-0110, Email: safavi_sara89@yahoo.com*

[2]*Professor, Department of Health Services Administration, Science and Research Branch, Islamic Azad University, Tehran, Iran, http://orcid.org/0000-0002-7506-7571, Email: sjtabibi@yahoo.com*

[3]*Associate Professor, Department of Health Services Administration, Science and Research Branch, Islamic Azad University, Tehran, Iran, https://orcid.org/0000-0002-2044-5600, Email: L.riahi@srbiau.ac.ir*

[4]*Professor, Department of Health Services Administration, Science and Research Branch, Islamic Azad University, Tehran, Iran, http://orcid.org/0000-0001-7386-9565, Email: mahmoodim@tums.ac.ir*

**Corresponding Author*

ABSTRACT

Introduction & Background: Although lean management methods have been wildly applied in hospitals, designing a comprehensive model for teaching hospitals was very limited. This study aims to propose a model for lean management in the hospitals of Shahid Beheshti University of Medical Sciences.

Methods: Considering the results, the present case study falls in the applied category. The research populations were managers at different levels of senior, middle and operational in SBMU teaching hospitals. The data obtained through a research-made questionnaire that its validity confirmed by a group of elite in lean management and its reliability calculated 0.82 using Cronbach's alpha. Collected data underwent exploratory and confirmatory factor analysis using SPSS and AMOS, respectively.

Results: According to exploratory factor analysis, the model variables consisting of seven factors and revealed 57.01 percentage variance. Using confirmatory factor analysis on the basis of goodness of fit indices, the designed model consisting of Hospital Waste Factor with factor loading as 0.714, Process Factor with factor loading as 0.851, Lean Team Effectiveness Factor with factor loading as 0.893, Medical Equipment Suppliers with factor loading as 0.925, Lean Culture Factor with factor loading as 0.894, Organizational Policy Factor with factor loading as 0.880 and Control Factor with factor loading as 0.838. The highest factor loading went to Medical Equipment Factor and Lean Culture Factor, respectively.

Conclusion: Considering the effect of the mentioned seven factors on lean management model, teaching hospitals seeking to implement lean management as a new approach, applying self-assessment system to determine real position of hospital to establish proposed lean management model appropriately.

KEYWORDS:
Lean management, Teaching hospital, Shahid Beheshti Medical University.

ARTICLE HISTORY:
Received Oct 11, 2021
Accepted Nov 09, 2021
Published Dec 22, 2021

DOI:
10.5455/jcmr.2021.12.04.11

VOLUME: 12
ISSUE: 4
ISSN: 2146-8397

INTRODUCTION

During the last two decades, request for health care services has been raised due to the rise of life expectancy and developments in technological and life style-related factors tended to severe changes in hospitals, consequently [1]. So, health care providers especially hospitals should creatively pave the ground to improve their services with focus on customers, value creation and waste elimination [2].

The early 2000s, applying lean approach especially by hospitals mildly spread in scientific studies [3, 4, 5]. In recent years, lean philosophy rapidly turned to the latest changes and lean

management considerably used to solve challenges of health system [5, 6, 7]. According to Arlbjørn, lean management is a sets of principles, techniques and management methods, established systems by organizational leaders, culture of organizational relations and all organized team efforts focused on waste elimination, reducing non value added activities and applying required control to improve care processes to reach a continual improvement process [8].

In Iran, hospitals spend about 50-80 percent of state health budget. So, near 7 percent of domestic gross product assignees to health expenditure and about 40 percent state health expenditure belongs to hospital services [9, 10]. Teaching hospitals face serious challenges such as increasing rate of patients, rising expectations for more improved and even costly services and shorter waiting time. State budget shortage along with unfavorable economic conditions and financial crisis bring about a need for apply a more optimal method to use rare resources [5, 10].

According to a systematic review by D'Andreamatteo from 2003 to 2018 and Tlapa from 2002 to 2018, most theoretical and experimental studies on lean hospitals are related to health services including emergency departments, surgery, pharmacy and diagnostic departments such as radiology and laboratory and mainly review success factors, barriers and challenges limited to one or more lean techniques combined with other quality approaches in a non comprehensive framework [11, 12]. These studies consider analysis of value stream mapping as the most important lean technique and mainly focus on assessment and process improving based on lean techniques intensive team [12, 13].

Organizing lean teams with experienced trained members and making effective relations between them to identify and eliminate waste resources is the fundamental basis of applying seven lean flows [14].

