CRANFIELD UNIVERSITY

ABDULAZIZ MARZOUQ ALMUTAIRI

A framework for implementing lean principles in supply chain at healthcare organizations

School of Aerospace, Manufacturing and Transport

PhD

Academic Year: 2019 - 2020

Supervisor: Dr. Konstantinos Salonitis

Associate Supervisor: Dr. Ahmed Al-Ashaab

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ABSTRACT

The aim of this research is to develop a framework to implement lean thinking in healthcare supply chain management (HSCM). The framework comprises four implementation phases namely; preparation state, assessment of the current state in terms of lean, developing the desired future state in terms of lean and steady (sustainable) state of new actions taken.

The developed framework covers the lean enablers, factors and the barriers that may hinder the lean implementation. The final edition of the framework was validated by three hospitals in Saudi Arabia. In addition, the developed framework includes model to assess leanness maturity of the HSCM. The HSCM leanness assessment model was developed by using multi-grade fuzzy approach. This approach consists of three levels; enablers, criteria and attributes. By using such approach, the HSCM leanness index was calculated and practices for further improvement were identified. Five enablers that are important for implementing lean principles in HSCM were identified. The enablers are medical management responsibility, healthcare supply chain processes management, medical human resource, consumer relationship and supplier relationship.

Nine lean barriers that are obstacle lean implementation include: existence of physicians' preferences, unpredictable patient demand, Inadequate knowledge and lack of understanding lean concept , identify type of waste through HSCM processes (delivering value to the patient), hospital culture and resistance to change, lack of hospital support, commitment and disbelief in lean , scarcity of qualified human resources and lack of training , assessment of the required level of leanness and lack of effective communication and information sharing. Prioritization and proposed solutions to overcome these barriers were provided. HSCM leanness assessment model was developed based on three levels: enablers, criteria, and attributes.

Mixed methods has been used as research methodology. The research has started with extensive literature review related to supply chain management and lean with focus on healthcare context. Next, the qualitative method was used during field study by using semi-structured and structured interview to capture the knowledge from experts (data collection).

The proposed framework enables decision-makers at healthcare providers to implement lean principles in supply chain management through a step by step process. Implementation of the framework will contribute significantly to improving the supply chain's overall performance, quality of work, reducing cost and eliminating wastes and on-time delivery.

Keywords:

Supply chain management, lean, healthcare, assessment, leanness, fuzzy logic, barriers, enablers.

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Abdulaziz Almutairi

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LIST OF ABBREVIATIONS

CBAHI	The Saudi Central Board for Accreditation of Healthcare Institutions
JCIA	Joint Commission International Accreditation
JIT	Just in Time
LSCM	Lean Supply Chain Management
SCL	Supply chain leanness
SCM	Supply Chain Management
TPS	Toyota Production System
VSM	value stream mapping
VM	visual management
RCA	Root-cause analysis
HSCM	Healthcare / hospital supply chain management

LIST OF PUBLICATIONS

JOURNAL PAPERS

1. Almutairi, A., Salonitis, K., and Al-Ashaab, A., (2019) "assessing the leanness of a supply chain using multi-grade fuzzy logic: a health-care case study", International Journal of Lean Six Sigma, Vol. 10 Issue: 1, pp.81-105.
2. Almutairi, A. Salonitis, K. and Al-Ashaab, A. (2019)" a framework for implementing lean principles in the supply chain at healthcare organizations: from Saudi Arabia's perspective" International Journal of Lean Six Sigma. (Published).
3. Almutairi, A. Salonitis, K. and Al-Ashaab, A. (2019)" barriers for implementing lean: prioritization and proposed solutions from Saudi healthcare' perspective." Total Quality Management & Business Excellence (accepted).

CONFERENCE PAPERS

1. Almutairi, A. Yuchun, Xu and Salonitis, K. (2016), "state-of-the-art insights for improving supply chain performance", Proceedings of the 10th conference of the Performance Measurement Association, Edinburgh, Scotland, 26-29 June 2016.
2. Almutairi, A. Yuchun, Xu. and Salonitis, K. (2017), "state-of-the-art lean six sigma practices", Proceedings of the 7th International Conference on Industrial Engineering and Operations Management pp. 5772 Rabat; Morocco (Scopus indexed)11-13April.
3. Almutairi, A. Yuchun, Xu. and Salonitis, K. (2017), "lean six sigma practices in supply chain", the 2017 International Symposium on Industrial Engineering and Operations Management (IEOM) pp. 218-220, Bristol, UK, July 24-25.
4. Almutairi, A. Salonitis, K. and Al-Ashaab, A. (2018),"Enablers and Main Factors for successful implementation lean principles in hospital supply chain: a Saudi case", the 8th International Conference on Operations and Supply Chain Management, Cranfield, UK, 09 - 12 September 2018.

1 Chapter One: Introduction

1.1 Introduction

The aim of this chapter is to present the sections below as illustrated in Figure 1.1.

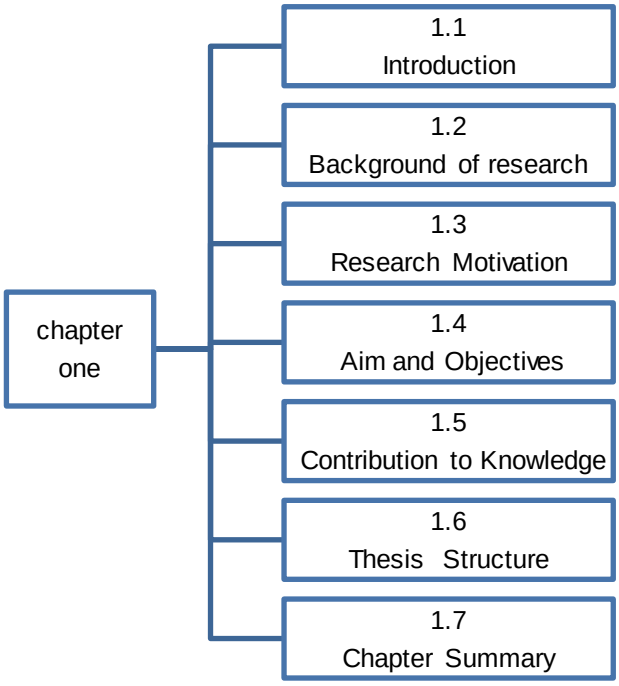

Figure 1.1 main sections of chapter one

1.2 Background of research

In health care sector, supply chain management (SCM) has always been important factor and key dimension to improve the performance of health-care organizations. Improving the efficiency of hospital supply chain management (HSCM) will enable organizations to offer better patients' services and reduce their inventories and costs. Health-care operating costs are increasing at a faster rate than other services or products, and health-care organizations are under continuous pressure to improve patient safety, reduce waiting times, cut operational costs, improve their services, and minimise errors (Salam & Khan 2016).

Lean is a widely known quality improvement approach initially used in the manufacturing and automotive industries but lately expanded to the health-care

sector (Moraros et al., 2016). Borges et. al., (2019) mentioned that there is a agreement on the potential of lean practices implementation in hospital supply chain. Womack and Jones (1996) recognize five basic principles of lean in their book Lean *Thinking*. The principles are "precisely specify *value*, by specific service/product, identify the *value stream* for each service/product, make value *flow* without interruptions and let customer *pull* value from the producer and pursue *perfection*"

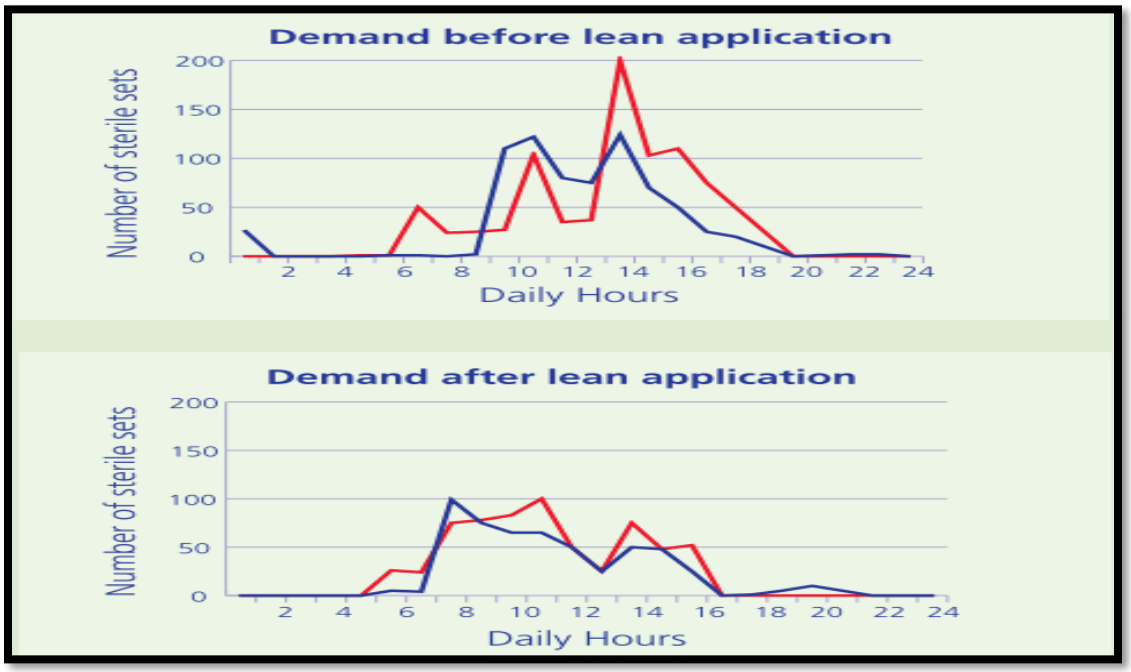

Figure 1.2 Number of sterile set before and after lean implementation (Westwood et al., 2007)

The number leaving theatre

The packs arriving at sterile services

Figure 1.2 shows lean implementation in Mayday Healthcare NHS Trust in sterile services. The chart clearly shows to what extent implementing lean approach is important for patients. The blue line shows the number leaving theatre and the red line the packs arriving at sterile services. It is clear from chart at the number of sterile sets was reduced after implementing lean. Many benefits were obtained from lean implementation including: the flow was improved, better availability, demand was smoothed, job was made easier and most work arrives on time.

Table 1.1 Saving resulted from lean implementation (Westwood et al., 2007)

Metric	Before change	After change	Improvement	Savings
Turnaround time (from receipt to results available)	62 -120 minutes	38 minutes	40% reduction	Equivalent to 2 beds a day

Table 1.1 shows 40% reduction was achieved after implementing lean in healthcare context and lean can save up to two beds a day.

Hereford hospitals achieved reduction in delay specimen reception Biochemistry, Figure 1.3. The maximum delay in minutes (blue line) after implementing lean was about 1 minute whereas previously was about 40 minutes before applying lean. Westwood et al., (2007) mentioned that Bolton Hospitals NHS Trust has

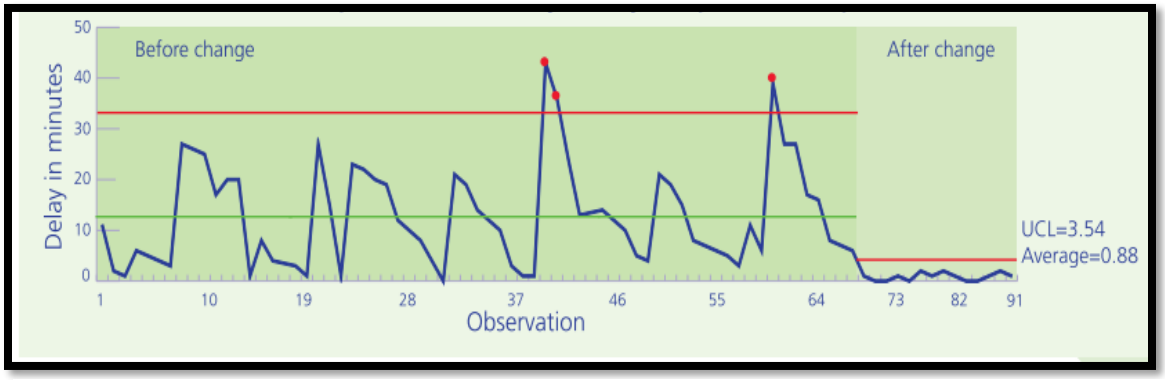

Figure 1.3 Hereford Hospitals - Biochemistry - Delays in specimen reception

applied lean approach and the following findings were achieved:

- **50%** reduction in hospital mortality for older patients.
- **37%** reduction in overall mortality for adult trauma patients.
- **32%** shorter length of stay.
- **30%** reduction in time from admission to theatre.
- **No** patients were transferred to the long-term rehabilitation ward.

The previous statistics and facts encourage and motivate the researcher to conduct his research in healthcare sector to take advantages of implementing lean approach in healthcare context.

Although patient care is the ultimate goal of hospitals, supply chain (SC) practices are crucial in guaranteeing availability, safety and affordability of medical

supplies. The right medicines and other medical supplies should be delivered at the right time, to the right patients and in the right condition (Moons et al., 2018). Currently, healthcare organizations are suffering from the rising cost of supply chain operations, lack of operational performance, growing costs of health-care services, patients' dissatisfaction with lack of inventory control, excess inventory levels, lack of information flow between parties, workflow interruptions, rework and increased health requirements that need to be solved to reduce overall costs and improve health-care services(Suárez-Barraza et al., 2012; Kritchanchai, 2012). The implementation of a lean thinking in HSCM setting delivers value for patients by providing value added and eliminating waste at reasonable cost. In lean, the focus is on eliminating waste to result in quicker flow, less variation, greater customer and shorter cycle time (Salam & Khan 2016). For a lean thinking process, steps that would not add value to the customer (patient in healthcare) should be eliminated through problem-solving for a streamlined process (Hurriyet et. al., 2020).

In the health-care sector, the importance of supply chain performance is rapidly gaining the attention of academics and practitioners alike. Lean is the approach of maximising value while minimising waste. Lean is a "dynamic process of change, driven by a set of principles and best practices aimed at continuous improvement" (Womack et al., 1990).

SCM can use the lean approach to reduce costs and improve quality and delivery (Salah et al., 2011). In the UK, NHS is using lean concepts to achieve their strategic goals (Antony et al., 2016). A lean supply chain management (LSCM) should allow a flow of medicines, medical equipment, services and technology from suppliers to patients without waste.

1.3 Research Motivation

Currently, healthcare organizations spend huge amounts of money to improve their performance and productivity in various fields. One of these fields is SCM. Poor operational performance is one of the main problems in SCM (Lai, Ngai, & Cheng, 2004; Sharahi & Abedian, 2009). In addition, a massive number of non-

value-added activities are executed throughout the SCM process. In hospitals, the costs of medical supplies are the second largest costs, after personnel (Moons et al., 2018). The lean concept can help eliminate wasteful practices across the supply chain (SC) activities.

The supply chain in healthcare organizations represents from 25 percent to 40 percent of hospitals' monthly budgets. Health-care organizations should improve their own SC to deliver materials and medications to their patients (Machado et al., 2014).

Hospitals have special features that impact the quality of patient care. For example, non-availability of medications or other medical supplies may postpone a surgical operation and probably results in hazards to the patient's health. Also, a shortage of stocks or overstocking of medical supplies causes supply chain inefficiencies and increases costs. Lega, Marsilio, and Villa (2012) pointed out the lack of literature on supply chain performance in public health-care institutions. Vries and Huijsman (2011) stated that the supply chain is a crucial and changing issue that impacts heavily on HSCM. A significant number of non-value-added (NAV) practices is executed throughout SC activities.

In a SCM context, the improvement of performance is becoming a must for those organizations looking for success. A high-performing supply chain may realize improved results (e.g. quality patient service and patient safety) and greater efficiency (Moons et al., 2018). Recently, the publication of descriptions of lean implementation in health care has significantly increased in the United States, Canada, Australia and the British National Health Service (NHS) (Filho et al., 2014). Lean is a continuous improvement approach that endeavours to improve speed, cost, quality, and patients' satisfaction(Gijo et al., 2013; Laureani & Antony 2017). In addition, a lean approach is a substantial practice to improve quality (Peter & Lawrence, 2002).However, recently, there is increasing concern about implementation failures in lean approaches in organizations (Sony et al., 2019; Albliwi et al., 2014; Laureani & Antony 2012).

One of the most important motivations for this research is that the developed countries are still focused on the lean approach as an improvement tool in their

health-care organizations. For example, lean is one of the most widely used continuous improvement tools in the United States and the United Kingdom.

Lean is utilized on a systematic basis across the UK's National Health Service (NHS), with a number of healthcare organizations stepping up to focus on organization-wide value systems to achieve their strategic goals. Lean implementation in a healthcare setting has become increasingly important in the existing body of research (Sobek & Lang, 2010). Also, Vries & Huijsman (2011) stated that the supply chain is a crucial and ever-changing issue for healthcare administrators, and has a significant impact on healthcare management.

1.4 Aim and Objectives

The aim of this research is to develop a framework to implement lean principles in supply chain management at healthcare organizations. Implementation of the framework will contribute significantly to improving the supply chain's performance, quality of work, reducing cost and eliminating wastes and on-time delivery.

To achieve this aim, the following are the objectives:-

1. To understand the best practices of healthcare supply chain management settings via a comprehensive literature review and case studies.
2. To determine the main enablers and barriers for healthcare supply chain management to implement lean thinking.
3. To develop a model to assess healthcare supply chain management leanness.
4. To assess leanness index maturity of the healthcare supply chain management leanness.
5. To develop a framework for implementing lean principles in healthcare organisations' supply chain management.
6. To validate the research outcomes via case studies and evaluated through experts' judgement.

1.5 Contribution to Knowledge

The originality of this research results from an addressing clear knowledge gap by developing framework that drives healthcare organizations in implementing lean practices in healthcare supply chain management in Saudi Arabia.

Contribution to the body of knowledge:

This research has presented a framework that drives hospitals in implementing lean practices in hospital supply chain management. Additionally, lean key challenges, main enablers and success factors were introduced. Furthermore, although the massive researches were published on leanness model, the existing literature fails to introduce an instrument or tool that can be used to assess the level of HSCM leanness.

Contribution to practitioners:

Supply chain management practitioners in healthcare organizations can benefit from findings of this research. Implementation of the framework will contribute significantly to improving the supply chain's overall performance, quality of work, reducing cost and eliminating wastes and on-time delivery. Additionally, flow of medical items, information flow could be improved. It will therefore reduce patients' waiting time, avoid shortage in necessary medical items and increase patients' safety. More details will be presented in chapter eight section five and six.

1.6 Thesis Structure

This thesis structured into seven chapters. The main contents of each chapter are illustrated below.

Chapter 1 Introduction: This chapter presents the background of the research and motivating to conduct this kind of study. The research aim and objectives are stated.

Chapter 2 Literature review: This chapter present the literature related to two main concepts of supply chain and lean to provide a deep understanding of the researched areas. Investigation of state-of-the-art in these areas enable the

researcher to identify existing research gap and better understanding of researched topics.

Chapter 3 Research Methodology: The chapter introduces the research methodology that has been developed to ensure that its design is suitable to achieve research aim and objectives and provide the answer to the research question. Also, justifications of approaches selected are illustrated.

Chapter 4 Lean implementation in HSCM: prioritization, barriers, proposed solutions and enablers: This chapter focuses on the main enablers and factors for the successful lean principles implementation in the supply chain are presented. Also, the main barriers that hinder healthcare organizations to implement lean practices in supply chain. At the end of this chapter, the results achieved are validated via expert's judgment.

Chapter 5 Supply Chain Leanness Assessment Model: In this chapter, the development of lean supply chain assessment model. The supply chain leanness index for three healthcare organizations has been calculated. At the end of this chapter, the assessment model and indices are validated.

Chapter 6 Framework of Lean implementation in Supply chain: This chapter shows the development of the framework by reviewing and understanding a number of relevant lean supply chain framework. Then, the initial framework was developed. Also, the current practices in three Saudi healthcare organizations. The initial framework is developed and revised based on data gathered from three healthcare organizations. The organizations have been selected based on a number of criteria.

Chapter 7 Validation of the framework: In this chapter, the key findings of this research are validated.

Chapter 8 Discussion and Conclusions: In this chapter, the key findings of this research are summarized. In addition, the contributions to the knowledge is presented. Accomplishment of the aim and objectives of this research is stated. The limitation and future work of this research are made.

1.7 Chapter Summary

This chapter has introduced a brief background about lean and supply chain concepts. The research drivers and motivation for carrying this research out are also presented. As a result, aim and objectives and question of research were identified.

