A Conceptual Model for a Hybrid Knowledge-Based System for Quality Management at Healthcare Environment

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Abstract

Healthcare organizations have adopted and applied different quality tools and models in recent times, with some even developing their own quality-based initiatives. For example, the approach of Lean Six Sigma (L6σ) has recently been implemented gradually and slowly in healthcare institutions. However, the nature and complexity of healthcare environment which directly impact on humans requires leaders/managers to carefully apply appropriate quality management systems suitable for this critical environment.

This paper aims to assist the healthcare leaders/practitioners in decision making for achieving benchmark standards, through a novel methodology of Artificial Intelligence (AI)/Knowledge Based system,. The paper proposes a conceptual model for Quality Management in a Healthcare Environment (QMHE). This conceptual model will be the framework for designing a hybrid Knowledge Based (KB) - Analytical Hierarchy Process (AHP) - Gauging Absence of Pre-requisite (GAP) system for Lean Six Sigma (L6σ) driven QMHE.

The paper will present an original and novel approach (KB/ES coupled with AHP and GAP analysis) for designing and implementing L6σ in QMHE. The KB system embeds GAP for benchmarking (evaluating the existing practices with the benchmarked ones), and AHP for prioritization of implementation.

The proposed KB system will benchmark the current position of QMHE with the ideal benchmark one (resulting from extensive evaluation by the KB/GAP/AHP system of international quality concepts in healthcare organizations).

Keywords

Lean Six Sigma (L6σ), Quality Management in Healthcare Environment (QMHE), Knowledge Based (KB) System, Gauge Absence Pre-requisites (GAP), Analytic Hierarchy Process (AHP).

1. Introduction

Healthcare systems have been under accumulative pressure to advance performance by controlling healthcare costs and ensuring high-quality services and better access to care (accessibility) at the same time (Chilingerian and Sherman, 2011). Integrated health systems are commonly considered to run trustable performance in terms of quality and patient safety as a result of effective communication and standardized protocols within hospitals (Gillies et al., 2006).

This paper propos a hybrid Knowledge-Based System (KBS) using an Expert System (ES) shell, combined later with Gauge Absence Prerequisites (GAP) and Analytic Hierarchy Process (AHP) methodologies to integrate the above factors with a view of achieving benchmark standards in healthcare.

1.1 Quality Management at Healthcare Environment (QMHE)

Healthcare management is no stranger to transformational efforts like TQM and process reengineering (Bigelow and Arndt, 2000). '*TQM has become something of a social movement and it has spread from its industrial origins to health care organizations, public bureaucracies, non-profit organizations and educational institutions* (Hackman and Wageman, 1995). Rao (2015) emphasized that although TQM has wide applicability in healthcare and extensively researched, there is no consensus on the definition of TQM in healthcare. Thus, healthcare organizations have adopted and applied different quality tools and models with some of them even developing their own quality-based initiatives.

Today, the most popular quality movement in the USA and many other countries is Six Sigma (6σ) (Black and Revere, 2006). 6σ began to be implemented gradually and slowly in healthcare institutions 2000 onwards (Black and Revere, 2006). Although, principle of 6σ can be found in the quality pioneers' writings like Deming and others since 1980s, Revere et al. (2004) claimed that 6σ emerged from the fertile environment created by the TQM movement in US healthcare organizations in which there was high need for significant, continuous improvement in the quality of patient care outcomes, processes, and services. Some operational inefficiencies are because of the direct health care service delivery process where as others are associated with administrative and operational health care system (Koning et al., 2006).

In the UK, the National Health Service (NHS) has implemented a number of quality improvement concepts, most notably 6σ and, more recently, Lean (Proudlove et al., 2008). Like 6σ, healthcare institutions adopted Lean system values from manufacturing (Vest and Gamm, 2009). Much of the attention is focused specifically on work processes, quality, and efficiency. Implementation of Lean in healthcare and the broader public sector are often stated (Radnor et al., 2006).