Regular daily interaction and enjoying several lean techniques such as value stream mapping and worksheet activity as logistic solutions to reduce public-sector health expenditure have been applied to identify and analyze waste resources specially caused by movement and transportation in service providing processes [15]. Meanwhile, rapid interaction and coordination among lean teams to reduce waiting time related waste and improve patient flow resulted to accelerate continuous improvement and using lean control techniques made patient care more effective [16, 17].

Designing standard workflow and check list to increase effectiveness used as a means to control safety and supervision in lean chain [18].

Meanwhile, 5s implementation to improve processes, giving quick response and applying lean visual management tools including checklist, poster and pocket cards to control safety opens the door for lean efficiency in line with customer-focused lean effectiveness [13].

On the other, organizational policy and senior management commitment to enforce lean successful interventions explained with the participation of beneficiaries in manager groups, internal consultants and staff and lean thinking as a creator of local lean models in every hospitals with the cooperation of front line staff, middle managers and executive leadership and establishing lean teams and spreading lean strategic thinking succeeded to improve quality of patient care and reduce care expenditure in public sector considerably [17, 19].

Organizational culture and preparing broad motives by senior leadership to encourage different professional groups are other factors required to lean enforcement [20].

Other organizational factors facilitate lean include active participation of senior manager in related lean programs, participation of all hospital professions and organizing training and retraining programs for hospital staff [21, 22].

So, it is needed to found the components in the hospital information system including data collection and monitoring, training, required tools and technology and work team interaction on the basis of lean thinking to create changes in all work processes [23].

Accordingly, a multi-dimensional process has been proposed in a software enjoying participatory management, making report to other sectors, staff training, lean culture improvement, support of senior management in technology change to assure continuity of organizational actions based on lean thinking [24].

Expanding lean thinking to improve quality and using hospital resources is other challenge facing managers of public sector [25].

Modelizing tools based on artificial intelligence combined with DMAIC and identifying and eliminating of seven wastes of lean are new deciding tools used by public hospitals' managers to meet required supply-chain [26].

Upstream and downstream activities, internal organizational activities, management area, choosing and assessing suppliers and keeping in contact with them are required to classify hospital supply chain [27].

Additionally, in ensuring that requirements of production, preparation and process are adaptive with a lean hospital, mutually effective relations between hospital and suppliers and beneficiaries participants has been emphatically considered [28].

Although lean management brings about great achievements, it would look doubtful that some specific lean tools could be achieved and quality improvement seen in some healthcare services [29, 30]. So, it is necessary to design a multi-dimensional model covering all basis, tools and techniques of lean management to enjoy whole related potentialities [31].

Therefore, it is required to study on different aspects of lean management from a systematically comprehensive view in

health care and provide an applied model for lean management especially in public hospitals meeting with budget shortage, financial problems imposed by government and increasing number of patients.

On the other, present study tries to clarify different aspects of lean management including lean team efficiency, waste, lean culture, organizational policy, relation with hospital suppliers, process factor and control mechanism and bring about a comprehensive model appropriate with current circumstances of teaching hospitals.

METHODOLOGY

The present study carried out in SBMU teaching hospitals, 2018. Research findings are applicable for the target group and as an inductive one leads to the final pattern. The data collected through a reliable and valid questionnaire consisted of 53 questions confirmed by a group consisting of 10 elite scientific and executive experts in lean management through a face-to-face interview.

Content validity based on a quantitative approach developed through Content Validity Ratio and Content Validity Index and in every stage questions were deleted if seemed necessary.

Finally the research method organized in two parts consisting personal and demographic information and related variable questions using a 5-point Likert scale represent 1 for very low, 2 for low, 3 for average, 4 for high and 5 for very high.

The study population consists of managers, heads, supervisions and officials of diagnostic and treatment departments and also staff at levels of senior, middle and operational. The sample size was 350 individuals in the all 12 SBMU teaching hospitals. At the end, 335 valid questionnaires were employed. To determine sample size for structural equation modeling, 5 to 10 sample considered per question [32]. In average, every question answered by 7 individuals.

When data entered into SPSS statistics, KMO and Kruit-Bartlett test carried out respectively to measure sample adequacy and possibility of doing exploratory factor analysis. Then, the primary model designed based on structural equation model and exploratory factor analysis and confirmatory factor analysis developed by AMOS for model validation.

The model confirmed based on fit indices such as Relative Chi Square, RMSEA, Comparative Fix Index, Goodness of Fit Index and Adjusted Goodness of Fit Index.