2 Chapter Two: Literature review

2.1 Introduction

In the first chapter, the research background, motivation, aim and objectives were presented. The aim of this chapter is to understand the state-of-the-art in lean concept and the supply chain management (SCM) with focus on health-care context. These concepts represent the main two bodies of current literature which form the real core of this study. The areas surrounding these two concept were covered as well. The main sections illustrated below in Figure 2.1. This chapter addresses the first research objective which is understand the best practices of healthcare supply chain management settings via a comprehensive literature review.

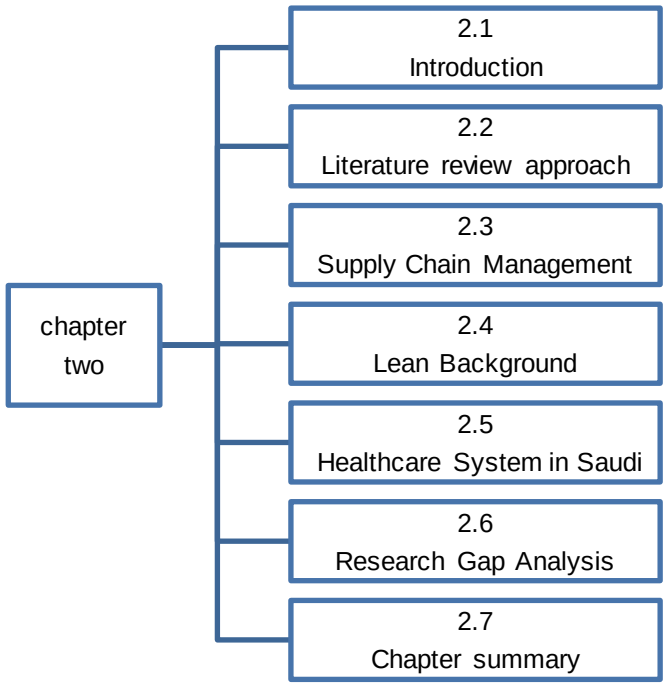

Figure 2.1 main sections of chapter two

2.2 Literature review approach

The research used several material sources, such as books, theses, reports, and many electronic sources, including Google Scholar, Emerald, Business Source Complete (EBSCO), Elsevier, Science-Direct, Scopus, and ProQuest. The reviewed literature was limited to cover the lean approach with context of supply

chain management with focus on healthcare sector. Keywords related to the topic were used: “lean”, “supply chain management”, “healthcare”, “hospital”. Non English articles were neglected.

A huge number of articles showed at the first round. The articles irrelevant to the aim of this research were excluded. The filtration process was conducted to remove redundancy by checking abstract and to what extent paper is related to the aim of research. The review mainly focus on lean implementation framework with focus on healthcare context. Lean supply chain management frameworks will reviewed and evaluated in chapter two and five for further details.

By carefully checking these articles many questions have raised including: what are differences between hospital supply chain management (HSCM) and other typical Industrial SCM, what are the main enablers, critical success factors and barriers for health-care organizations to implement lean practices in supply chain management, how to assess supply chain management leanness in health-care organizations and how to implement lean thinking in supply chain management in healthcare organizations. These questions were not addressed and this research will answer these at the end.

2.3 Supply Chain Management (SCM)

2.3.1 Introduction

The SCM plays a vital role in improving the performance of the SCM including reducing costs and increasing profitability through effective distribution. The optimization of an organization’s resources is one of the important roles of SCM.

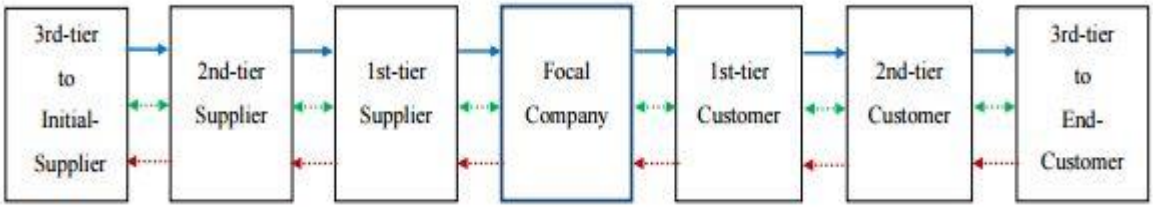

Figure 2.2 SCM Structure (Lambert & Cooper, 2000)

SCM starts from raw material through distribution until it reaches the customer (Hjaila et al., 2016). In general, there are three various continuous major in a normal SCM: material, information and cash flow.

2.3.2 Definitions

According to Jones & Riley (1985), “SCM deals with the total flow of materials from suppliers through end users”. While (Mentzer et al., 2001) defined SCM as “ a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flow of products, services, finance, and/or information from the source to a customer”. Monczka et al., (1998) indicated that SCM can be defined as “a concept whose primary objective is to integrate and manage the sourcing, flow, and control of materials using a total systems perspective across multiple functions and multiple tiers of suppliers”.

The Council of SCM Professionals defines SCM as follow: “SCM encompasses the planning and management of all activities involved in sourcing, procurement, conversion, and all logistics management activities. Importantly, it also includes the coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, SCM integrates supply and demand management within and across companies.

SCM is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all the logistics management noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology.”(Kate, 2013).

Although most SCM definitions differ, they agree on many points: SCM starts with the raw materials to end users and seeks to meet customers’ needs, Table 2.1. SCM plays a crucial role in achieving competitive advantage and optimising an organisation’s resources, and has is significant in enhancing organizational performance as a whole.

Table 2.1 supply chain management definition

Author(s)	**Definition**
Larson (2003)	"A set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements."
Christopher (2005)	"The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the SCM as a whole."
Stadtler (2008)	"The task of integrating organizational units along a SCM and coordinating material, information and financial flows in order to fulfil (ultimate) customer demands with the aim of improving the competitiveness of a SCM as a whole."

Source: researcher (2018)

2.3.3 The Importance of SCM

Today, SCM is vital to success at any organization. Enhancing organisational profitability and productivity deeply depend on SCM. SCM is one of the most competitive areas for any business organization (Punniyamoorthy et al., 2013). In addition, SCM is considered a cornerstone of any organization. As such, any imbalance in SCM will be lead to a real hurdle when trying to attain high levels of performance. It is worth mentioning that the importance of SCM must be taken into account in terms of the sensitivity and importance of the health care sector. For example, SCM in healthcare sector is more important than in the petrochemical sector (Awasthi & Grzybowska 2014).

According to Mellat-Parast & Spillan (2014), SCM plays a vital role in the capability of companies to be competitive with respect to market share. William et al., (2005) mentioned that successful SCM has brought about a set of benefits involving elevated client value, raised profitability and decreased levels of average inventory and cycle times. Vries & Huijsman (2011) indicated that current research has indicated a considerable part of the costs linked to SCM in the health care sector can decrease by applying effective SCM. Pasutham (2012) pointed that companies have improved the principles of SCM substantially. SCM is more and more significant to business operations that supply services and items to end clients.

According to Fawcett, Magnan & McCarter,(2008) there are many benefits from successful SCM, such as on-time delivery, responding to customer orders, customer satisfaction, order fulfilment lead time, purchased item cost, organisational profitability, dealing with unexpected issues, costs of inventory, increased revenues, reduced logistics cost and decreased order cycle time.

SCM for healthcare providers is vital to either the success or failure of an organisation and has many advantages. Jahantigh & Malmir (2015) found that health care providers which applied SCM successfully reduced storage usage by 50% while increasing on-time delivery by 40%. A nine-fold decrease in out-of-stock rates was also achieved.

2.3.4 Healthcare SCM

Recently, SCM has received considerable attention in the healthcare sector. Expenditures for healthcare materials and supplies have constituted up to 45% of a healthcare's operating budget (Kowalski, 2009). With the expected growth direction, healthcare systems may in the near future spend more on their SCs than on labour (DeJohn, 2009). As a result, SCM has become one of the most significant areas for the executive leadership and decision makers of hospitals (Barlow, 2010c).

According to Lee & Schniederjans (2011) the SCM in healthcare can be defined as "a set of approaches to efficiently integrate suppliers or venders, transport, hospital services (including outpatient, emergency, in-patient, laboratory, radiology, stores and purchases, food, laundry and medicines/equipment) to achieve Total Quality Management (TQM) in healthcare services by optimum utilization of resources". SCM in healthcare consists of operations and activities that ensure raw materials and services flow seamlessly and continuously to deliver healthcare needs (Lee & Schniederjans, 2011). SCM among healthcare providers encompasses internal and external chains. The internal chain contains, for example, storage, patients and patient care sections. The external chain contains manufacturers, suppliers, distributors and others (Schneller & Smeltzer, 2006).

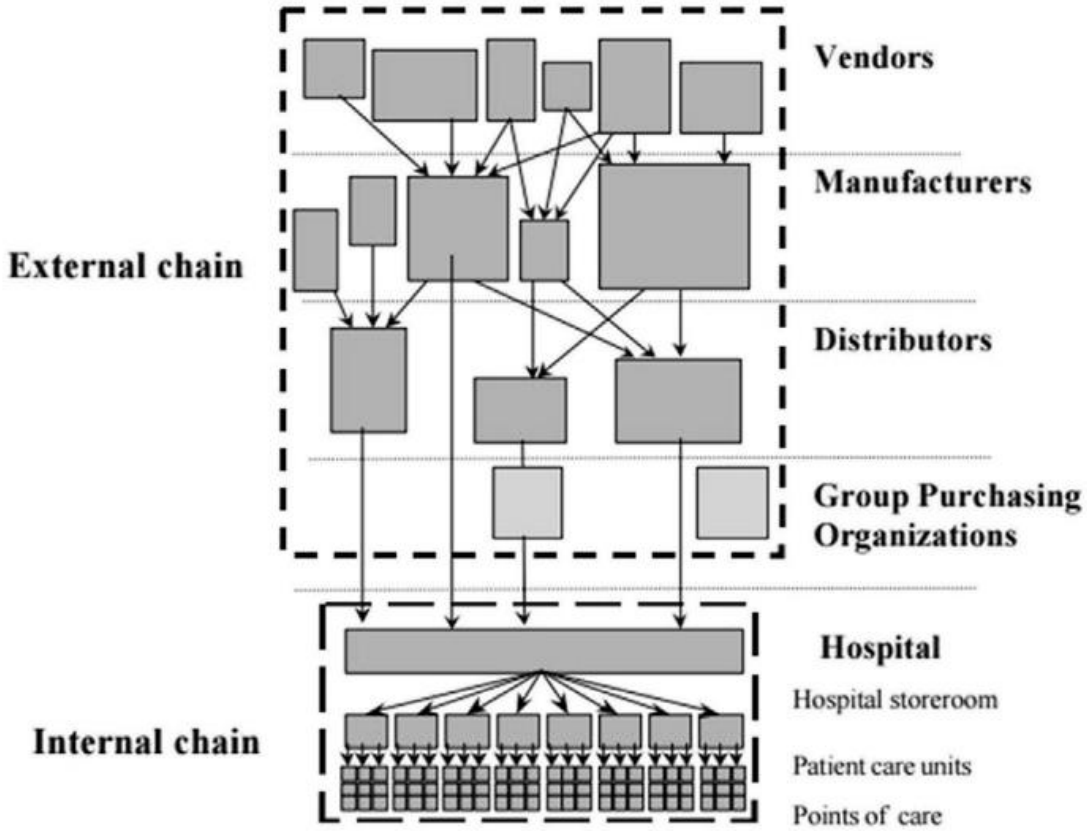

Figure 2.3 Healthcare SCM (Gonul Kochan et al., 2018)

Hospital SCM processes have three types of flows: “information flow, financial flow, and physical product flow” Information and financial flows are related to SCM design decisions for effective physical product flow and improved organisational performance. While the physical product flow manages customized services and products for the treatment of patients requirements and their needs. (Singh et al., 2006; Kowalski, 2009; Lee et al., 2011).

Joint Commission International (JCI) Accreditation Standards for Hospitals defined SCM as “SCM is key to ensuring the safety and quality of the hospital’s supplies. The SCM includes the steps from origination to delivery of supplies to the hospital” (JCI, 2017) While Pinna et al., (2015) defined SC in healthcare, in line with this study, as “upstream and downstream relationship with supplier and customers and to solving problems of functional divisions that occur within and between organizations”. Figure 2.3 shows the overall SCM process in the healthcare sector from the first step, raw material, up to reaching the end users.

Over recent the quality of healthcare services has become a globally vital concern, especially with increased worries about the escalation of medical cost, medical errors and patient safety. Implementation of effective SCM in the healthcare sector can lead to benefits. There is a general consensus that SCM brings added value to healthcare organizations, improving competitive advantage and organizational performance (White & Mohdzain 2009; Vries & Huijsman 2011). Furthermore, saving a considerable amount of money is one of the benefits when SCM is applied effectively in the healthcare sector (Oliveira & Pinto 2005; Al-Saa'da et al., 2013).

In addition, many researchers show the importance of SCM in healthcare and its role in preventing medical errors, improving healthcare provider (hospital) performance, decreasing waste, producing value added operations, improving operational efficiencies and helping to improve quality of care (Ford & Scanlon, 2007; Mustaffa & Potter, 2009; Kumar, Ozdamar, & Zhang, 2008; White & Mohdzain, 2009; Al-Saa'da et al., 2013).

In recent year, due to the complexity of SCM in healthcare, the integration upstream and downstream has become increasingly significant. Healthcare providers and firms have to do accurate tasks as cost of mistake might be people's life(Kritchanchai, 2012; Turhan & Vayvay, 2009). The health care sectors are usually depicted as a different from other service providers. The healthcare providers have distinguished by sets of specificities that undoubtedly impact the area of SCM(Lega et al., 2013).

2.3.5 Hospital SCM (HSCM) and other typical Industrial SCM

Although the HSCM shares several similarities with other industry SCM, there are differences in HSCM that are related to specific characteristics and requirements (Matopoulos & Michailidou, 2013). Health care sectors are usually depicted as different from other service providers, as healthcare providers are distinguished by sets of specificities that undoubtedly impact the area of SCM (Lega et al., 2013). Healthcare organizations are the place where mistakes and errors cannot be tolerated. A simple error can cost a person their life, so mistakes and defects

must be eliminated from any department in healthcare organizations including SCM. Because the sensitivity of HSCM, healthcare providers have to complete accurate tasks because the shortage in medical supplies is not acceptable as it directly affects the patients' safety and health and the cost of a mistake might be people's lives (Kritchanchai, 2012; Turhan & Vayvay, 2009).

The healthcare sector has historically sighted itself as different from other sectors in terms of operations (de Vries et al., 1999). There are different factors that make SCM in healthcare providers different from others. First, clinical variability is connected to the presence of several illnesses, riskiness levels and responses to remedies. Secondly, some of departments are impossible in terms of predicting demand because it changes from time to time (patient flow), such as an emergency department. Next, due to different predilections, approaches and abilities between care professionals, the SCM is unstable (Litvak & Long 2000; Noon et al., 2003). Moreover, SCM in the healthcare sector is critical due to the importance of cost control and material flow of medicines.

Also, SCM in hospitals are very important because medicines, medical devices and other medical supplies are directly related to people's lives (Jaekwon & Jongsik 2017). which requires enough and precise medical supplies according to the patient's requirements and needs (Narayanamurthy & Gurumurthy 2017). In addition, in the hospital, the inability to meet patient needs or demands have more serious consequences than in other sectors because limiting patients' needs could have severe results, including patient death and medical malpractice. Hospitals must incur the high costs of having enough medical supplies to provide timely healthcare to all patients (Chen et al., 2013). Patient safety is the primary focus and ultimate goal of a hospital. HSC not only delivers medical items to patients but also, safety issues within services (Supeekit et al., 2016). All of these justifications create an overwhelming opportunity to improve SCM performance in the healthcare sector and form a solid ground to conduct this research.

2.4 Lean Background

From the early 1990s, lean concept has a significant interest in academic research. The term "Lean" was coined by Krafcik in 1988 during his Master's thesis at MIT Sloan School of management. The concept was more popular after best-selling book "*the machine that changed the world"* by (Womack et al., 1990). The key aim of lean is to banish waste in order to improve product or service and deliver it on time at the lowest cost (Danese et al., 2018). Lean is popular business strategy for enhancing and enabling improvement initiative in public sector including health-care (Albliwi et al., 2014). Health-care sector worldwide have embraced process improvement approaches from the manufacturing sector, such as Lean concept. Recently, a growing number of lean applications can be adopted beyond the manufacturing sector (e.g. healthcare and SCM) (Danese et al., 2018). Lean is seen by numerous as complementary process excellence methodology is often worked in order to maximise the benefits achieved from initiatives (Salah et al., 2010). Lean is the most substantial continuous improvement (CI) methodologies for achieving service and operational excellence in any organization. According to Byrne et al., (2007) has indicated that lean has been seen the main key of success in any organization. Lean can assists health-care organizations in tackling a wide variety of issues encountered in health-care services(Glasgow et al., 2010).

2.4.1 Lean definition

It is clear from the literature that there is no agreement between authors and lack of consistent clarity on the Lean definition (Gupta et al., 2016). Table 2.2 shows lean definitions illustrated throughout the literature.

Table 2.2 Lean definition in literature

Author(s)/year	Definition
Womack, J. P. et al., (1990)	"Lean is an approach which uses half the hours of human effort in the factory, halves the defects in the finished product, requires one-third the hours of engineering effort, half the factory space for the same output, a tenth or less of in-process inventories"

NIST (2000)	"A systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection"
Cooney (2002)	"Lean takes a broad view of the production and distribution of manufacture, developing a production concept that encompasses the whole manufacturing chain from product design and development, through manufacturing and distribution"
M. George (2003)	"Lean is to accelerate the velocity of any process by reducing waste in all its forms"
Hopp & Spearman(2004)	"Production of goods or services is Lean if it is accomplished with minimal buffering costs"
Shah & P. Ward (2007)	"An integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimising supplier, customer, and internal variability"
Hallgren & Olhager (2009)	"Lean manufacturing is a programme aimed mainly at increasing the efficiency of operations"
Radnor (2010)	"A management practice based on the philosophy of continuously improving processes by either increasing customer value or reducing non-value adding activities (Muda), process variation (Mura), and poor work conditions (Muri)"
Elsharydah, et. al.,(2020).	"Lean is a systematic approach to identify and eliminate non-value-added activities or waste through continuous improvement process"

2.4.2 Lean principles within the healthcare context

The concept of lean has evolved from the Toyota Production System (TPS) during the 1950s (Antony, 2011; Zhou, 2020). Lean focuses on process, specifically on eliminating waste and adding value to result in quicker flow, less variation, greater customer satisfaction and shorter cycle time (Sinclair et al., 2005). Another concentration of lean is on cost minimisation (efficiency) with the aim of providing services and products at the least cost and as speedily as possible. Antony (2011) noted lean offers a group of tried and tested techniques and tools that reduce setup time, equipment time and lead time, diminishing scrap levels, inventories and the amount of reworking needed.

In recent decades, it was revealed that lean has been vastly implemented in manufacturing industries, particularly in the automotive industry where it was originally launched. However, recently, because of the clear benefits obtained by

implementing lean, the importance of lean in non-manufacturing industries is increasing exponentially. Lean is not strictly for manufacturing, but an administration strategy that is applicable to non-manufacturing organisations because it deals with business process. There are different sectors that have applied lean practices, including, for example, the NHS (Esain et al., 2008) and universities (Radnor & Bucci 2011). Lean implementation encompasses a wide range of administration practise that can be applied in non-manufacturing and manufacturing industries. Some of these practices are: just-in-time (JIT), Kaizen, Total Quality Management (TQM), Value Stream Mapping (VSP) and Total Productive Maintenance (TPM) (Shah & Ward 2007; Camacho-Miñano et al., 2013).

A large number of authors recognise five basic concepts of lean. These have their origin in Womack and Jones' original lean concepts, as demonstrated in their lean thinking. The concepts are: identifying the value stream, using the pull technique, specifying value and striving to perfection (Womack & Jones 1996). Achieving the aim of eliminating waste necessitates setting up the value of a process by distinguishing between value-added activities and non-value-added activities to remove waste so that every activity adds value to the process to accelerate cycle time, reduce cost and improve quality.

Radnor et al., (2012) used the following lean principles in the implementation of lean in the English NHS based on Womack & Jones (1996). These five lean principles are seemingly the most cited in the literature. Womack & Jones assured that implementing these principles correctly and all together would enable organisations, including health care organisations, to implement lean successfully. Al-Balushi et al., (2014) mentioned that in healthcare context, lean call "Lean Healthcare Management System" or mostly common "lean health" and lean principles should redefinition for purpose of healthcare. The following sections highlight the five lean principles in healthcare context.