Another such example is the Swedish health care which has established in the last decade a measurement system for following up lead-times in order to deal with long waiting times and delays (Kollberg et al., 2006). They added that the first step in applying Lean thinking in health care to place the patient in the center and include time and comfort as key performance measures of the system.

1.2 Lean Six Sigma (L6σ)

Lean Six Sigma (L6σ) as a phrase is known to define the integration of L6σ concept of quality. It is about getting and achieving service improvements rapidly with its focus on customer's value. Snee (2010) defines it as '*a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results'*. The integration of lean and 6σ aims to target each and every opportunity for improvement in particular organization and attempts to provide empowerment even at the higher-level process analysis stages (Pepper and Spedding, 2010). Lean will help to reduce work lead times, remove all practices of waste, reduce setup times, and map the value stream (services line in hospital area). In addition, 6σ can add value to Lean by utilizing data in decision-making and use methodologies that enhance a scientific method to quality (Arnheiter and Maleyeff, 2005). George and George (2003) highlighted three reasons '*Why Services Are Full of Waste'*: Service processes are usually unhurried processes, which are expensive processes; service processes are slow because there is far too much work in process often the result of needless complication in the service proposing; and in any slow process, 80% of the delay is caused by less than 20% of the activities.

1.3 GAP and AHP

GAP analysis is a methodology to assess the gap between the manufacturer's (services at healthcare organizations) necessary pre-requisites for benchmark implementation compared to its current status level (Mohamed, 2013). In any type of application, an audit should be conducted to assess the gap between what actually exists in a specific environment and the essential or desirable prerequisites for effective implementation (Milana et al., 2014, J. Aldairi, 2015, Kochhar et al., 1991). After this GAP analysis audit, Problem Category (PC) should be detailed into two reports: all positive elements and procedures already existing in one report and all negative elements representing non-existence of data, poor systems in the other report (Khan, 1999).

Saaty (1980) defined AHP as a systematic analysis method established for multi-criteria decision. Bautista (2007) organized the analytical thought based on hierarchy construction, priority setting and logical consistency. Wang et al. (2007) summarized the steps of AHP as: determining and structuring of all elements interfering into the decision-making problem, developing judgment matrices, computing of local priorities and getting alternatives ranking. AHP technique processes the complex decisions to a series of pair-wise comparisons until it grasps the decision by giving a clear rationale for the judgements being concluded (Aguilar-Lasserre et al., 2009).

2. Research Background

According to Irfan and Ijaz (2011) the high level of patients' expectations about the service quality had pressured the healthcare service providers to detect the key factors that are essential to raise healthcare services that root patients satisfaction and decrease time and money involved in managing patient's complaints.Brown and Patterson (2001) raised a major controversy in the famous report, *To Err is Human*. The report recognized healthcare error as a major public health subject leading to the death of at least 44,000 and perhaps as many as 98,000 Americans each year in US hospitals.

The National Health Service (NHS) in the UK distributed a report in June 2000 detecting the important effect of adverse events in the NHS (Baker and Norton, 2002) and (Vincent et al., 2001). Integrated health systems are commonly considered to run trustable performance in terms of quality and patient safety as a result of effective communication and standardized protocols within hospitals (Gillies et al., 2006). They concluded that health plans used in the care delivery system is related to clinical performance measures but does not consider patient perceptions of care which is supposed to consider by this project system. They (Suter et al., 2009) recommended that current knowledge on health systems need to be integrated to advance effective service delivery with evidence-informed decision-making as an expectation in healthcare management and policy (Cookson, 2005).

The Oman's Health vision 2050 report (Health, 2014) highlighted a number of challenges for enhancing and developing health research which will reflect on the quality of healthcare such as: insufficient funds, lack of research prioritization with the national plans, poor coordination between MOH and other healthcare organizations within Oman, poor communication of research results, limited research topics implemented, insufficient follow-up of the outcomes and weak of research culture among health care providers.