RESULTS

Based on descriptive data, women hold 70.4 percent of all sample managers at senior, middle and operational level and 29.6 percent of respondents were men.

Most respondents were in the age group of 35-44 years standed 43.3 percent. By organizational position, operational managers including executive officials reported the highest percentage at 46 percent. Among other managers supervisors reported 43.3 percent at middle level and hospital managers or CED reported 10.7 percent at senior level.

By the years of service, the highest percentage standed for 15 to 24 years at 58.8 percent. KMO and Kruit-Bartlett's Test of Sphericity used to measure possibility of exploratory factor analysis through Principal Component Analysis and Varimax Rotation on 53 main items and confirm sample adequacy and that correlation matrix were statistically different from zero. Findings indicated that the KMO measure of sampling adequacy yielded a value of 0.85 as $p<0.0001$; so, it is said to be statically significant.

For factor extraction, exploratory factor analysis performed with different factors using Varimax Rotation and correlation coefficient of 0.45. Finally, seven-factor solution was recommended and 57.01 percentage variance accounted for in a seven-factor solution to determine research variables.

The highest percentage went to the first factor with 10.038 percentage variance and the lowest one went to the seventh factor with 5.960 percentage variance (Table 1). Factors assigned and confirmed by lean elits through considering each factor variables and assessing glossary of lean terms implicit nature of variables, current theories and previous research findings.

Factor 1 called The Waste Minimization Factor including waiting, transportation, supplies and additional processes in service providing activities. Factor 2 called The Process Factor presenting various practices affect service providing processes based on lean approach.

Factor 3 called the Hospital Suppliers Factor consists of key characteristics related to the connections between hospitals and suppliers, items and capital medical equipment's. Factor 4 called The Lean Team Efficiency Factor related to hospital team activities and team efficiency. Factor 5 called The Culture Factor includes cultural basis and requirements related to organizational culture effective on lean establishment in hospital. Factor 6 called The Organizational Policy Factor considers the role of senior leadership in the shift to a lean culture and all adapted policies adapted. Factor 7 called The Control Factor considers mechanisms of controlling manpower, positions, equipments and processes related to lean implementation and patient safety (Table 1).

(Table 1) shows specific value, variance percentage and cumulative variance percentage of factors obtained from exploratory factor analysis. Confirmatory factor analysis through AMOS used to confirm the proposed model. (Table 2) shows factor loadings of exploratory and confirmatory factor analysis.

Goodness of fit index used to confirm model fit (Table 3). The standardized chi-square showed 2.00 for the model. Since chi-square value should be less than 3 based on fit index criterion [33], so the said model shows the goodness of fit.

In addition, RMSEA as another fit index that assesses the

discrepancy between the hypothesized model covariance matrix with the observed ones and should be smaller than 0.08 [34] is 0.04 in this model. So, the baseline data are appropriate with the proposed model. Comparative fit index that accounts correlation between variables and compare the fit of the hypothesized model with that of a baseline model that variables are uncorrelated is 0.95 in this model and acceptable [34].

GFI assesses variances and covariances relatively. GFI value ranges between 0 and 1 and should be equal or greater than 0.9 [35].

GFI is 0.91 in this model. Adjusted goodness of fit index is another index which should range between 0 and 1 [32]. and is 0.9 in this model (Table 3).

(Figure 1) is a schematic diagram of factors related to lean management of teaching hospitals of SBMU obtained through confirmatory factor analysis by AMOS.

DISCUSSION

This study aims to design a lean management model for SBMU teaching hospitals to improve efficiency, comparative potential and quality and represents that model variables consisting of seven factors including waste, process, hospital suppliers, lean team efficiency, lean culture, organizational policy and control. According to the total percentage variance, the highest percentage accounted for waste factor with 10.038 percentage variance.

Of course, it should be acknowledged that waste elimination is at the heart of hospital lean management to improve high quality services and can be accomplished just through eliminating all waste resources and focusing on value added points [4, 16, 26]. Meanwhile, the highest loading factor went to transportation waste following EFA and CFA exploratory factor of variables in waste factor group.

Any movement of manpower and patient further than necessary with non-value added activity can be a result of improper facility layout, poor information about patients and service providing and generate transport waste; however, lean creative tools such as spaghetti plot, value stream mapping and daily worksheet used to reduce waste and subsequently hospital resources [15].