2.4.2.1 Specify the value desired by the patient

Value is always defined by the patient's requirements and needs for a specific service or product. In health care, the ultimate goal of any hospital is make

patients safe by meeting all their needs in a suitable timeframe with robust quality and the right quantity. Identifying patients' value is the starting point to implementing lean and a critical issue, as well. The real value can be specified by the customer (patient) (Womack & Jones,1996). Identification of patients' value accurately plays a vital role in eliminating waste from SCM processes. Patient value can be maximised by reducing wasteful activities as much as possible from patient services (Westwood et al., 2007).

In healthcare setting, value refers to "whatever service or work is required or demanded by the customer group" Al-Balushi et al., (2014). Poksinska (2010) mentioned that the actual customer group are "patients" and "clinicians".

2.4.2.2 Mapping the value stream or patient journey

Once the end goal (value) has been identified, the next step is mapping the value stream. The main goal of the value stream is to identify all non-added-value activities and steps that do not add value to the patients' attempt to eliminate them as much as possible. A value steam is a set of actions required and certain processes used to bring services/product to the patients (customers). All non-value-added practices will be eliminated after the entire value stream is defined (Womack & Jones 1996). It is important to understand the entire process of practices and then determine the most appropriate value stream with respect to patients (customers), thus each practice and activity should add value to the patient. Identifying all the steps in the value stream for each process in SCM practices will lead to eliminating those steps that do not add value. Value stream mapping, in some cases, needs re-engineering processes and can be part of the SCM, such as procurement and delivery processes.

Henrique et al., (2016) mentioned that VSM play role in healthcare context to identify wastes and operational bottlenecks that hinder patients' treatment. A value-stream mapping (VSM) shows healthcare staff the importance of their efforts in eliminating non-vale added activities. This step is an important for SCM employees to identify any process does not add value for patients (Al-Balushi et al., 2014). Many studies show VSM is the most used tool in healthcare(Isack et al., 2018).

2.4.2.3 Create Continuous Flow

After the waste has been eliminated from the value stream, the next step is to be sure the rest of the steps smoothly flow without delays, bottlenecks or interruptions. Creating a flow in terms of processes enable SCM departments to explore problems that inhibit smooth flow and take suitable corrective actions. In addition, flow without interruptions can lead to reduced processing time, lead time and overall operational cost (Womack & Jones1996).

In healthcare context, lean is an important technique for the improvement of patients' flow in many medical department such as emergency department(Chan 2014). Some authors redefined "flow" in healthcare to as "capacity". Capacity is "the ability or extent the healthcare setting is able to accommodate or decrease the demand for any given value" (Al-Balushi et al., 2014). Continuous flow defined as "patients proceeding smoothly from one value added step to another one without waiting, as waiting is a non-value-added step" (Reijula & Tommelein 2012).

2.4.2.4 Establish pull (let the patient pull)

According to Womack & Jones (1996), "pull is a simples term whereby no one upstream should produce a good or service until the customer downstream asks for it". Once flow is improved, time to patients (customers) can be significantly enhanced. This facilitates an organisation (e.g., health care) to deliver products (medicines, medical equipment, etc.) as needed. This means patients can "pull" medicines or medical supplies from a supplier as actually needed. As a result, medicines do not need to be supplied in advance or stored. Inventory management is expensive and should be reduced as much as health care organisations can. In short, pull is actually what the accurate demand of the patient (customer) is.

In lean healthcare, "pull" is most known in the literature as "demand" (Poksinska, 2010; Al-Balushi et al., 2014). Due to patients' urgency and unexpected activities are vary in many cases, healthcare organization need to match "pull" with "flow" as this strongly related to success of lean implementation in healthcare context

(Al-Balushi et al., 2014). Patients must be 'pulled' to ensure continuous flow can be achieved (Reijula & Tommelein 2012).

2.4.2.5 Pursue perfection

After accomplishing identification of patients' value, mapping the value stream, creating flow and establishing pull, the fifth lean principle is strive for perfection. While the previous four principles are a great start, the fifth principle is perhaps the most important. This principle creates lean thinking and makes process improvement part of health care culture (hospital culture). It is important to understand lean is a dynamic approach and requires continuous effort to perfect. Complete waste removal is the perfection. At this level, each activity/process creates value for the patient. Westwood et al., (2007) mentioned that lean implementation in health care settings can result in identifying wasteful steps, leading to safer health services to patients without delays.

Sustainability of achieved improvements is considered to be one of the most source of continually eliminating wastes from the processes. One of the main reason of lean has not achieved in healthcare context is not well represented (Isack et al., 2018). This gap can be achieved in this study by presenting how to achieve "seek perfection" principle in healthcare context. More details will be in chapter five.

2.4.3 Value and waste

As mentioned earlier, two important elements in lean implementation are how to add value (value) to patient (customer) and how to eliminate wasteful steps or non-added-value activities (waste). There are two main values - value-added (VA) activities / processes (steps) and non-value-added (NVA) activities. VA should be enhanced while NVA should be removed as much as possible. VA activities are those processes / steps that create value for the end customer (i.e., patients in healthcare). The value can be defined by the end customer (patients in health care) willing to pay for it (Maleyeff 2006). Meanwhile, NVA activities are those processes / steps that do not create value for the end customer (i.e., patients in health care). Customers are not going to pay for them. NVA should be

eliminated as these processes or steps cause delays and waste an organisation's resources (Maleyeff 2006).

In lean, there are different kinds of waste. According to Pepper & Spedding (2010), there are seven types of waste: unnecessary inventory, over production, waiting, defects, excessive transportation, inappropriate processing and unnecessary motion. These seven kinds of waste are related to what customers' value. A lean initiative employs value stream mapping to expose waste and find value. A number of authors had added unused people (Kilpatrick 2003). In general, waste exists in most organisations in different manners. Although several authors mentioned there are seven wastes, Petersson et al., (2010) believe there is eight forms of waste, which are the seven wastes mentioned before in addition to unused (untapped) resources.

2.4.3.1 Wastes in Healthcare Context

From healthcare perspective, there are seven types of wastes (Westwood et al., 2007):

- **Correction** (defects): rework or repeating thing due to incorrect processes information for example incorrect medicines.
- **Waiting:** hospital staff unable to process their work because they are waiting for information, equipment or people. For example waiting for doctors to discharge patients
- **Transportation**: moving information and medical materials unnecessarily. For example, HSCM staff unneeded walking to the other department.
- **Over processing:** unneeded processing activities that do not add value for patients. For example repeated clerking of patients
- **Inventory:** patients waiting in a queue or extra work in progress or stock Information. For example, unnecessary items in storerooms that is not being used or patients waiting to be discharged
- **Motion:** Things not easily accessible or unnecessary staff motions. For example, unnecessary medical staff movement looking for medication sheets.

- **Overproduction:** requesting more than is needed such as asking unnecessary medical items “just in case”.

2.4.4 Lean in service sector

Over the last two decades, there has been much growth in the service sector. Decision makers at service organisations pay attention to the effectiveness and efficiency of their operations. However, although there is a critical role played by the service sector for the worldwide economy, the productivity and contribution of this sector has been less than that of the non-manufacturing sector (Suárez-Barraza et al., 2012).

The service sector is different when compared to other sectors, such as manufacturing. Therefore, the term “service” should be defined to understand lean in the service sector. Grönroos (1990) defined service as “an activity or series of activities of a more or less intangible nature that normally, but not necessarily, take place in interactions between the customer and service employees and/or systems of the service provider, which are provided as solutions to customer problems”. Other authors have stated: “Service is any act or performance that one party can offer to another that is essentially intangible and does not result in ownership of anything” (Kotler 2003, p.444).

After reviewing the literature, it is clear that the concept of lean has been vastly implemented throughout the manufacturing industry, more so than the service sector. The service industry’s implementation of lean practices includes those firms in health care, banking, government, non-profit organisations, public interest services, consulting (Gupta et al., 2016), NHS (Esain et al., 2008), higher education (Radnor & Bucci 2011) software, fast food, housing, construction, airlines, healthcare, legal services, public services and care services (Psomas et al., 2018).

Womack & Miller (2005) mentioned that lean is not strictly for the manufacturing sector, but a management approach that can be implemented in the service sector. Hanna (2007) stated lean in the service sector is a long way behind other sectors, such as manufacturing. Hence, this study contributes to the body of

knowledge of lean in one of the most important service industries, which is health care.

Lean implementation in the services sector can lead to many advantages and improvement in the reduction of waste, process variability and customer satisfaction (Gupta & Sharma 2018). Hence, implementing lean principles will surely have a huge impact on service cost. Lean principles in the service sector cannot be implemented directly owing to many elements, such as characteristics of services, respect for humanity and voice of the customer. Lack of awareness regarding the benefits of implementing lean and the ability to identify the waste in service organisations is considered the main challenge in implementing lean in service sector, though it really is one of the most effective tools to change an organisation (Gupta & Sharma 2018). It was noticed that there is a clear growth of literature discussing lean implementation in the services sector, such as health care, public services, finance, information technology or the public sector.

2.4.5 Lean supply chain management (LSCM)

Lean approach can be used by organizations seeking to integrate their SCM departments and practices. When lean is applied across the SCM, the SCM is referred to as a LSCM (Ugochukwu et al., 2012). LSCM is one way to lower costs and improve the quality and availability of the service/product (Jasti & Kurra 2017). Implementing lean in supply chain management can assist healthcare organizations improve; patient safety, medication distribution systems, supply chain cost management, internal interaction between employees, and instrument utilization (Khorasani et. al., 2019).

LSCM is defined as “a set of organizations directly linked by upstream and downstream flows of products, services, information and funds that collaboratively work to reduce cost and waste by efficiently pulling what is needed to meet the needs of individual customers” (Vitasek et al., 2005). SCM management (SCM) can use the lean approach to reduce costs and improve quality and delivery (Salah et al., 2011). In the SCM context, performance improvement is becoming a must for those organizations looking for success.

SCM plays a vital role in reducing the final cost of services or products. A huge number of NVA activities are performed throughout the SC process. Lean principles help to eliminate waste activities across the SCM processes, and are tools that endeavour to improve quality and speed, reduce costs, and increase customer satisfaction (Laureani & Antony 2017). In addition, lean tools substantially improve quality (Peter & Lawrence 2002) in the healthcare sector (Gijo et al., 2013). However, there is increasing concern about failures in the implementation of the lean approach in SCM. The SCM play a vital role in improving the performance of the SCM, reducing costs and increasing profitability through effective distribution. The optimization of an organization's resources is one of the most important roles of the SCM, which deals with raw material and distribution to the customer (Hjaila et al., 2016).

Found & Rich (2007) studied lean SCM (LSCM) frameworks with the survey approach. This study applied empirical research to find out the applicability of the suggested LSC frameworks, but did not include validity and reliability analysis. A number of researchers have developed LSC frameworks to fulfil the requirements of the manufacturing industry (Jayaram et al., 2008). However, no LSC framework has been developed for the SCM in a healthcare setting.

The Lean approach has a significant place for reducing and developing the actions which do not have inner process in SC in the organizations. The aim of Lean is defining, analysing, correcting and improving the variables, which impact the quality of SCM process in order to decrease the failures and to suggest the improvement tools for the processes(Erbiyik & Saru 2015). It is essential for the success of an organisation and its suppliers that wasteful operations are removed and total SCM costs be minimized by implementing continuous improvement approach such as lean (Dasgupta 2003). According to Kiemele et al., (2007), lean must be used to eliminate waste across SCM activities and to design and understand processes that can delete rejected orders due to product damage and build an operating paradigm whereby orders are manufactured, packaged, and transported depending on customer requirements.

SCM and continuous improvement (such as lean) are directly related. Understanding SCM relationships and dynamics is fundamental driver of business performance (Salah et al., 2010). The significant matter of how to integrate SCM with lean management is still being developed and investigated (Rong et al., 2011).

2.4.6 Barriers to successful lean implementing

Identification of obstruction prior to the implementation of lean or any quality improvement approach within an organisation is extremely important (Yadav and Desai 2016) as controlling barriers after lean implementation becomes difficult to manage for decision makers. Implementation without taking lean barriers into account creates serious problems, wastes human efforts and consumes time and resources while also possibly leading to failure. Thus, barrier identification is considered a precautionary step for preventing organisation suffering from serious issues.

De Souza & Pidd (2011) mentioned that there are many lean implementation barriers in health care, including lack of understanding of the lean concept by health care professionals (perception). Many clinicians, nurses or other medical staff believe that every patient is different, so the lean concept to them is only valid for similar products, like those produced in manufacturing plants. This is a misunderstanding of lean principles in the health care context. In addition, with data collection and performance measurement, poor performance measures and problems in data gathering are significant issues. Further, resistance to change is seen as a problem in lean implementation. Culture and lack of health care professionals' skills are also a real problem in adopting lean concepts. Moreover, hierarchy and management roles, changes in strategy and governmental policy can be barriers, as well.

Albliwi et al., (2014) mentioned that several barriers lead lean to fail in the health-care organizations include:

- resistance to culture change and organizational culture
- large investments in training in health-care;

- lack of management support;
- statistical competence;
- project selection;
- ineffective channels for communication;
- difficult to measure patients' satisfaction due to the busy environment in healthcare

Radnor et al., (2006) identified a variety of barriers to successful lean implementation initiative, including:

- resisting to change by people
- Improvement team (lean committee) members poor selection
- Failure of top management to drive change
- Silo working (isolate one system, process, department, etc. from others)
- Poor link between improvement initiative (i.e. lean) and strategy
- Lack of resources (financial, human resources, etc.) to support the initiative and the changes
- Lack of communication of change programme throughout the organisation.

Yadav et al., (2018) divided lean barriers into:

- **Strategy-based barriers** including poor strategic planning, lack of link between strategic goals and continuous improvement (such Lean) projects, limited financial resources, weak system for performance measurement, Lack of executives management commitment, support, and involvement, unexpected cost for implementing lean, poor vision about lean.
- **Technology-based barriers** including lack of technical communication between departments, poor training and education, lack of identify suitable lean tools, Inefficient data analysis, and weak of technological resources.
- **Social-cultural barriers** including culture change resistance, dearth of workers engagement and employees' autonomy, Poor human resources rewards in terms of lean project, lack of teamwork trustworthy.

- **Organisational barriers** including lack of organisational resources, lack of infrastructure, weak organisational Capabilities, adopting another organisation's lean strategy, bad selection of nominees for lean training, misalignment between goals of lean project and customer demand.
- **Individual-based barriers** including neglecting voice of customer (VOC), poor of consideration of the human issues, lack of lean initiative management, Lack of a roadmap to guide lean implementation, lean considered as time consumption and non-value added.

Gupta et al., (2016) believe that services sector face constrains differ from manufacturing sector. The main reason behind is the waste in service sector is intangible. Intangibility of waste increase the difficulty to clearly identify it. In addition, constrain to implementing lean in the service sector is the poor of awareness about the advantages of implementing lean in service organisation (including health-care). Another lean hinder is poor engagement for people and employee respect. Culture change is another challenge for implementing lean in service organizations.

In service sector, (Sarkar, 2007) believes lean implementation facing many constrains including:

- Processes are not tangible (not visible);
- Processes are complex;
- Processes are people Intensive;
- Processes are mainly depend on technology;
- Very little references (e.g. books of knowledge and literature) for service Lean;
- Concept of flow and pull;
- Processes cut through supplier or vendors.

Grove et al., (2010) mentioned in health-care there are several barriers when hospitals attempt to implement lean concept:

- Defining the waste;
- Understanding of lean;

- Poor communication;
- Limited leadership;
- Target focused (clear targets);
- Identify the customers and their value; and
- Process variability

Radnor & Boaden (2010)divided lean challenge in public sector including health-care into:

- People issue
- Processes issue
- Sustainability issue

Albliwi et al., (2017) compared barriers of lean implementation in the literature with lean in Saudi context in Table 2.3.

Table 2.3 comparing top five lean implementation barriers(Albliwi et al., 2017)

Frome Saudi organizations	From Literature
Time-consuming	Time-consuming
Lack of leadership	Lack of resources
Lack of awareness of lean benefits	Unmanaged expectations
Convincing top management	Lack of awareness about lean benefits
Internal resistance	Lack of training or coaching

Ultimately, it is clear that there are no specific barriers for all sectors. Lean barriers differ from one context to another and from one industry to another. An organization's capabilities, technology base and cultural matters (employee culture) all shape how an organisation intends to implement lean and to what extent. As such, the organisation may decide to continue, postpone to a certain time or refuse to implement the lean initiative permanently.

The lean implementation success rate is commonly reported low because of shortage of visibility regarding barriers and solutions. Also, understanding of organizations' context is key for the suitable lean implementation in supply chain(Tortorella et al., 2017). Healthcare organizations have their own context and barriers in HSCM is not covered yet. Top management face other issue also, which arises due to a large number of barriers and solutions affecting the

situation. In a real-life scenario, it becomes indeed challenging for decision makers to overcome all barriers and apply all the solutions simultaneously because of several unavoidable limitations. That is why, ranking and prioritising the barriers and solutions becomes extremely important and useful for them to plan their improvement initiatives. Therefore, the real-life scenario, organizations must focus on high-priority barriers/solutions and avoid/implement them accordingly (Yadav et al., 2018).

The prioritization of barriers is extremely important for hospitals so that they can avoid the most barrier that may lead to fail lean implementation. The barriers rankings have obtained will help healthcare providers for apply lean successfully by concentrating on the prioritised barriers and therefore enhance the effective rates of lean adoption. Also, proposed solutions to avoid lean implementation barriers have not introduced yet in HSCM setting. Hence, the aim of this chapter is to address this gap and to present the main barriers for implementing lean principles from HSCM decision makers' perspective.

Glasgow et al., (2010) reviewed 47 studies in health care and mentioned that 62% of Lean projects failed due to a lack of stakeholder acceptance. These failures with the findings are not because of a lack of improvements, most of the organizations failed to pay attention to the barriers or critical success factors (CSFs) during lean implementation. After reviewing literature, barriers and enablers for implementing lean principles in hospital supply chain management have not been investigated especially in Saudi Arabia and gulf region. Most of existing studies have extracted their set of challenges, enablers, and tools from manufacturing point of view while form healthcare perspective was neglected. There is gap that need to be filled in the lean literature such as challenges, motivation factors, and limitations(Vashishth et al., 2017;Laureani & Antony 2011; Pepper & Spedding 2010).

2.4.7 Success factors in implementing Lean

First, it is important to understand what CSFs are. Rockart (1979) defined CSFs as "the limited number of areas in which results, if they are satisfactory, will

ensure successful competitive performance for an organization". Lönngren et al., (2010) defined CSFs as "the internal and external parameters which have an essential influence on a company's success or failure". CSFs can be described as one of the most important processes for accomplishing effective quality (Habidin et al., 2013).

Many researchers have asserted the significance of investigating and examining such factors that take into account effective application of any new initiatives of improvement (Moustfa 2015). To achieve effective SCM and improve its performance in the health care context, there are many practices (factors) that should be considered (Kritchanchai 2012).

A number of researchers have mentioned that failure to resolve critical success factors at all decision-making levels definitely leads to dire consequences and can be devastating. Mohammadi (2013) mentioned that if organisations fail to satisfy a limited number of areas (CSFs), it will surely cause their failure. In other words, to succeed in the business, CSFs are the few main areas where "things must be used in the right way".

The type of industry plays important role in generating CSFs. Further, the concept of CSFs can be applied to different industries, such as public service, educational or non-profit organisations. In this research, the context is the health care industry.

Lean CSFs are different from context to context and from organisation to organisation based on strategies, resources, capabilities and mission because of different operational domains (Caralli 2004; Mohammadi 2013).

Stated another way, CSFs mainly depend on context and are affected by cultural and environmental factors. More details will be presented in chapter four.

2.4.8 Lean tools

There is a need to use tools or techniques to achieve the desired objectives of implementing the lean approach. Womack , (1990) mentioned that if lean tools are implemented in a proper way, they enhance operational procedures and

inventory control while also improving quality and eliminating waste. However, there is no single magic lean tool that can be implemented to improve any work environment. Combined lean tools should be used to finish lean projects successfully. The tools selected mainly depend on the suitability to the organisation's operations and processes. Owing to the plethora of lean tools, the following tools presents those that are most common in greater detail; value stream mapping (VSM), standardisation, visual management (VM), root-cause analysis (RCA), poka-yoke, 5S and kaizen.