The originality of this research is to outspread the use of KBS with GAP and AHP to design an integrated KBL6σ-QMHE to be used in healthcare environment. This will accomplish the necessities of investigating quality problems and recommend suitable solutions according to international best practices. The proposed system will benchmark the current position with the ideal framework resulting from extensive evaluation of international quality concepts that are applied in healthcare organizations, thereby recommending some solutions to overcome the identified gaps. Hence, the research will provide an active decision support system that will assist top management, quality managers, and practitioners in the healthcare organizations to arrange and monitor their performance and enhance their productivity towards a benchmark standards.

3. The Conceptual Model

Principally, this paper concentrates on suggesting a Conceptual Model for KBL6σ of Quality Management at Healthcare Environment because no such model exist for implementing L6σ to assess quality at healthcare organizations. The Conceptual Model will be divided to three stages as:

3.1 Planning Stage

As Figure 1 shows, the researcher is going to consider three areas in planning stage: organization's statement, allocating resources, and assessment of quality dimensions. In this stage, general information on the organization will be addressed in order to assess strategic competencies and readiness to change into the L6σ quality management system.

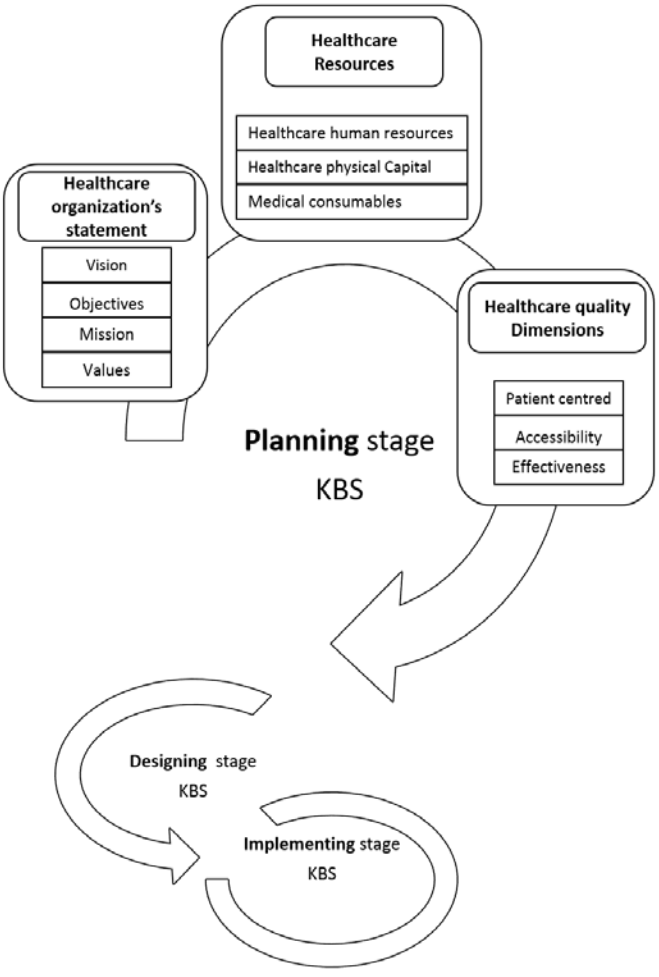

Figure 1 Planning stage of the Conceptual Model

3.2 Designing Stage

After a systematic review of different healthcare standards such as: Joint Commission International (JCI) (JCI, 2010), Accreditation Canada International (ACI) (International, 2016), National Health Services (NHS) (NHS, 2011), and Saudi Arabia Healthcare standards (Council, 2006), and since the aim of this research is to overcome the quality management issues at healthcare organizations, the research will focus on Governance standards and Leadership standards to cover all possible quality management perspective issues. The research will depend on ACI standards to apply both perspectives.

Governance is an entity (for example, a ministry of health), an owner(s), or a group of identified individuals (for example, a board or governing body) responsible for overseeing the organization's operation and accountable for providing quality health care services to its community or to the population that seeks care. This entity's responsibilities and accountabilities are described in a document that identifies how they are to be carried out (JCI, 2010).