5s or workplace cleanliness had the highest loading factor among the variables of process factor. Noteworthy, Schonberger introduces cleanliness system as one of the most significant lean methods since it focuses on increasing customers through applying quick response [13].

Patient flow chart analysis had the highest factor loading following the CFA. According to (Tlapa et al., 2020), (Schonberger et al., 2018), (Skeldon et al., 2014), (Chiarini, 2014) and (Dart, 2011) enforcing value stream mapping would tend to waste elimination in patients processes and catch to the fundamental lean basis that is improving healthcare quality and reduce public health expenditure.

"Suppliers' quality over quantity model" had the highest leading factor following EFA of medical equipment supplier variables, in favorable of the study by Hicks in which an endoscopy unit was redesigned and equipped through holding a workshop and attracting participation of related beneficiaries.

The results demonstrated beneficiaries' satisfaction and healthcare quality improvement align with expenditure reducing [28]. In order to optimize supply chain management, Jordon designed a decision-aided software based on artificial intelligence and using problem solving method and optimized pharmaceutical supply chain resulted to improve the quality of related procurement and dispatching process [26].

Following CFA, the highest path coefficient went to "suppliers' flexibility" variable. Wijewardana reviewed various components of lean supply chain including medical equipment suppliers, all required treatment services, admission and discharge, infrastructure and environment in 3 teaching hospitals and acknowledged that applying mentioned components and making effective relations with suppliers can be reached through quick, flexible and continuous reaction to the market changes, suppliers' dynamics and customers' expectations [27].

"Lean strategic thinking" variable had the highest variable variance following EFA. In study by Dart, a lean team organized by members familiar with lean thinking and performed 16 value stream mapping including 96 quick process improvement like Kaizen, that attracted participation of over 1300 medical staff in lean enforcement through lean strategic thinking [19].

Andersen introduced multi-skilled and multi-functional members equipped with lean strategic thinking as operational components caused to lean improvement in health care providing [17]. Crema enjoying external consultants experienced in problems, aims definition, computing activities based on PDCA cycle and collected information analysis organized a full-time internal team and drew a cycle for improvement of patient care through lean strategic thinking which enforced in Italian teaching hospitals [24].

"Daily quick relationships between team members" variable had the highest loading factor following CFA of lean team effectiveness factor. In the study by Chiarini, the lean team could reduce transportation waste and subsequently hospital-acquired infection through quick mutual relationships and flexible coordination [15].

Yousri revealed in the study that keeping orthopedic and anesthesia team coordinated and waste reducing through elimination of delays in operating rooms caused efficiency and function improvement [25].

In the study by Sloan, effective relationships between lean team members for waste identification and establishing appropriate interaction with redesigning engineers in pathology department tended to related waste identification

and redesigning based on lean principles [14].

Following EFA and CFA of variables of lean culture factor, "senior management commitment in following-up changes required for development of hospital lean plans" had the highest loading factor.

These results confirmed the findings of Eriksson, Andersen, Dart and Aij. In the study by Eriksson, senior manager of every three Swedish teaching hospitals enjoyed collaboration between first line and second line managers, clinical key persons like physicians and change agents to impact on treatment process and participation among juniors in lean projects [20].

Andersen introduced lean culture as one of the main principles of lean management and acknowledged senior management commitment to develop lean plans recognized by all staff [17]. Dart indicated that support of employers by senior and middle managers could inspire motivation and increase participation in performing lean principles [19].

In addition, Aij accounted that supporting experienced managers of healthcare system play a significant role to guarantee successful implementation of lean principles in the largest teaching hospital in the Netherlands [21].

EFA of organizational policy factor variables specified "staff development and training policy" with the highest variance. So, the most prominent lean facilitators are holding employee training courses and paying attention to employees' development and retraining under the umbrella of other supportive policy of organization, like mentioned by Aij, Shortell, Holden and Crema.

The highest loading factor of organizational policy factor variables is "beneficiaries' participation in strategic continuous improvement". Andersen examined relative significance of empowerment practices for lean intervention through interview with three beneficiary groups including managers, internal consultants and external employees and concluded that lean management is introduced by managers, exchanged by internal consultants and implemented by employees and is more developing than static [17]. Hicks surveyed on the opinion of beneficiaries about implementing lean principles in designing a structural model for healthcare centers. Raising efficiency and effective consequences to identify beneficiaries and their needs and improving evaluation criterion for lean planning was the result [28].