2.4.9 Previous studies on lean in the service sector

Due to the importance of Decision makers in at service sector organizations must pay attention to the efficiency of their operations, including SCM practices. In this section, Table 2.4 shows studies related to lean implementation in the different services sector. More details about previous studies on lean specifically in supply chain management context will introduced with more details in chapter five.

Table 2.4 Previous Studies on Lean Implementation in the service Sector

Sector	Author(s)	Summary of Study
Healthcare	Laing & Baumgartner (2005)	5s, as one of most popular lean tool, was implemented in an endoscopy department in the hospital. The lean implementation in a storage room led to reducing cycle time by approximately 17 minutes, saving approximately $1,000 on supplies, eliminating approximately 0.8 full time employees, a 66% decrease in terms of on-hand resources and savings of $7,000 on inventory.
	Kim et al., (2006)	The authors describe principles of lean and how they can be implemented in the health care setting. They portray some of the early success stories of lean management in different hospitals. The study finds health care organisations are suitable for use of the lean concept, which could significantly impact how hospitals introduce health services to patients. Patient safety, efficiency, quality and appropriateness was improved.
	Ballé & Régnier (2007)	The study showed 5s is a strong starting point for implementing lean and kaizens. Many improvements in a hospital were noted, leading to improved patient safety. These interventions included VM, redesigning storerooms and clearing unnecessary items. These steps helped easily establish checklists to keep order and identify unneeded products.
	Fillingham (2007)	The study was implemented in the NHS Trust, UK. The authors showed that hospitals can save patients' lives by implementing lean concept. Lean cannot be implemented as is from the

Sector	Author(s)	Summary of Study
		manufacturing sector but thinking about the nature of health care should be taken into account. There was a 33% reduction in length of stay, 36% reduction in terms of mortality and paperwork decreased by 42%.
	Ann Esain et al., (2008)	The implementation of lean in the NHS was mentioned by the authors and many benefits from transformation processes were identified. NHS gained great advantages from its adoption of the lean concept and achieved patient satisfaction, process improvement and the enhanced performance.
	Kim et al., (2009)	The authors implemented the lean concept with a focus on patients' safety. They used 5s as the lean tool to improve workplace visualisation. After implementing the 5S technique on supply carts, medical staff could more safely and easily identify quality issues because the content and layout of each cart was clean and orderly identical.
	Waldhausen et al., (2010)	At a Seattle, USA children's hospital, Rapid Process Improvement Workshops were used to implement the lean approach. The findings showed that room time was improved 49 minutes to 33 minutes in one month. Physician-patient face-to-face time rose from 30% to 61% at one month. Also, In a four-hour clinic, the number of patients increased from 10 to 12.
	Dart (2011)	The author mentioned that lean is not a physical technique but a transformational tool and strategy management approach that can address several health care barriers. RIEs were used as the lean tool. Lean implementation in the health care setting can lead to many advantages, such as reducing cost, improving quality, create value for patients and increasing efficiency.
	Radnor et al., (2012)	The author's investigation showed lean implementation in four cases studies in the English NHS. Lean tools, such as 5s, kaizen blitz and RIEs were used in these cases. Authors stipulated lean implementation should include four phases: (1) definition of lean; (2) the steps undertaken; (3) the readiness of organisation; and (4) sustainability of process improvements.
	Young (2014)	NHS implemented lean in cardiac surgery to improve patient care. The results of this study showed many benefits from lean implementation, such as 61% lower mortality compared with the regional rate. Serious complications were 57% compared with the regional rate. Also, $884,900 was saved.
	Kanamori et al., (2015)	In this study, 21 health care professionals were interviewed and identified many themes to implement lean. Lean implementation created benefits in the health centre, including improved orderliness, removal of unwanted items and improved labelling indicators of service units. Additionally, the behaviour and attitude of patients and staff was enhanced, making services more safe, patient-centred and efficient with the 5s tool.
Sector	**Author(s)**	**Summary of Study**

Sector	Author(s)	Summary of Study
Public	Radnor et al., (2006)	Authors evaluated lean implementation in the public sector in Scotland. The organisations benefited from lean implementation in terms of processing time being improved, customer wait times decreased as well as enhanced service performance. In addition, understanding of customer needs and requirements was improved and employee satisfaction increased.
	Barraza et al., (2009)	The case study approach was used in the Spanish context. The main findings were that three lean tools; gemba kaizen workshops, 5S and process mapping positively impacted local council process systems. These tools improved the quality and processes of public services delivered by the councils. Lean implementation is relevant to local government and improves public services for citizens.
	Zokaei et al., (2010)	The implementation the lean approach took place at three local governments (councils). These public organisations measured their level of lean (leanness) before and after implementing the lean concept and then identified the benefits from adopting it. The results indicated that the impact of lean implementation differs from one organisations to another. However, all of them noted positive effects on their performance.

Sector	Author(s)	Summary of Study
Higher education	Comm & Mathaisel (2005)	In this research, the authors developed a questionnaire and 18 public and private universities in the USA were investigated. The results showed that the implementation of lean often improved operational efficiency, reduced waste and led to sustainability.
	Radnor & Bucci (2011)	A case study approach was used by the authors. All five organizations were from higher education in England, Wales and Scotland. Interviews were conducted on an individual and over-the-phone basis. The main findings of this study were that higher education is still in the early stages in terms of lean; there are great opportunities for improvements; there was a clearly poor understanding of lean principles; higher education has a lack of sustainability and poor lean culture; and there is a need for more concentration on value from customers (students) as well as increased senior management commitment.
	Svensson et al., (2015)	A single case study was conducted on the King Abdullah University of Science and Technology (KAUST). The implementation of the lean concept combined with six sigma resulted in improved efficiency and business processes, with 350 academics trained and 200 yellow belts and green belts also trained. Processes were improved in finance, administrative and research functions. Training was the main factor underlying implementation of lean successfully.
Sector	**Author(s)**	**Summary of Study**
Services	Swank (2003)	The author mentioned that lean can be used at service organisations, including financial companies. In implementing the lean concept at Jefferson Pilot Financial (JPF), they employed five

		lean experts. After the team put lean place in areas needing to be improved, impressive findings were noted, including the reissue rate was reduced, staff costs were decreased, error diminished to 1%, and the revenue and policies were improved within three weeks.
	Staats & Upton (2009)	The authors' investigation focused on lean principles at an Indian software companies. Case studies and empirical analysis were utilised. Most cases showed that lean is better than other tools. The results demonstrated the impact lean concept on productivity, coordination, problem solving and standardisation.
	Catarina Delgado (2010)	In this study, researchers combined lean with six sigma to improve financial service organisations. The main results of this study were customer satisfaction was increased, processes were improved, revenue was increased, there was operational cost reduction and a rise productivity.

2.4.9.1 Lean implementation in Saudi Arabia

Although there have been many attempts to implement lean or lean six sigma in Saudi organizations, there is a shortage of evidence in lean literature regarding the Kingdom of Saudi Arabia setting. In most sectors in Saudi Arabia, including the health care sector, education sector and other government and non-government sectors, none exists. This absolutely suggests the need for further research to be conducted to understand the current situation of lean applications in the Saudi context (Albliwi et al., 2017). This point enhances the strength of this study to conduct further investigation in terms of lean in Saudi Arabia and address this gap.

Health care context: A number of articles have been published on lean in the health care sector in the Saudi context. One study aimed to reduce average waiting time (in a vaccination area) from 25.4 to 10 minutes. Waiting for long times creates patient dissatisfaction and puts nurses and physicians under pressure (El Faiomy & Shaban 2012). Another case study was conducted in an emergency department and attempted to improve the patient flow by implementing lean tools and six sigma methodology in a comprehensive framework. The findings of the research showed the most important variables impacting patient satisfaction with patient flow, including the layout of the emergency department, waiting time, effectiveness of the system and complaints (Al Owad et al., 2013).

Construction context: In the construction sector, there are several studies published. The first paper attempted to implement lean, green and six sigma together to treat issues related to delays and quality in residential construction. Many procedures were developed to avoid waste and reworks, and RCA was applied. The study showed that the causes of delays were poor construction execution, unskilled workers, weather conditions and others (Banawi & Bilec 2014).

In another case study, there was the development of stage two (phase II) of the Jubail Industrial City. Contractors were 25% delayed compared with scheduling to establish 405 villas for the local community. The authors combined lean and six sigma to improve productivity and mitigate delivery delays. Lean eliminated waste and six sigma reduced common causes of variation. With this, lean and six sigma techniques were successfully implemented to improve processes within the construction sector.

Sarhan et al., (2018) focused on barriers to lean implementation. Twenty-two barriers were identified and 282 experts from the construction sector participated. One of the most influential barriers and serious issues is national culture. The role of national culture in lean implementation within construction is very crucial and studies in this context are limited. Further investigation was recommended.

Petrochemical and oil and gas context: This sector is a very important industry owing to the Saudi economy mainly depending on petrochemicals and oil and gas. Implementation of lean in this sector will reduce costs and therefore increase profits. In this sector, Bubshait & Al-Dosary (2014) conducted their study to reduce the failure rate of choke valves by implementing lean and six sigma tools seeking to raise availability of production wells. Many tools were implemented, such as brainstorming, supplier-input-process-output-customer SIPOC approach, failure mode-and-effect analysis (FMEA), cause-and-effect matrix, the 5 whys and fishbone. The implemented framework follows: define, measure, analyse, improve and control DMAIC phases. The study concluded with several improvement recommendations.

Dhafer (2012) carried out a study within a Saudi Aramco refinery plant in Riyadh. The study implemented lean and six sigma together in over 2000 work orders. Value stream mapping was employed to show material and information flow and therefore identify NVA steps. DMAIC was implemented to address opportunities for improvement.

Manufacturing and small- and medium-sized enterprises (SMEs) context:

SMEs play a vital role in the Saudi economy and constitute 20% of Saudi Gross Domestic Product (GDP). Karim et al., (2011) investigated to what extent lean manufacturing was implemented within Saudi manufacturers. Also, barriers and benefits of lean manufacturing implementation were assessed. The study showed that large manufacturers are most likely to apply and gain the benefits of lean implementation versus SMEs. Alkhoraif & McLaughlin (2018) conducted an exploratory study to discover the impact of organizational culture in terms of facilitation of lean implementation. The authors carried out 29 interviews with many manufacturing organisations across different industries. The findings showed the inhibitors and enablers of organisational culture when Saudi manufacturing SME attempted to leverage the lean concept.

Higher education context: King Abdullah University of Science and Technology (KAUST) launched the lean/six sigma approach in 2011 to improve process quality in administrative activities and give staff a platform to initiate and adopt process improvements. The lean initiative contributed to the KAUST operational strategy delivery. The concentration of the initiative was on streamlining the boost functions so that these administrative services were delivered efficiently and smoothly to beneficiaries, including staff, students and faculty. It assisted increasing the effectiveness and efficiency of all processes. By the second year of the initiative, 25 projects had been successfully completed. Regardless, except for the lean project at KAUST, no additional research has been carried out on higher education institutions in Saudi Arabia. In fact, there are a very limited number of publications that target any CI practices in Saudi Arabia (Svensson et al., 2015). Although there have been many attempts to implement lean in different

sectors in Saudi Arabia, lean implementation in hospital SCM have not been addressed yet.

Almutairi et. al., (2019) mentioned that little attention has been paid to implementing a lean approach by health-care providers in developing countries. It can be noted that all previous frameworks addressed either a single aspect of SCM (Gunasekaran et al., 2001; Chan & Qi 2003;Gunasekaran et al., 2004 ; Huang et al., 2005; Bhagwat & Sharma 2007; Robb et al., 2008; Lin & Li 2010) or focused on the non-health care sector (Bhagwat & Sharma 2007; Pasutham 2012) while other authors concentrated on the importance and the benefits gained from improve SCM performance, such as preventing medical errors, enhanced health care provider (hospital) performance, decreased waste, producing VA operations, improving operational efficiencies and helping maintain quality of care (Ford & Scanlon 2007; Mustaffa & Potter 2009; Kumar, Ozdamar & Zhang 2008; White & Mohdzain 2009).

Most of the extant research conducted on SCM and its performance either concentrates on medical departments, such as Thunaian (2013) or on other sectors, such as the food industry (Bottani and Bigliardi 2010), universities (Libing, Xu and Ruiquan 2014) or SCM but in different industries and countries, such as Bhagwat and Sharma (2007). Many authors have mentioned that there is a scarcity of studies concentrating on SCM performance improvement (Mustaffa and Potter 2009a; Gopal & Thakkar 2012; Piotrowicz & Cuthbertson 2015; Hong et al., 2012; Al-Saa'da et al., 2013). Whilst many have tried to create a helpful framework for improving SCM across different sectors, none of the present frameworks have attempted to improve SCM by integrating lean and SCM within health care settings, especially in the Middle East.

2.5 Healthcare system in Saudi

This study was carried out in the context of the Saudi Arabian healthcare sector. In Saudi Arabia, the government is obliged to provide free health care services to all citizens. The Saudi Ministry of Health (MOH) is considered the regulator and controller of health services and headed by the Minister of Health. The MOH is

committed to the goal of “health for all” (Albejaidi 2010). MOH is responsible for planning, regulation of health services and implementing Saudi healthcare policy. Mediating health services provided by the private sector and the price of pharmaceuticals and medical devices are other tasks of the MOH.

As stated earlier, Saudi Arabian health care services are currently provided free of charge to all citizens and expatriates working in governmental agencies, mainly through the MOH (Khaliq, 2012). In Saudi, there are three types of health care systems (three-tier) - primary, secondary and tertiary - and there are 19 health regions, with each region directorate responsible for many hospitals, medical centres, health offices and also private health care in that region. In some cases, health care directorates make their decisions in conjunction with the MOH and in cooperation with other health care systems (i.e., Interior Ministry health care system) (Al-Yousef et al., 2002). A total of 298 public and 137 private hospitals provide hospital health care services in Saudi Arabia. Using 259 hospitals, MOH supplies approximately 60% of hospital services (MOH 2016) as mentioned in Figure 2.4.

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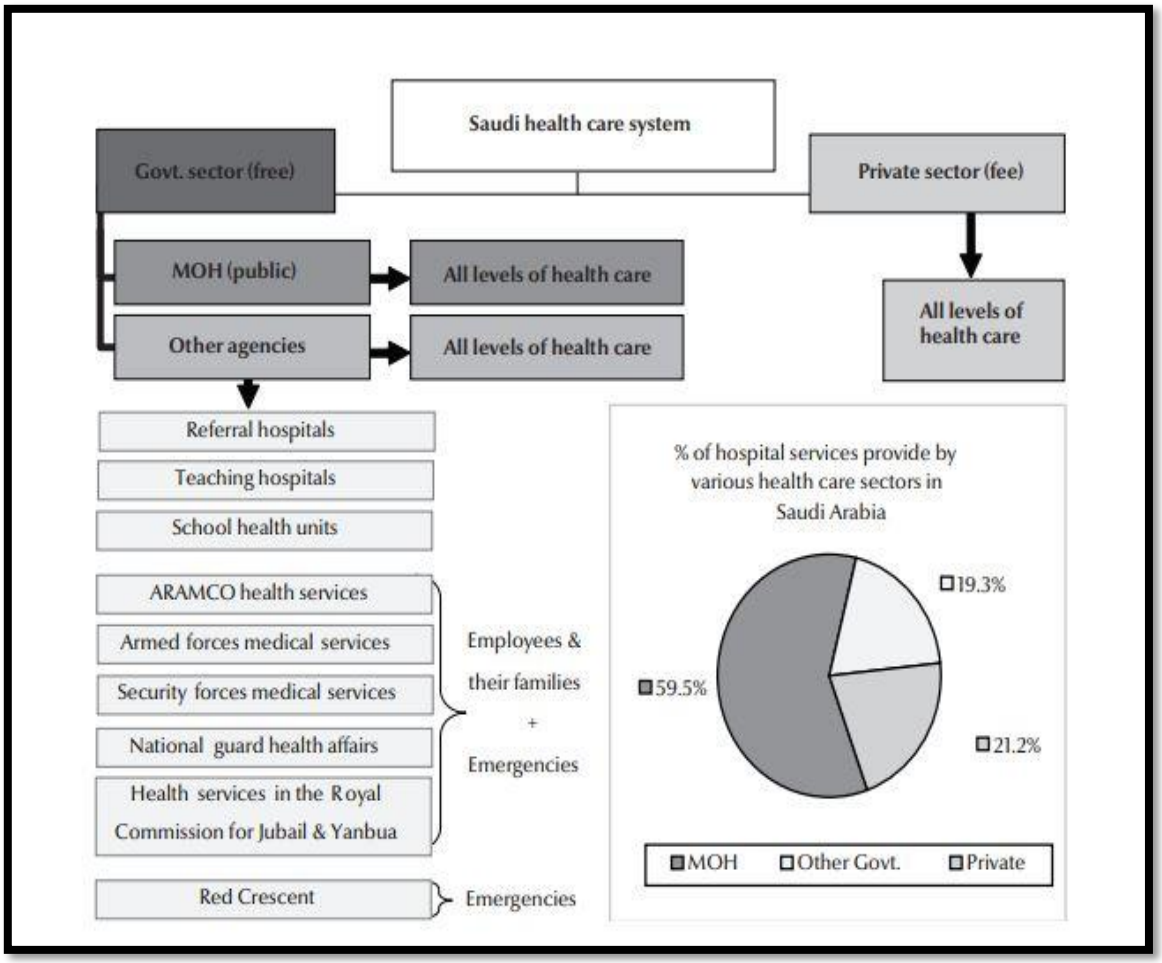


Figure 2.4 Saudi Arabian Health care system (MOH, 2016)

A total of 298 public and 137 private hospitals provide hospital healthcare services in Saudi Arabia. Using 259 hospitals, MOH provides approximately 60 percent of hospital services (MOH, 2016). In addition to the Ministry of Health, there are other government agencies providing health care, such as the Ministry of National Guard, the Ministry of Defence and Aviation, the Ministry of the Interior, Ministry of Education, and the Red Crescent Society (Albejaidi 2010). These agencies are independent of MOH in terms of the recruitment of medical personnel, management of health facilities, and budgetary allocations.

2.6 Research Gap Analysis

The primary objective of the literature review was accessing an up-to-date understanding of lean practices and SCM with a focus on the Saudi context. Most

research studies have analysed lean practices individually or SCM individually while a few focused on lean and SCM together, especially in the health care sector. In addition, a number of studies have highlighted lean in many industries. A few addressed lean in the health care sector in general and SCM in particular.

Today, health care organizations are suffering from barriers that need to be resolved in order to build the perfect organisation. One of these issues is a lack of operational performance in terms of SCM management. Vries & Huijsman (2011) mentioned that SCM is imperative. Additionally, it heavily impacts HSCM activities. With this, the lean concept has led to effective and efficient continuous improvement methodology at several health care organisations (Roberts et al., 2017).

An attempt was made to understand the previous work on lean and SCM in the scope of health care. All sections in this chapter attempt to present the state-of-the-art and a better comprehension of lean and SCM concepts. Lean and SCM represent the main bodies of this study.

The following points summarised the main observations drawn from literature:

- It is clear that most lean implementation research has been carried out on the manufacturing sector; few studies have focused on the service sector.
- Most studies have been conducted in developed countries while a few were in developing countries.
- The implementation of lean is a daunting task and more difficult in the service sector. A vast number of organisations failed to implement lean for many reasons, such as readiness for lean implementation and ignoring lean barriers before starting the lean journey.
- Identifying the level of lean (leanness) in health care organisations is important to be aware the position the organisation is in with regards to lean. However, there is shortage of knowledge in this context.
- Although extensive research has been carried out on lean and SCM management, the integration of these two concepts, especially in health

care, has not been addressed adequately in the Middle East, in general, and in Saudi Arabia, in particular.

After reviewing the literature, the following research gaps were clearly revealed:

- There has been a shortage of efforts carried out to accurately determine how the lean concept can be implemented in HSCM, especially in the health care context.
- Although the majority of studies have been conducted on lean in the service sector, there is no model developed that can be used to assess the degree of leanness in HSCM.
- Despite lean enablers, factors and barriers playing a crucial role in the success or failure of lean implementation in the health care sector, these elements have not been investigated yet in HSCM.
- Whilst many efforts have been seen with respect to building a helpful framework for the implementation of lean in the service sector, none have been developed for HSCM.

This study addresses these gaps via building a framework using state-of-the-art literature and knowledge to develop a lean hospital SCM framework and generating a model for assessing the implementation of lean in HSCM. These gaps were noticed after reviewing literature extensively and mentioned in section 2.2. This section assure the need for conducting this study to fill these gaps by addressing questions raised in section 2.2.