After that, GAP and AHP techniques will be used in such approach with statements of positive implementations. This has driven the mission by inserting both methods into the KBL6σ of quality management at healthcare conceptual model as Figure 3-2 shows.

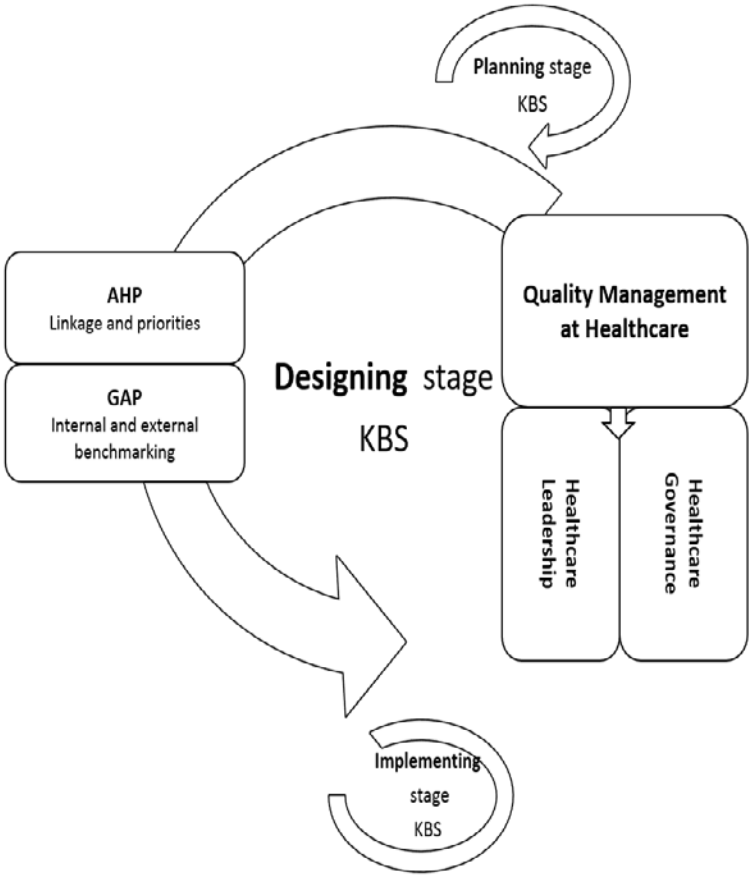

Figure 2 Designing stage of the Conceptual Model

3.3 Implementing Stage

The KBL6σ-QMHE system will measure the L6σ Pre-implementing stage in the healthcare organization by three items: its ability to select and identify the services needed based on the patient and employees requirements and needs, its ability to draw value streams and the matching of its prioritization to patient and employee's needs. Moving to second part, George and George (2003) summarized the phases of deployment as occurring into four phases:

a. Readiness: Detecting all the influences that should be reflected when structuring how L6σ will be used to more efficiently implement the organization's strategy.

b. Engagement: Getting people enthusiastic about L6σ by practicing its role in assisting them attain their annual and quarterly goals.

c. Mobilization: Founding the organizational set-up and getting other elements in place for deployment.

d. Performance and Control: Applying deployment plans, creating control measures and processes to guarantee that L6σ improvements sustain and that efforts continue closely bring into line with business strategies.

In the Evaluating stage, a process called DMAIC will be used as a tool to improve L6σ process in the healthcare organization. This process can be explained as: *Define* which process or product that needs improvement, *Measure* data that help set priorities and criteria, *Analyze* carefully required measurements, *Improve* result of analysis accordingly and *Control* if the implementation was successful and make sure that improvement is continuous over time (Lin et al., 2013).

Figure 3 shows the conceptual model of implementation stage that contains three sub-stages of implementing L6σ in healthcare environment.