Following EFA of control factor variables, "using an audit checklist visible for staff " had the highest variance. In this way Skeldon using an audit checklist could improve quality supervision and increase length of visit by every physician and average proportion of value added time of every visit in comparison with pre-lean implementation [16].

Through elimination of undesirable care processes for cancer patients in a public center by Zhu using visual management such as redesigning related pamphlets and appointing nurses dedicated for patient education, reengineered work process in a teaching cancer treatment center and increased patient admission up to %30 [18].

According to Schonberger, visual management tools such as one-page patient handout classified as one of the most prominent lean methodology [13].

Following CFA of control factor, the highest loading factor went to "key performance indicator" variable. In order to implement different lean versions in public hospitals in Norway, Andersen introduced control mechanism as one of the lean fundamental dimensions in which periodic supervision and assessment of health care providing process managed based on key performance indicators such as customer focus, team work and palpable measures including concrete quick results [17].

To assure continuous development based on lean thinking, Holden used supervision and control techniques including collection of data from patients' medical records and related processes, weekly review of consequences related to quantization of processes visible to the public, testing performance based on indicators, drawing quarterly auditing, in emergency department of teaching hospitals in The US, Australia and Canada [23].

Laying out a change management plan by senior managers and monitoring developing procedure by lean teams prevent disruption in control performance indicators as the most significant control factor variable, since the main challenges when implementing lean is more individuals and their acceptance of change rather than process factor. Meanwhile, it should be accented that internal factors are not always considered as the effective or deterrent factors of lean implementation.

Certainly, implementing a successful lean programs in hospitals requires continuous communications and decisions of officials and organs playing role on hospital final output that is a healthy person including private sector and external factors such as dominated circumstances, specifically upstream policies, strategies and financial and moral support particularly for teaching hospitals, dedicated budget granteed by MOH and medical universities to create necessary infrastructures. The highest loading factor goes to supplier factor and suppliers flexibility variable.

Since the supplier factor measures the supply chain responsiveness according to accidentally changed request, information and medical equipment, it is recommended to design and manage the supply chain especially in teaching hospitals dealing with shortage of resources in three processes including information management, supply management and relation management and measure performance of supply chain qualitatively and quantitatively.

With no attention to factor analysis of requirements, infrastructures and organizational necessity of current circumstances, this proposed confirmatory model presents factors affecting lean implementation in the mentioned hospitals. Considering organizational necessities and required

infrastructure hospital managers should apply self assessment system to analyze the current circumstances and determine the gap between optimal circumstances with the current one and clarify the importance of implementation lean management in hospital.

CONCLUSION

Public hospitals as a part of national healthcare system impose a heavy financial burden on government. So, managers of public hospitals try to minimize expenditure and maximize functional efficiency and provide their services with high quality, competitive cost and timely delivery of appropriate care. Achieving this goal, lean management should be implemented as one of the most developed management system that is comprehensive and is on the top of other management techniques. According to the results of this study, effective factors including waste, process, medical equipment suppliers, lean culture, lean team effectiveness, organizational policy and control are significant for lean management in teaching hospitals, and these hospitals seeking to implement lean management as a new approach, applying self-assessment system to assess related infrastructures to determine a gap between current circumstances and optimal circumstances and indicate real position of hospital to establish proposed lean management model.

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Table 1: Specific Values, Variance Percentage, and the Cumulative Variance Percentage of Identified Factors

Factors	Specific value	Variance percentage	7Factors Cumulative Variance %
Waste	4.70	10.038	10.038
Process	4.69	10.016	20.054
Medical equipment suppliers	3.41	8.266	28.320
Lean team effectiveness	3.36	8.173	36.493
Lean culture	3.30	7.358	43.851
Organizational policy	3.10	7.199	51.05
Control	1.98	5.960	57.01

Table 2: Main factor loading & Factor Loading for Items in Exploratory and Confirmatory Analysis