2.7 Chapter summary

The main purpose of this chapter is to provide a better understanding of the topics under investigation and therefore detect any research gaps in the current literature. This chapter mainly focused on two concepts; lean and SCM. Chapter started with lean concept and has been organized in the following order: in section 2.1 an overview introduction on the areas of research was presented. Then, lean definitions from different perspectives were introduced in section

2.2.1. After that in section 2.2.2 lean principles were illustrated. Next, in section 2.2.3 type of wastes and values were presented followed by lean in service sector in section 2.2.4. Barriers that hinder lean implementation were presented in section 2.2.5 and in section 2.2.6 success factors for implementing lean were introduced. These sections followed by lean that can be used in implementing lean and illustrated in section 2.2.7. Next, previous work in the area of implementing lean in different industries was presented in section 2.2.8 and followed by lean and other concept such as six sigma and lean six sigma in section 2.2.9. Lean implementation in Saudi context was described in section 2.2.10. The second concept is SCM. In section 2.3.1 introduction about SCM was presented then followed by different definitions of SCM in section 2.3.2. Importance of SCM in general and in healthcare in particular was introduced in section 2.3.3 and this section followed by healthcare SCM. Next, in section 2.3.5 hospital SCM management was compared with other SCM industry. Healthcare system in Saudi Arabia was outlined in section 2.4. In section, 2.5 the research gap analysis was described. Finally and briefly chapter content was present.

3 Chapter Three: Research Methodology

3.1 Introduction

In the previous chapter, the main research problems have been illustrated along with research aim, objectives and question. The pertinent literature has been illustrated in Chapter two. Thus the main aim of this chapter is to explain and highlight how the research design and methodology have been adopted to achieve research aim and objectives. The main sections of this chapter illustrated below in Figure 3.1.

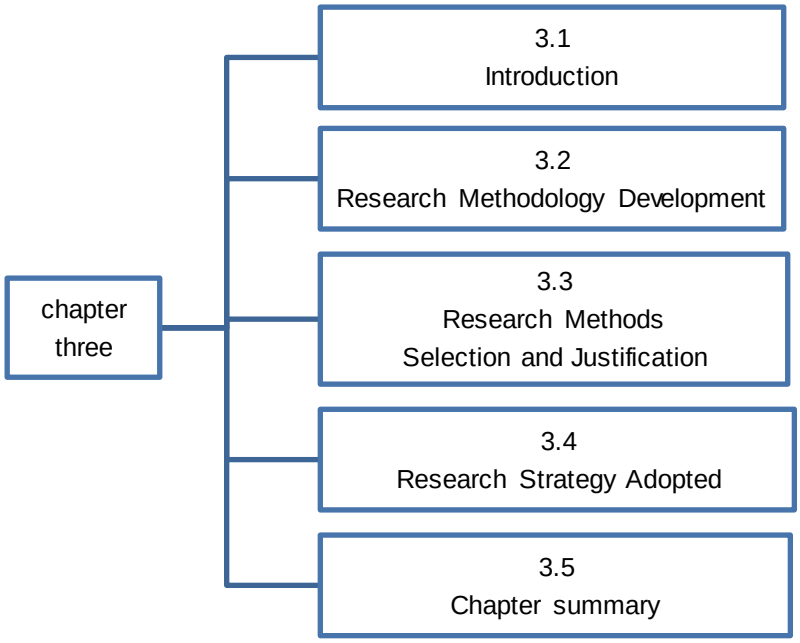


Figure 3.1 main sections of chapter three

Figure 3.2 showed the research methodology. A research strategy is chosen based on the research aim, objectives and context so select a research methodology over others needs justification; those justifications will be presented in this chapter as well in details. Research approach will be selected depending on nature of research and justification for this selection will be illustrated. Data gathering methods will be highlighted and the justification selecting those methods will be provided. Reasoning for all activities have been undertaken will be presented in details. In the last section, chapter summary will be presented.

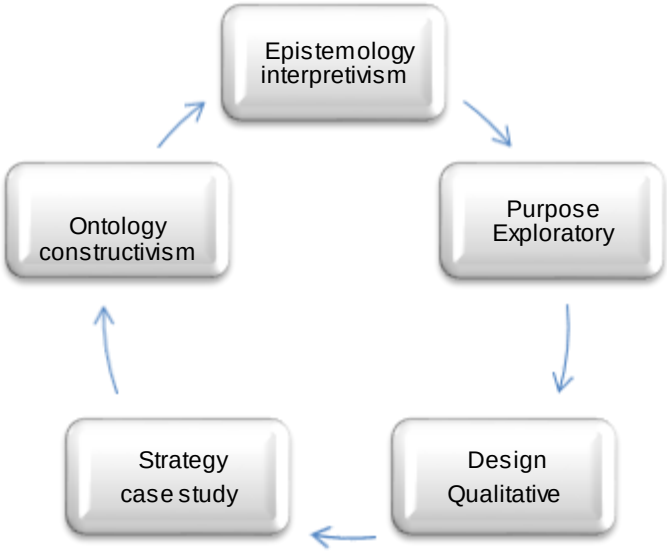


Figure 3.2 Research methods selection

3.2 Research methodology development

In this section, the various research approaches will be presented and based on the research context, aim and objectives, a research strategy is chosen. Therefore, the matters concerning to the data collection used are examined.

3.2.1 Research context

It is important to illustrate the research context in order to customize a suitable research methodology. The research is concentrated on the interaction between SCM and Lean practices with focus on healthcare context. The research has used several material sources encompassed: books, theses, reports, and many electronic sources including: google scholar, Emerald, Business Source Complete (EBSCO), Elsevier, Science-Direct, Scopus, and ProQuest etc. The relationship between SCM and Lean practices were the cornerstone when literature intensively checked. Available healthcare provider support (industrial support), the knowledge gaps identified and the research areas were the key factors determining the context this research.

3.2.2 Research Paradigm and Philosophy

As the philosophical research is consider one of research pillars, it is important to understand the meaning of paradigm. According to Wilson (2001) a paradigm is “a set of beliefs about the world and about gaining knowledge that goes together to guide people’s actions as to how they are going to go about doing their research”.

Also, the research paradigm can be defined as “a framework that guides how research should be conducted; it is based on people’s philosophies and assumptions about the world and the nature of knowledge” (Collis & Hussey, 2013, p43). It is more than merely philosophical framework; it likewise evidence how research should be carried out. Thus, once the researcher have identified research paradigm, the first step for designing research should be taken, which is to select a methodology that reflects the philosophical assumptions of researcher paradigm (Collis & Hussey, 2013, p59).

Burrell & Morgan (1982) identifies three main reasons why the paradigm and philosophy of research is significant. First, the research philosophy assists the researchers specify and revise the research methods to be employed in a research. Second, understanding the research paradigm and philosophy helps and enables the researcher to evaluate various research methodologies and select the suitable one. Third, it assists the researcher to be innovative and creative in the choosing a new approach which may have not been used by other investigators. Easterby-Smith et al., (2012) claim the research philosophy as illustrated in Table 3.1.

Table 3.1 Main philosophy (Easterby-Smith et al., 2012)

philosophy	Description
Ontology	“Philosophical assumptions about the nature of reality”
Epistemology	“A general set of assumptions about the ways of inquiring into the nature of the world”

3.2.3 Position of Researcher

Figure 3.2 shows the researcher's position. Lincoln & Denzin (1994) see Ontology as "addresses how the researcher explains the reality from the researcher's standpoint". Ontology describes views of people on the nature of reality either subjective (in our minds) or objective (really exists)(Flowers, 2009).

Creswell & Clark (2007) claim that there are only two schools of thoughts: positivism and interpretivism. **Positivism** *"*believes that there is a single reality shared by everyone in the world which is not known to anyone". Therefore, in this philosophy, a framework developed based on reality extracted from literature to explain the phenomena. The Positivism thought claims there is only a single reality which is external to the investigator, the investigator needs to be objective in the gathering and analysis of data. The deductive approach tends to be used more as an option for positivist research (Creswell, 2013). This approach was not fit to the aim of this research.

Interpretivism *"*believes in multiple realities which are carefully socially constructed from the relative context. This reality is known to experts, consultants and every society". Therefore, in this philosophy, proposed frameworks are designed by experts and presented from different point of view. The Interpretivism thought claims that multiple realities according to the different contexts exist and that the investigator becomes part of this research process by understanding and interpreting. The inductive approach tends to sit with the interpretive paradigm (Creswell, 2013). Epistemology as "answers the question of how things really work, and what are the best ways to acquire knowledge. Hatch (2012) assured that interpretivism aim to extract meaning from reality by understanding the people's views. Therefore in this study the researcher is constructivist (believe that the reality is socially constructed) in terms of the ontology and the interpretivism epistemological position.

3.2.4 Research Purpose

According to numerous researchers and authors the purpose of the research could be one or more of exploratory, descriptive and explanatory (Yin, 2014).

The research purpose may change over time, so it may have more than one purpose (Robson, 2011).

Descriptive: The goal of this research to describe the profile of individuals, events situations or organizations accurately(Robson, 2011).

Explanatory research is focused on causal relationships. It is useful to build causal relationship between different variables to understand the issue or phenomena that is researched(Robson, 2011; Saunders et al., 2012). According Saunders et al., (2007) quantitative data are required in explanatory approach. Table 3.2 shows the characteristics of each research purpose.

Table 3.2 Type of research purpose(Robson, 2011)

Category	Characteristics
Exploratory	Used in case of little understood situations search new views Questions to be asked evaluate phenomena in a different view Build hypotheses and generate ideas Mainly focused on qualitative approach
Descriptive	Describe an accurate profile of situations, events or persons. Previous knowledge of situations is extensively required. Flexibility of research design may be qualitative
Explanatory	Looking for explanation of a phenomena or problem. explain patterns relating to the phenomenon being researched relationships between factors of the phenomenon Works with qualitative or quantitative.

Exploratory: research is a worthy means to discover "what is happening; to seek new insights; to ask questions and to assess phenomena in a new light"(Robson 2011). It is useful to use this type of research to clarifying and understanding of phenomena. In addition, it used also if researcher is unsure of nature of a certain issue precisely. According to Saunders et al., (2009), there are three main ways of carrying out exploratory research: searching of the literature, interviewing expert in the certain field, and carrying out focus group interview. Exploratory approach endeavour to construct hypotheses instead of test them. However, to carry out exploratory research, data is probably to be qualitative (Saunders et al., 2007).

3.2.5 Research Design

There are two main research categories to design research namely: quantitative and qualitative.

3.2.5.1 Quantitative Method

A quantitative research design is concerned with finding out a causal relationship, forecast or explanation of a relationship comparing or relating several factors (variables) under examination(Creswell, 1994). A quantitative method follows the positivism paradigm. The positivism paradigm is mainly based on rules of measurement, logic, prediction, principles and truth(Weaver & Olson 2006). A quantitative research design is deductive in nature where the researchers deal with numerical data, perception and testing. Creswell (2013) confirms that this approach is utmost suitable when the main aim is to recognise the factors (variables) which may effect on the outcomes and to identify the best predictors of the outcomes. The Quantitative research design places significant concentration on statistical generalization of results that research to demonstrate and predict social phenomena by searching causal relationship between constituent factors (Muijs, 2011). Creswell (2013) illustrates that the main purpose of quantitative approach is to test hypotheses with regard to the relationship between variables under examination in the study. This method uses sampling approach to boost the generalization of the results from the certain study population to a bigger population by adopting deductive approach.

3.2.5.2 Qualitative Method

A qualitative research design has become significant forms of research for the social sciences in several fields such as management (Saunders et al., 2009). The qualitative research design is inductive in nature and includes some type of interaction between people and researcher(Hussey & Hussey, 2003). Qualitative approach is usually small-scale and emphasize on details rather than statistical methods. Qualitative approach may be utilized as first stage in the design of interview surveys(Hakim, 2000). In the qualitative method, the researchers deal with qualitative data and acts as instrument for data gathering. The nature of data

in qualitative method are primarily are words, action, non-numerical and behaviour. Table 3.3 illustrates the difference between two approaches.

Table 3.3 Quantitative and Qualitative Approaches(Zikmund et al., 2012; Bryman & Bell 2007)

aspect	Quantitative	Qualitative
Purpose	prediction ,test Hypotheses	Understand meaning
Approach	Measure and test	Observe and interpret
Data collection	Questionnaire, secondary data	Interviews, documents, observation
independence	Findings are Objective	Findings are Subjective
Sample	Large size	Small size
Philosophy	Positivism	Interpretivism (Phenomenology)
Analysis	Deductive	Inductive
Generalization	generalized	Unique case selection

3.2.5.3 Mixed Method

There is no research that claims that only one research method may be employed in an investigation. Utilizing more than one method can has essential advantages, even though it adds to the time required. Employing more than one method to research implies that various purposes may be served and that triangulation of findings is facilitated (Saunders et al., 2009). Triangulation means combining quantitative and qualitative methods(Flick 2009). Several practical matters are linked to these combinations of various research methodologies in the design of one study. Triangulation of quantitative and qualitative can concentrates the single case. The same respondents are fill in a survey (questionnaire) and interviewed. According to Flick, (2009) there are four types of tringulation: data, investigartor, theory, and methodological tringulation. Quantitative and qualitative methods have their own weaknesses and strengths. Table 3.4 illustrates the strengths and weaknesses of quantitative and qualitative methods.

There are several advantages of including several sources of methods of analysis. It brings about to the case being sudied becoming more accourate and convincing(Yin 2003). In addition, one of the most obstacles the researchers encounter is to ensure that the data being gathered are reliable and valid. So,

several researchers employ triangulation to validate their findings by using more than one method(Remenyi et al., 1998).

Table 3.4 Quantitative and qualitative research (Robson, 2011)

Method	Strengths	Weaknesses
Quantitative	Enables researcher to do statistical comparison	Lack of flexibility
	Precise and accurate measurements	Costly
	Less time consuming	Limited studies
	Shows causal relationship	Does not respond to environmental factors
	Findings are verifiable	Does not take into account for unique people's experience
	Findings are replicable	Removed (eliminated) from daily life
qualitative	Direct contact with participants	Bias is possible
	It is not costly	Difficulties with Validity and reliability
	take into account for unique people's experience	Time consuming
	Direct face with real-world	Is not accurate measurements

3.2.6 Research approach

There are two main research approaches: inductive and deductive. Saunders et al., (2009) distinguish between two approaches in terms of relative emphasis upon testing theory (deduction) and building theory (induction). the deductive approach defined as "a study in which a conceptual and theoretical structure is developed and then tested by empirical observation" Veera et al., (2008).

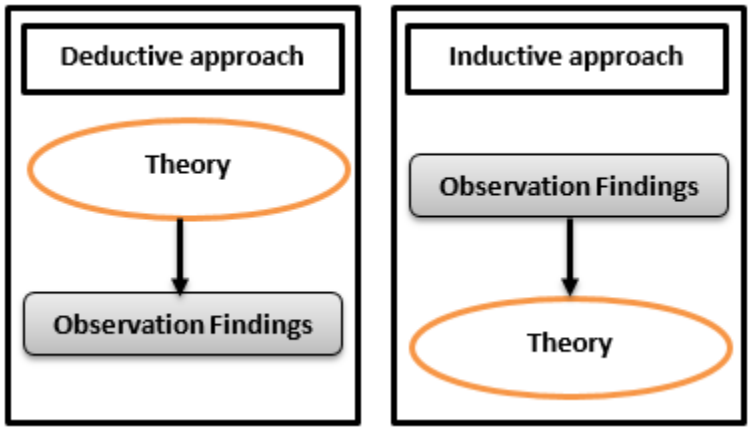


Figure 3.3 Deductive and inductive approach(Bryman 2012, p26)

Deductive approach (theory-then-research) builds hypothesis (hypotheses) from theory (literature) and use gathered data to reject or accept them. Bryman (2012) compared between dudctive and inductive as shown in Figure 3.3.

This includes developing framework/ model for testing a number of constructs that depict relationships between its constituents and designing data collection tool (for example questionnaire) to test the framework/model, testing hypotheses using the gathered data and refining the framework/ model and its related theories(Reynolds, 1979).

On the other hand, inductive approach (research-then-theory) believes that the research should not start with empirical research and testing hypotheses but should be develop theory. According to Saunders et al., (2009), inductive approach starts with collect data, develop theory and analysis data based on collected data. Table 3.5 illustrates the comparison between deductive and inductive approach.

Table 3.5 Deductive and inductive approaches(Saunders et al., 2009)

Deduction	Induction
Scientific concepts (principles)	Understanding of the human behaver to phenomena
Starting from theory to data	Starting from data to theory
Quantitative data	Qualitative data
Highly structured approach	Flexibility for changes
The researcher is not of what is being studied	The researcher is a part of research of what is being investigated
Selecting sample of sufficient size in order to generalise findings.	Generalization is less concern

3.2.7 Research Strategy

Research strategy can be defined as " a structured set of guidelines or activities to assist in generating valid and reliable research results" (Awasthy et al., 2012). Saunders et al., (2012) defined research strategy as" a general plan of how the researcher will go about answering the research question and meeting the research objectives". Robson, (2011) divided the research strategy into:

- Case study
- Ethnographic study

- Grounded theory

Table 3.6 shows the three research strategies presented by Robson (2011).

Table 3.6 Qualitative research strategies

Strategy	Definition	Features
Case study	"Detailed, intensive knowledge Dealing with a small number of cases"	Single case selection Study of the case within its context Use of different data collection tools.
Ethnographic study	"Aims capture, analyse, and explain how a group, organisation or community live and experience the world"	Selection of a community, group, or an organisation Researcher involvement in the setting observation can be used
Grounded theory	Target to build theory based on the data gathered from the field.	applicable to a wide range of issue interview-based introduces comprehensive recommendations for theory building and data analysis

The following sub-section focuses on the case study as the selected research strategy adopted to conduct this research.

3.2.7.1 Case Study as a research study

Case study strategy has been vastly used across social science and the most often described as qualitative strategy(Creswell, 2013; Denzin & Lincoln 2011). Table 3.7 shows definition of case study from different authors' point of view.

Table 3.7 Case Study Definitions

(Author, year)	Definition
(Yin 2014)	"An empirical enquiry that investigate a contemporary phenomenon with its life context, especially when the boundaries between phenomenon and context are not clearly evident".
(Saunders et al., 2012)	"A general plan of how the researcher will go about answering the research questions and meeting the research objectives".
(Peter 2010)	"A social phenomenon which carried out within the boundaries of one social system or within the boundaries of a few social systems".

The main aim of case study is to deeply understand events or organization(Peter 2010). Yin (2014) confirmed that case study strategy highlight knowledge about

a case or a small numbers of cases in details. Tellis (2005) mentioned that case study can be empirical or theoretical or both. Moreover, the case study may be exploratory, explanatory, or descriptive. Frequently, case studies utilise for conducting research in management field(Saunders, 2012; Yin, 2014).

The case study strategy can be used for single or multiple-cases approach. Eisenhardt (1989) claims that single and multiple case can be uses for exploratory research. Table 3.8 compares single and multiple case.

Table 3.8 single and multiple case comparison (Darke et al., 1998)

Single case	Multiple cases
Unique and extreme case suitable where it represents a crucial case Allows to examine and investigate issue more depth. Revelatory case	Comparison between cases for analysis purpose. Investigates a certain issue in several settings anticipate similar findings or to produce contrasting findings for expected reasons

Yin (2014) mentioned there are six main sources in conducting case studies which are: interview, documents, observation, record, participant-observation and physical artefacts (e.g., computer downloads of personnel's work)

3.2.8 Data Collection technique

Data can be either primary or secondary data. Primary data is data gathered by researcher and it can be gathered by interviews, observations or survey. It is time consuming and slightly costly. Secondary data is data gathered by another researcher for a different aim. The gathering of secondary data is usually less time consuming and cheaper than the gathering of primary data(Saunders et al., 2009).

Selecting data gathering tool(s) mainly depends on the type of information that is needed, from whom and under what conditions and there is no single technique has more advantage more than others(Robson, 2011). There are many data collection techniques that can be used during data gathering. Using two or more technique will enhance and support research results(Benbasat et al., 1978). Yin (2014) claimed that the most popular data collection techniques in qualitative

research are interview, focus group (sometimes called group discussion) and observation as shown in Table 3.9.