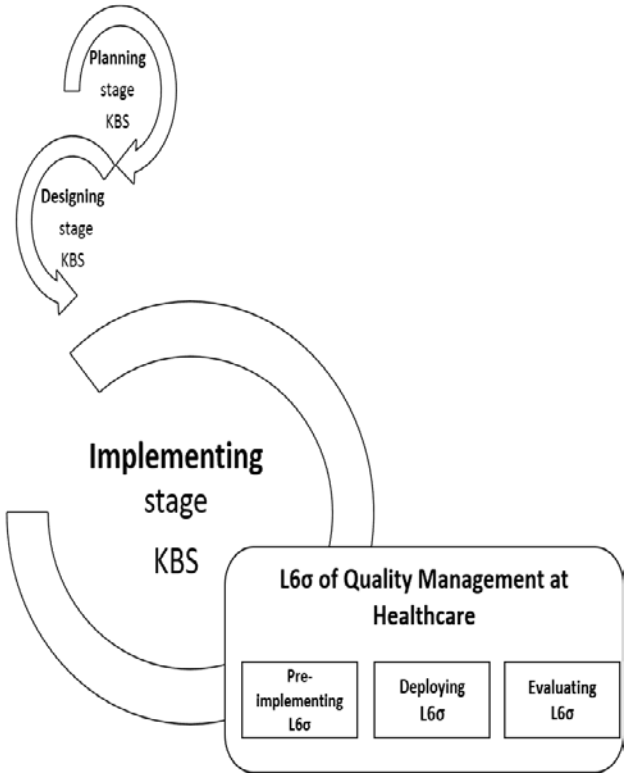

Figure 3 Implementing stage of the Conceptual Model

4. Methods and Techniques in Developing the KBL6σ-QMHCE

KBS is one of the Artificial Intelligence concepts and methodologies. The final goal of KBS is to capture and embed experts' experience into a single knowledge base (Chapman and Pinfold, 2001). It is derived from various sources such as human expert, research papers, and books (Comesaña Benavides and Carlos

Prado, 2002). Sunnapwar and Kodali (2006) emphasized that ES/KBS should be implemented carefully because it is expensive and relative investments are not reversible. Currently, KBS is widely applied in business organisations to facilitate the decision making process (Udin, 2004, Moud Nawawi, 2009) because it is a time-saving and repetitive decision-making tool. It makes uncommon expertise more commonly available and provide beginners a trusted information. By implementing KBS, there is no need to refer experts each time to get a very basic information. The approach of a KBS with GAP and AHP will improve the design and development of KBL6σ of quality management at healthcare organizations, which has not been executed in the past. Therefore, GAP analysis will simplify the benchmarking of the existing organization state with the preferred one, while AHP will be used to prioritize the suggested solutions based on GAP analysis and weightage criteria to achieve benchmark.

5. Conclusion

In order to produce an effective KBL6σ-QMHE system, this paper has defined the main practical steps representing strategic and operational phases. The model shows the planning stage in the strategic phase, in which the organization's statement is recognized and resources and healthcare quality dimensions are assessed. The phase is extended to include the designing stage, which includes the main area of this research that deals with the core assessment components of the KBL6σ-QMHE system (i.e., Governance perspectives) and how they interact with sustainability metrics. The implementation phase arises last to represent the operational side. The hybrid Knowledge-Based System (KBS) will be combined later with Gauge Absence Prerequisites (GAP) and Analytic Hierarchy Process (AHP) methodologies.

Future work will consider further development of the model to be applied practically in healthcare environments.

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Biography

Yousuf Al Khamisi earned a BsN degree in Nursing from the Sultan Qaboos University (SQU), Muscat, Sultunate of Oman. He also holds a MBA from the University of Birla, India. He has been involved with a number of quality management projects while working in Sultan Qaboos University Hospital, Oman. He is currently a PhD student within the School of Engineering, University of Bradford with research interests in Knowledge-based systems, Lean Six Sigma, quality management, and healthcare organizations. He is also a member of Automotive Research Centre within the School of Engineering.

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