Main factors	Factors	Abbreviation	Exploratory loading factor	Confirmatory loading factor	Confirmatory loading main factor
Waste	The waste of waiting	W1	0.477	0.483	0.714
	Medical supply waste	W2	0.635	0.452	
	Transportation waste	W3	0.741	0.681	
	Waste in the service process	W4	0.513	0.643	
Process	5s	P1	0.635	0.552	0.851
	Technical training to operators for preventive maintenance	P2	0.597	0.642	
	Setting up general system for a repairment and preventive maintenance	P3	0.616	0.710	
	Value stream mapping	P4	0.519	0.730	
	Workstation design ergonomics	P5	0.521	0.660	
	Warning system to prevent medical error	P6	0.565	0.694	
	Setting standard working protocol for healthcare services	P7	0.478	0.606	
Medical equipment suppliers	Suppliers' flexibility	S1	0.583	0.859	0.925
	Quality preference	S2	0.646	0.774	
	Mutual commitment between hospitals and suppliers	S3	0.615	0.766	
	Keeping long-term relationship with suppliers	S4	0.620	0704	
	Suppliers' awareness of hospital development plan	S5	0.541	0.780	
	Suppliers assessment	S6	0.541	0.785	
Lean team effectiveness	Holding short-term meetings for teams	T1	0.508	0.675	0.893
	Quick connections between members	T2	0.604	0.744	
	Enjoying suggestion management system	T3	0.593	0.719	
	Updating standard team activity	T4	0.515	0.661	
	Enjoying strategic thinking in teams	T5	0.689	0.726	
	Continuous training of members	T6	0.595	0.678	
	Lean Implementation by teams	T7	0.575	0.728	
	Delegation to lean teams	T8	0.616	0.726	

	Developing team work culture	T9	0.601	0.668	
Lean culture	Recognition of organizational key values by employees	C1	0.561	0.627	0.894
	Promoting safety culture to prevent medical error	C2	0.506	0.710	
	Change acceptance culture	C3	0.490	0.751	
	Promoting customer orientation	C4	0.472	0.716	
	Senior management commitment to develop lean plans	C5	0.677	0.815	
	Efficient contact procedures among employers	C6	0.601	0.749	
	Motivating employees to implement lean plans	C7	0.666	0.756	
Organizational policy	Participative management approach	P1	0.636	0.789	0.880
	Lean strategic planning in hospital	P2	0.655	0.755	
	Beneficiaries' participation in strategic continuous improvement	P3	0.683	0.823	
	Senior management active participation in audits	P4	0.537	0.750	
	Decision-making policy based on organizational long-term goals	P5	0.606	0.798	
	Strategy of identifying and removing potential risks	P6	0.656	0.815	
	Senior management policy for employee training	P7	0.686	0.762	
	Regular organizational planning for general preventive maintenance and repairment	P8	0.635	0.742	
Control	Daily visits based on work standards	Ct1	0.588	0.677	0.838
	Visual control of patient marker systems	Ct2	0.630	0.678	
	Installing audit checklist visible for staff	Ct3	0.738	0.771	
	Key performance indicators (Safety, Quality, Service Providing, Cost, Professional ethics)	Ct4	0.671	0.825	
	Employees' self-assessment system	Ct5	0.663	0.766	
	Safety analysis report	Ct6	0.594	0.775	

Table 3: Goodness of fit indices

CFI	AGFI	GFI	RMSEA	χ^2/DF	P
0/95	0/90	0/91	0/04	2/00	0/001

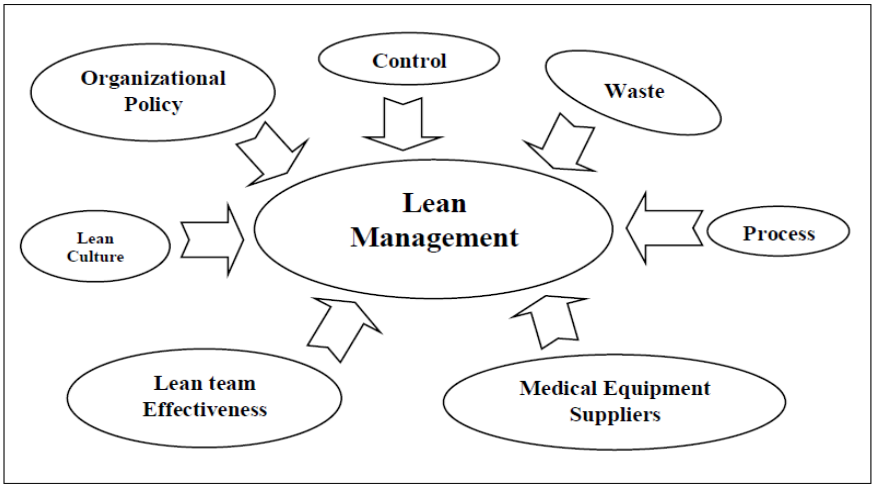

Fig.1: The schematic diagram of factors affecting lean management in SBMU teaching hospitals