Table 3.9 Data collection technique (Yin, 2014)

Interview	Focus group	Observation
Allows investigators to earn insight into behaviour and attitudes of interviewed	Small group of people meeting for discussion , this enable the discussions to be represented	Allows investigators to gain view into the 'bigger picture'
Deep understanding in-detailed of the phenomenon being investigated	Usually occur in a mutual locations	Enable the investigators to view practices unfold first hand
Allows participants in the interview to voice opinions clearly	Investigators needs to be able to understand differences between the interviewees	Enable practices to be seen from the social point of view
Carried out in the workplace and arranged for the research purpose	Views becoming impacted by others.	Carried in workplace of participants

3.2.8.1 Interview

An interview is a considered to be one of the most used qualitative research data collection technique. The main aim of interviews is to capture and an understanding of the research subject from the interviewees' view of point(Robson, 2011). In this research, interviews are adopted as the main source of data collection in this qualitative research. Robson (2011) divided the interviews into three kinds, (Table 3.10): structured: use questionnaires based on a predetermined questions using fixed wording. Semi-structured: allow the investigator to use a list of questions and themes to be covered. Unstructured interviews: are informal and allow the investigator to discover in depth an area in which the researcher is interested.

After reviewing the literature, a pilot study was conducted as a first step to capture real-life scenario in term of lean practices. It is often helpful to carry out a pilot study prior the beginning of a full-scale research study. It can consider that a pilot study is a mini-version of a full-fledged research study. The pilot study can be considered as a feasibility study. It can be used as a pre-test for a tool such as questionnaire to guarantee the clearness of the questions. One hospital (medical

city, 1500 bed) was participated in the pilot study followed by two healthcare organizations in the main study.

To evaluate and understand the present situation more deeply in terms of lean practices and lean implementation enablers and challenge in health care organizations in Saudi Arabia, a semi-structured interview has been conducted. Experts were asked the following questions during semi-structured interview (appendix A):

1. Do you believe implementing lean thinking will improve/enhance the HSCM processes?
2. Do you think there are improvements needed in the HSCM processes?
3. What is driving your hospital toward becoming lean?
4. What are the factors contributing to the success of lean thinking in the HSCM processes?
5. What are the barriers to implementing lean thinking in the HSCM processes?
6. What solutions may have required to overcome the current barriers?
7. Is there any aspect (factors to success, barriers), which you feel is important for the topic and the research have not covered?

The interviews carried out with key and experienced employees from the supply chain in healthcare sector of Saudi Arabia. The researcher carried out semi-structured, telephone and face-to-face interviews with a sample of professional and experienced directors responsible for the SCM activities in healthcare organization in Saudi Arabia as shown in Table 3.10. The field study showed the researcher to gain a better understanding the present issues experienced by healthcare organizations in the SCM. From the interviews, lean practices, lean enablers, and lean implementation barriers, were identified by the respondents. More details will discuss in chapter five.

Table 3.10 List of Experts participated

No	Position	Experience (year)	Interview method	Interview's Length (minutes)
1	CEO's assistant for logistic	22	Face-to-face	90
2	Material management director	28	Face-to-face	75
3	Purchasing and Tendering director	20	Telephone	60

In this research, three Saudi healthcare organizations were participated in the main study. The semi-interviews were carried out with experienced employees within the SCM in the healthcare sector of Saudi Arabia who qualified (for example, lean six sigma green, black or master belt, or who participated in continuous improvement projects). From the interviews, many important lean enablers/factors and barriers were identified by the respondents. Following structured interviews using 5 point Likert scale. Employing 5 point Likert scale assisted participants to prioritize the relative importance of the main enablers, factors and barriers that are crucial for implementing lean practices in HSCM. Participants were asked the following questions (appendix A):

To what extent do you believe that:

- *Lean barriers represent the real obstacles for implementing lean in HSCM*
- *The proposed solutions significantly and effectively contribute to overcome lean implementation barriers in HSCM?*

More details will be presented in the chapter four. From the data gathered from the interviews, the model for leanness assessment for HSCM was developed. The model was developed based on literature review and experts' opinion from three Saudi healthcare organizations. The purpose of the developed model is to assess the leanness level of HSCM in Saudi context. More details will discussed in chapter six.

To evaluate and understand the present situation more deeply in terms of barriers of lean in hospital supply chains in Saudi Arabia, a semi-structured interviews have been conducted. The interviews were carried out with experienced employees from within the supply chain in the healthcare sector of Saudi Arabia

who qualified (for example, lean six sigma green, black or master belt (LSSGB), (LSSBB) or (LSSMBB), or who participated in continuous improvement projects. Moreover, the issues and problems identified in the literature review have been compared with the first-hand accounts of those qualified practitioners. Interviews with respondents were conducted in their hospitals. From the interviews, lean barriers were identified by the respondents. The researcher continued to interview respondents until the point at which no new data was shown that added new idea for building the theory.

In this stage, the main barriers that negatively impact the successful implementation of lean in HSCM were prioritized to enable healthcare organizations pay their attention on the most important barriers. To do so, structured interview was conducted with experts by using Likert scale (rating scale). Using rating scale provides precise answer rather than true/false or yes/no (Neuman & Robson, 2004).

Table 3.11 Advantage and disadvantage of types of interview

Interview kind	Advantages	Disadvantages
Structured	Cost effective and quick	No flexibility
	Data can be easily analysis	Interviewer do not know the participants' reasons for their opinions about the phenomena
semi-structured	Gives researcher the space to discover general opinions in details	Time consuming to analysis data by several participants
Unstructured	The interaction between researcher and respondents allow for more validate data. Flexibility in a new direction if the investigator change research questions	Costly and time consuming Difficult to analysis data Lose control of the interview

3.2.8.2 Focus group

Focus group is a popular data technique in several fields of social research. It can be considered as "group interview" rather than one-to-one interview Focus group can be taken as brainstorming session, therefore the expert opinions would be captured from cooperative organizations. Experts involved in focus group can

play vital role in validating the research and reducing the bias level (Robson, 2011). Table 3.11 shows pros and cons of the focus group.

Table 3.12 pros and cons of focus group (Brod et al., 2009)

pros	cons
Efficient method for data collection in qualitative research Dynamics of group help in concentrating on the most important issues Participants tend to share their experience flexible and cheap Free to express opinions and views.	limited number of questions to be asked Facilitating the group process requires considerable expertise Difficulty to manage the group. Participants Conflicts may arise. Consensus and agreement of opinion between Participants

In this research, there were 15 respondents that participated in the focus group process. Group discussions were held to capture experts' feedback and to check the validity of the framework. Group discussions were conducted in each hospital and validity-centred sessions were held about the following point: "To what extent the LHSC framework phases, barriers and lean enablers considered to be vital for successfully implementing lean in SCM in healthcare organizations?" For example, group's comments overview by experts from hospital (X) *"It is an applicable and helpful framework. All of the hospital supply chain departments could implement lean successfully if they follow phases and take into account lean enablers and lean challenges. Also, the framework is useful in identifying the waste in SCM practices. The hospital should ensure that their people are ready to implement the lean initiative."* More details about focus group will discussed in chapter seven.

3.2.8.3 Observations

Observation can be used in qualitative research to gathering data. Robson (2011) mentioned that direct observations are vastly employed in qualitative studies. Direct observations allow the researcher to notice real-life scenario and capture practices that occurred in the supply chain management in the targeted hospitals in terms of lean activities. Direct observations has been used in this research in several forms: during interviews and meeting with participants as well as hospitals visits.

3.2.9 Data Analysis

O'Leary (2017) mentioned that thematic approach is used for data analysis in qualitative research. Thematic analysis was used with the participants' engagement. Due to this research mainly adopt qualitative methods, so the most appropriate approach for analysing data is thematic analysis. Saturation level was reached after 15 interviews from three different hospitals. Data coding were employed in this study. Due to the limited number of interviewees, data analysis software was not used. Categorization of data (coding) can be done manually as the researcher did in this study. Transcripts were carefully read and coded and the framework was developed based on the main emerged themes. The emergent themes were assessed and evaluated by experts. Finally, the interventions were carefully developed to meet themes' requirements. More details will presented in chapter seven.

3.3 Research Methods Selection and Justification

3.3.1 Justifications for selecting interpretive paradigm

In this research, the investigation of the research problem is mainly based on an issue that is direct related to in real-life scenario and experience and there is no clear theory exist yet for implementing lean in supply chain in healthcare organizations in the Middle East in general and in gulf region in particular. To capture an in-details understanding of social reality via investigating people's (participants) opinions, interpretations and attitudes in implementing lean practices at HSCM. Therefore, phenomena interpretation constructed based on experts' knowledge, interpretations and understanding. The knowledge and theory is socially constructed through the interpretations of the participants in the practices of lean supply chain in healthcare context. Therefore, in this research, interpretivism position was employed where social reality, multiple entity, can be explored Collis & Hussey (2003). Hudson & Ozanne (1988) mentioned that "interpretivists believe that reality is multiple and relative".

3.3.2 Justifications for selecting exploratory study

After recalling the aim and objectives of this study, the research purpose needs to be defined .Robson, (2011) mentioned that the exploratory research is to discover 'what is happening; to seek new insights; to ask questions and to assess phenomena in a new light'. After reviewing the existing literature in the context of lean supply chain management especially in healthcare context, there is no much known about the lean practices in the context of hospital supply chain management (HSCM). Since the implementation of lean practices in HSCM has not been investigated enough and there is very little information about how lean can be implemented in HSCM. As a result, it is clear that the exploratory study is selected as most suitable for the aim and objectives of this study.

3.3.3 Justifications for selecting qualitative approach

There are many reasons behind selecting qualitative approach. First, the research's topic needs further investigation and in-depth understanding by interviewing people where their behaviour are not under control. Second, since the research attempts to earn understanding of lean practices and its application in HSCM, qualitative approach has ability to provide fully understanding and richer description. Third, in spite of the lean concept has been implemented for several decades ago, this concept is still new in the service sector especially in HSCM. Fourth, the research aims to attempts to answer "HOW" question which is impossible with quantitative approach. Finally, this research adopts case study strategy which is suitable for qualitative approach.

3.3.4 Justifications for selecting case study as research strategy

A number of factors have taken into account once select case study method: data gathering tools, the research context and involvement of the collaborating organization. Further, This research exploratory study and according to Robson (2011) the case studies are connected to exploratory research. The purpose of this research is exploratory and cases studies are appropriate for exploratory research thus case study is suitable for this research. According to Yin (2014), case study is suitable to investigate a topic which rarely has been conducted to

understanding the nature of issue happened. Moreover, case studies perhaps offer depth and richness of information not introduced by other methods. Case study is suitable to study an area in which no much studies have been conducted. In this study, the studies of implementation of lean practices in HSCM is relatively limited and can be considered as new phenomena especially in healthcare context in Saudi Arabia.

3.3.5 Research Trustworthiness

One of the most important that should be taken into account in qualitative research is validity. Validity and reliability used for rigour of the research and testing the quality of case study of research(Lietz & Zayas, 2010**;** Yin, 2014). Robson, (2011) defined the validity as "the degree to which the research provides a true picture of the situation being studied". Validity has two forms namely internal and external validity. Internal validity can be defined as "how well the observations made by the researcher match the theories they comprise"**.** LeCompte & Goetz (1982) mentioned that if the researcher spends a long time within research environment, internal validity is a key point (strength) to qualitative studies context. External validity (generalizability) refers to the extent which the study's findings applicable over social situation, such other organizations (Saunders *et al.,* 2009). Since lean and SCM practices are different from context to context and from organization to organization(Caralli 2004; Mohammadi 2013), It is difficult to achieve external validity (external generalisability) within a qualitative research settings, because the results of the study make sense for certain people, organizations or context investigated.

Saunders *et al.,* (2009) assured that validity is concerned with whether the findings are really about what they appear to be about" whereas reliability concerned with the reliability of the methods and practices used; the data collection methods should be structured and consistent, as well as the research strategy and alternative researchers would reveal similar information and results.

The validity can be damaged by different type of threats. Due the nature of research topic and the researcher is involved in research process, biases are

likely to occur. The biases may take three forms; researcher bias, respondent bias, and reactivity (Robson, 2011). Researcher bias may result from the preconceptions and assumptions that the investigator likely bring to the situation, which likely affect the method in which they behave in the study setting. Respondent bias refers to either interviewee trial to secrete information from the investigator (such as sensitive information) or interviewee trial to give the answer which would satisfy the investigator. Finally, reactivity. it refers to the "potential for the researcher to exert an impact on the participants thereby changing the findings of the study" (Lietz & Zayas, 2010, p.191). Reactivity may impact the behaviour of the respondents and therefore results of study.

Table 3.13 strategies to mitigate the risk of bias

Criteria	description
Prolonged involvement	The time that the investigator spends within the research setting and respondents to understand the phenomena, culture and situation. Interaction between researcher and participants over a period of time. In this research, the investigator bias will be appear during building relationships with the respondents.
Triangulation	"The use of different data collection techniques within one study in order to improve the research rigour".
Peer debriefing and support	"Debriefing sessions with other researchers which leads reduce researcher bias"
Member checking	"Presenting results and analysis to participants in order to get feedback".
Audit trail	"Keeping a full track and record of all the activities conducted during the study"
Purposive sampling	"Researchers a degree of control rather than being at the mercy of any selection bias inherent in pre-existing groups".
Research dissemination	"Activities through which research was publicised resulted in the refinement of research due to criticism and feedback"
Negative case analysis	"Refining an analysis until it can explain a majority of cases".

To overcome these biases, Lietz & Zayas (2010) and Robson, (2011) proposed many of strategies that can be used to mitigate / avoid risk of bias, Table 3.12 . However, it is not necessary to employ all of these strategies. Authors assured that "no project is expected to employ all of these strategies" and "not all strategies need to be utilized for a study to be trustworthy (Lietz & Zayas, 2010). Guba & Lincoln (1994) propose four aspects of trustworthiness that qualitative research should employ as illustrated in Table 3.13;

1. Credibility (internal validity)

Credibility refers to "the degree to which a study's findings represent the meanings of the research participants" (Lincoln & Guba, 1985). To achieve credibility in qualitative research should manage the threats of bias and research reactivity (Padgett, 2008). Triangulation and member checking are strategies that increase credibility and can be used to reduce the risk of bias and research reactivity (Padgett, 2008;Lietz & Zayas, 2010). Triangulation can be defined as "a concept adapted from navigational science involving the use of "two or more sources to achieve a comprehensive picture of a fixed point of reference" (Padgett, 2008, p. 186). According Liamputtong & Ezzy (2009)**,** reliability of the research is judged by its credibility. Padgett (2008) claims that triangulation is relevant with case studies in particular (in this research three healthcare organizations).

2. Transferability (external validity)

Transferability (sometimes called generalizability Gelo et al., 2008) refers to "the degree to which the findings are applicable or useful to theory, practice and future research" (Lincoln & Guba, 1985) "generalizability (transferability) is not a priority in qualitative studies" (Padgett, 2016) and qualitative investigators are not looking for generalizability (Lietz & Zayas, 2010).

3. Dependability (reliability)

Dependability (sometimes called auditability) refers to "the degree to which research procedures are documented allowing someone outside the project to follow and critique the research process" (Lincoln & Guba, 1985). Peer debriefing and audit trail can be used to enhance dependability(Lietz & Zayas, 2010). Engaging and involving experienced colleagues and discussion with researchers about the research can enhance process of research and creating new sights and identifying any potential weakness in research process (Padgett, 2008). Academic staff and researchers from Cranfield University and other academic institutions were engaged and consulted to take advantage their views.

Confirmability (objectivity)

Confirmability refers to “the ability of others to confirm or corroborate the findings” (Lincoln & Guba, 1985). Lietz & Zayas (2010) suggest strategies that increase confirmability such as peer debriefing, audit trails and member checking. Peer debriefing defined as “meeting with mentors or other researchers engaged in qualitative research to dialogue regarding research decisions” (Lincoln & Guba, 1985).

Table 3.14 Aspects of trustworthiness

Aspect of trustworthiness	Actions taken to increase research rigour and reduce researcher bias
Credibility (internal validity)	Triangulating sources of data Prolonged engagement with respondents
Transferability (external validity)	Transferability (generalizability) is not the aim of qualitative studies Deep understanding in-detailed of the social phenomenon is more important than looking for generalizability
Dependability (reliability)	Engaging researchers, colleagues and discussion with academic staff(Peer debriefing) Documenting the activities carried out during the study.
Confirmability (objectivity)	Data from participants’ point of view was used to build theory (member checking) Findings were submitted to respondents to confirm their agreement.

Lietz & Zayas (2010) assured that returning to a sample of respondents to confirm the findings (member checking) can reduce bias and increase confirmability.

3.4 Sampling

The sample of this research is the ministry of healthcare in Saudi Arabia. All targeted healthcare organizations should be working under the same healthcare system (in this study, all organizations under ministry of health (MOH)). Different healthcare system may lead to different findings and this point needs further investigation. The case study (hospital) was selected from those healthcare organizations are keen to implement lean practices in their SCM and which are accredited by both the Saudi Central Board for Accreditation of Healthcare Institutions (CBAHI) and the Joint Commission International (JCI). The reasoning

behind these criteria was to make sure there was a rigorous foundation on which to implement change initiatives such as lean. In addition, existing knowledgeable and experienced employees in healthcare organization is another reason for selecting certain organizations. More details about Saudi healthcare systems are mentioned in chapter two.

3.5 Overview of Research Strategy Adopted

After describing the research context, paradigm, purpose, design, approach, strategy, main data gathering tools and reasons for selecting a certain approach, this section illustrates adopted research methodology. The adopted research methodology is illustrated in Figure 3.4. The research methodology is splitted into four phases as the following:

Phase 1: Understanding the context;

Phase 2: Research strategy development;

Phase 3: Data collection and framework development; and

Phase 4: Validation

3.5.1 Phase 1: Understanding the context

This phase focus on understanding of lean and SCM and their surrounding areas by reviewing current literature and attending lean six sigma black belt training (LSSBB) Course in service sector. The research used several material sources, such as books, theses, reports, and many electronic sources, including Google Scholar, Emerald, Business Source Complete (EBSCO), Elsevier, Science-Direct, Scopus, and ProQuest. The literature reviewed and a number of areas were covered including lean services, lean implementation, lean SCM, hospital supply chain management, and leanness assessment. Then, the research problem and gaps were identified. And then, the research aim and objectives were proposed. In this phase, research problem, aim and gap were identified and the appropriate research strategy was selected. According to Yin (2014), case study is suitable to investigate a topic which rarely has been conducted to understanding the nature of issue happened and most suitable of study for obtaining deeper understanding.

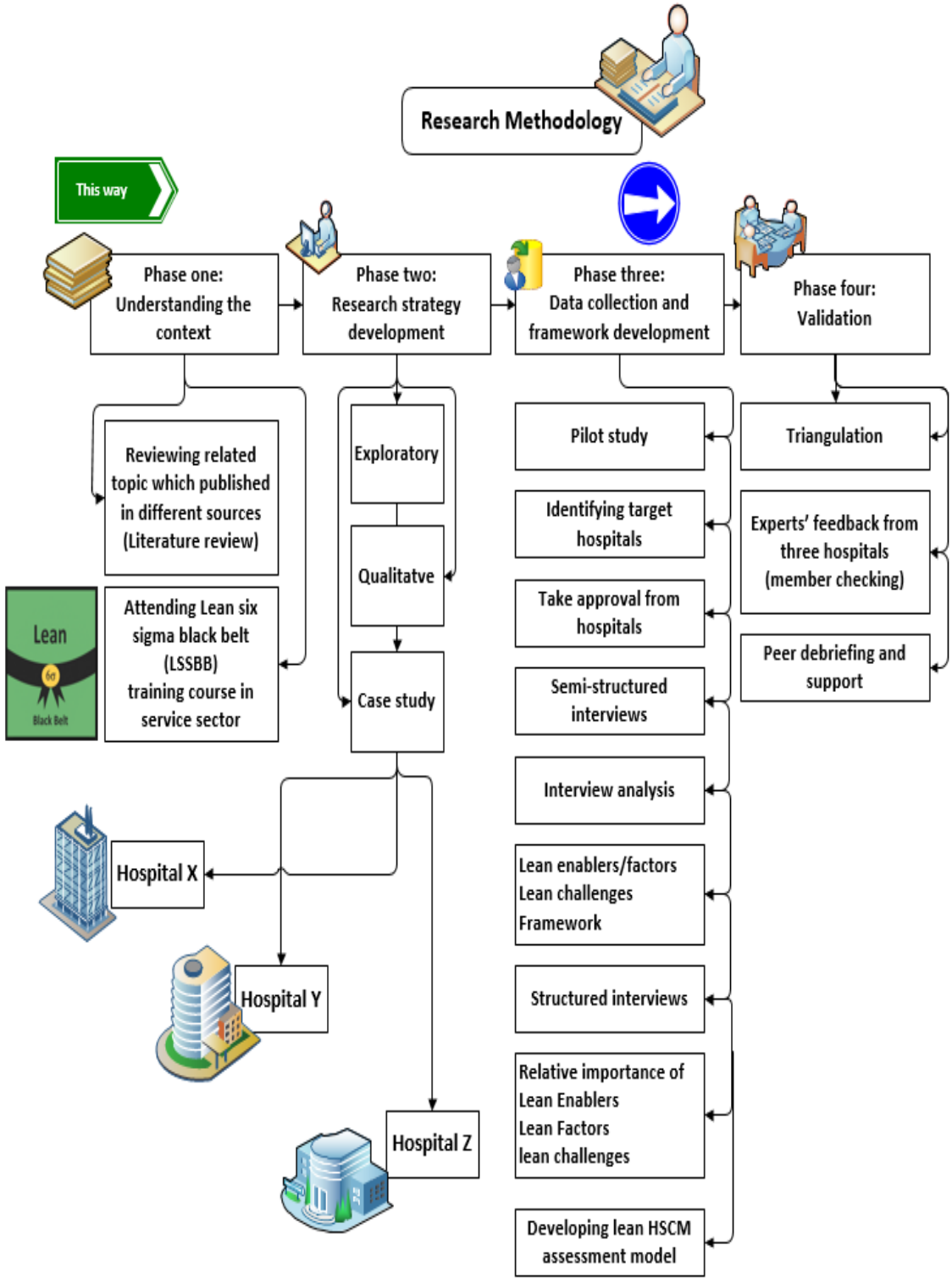


Figure 3.4 Research Strategy for developing the framework

Since the implementation of lean practices in hospital supply chain is a relatively new phenomenon and the investigation is based on a phenomenon that is related to and rooted in work-life experience, exploratory and case studies are a more appropriate strategy to understand real life situations.

3.5.2 Phase 2: Research strategy development

Exploratory study was selected as most appropriate purpose to achieve the aim of this study. The aim of this research attempts to answer “HOW” question which is most appropriate with qualitative approach. Inductive approach was applied which linked to qualitative studies. Finally, this research adopted case studies which is appropriate for qualitative research. Three healthcare organizations were participated in this study.

3.5.3 Phase 3: Data collection and framework development

The aim of this phase is focused on data gathering and ideas generation. The selection of the healthcare organizations was in accordance with certain criteria. At the beginning, due to the nature of healthcare service sensitivity, the researcher was asked to attend Web-based training course "Protecting Human Research Participants". The course is running by The National Institutes of Health (NIH) Office of Extramural Research (Appendix B). After that, pilot study was conducted. It is often helpful to carry out a pilot study prior the beginning of a full-scale research study. It can consider that a *pilot study* is a mini-version of a full-fledged research study. It can be used as a pre-test for a tool such as questionnaire to guarantee the clearness of the questions. The pilot study can be considered as a feasibility study. One healthcare organization (medical city) and three managers were interviewed. The managers were selected based on their experience to give the researcher confidence that respondents have adequate knowledge of lean concept and SCM practices

The findings of pilot study resulted in understanding to what extent healthcare organizations implement lean concept in their SCM and knowing the current lean practices, enablers and hinders in HSCM. Further information will be introduced in chapter five.

3.5.4 Phase 4: Validation

The last phase of adopted research methodology is the validation of the final findings. The final LHSCM framework was validated by adopting common validation strategies. The framework validated qualitatively and quantitatively (statistical). In terms of qualitative validation, the framework was developed and finalized by working cooperatively with three healthcare organizations. The main purpose of those is to collect opinions about to make sure of the feasibility of the phases and activities of the framework. Quantitatively the framework was validated by using Minitab® 18 software. Further discussion will be presented in chapter seven. The following sections will illustrate the research methodology in each stage of this research project in details.

3.6 Methodology for Identifying Lean SCM barriers and enablers

Figure 4.5 illustrates the methodology employed to identify barriers and enablers for implementing lean in supply chain management at healthcare organizations. There are four phases were followed in this study to achieve the research aim.

3.6.1 Phase 1: Reviewing of literature

The research used several material sources, such as books, theses, reports, and many electronic sources, including Google Scholar, Emerald, Business Source Complete (EBSCO), Elsevier, Science-Direct, Scopus, and ProQuest etc. The barriers of implementing lean activities in healthcare supply chain management were the cornerstone when literature was intensively checked with focus on Saudi context. The gaps were identified and the research areas were the key factors determining the context of this research.

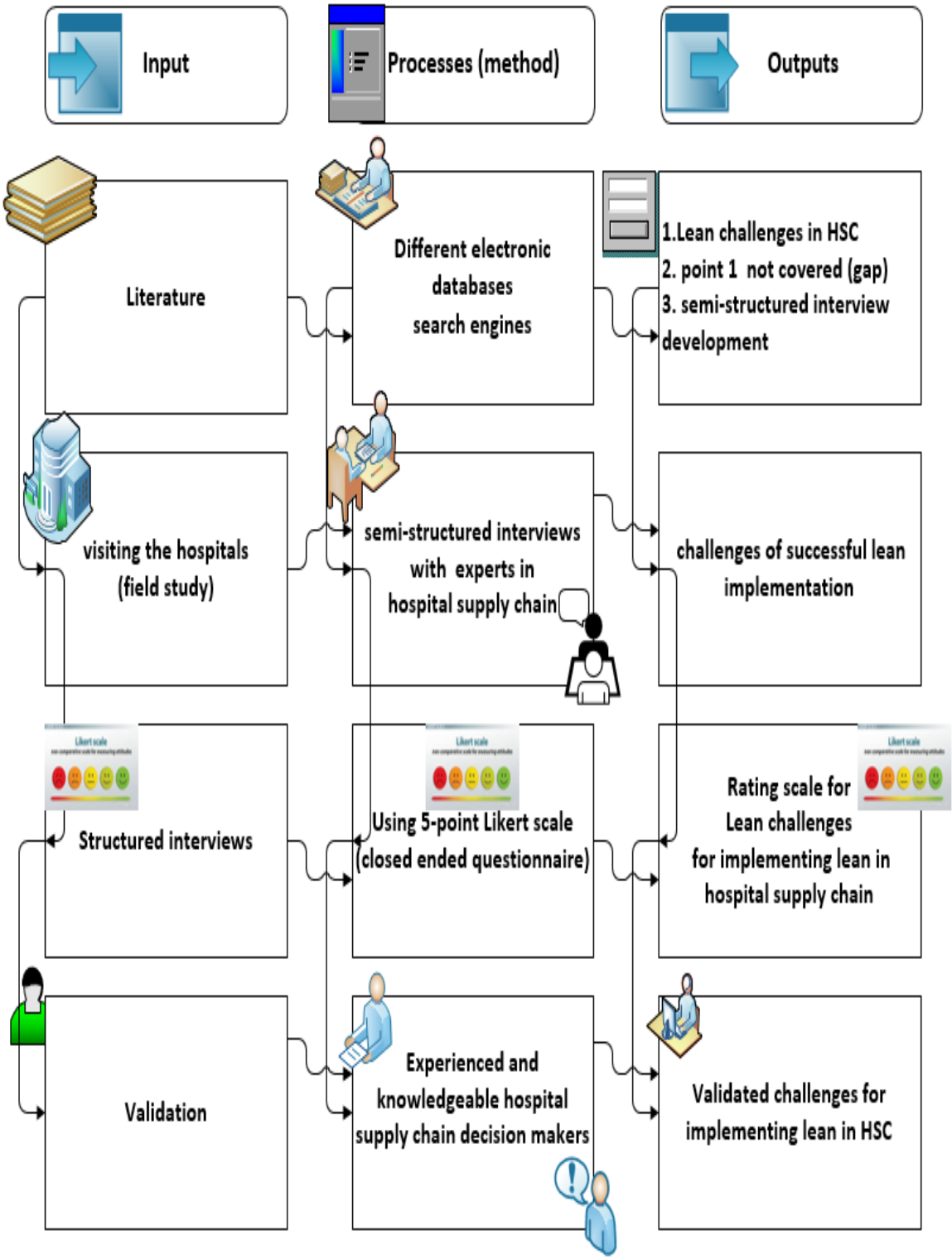


Figure 3.5 Methodology for identifying lean barriers and enablers in SCMH

3.6.2 Phase 2: Visiting healthcare organizations (field study)

To identify the lean implantation barriers from real life scenario, healthcare organizations were visited and 15 interviews with three different healthcare providers in Saudi Arabia.

This research is an exploratory study and case study approach. Exploratory research is a worthy means to discover "what is happening; to seek new insights; to ask questions and to assess phenomena in a new light" (Robson 2011). It is useful to use this type of research when clarifying and understanding phenomena. Since the barriers of lean implementation in healthcare supply chain management has not been investigated enough and there is not enough information about how lean barriers can be avoided in the HSCM, exploratory approach is adopted in this study. The main aim of a case study is to deeply understand events or organizations (Peter 2010). This study aims to help decision makers in healthcare institutions explore and determine how to avoid lean barriers in the supply chain context.

The case study is suitable for this type of research because the phenomenon requires investigating real life situations. According to Yin (2014), case study is suitable to investigate a topic which rarely has been conducted to understanding the nature of issue happened and most suitable of study for obtaining deeper understanding. Since the implementation of lean practices in hospital supply chain is a relatively new phenomenon and the investigation is based on a phenomenon that is related to and rooted in work-life experience, case studies are a more appropriate strategy to understand real life situations. The study of implementation of lean practices in HSCM is relatively limited and can be considered as ne phenomena especially in healthcare context in Saudi Arabia. So investigation lean implementation barriers is worthwhile.

3.6.3 Phase 4: Validation

According to Yin (2014), research validity is considered to be one of the most important criterion of research and an essential point of the trustworthiness of research results. This research has employed experts' judgement as validation

approach. The main purpose of these questions are to give their opinions about the barriers and its importance and effectiveness of proposed solutions. Further details will be discussed in chapter of validation (chapter seven).

3.7 Methodology adopted for computing HSCM index

The methodology, Figure 5.4, begins with an extensive review of the lean assessment and multi-grade fuzzy logic literature by referring to journal databases such as Science Direct, Emerald, Taylor and Francis, and Springe. The term “leanness” or “lean” was used with “assess”, “evaluate” and “measure” to identity the relevant work. Following this, an initial model (first version) was developed for leanness measurement. This step was followed by conducting semi-structured interviews with academic experts in lean who work on continuous improvement projects. These academic experts were interviewed during scientific gatherings, such as conferences and symposiums. Each interview was conducted independently and lasted between 40 and approximately 60 minutes. During the interview, the model was explained clearly, as were its items. The participants were asked for their opinion on the developed model in order to assess the model’s feasibility and its validity. After responding to the experts’ valuable comments, the researchers ended up with the second version of the model. The selection of the healthcare organisations was identified based on certain criteria, including the ability to participate and the keenness to implement lean practices. The second version of the model was revised based on semi-structured interviews with fifteen experts working in the supply chain within the healthcare sector. The number of experts was selected based on the organisational structure (concerned hospital); as each hospital contains main five departments, so five experts were selected from each hospital. Interviewees’ experience (working experience ranged from 18 to 25 years) and involved in lean project or participated in continuous improvement initiatives, as mentioned in Table 3.15.

Table 3.15 Experts who participated in assessment process

No	hospital	Interviewee's role	Experience (Years)
E_1	X	Associate executive director for supply	25
E_2	X	Purchasing and tendering manager	20
E_3	X	Material management manager	28
E_4	X	Medical equipment manager	15
E_5	X	Store manager	22
E_6	Y	Associate executive director for supply	18
E_7	Y	Procurement and contracts manager	21
E_8	Y	Demand planning and forecasting manager	19
E_9	Y	Medical purchasing manager	17
E_{10}	Y	Medical warehouse manager	21
E_{11}	Z	Associate executive director for logistics	19
E_{12}	Z	Purchasing and tendering manager	16
E_{13}	Z	Material management manger	18
E_{14}	Z	Medical equipment manager	15
E_{15}	Z	Store manager	17

As mentioned earlier in Chapter 4, the names of the hospitals were encoded, yielding hospital (X), hospital (Y) and hospital (Z). In addition, fifteen interviewees is deemed to be an acceptable number and has been used by many researchers (Vinodh & Prasanna, 2011; Elnadi & Shehab, 2016). In some studies, fewer than fifteen participants is also acceptable. Behrouzi and Wong (2013) interviewed three interviewees from the supply chain in their study. For approximately 60 minutes, each participant discussed the model and its ability to measure hospital supply chain leanness. Responses to the experts' feedback resulted in revising the second version of the model by removing, adding or changing the name of the model's items. Following this, three hospitals were visited for data collection to compute the hospital supply chain leanness index. Each respondent (expert) was asked to complete a spreadsheet in Excel to identify relative weight (importance) for each enabler, criterion and attribute, Figure 5.3. Attributes were scored by experts to assess the extent to which each attribute is implemented at the hospital in supply chain management processes. More details on this will be discussed in the upcoming sections.

As mentioned earlier the healthcare organisations were selected from those healthcare organisations which are keen to implement lean practices in their

supply chain management and which are accredited by both the Saudi Central Board for Accreditation of Healthcare Institutions (CBAHI) and the Joint Commission International (JCI). The reasoning behind these criteria was to make sure there was a rigorous foundation on which to implement change initiatives such as lean. A multi-grade (multi-attribute) fuzzy logic was then used for leanness measurement. The leanness index was calculated, and the results were validated. This step was followed by the identification of weaker areas that might require further improvements.

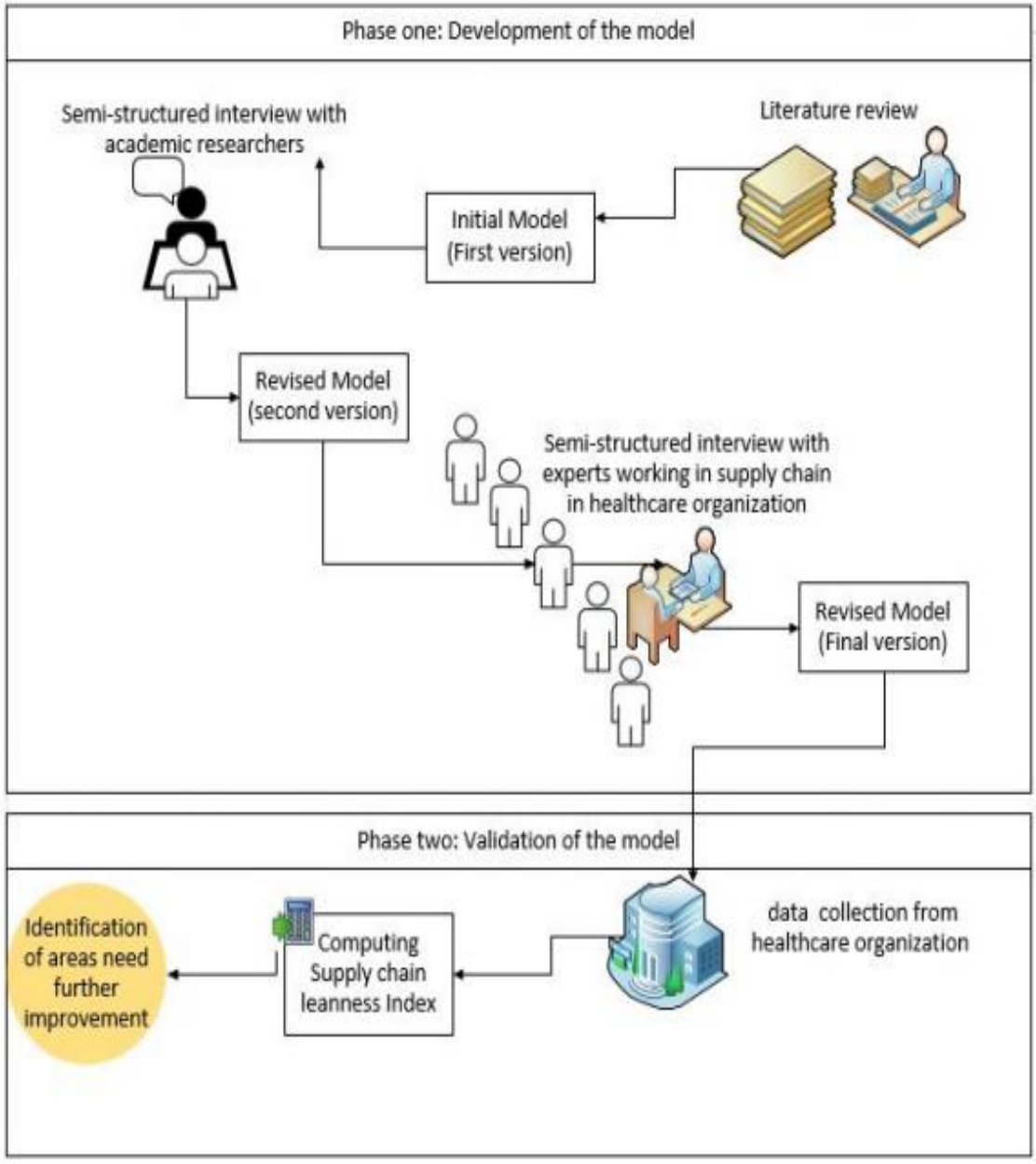


Figure 3.6 Methodology development for computing HSCM index

3.8 Methodology for development of HSCM framework

First, it is important to know and understand what a framework is within research context. Anand & Kodalik (2010) defined framework as "a guiding torch that helps a manager in providing necessary direction during the change management programmes that implemented in an organization". Figure 6.2 shows the methodology adopted for developing the framework.

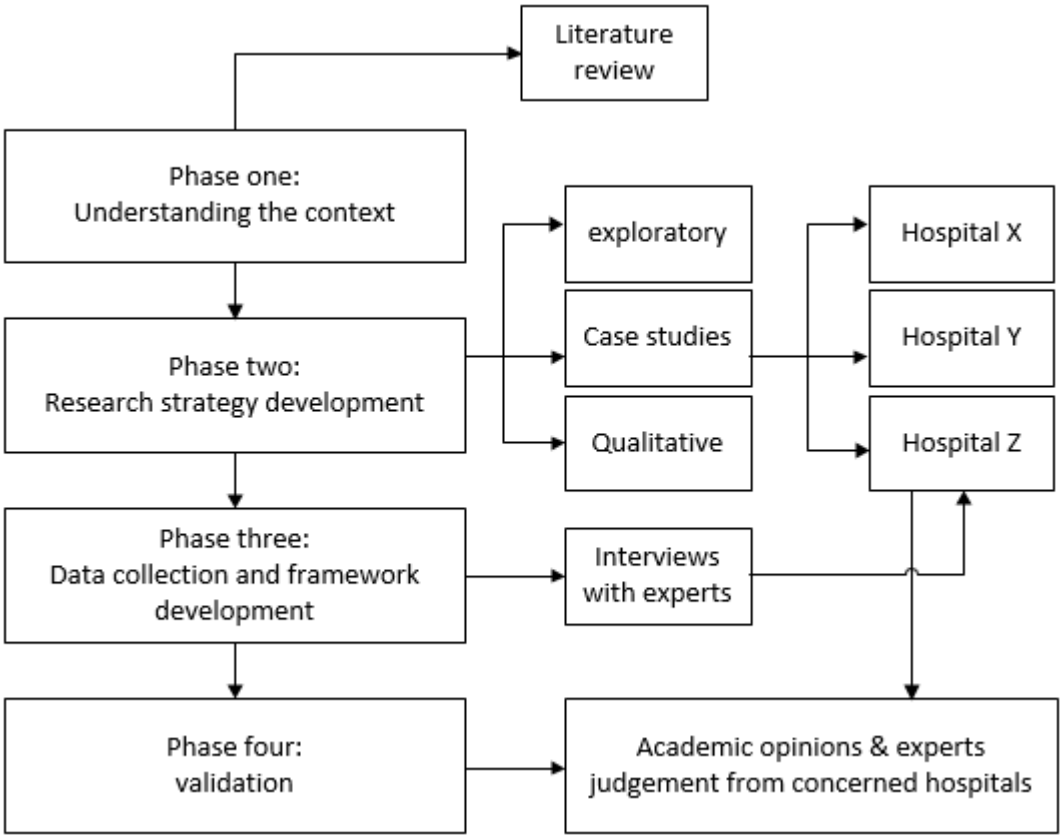


Figure 3.7 Methodology for developing HSCM framework

According to Miles & Huberman (1994) conceptual framework defined as "a visual or written product, one that "explains, either graphically or in narrative form, the main things to be studied the key factors, concepts, or variables and the presumed relationships among them". There are four sources to build framework for research namely experiential knowledge, existing research and theory, exploratory and pilot study and thought experiments(Maxwell 2005).

3.8.1 Phase One: Understanding the context

This chapter begun with explore and understand the-state-of-the-art of lean supply chain management (LSCM) frameworks with focusing on healthcare context by identifying relevant databases. Cooper (1988) claims that the literature can be reviewed based on the purposive selection method in which solely related publications vital to the research area where selected to be reviewed. So the selected publications specifically concentrated on lean implementation in different industries with focusing on healthcare sector. The literature review revels that there is a clear shortage studies in developing framework for implementing lean in HSCM. Additionally, it has noticed that the most existing lean implementation frameworks were conducted in manufacturing sector compared with lean implementation in service sector especially in healthcare SCM context.

Different electronic databases were reviewed; Science Direct, Scopus, Emerald, ABI/INFORM, Taylor and Francis, SAGE, and EBSCO. To identify relevant articles, 'lean implementation', 'lean roadmap', 'lean framework' 'supply chain management', 'hospital',' healthcare' were used as keywords. Papers and articles not fitting the aim of research, not in English have been neglected. The knowledge gap was identified and the research areas were the key factors determining the context of this research.

3.8.2 Phase Two: Research Strategy Development

The exploratory study is better describing the aim and objectives of this study. Robson, (2011) mentioned that the exploratory research is to discover 'what is happening; to seek new insights; to ask questions and to assess phenomena in a new light'. According to Yin (2014) case study is suitable to study an area in which not a lot of studies have been conducted. In this study, since the implementation of lean practices in hospital supply chain is a relatively new phenomenon and the investigation is related to and rooted in work-life experience, case studies are the more appropriate strategy to understand real life situations. The study of implementation of lean practices in HSCM is relatively limited and can be considered as new phenomena especially in healthcare

context in Saudi Arabia. Three Saudi hospitals were visited to capture industrial practices in terms of lean. More details in section 4.4.

3.8.3 Phase Three: Data collection and framework development

For collecting data and information, interviews were carried out with experienced employees from within the SCM in the healthcare sector of Saudi Arabia who qualified and participated in continuous improvement projects. From the interviews, many important factors and operational considerations were identified by the respondents. Since all healthcare organizations participated in this study are competing to get the national quality award, the enablers and factors were grouped according to the King Abdulaziz Quality Award (KAQA) that represents the National Quality Award in Saudi Arabia. KAQA has the same enablers as European Foundation for Quality Management (EFQM) model. The reason behind this was to maximize the benefits from implementing the framework by facilitating implementing lean principles. In this study, KAQA was used for self-assessment and to identify areas for further improvement (Dodangeh & Yusuff 2011), which is an aim of this study. Further, KAQA can be used in certain subsectors in healthcare settings (in this case, supply chain departments) (van Schoten et al., 2016).

Due to the importance of hospital's consumers (physicians/patients), as both of them are the pillar of healthcare services, enablers for consumers have been independently identified. Also, any factors related to healthcare policy and strategy has been classified under leadership factors because the strong relationship between strategy and leadership and leaders is responsible for drafting, forming and executing the hospital's strategy.

The development process of the framework was based on reviewing literature and interviewing experts from three Saudi healthcare organizations as shown in Figure 6.3. The framework is built based on four phases as elaborated in the following section.

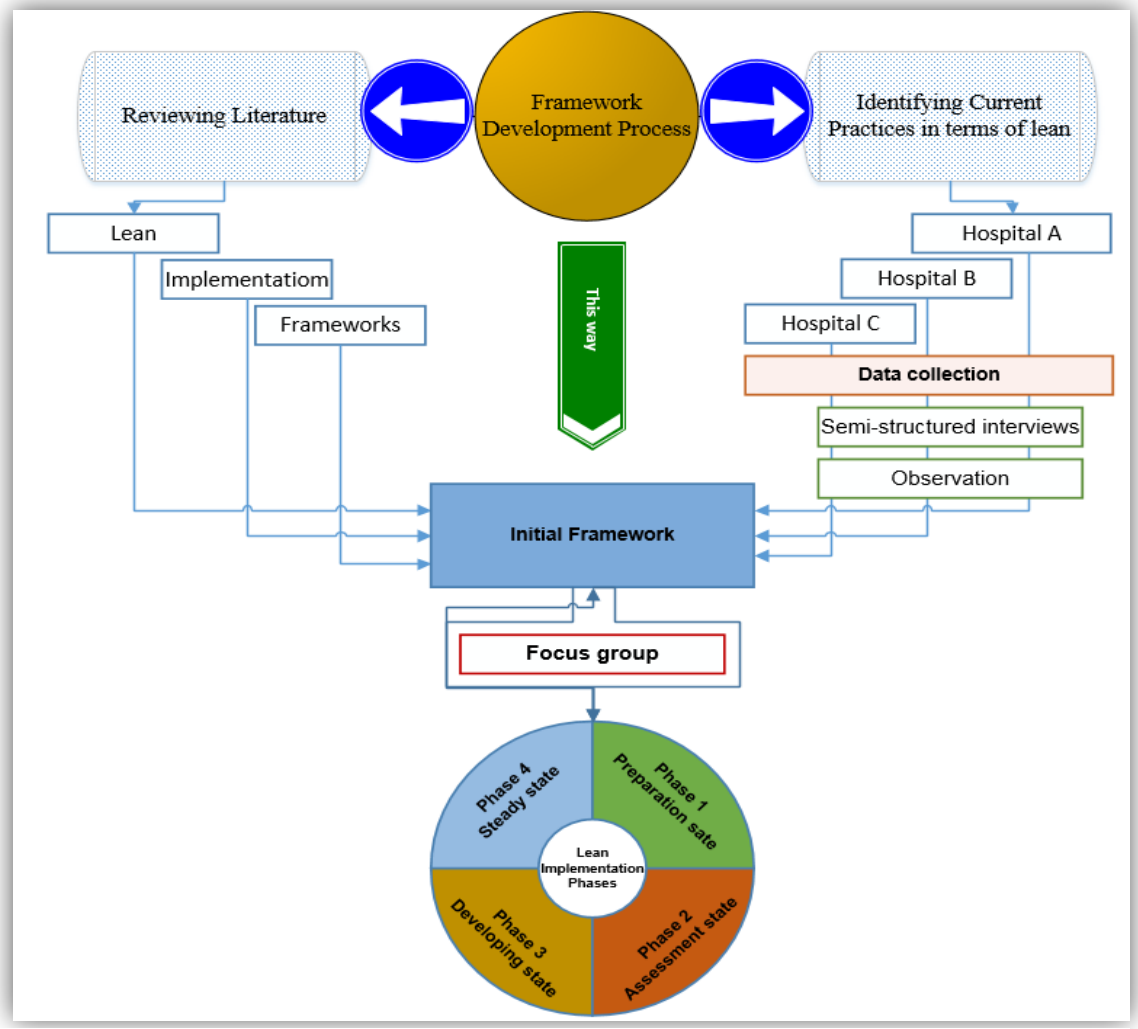


Figure 3.8 Framework development process

3.8.4 Phase Four: Validation

This research has employed two types of validation which are qualitative validation and quantitative (statistical) validation. The main purpose of those is to collect opinions about to make sure of the feasibility of the phases and activities of the framework.

3.9 Chapter summary

In this chapter, the research methods and data collection techniques were presented. Next, the rational of the selected research methods and strategy were justified. Then, research methodology adopted was illustrated. The next chapter will explain a framework that can be used to implement lean approach in HSC.

4 Chapter Four: Lean implementation in HSCM:

prioritization, barriers, proposed solutions and enablers[1]

The aim of this chapter is to provide the main barriers that are considered to be the hinder for the successful implementation of lean in healthcare supply chain management (HSCM). Also, prioritization of these barriers and proposed solutions will be presented. Additionally, main enablers and factors that play vital role in success of implementation of lean will be highlighted. The main sections of this chapter illustrated below in Figure 4.1. This chapter addresses the second research objective which is determine the main enablers and barriers for healthcare supply chain management to implement lean thinking.

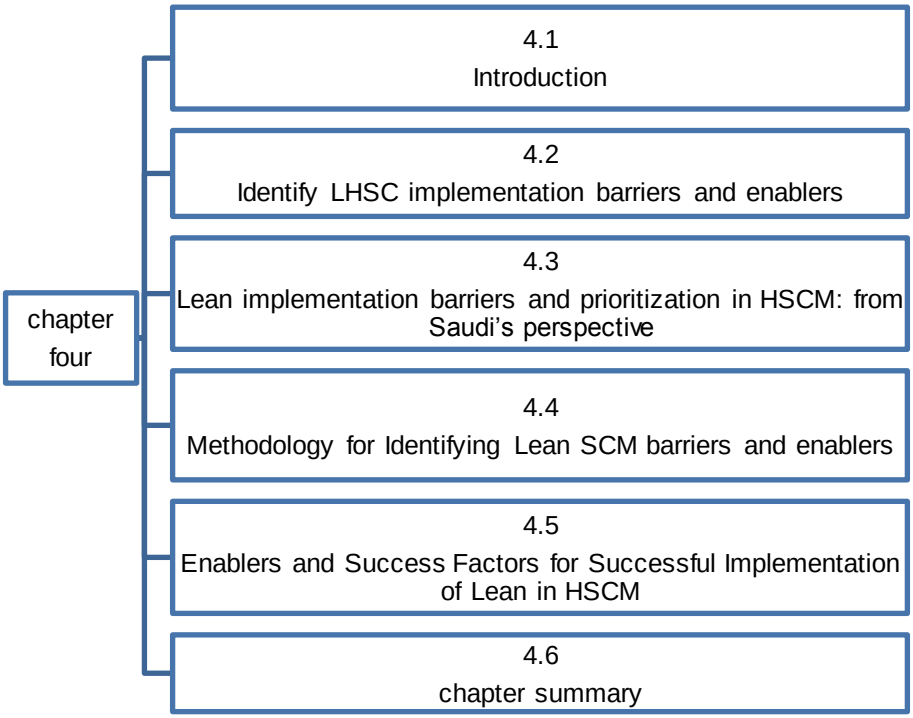


Figure 4.1 main sections of chapter four

[1] Part of chapter four has been accepted: Almutairi, A. Salonitis, K. and Al-Ashaab, A. (2019)" Barriers for implementing lean: Prioritisation and proposed solutions from Saudi healthcare's perspective" Total Quality Management and Business Excellence

4.1 Introduction

The successful lean implementation in healthcare is not easy task and it's linked to overcome barriers of implementation that should be removed before starting lean journey. Existence of these barriers will work as hinders for implementing lean in HSCM. In addition, to enable healthcare organizations to execute lean concept successfully, many enablers should be achieved for successful implementing lean in HSCM. Also, understanding what are the most suitable tools for implementing lean project in healthcare context is critical factor during lean journey. Misapplication of lean techniques in terms of using a single tool, or select wrong tool, or using the same tool for different problem is considered one of the most reasons behind the unsuccessful of lean implementation initiative.

Several organisations attempt to adopt the lean management philosophy without necessarily understanding the lean principles and the possible barriers that they will have to face during the implementation. Most of these entities struggle a lot to attain the desired outcomes and give up eventually (Yadav et al., 2018). Identification of potential barriers and obstacles prior to the implementation of lean or any other continuous improvement tool within the organisation is quite significant, as trying to control the barriers it has started becomes a hard task for the practitioners (Yadav & Desai 2017). The healthcare organisations, as of any other sectors organisations, should address barriers before beginning their lean journey (Matteo et al., 2011).

Glasgow et al., (2010) reviewed 47 studies in health-care and mentioned that 62% of the reported lean projects failed. These failures in most of the cases are attributed to organisations failing to pay attention to the barriers and the Critical Success Factors (CSFs) before and during lean implementation. After reviewing literature, it was found that barriers for implementing lean principles in healthcare in general and in the hospital supply chain in particular, have not been investigated. Most of the existing studies have extracted their set of barriers from manufacturing point of view while the healthcare perspective was neglected.
Literature review also revealed gaps that need to be filled, especially in healthcare context, such as lean barriers, and motivation factors, (Vashishth et

al., 2017; Laureani & Antony 2011; Pepper & Spedding 2010). Moreover, there is a clear shortage in the literature with regards the ranking or prioritization of the barriers and enablers for lean implementation even though they are crucial and impact on healthcare organisation's performance (Yadav & Desai 2016).

Understanding of organisations' context is key for the suitable lean implementation in the supply chain (Tortorella et al., 2017). Healthcare organisations' have their own context and barriers in healthcare supply chain management (HSCM), which has not been covered yet. In a real-life, it becomes indeed challenging for decision makers to overcome all barriers and apply all the solutions because of several unavoidable limitations such as the associated cost (Yadav et al., 2018). That is why ranking and prioritising the barriers and the potential solutions becomes extremely important and useful for them to plan their improvement initiatives. Interviews have been conducted with experienced staff who is working at healthcare organisations to discover lean implementation barriers in hospital supply chain and make sure that these factors are related to hospitals. The staff has been selected based on their experience, knowledge, and understanding of lean concepts, and their track record in participating continuous improvement initiatives. The main reason of the focusing on some barriers and neglect others are that individual barriers possess different levels of significance that change with organisation, its priorities, its nature and its type (Yadav et al., 2018). In addition, it is extremely difficult for healthcare organisations to overcome all of these barriers simultaneously (Yadav & Desai 2016).

Considering different healthcare systems and different organisational cultures make this study the first of its kind. The purpose of this study is identifying barriers for implementing lean in a hospital supply chain from the Saudi perspective, prioritize them and indicate how to overcome these barriers.

To achieve the aim of the chapter, Figure 4.2 illustrates steps employed to identify barriers. The research used several material sources, such as books, theses, reports, and many electronic sources, including Google Scholar, Emerald, Business Source Complete, Elsevier, Science-Direct, Scopus, and ProQuest,

etc. The barriers of implementing lean activities in HSCM were the cornerstone when literature was intensively checked with focus on the Saudi context. The gaps were identified, and the research areas were the key factors determining the context of this research.

Because the barriers of lean implementation in healthcare supply chain management have not been investigated enough and there is not enough information about how lean barriers can be avoided in the HSCM, the exploratory approach is adopted in this study. This study aims to help decision makers in healthcare institutions explore and determine how to avoid lean barriers in the supply chain context.

This research has employed experts' judgement as validation approach. Employees mentioned in Table 4.1 were partipated in the survey. More details about validation process will be presented in 7.2.

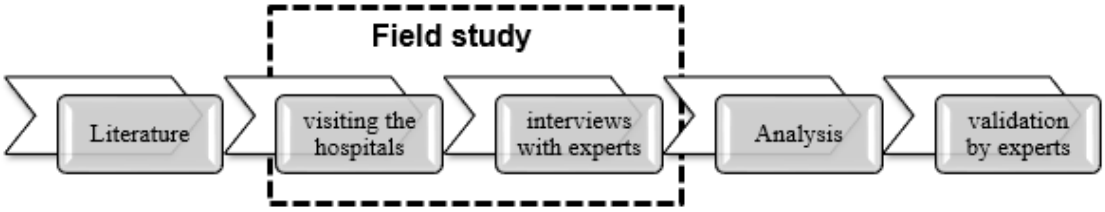


Figure 4.2 Methodology adopted

Table 4.1 Experts participated in identifying lean barriers

No	hospital	Interviewee's role	Experience (Year)
1	X	Associate executive director for supply	22
2		Purchasing and Tendering manager	20
3		Material management manger	28
4		Medical equipment manager	15
5		Store manager	22
6	Y	Associate executive director for supply	18
7		Procurement and contracts manager	21
8		Demand planning and forecasting manager	19
9		Medical purchasing manager	17
10		Medical warehouse manager	21
11	Z	Associate executive director for logistic	19
12		Purchasing and Tendering manager	16
13		Material management manger	18
14		Medical equipment manager	15
15		Store manager	17

Hence, the aim of this chapter is to address this gap and to present the main barriers for implementing lean principles as well as the main enablers that are considered. Also, this chapter aims to priority barriers to implement lean in HSCM. How to overcome such barriers is another goal of this chapter.

4.2 LHSMC Implementation Barriers

Identification of any barriers prior to the implementation of any lean concepts or any quality improvement approach within the organisation is extremely important (Yadav & Desai, 2016). After extensive literature review, the lean barriers are grouped into: individual –related barriers or organizational-related barriers as mentioned in Table 4.2.

Individual –related barriers: lack of employee involvement/engagement is another barrier. A willingness of the medical staff to implement lean transformation and a commitment to apply revised process improvement is crucial to the success of the lean initiative (Laureani et al., 2013). Also, lack of training and education. Nwabueze (2012) mentioned that there are many issues related to executives, for example, a poor investment in staff training and believing that training is just extra cost and waste of money and employees' time. Moreover, shortage of experience/knowledge in lean is one of the most important barrier. Grove et al., (2010) mentioned that one of lean implementation challenges is poor understanding of lean concepts. Deficiency of top management commitment is another barrier. Senior managers should be willing to show their support and commitment for any lean initiative whenever problems arise(Al-Balushi et al., 2014).

organizational-related barriers: Bhasin, (2012) mentioned that culture change is one of the most serious issues that health-care organisations are facing and the organisational culture determines which approach and methodology is most suitable for an organisation. In addition, poor organisation capabilities/resources can be considered barrier for implementing lean. In some cases and due to the lack of a hospital's capabilities, a hospital cannot overcome some of the

challenges in its current situation. In this case, lean initiatives are postponed until the challenges are resolved (D'Andreamatteo et al., 2015; Kim et al., 2006). Lack of awareness of lean is another hinder for implementing lean. Psychogios et al., (2012) mentioned that insufficiency of awareness is a considerable challenge for lean project, e.g. a lack of awareness of the benefits of lean as well as a poor of top management support.

Poor communication within departments is another barrier. The lack of communication within the healthcare is a main challenge for the lean implementation((Antony et al., 2007; Grove et al., 2010). In addition to the previous barrier, lack of a performance measurement system many organisations have failed to earn any advantages from lean application due to the unclear understanding of leaders of lean performance and how to assess its impact on the performance (Karim and Arif-Uz-Zaman, 2013). Also, poor linking of lean to employees' rewards Apply effective rewarding and recognition system (incentive) in healthcare organization can be considering a motivational approach for implementing lean concept and facilitate change transformation (Al-Balushi, 2014).

Table 4.2 Lean Implementation key barriers

Category	Barrier	Literature support
Individual-related	Resistance of culture change	Yadav et al., (2018); McLean and Antony (2014); Antony et al., (2012); Pedersen and Huniche (2011); Pepper and Spedding (2010)
	Lack of employee involvement/engagement	Yadav et al., (2018); Albliwi et al., (2014); Arumugam et al., (2012)
	Lack of training and education	Yadav et al., (2018); Albliwi et al., (2014); Panizzolo et al., (2012); (Hilton & Sohal, 2012); Psychogios et al., (2012); Chakravorty and Shah (2012); Pedersen and Huniche (2011); Snee (2010)
	Wrong selection of lean tools	Yadav et al., (2018); Albliwi et al., (2014); Karim and Arif-Uz-Zaman (2013); Nwabueze (2012); Reijula

		and Tommelein (2012); Antony et al., (2012)
	Data collection, analysis and interpretation of obtained findings	Gijo and Antony (2014)
	Poor project selection and prioritisation	Albliwi et al., (2014); Chakravorty and Shah (2012); Pedersen and Huniche (2011); Snee (2010)
	Shortage of experience/knowledge in Lean	Yadav et al., (2018); Albliwi et al., (2014); Panizzolo et al., (2012); Reijula and Tommelein (2012)
Organizational – related	Poor organisation capabilities/resources	Yadav et al., (2018); Albliwi et al., (2014); Antony et al., (2012); Pedersen and Huniche (2011)
	Lack of awareness of lean	Yadav et al., (2018); Albliwi et al., (2014); Psychogios et al., (2012); Panizzolo et al., (2012); Pedersen and Huniche (2011)
	Deficiency of top management commitment	Yadav et al., (2018); Gijo and Antony (2014); Albliwi et al., (2014); Nwabueze (2012); Reijula and Tommelein (2012); Antony et al., (2012);Chakravorty and Shah (2012); Snee (2010)
	Poor communication within departments	Yadav et al., (2018); Albliwi et al., (2014); Gijo and Antony (2014); Antony et al., (2012); Chakravorty and Shah (2012); Pedersen and Huniche (2011); Snee (2010)
	Lack of a performance measurement system	Yadav et al., (2018)
	Sustainability of achieved findings	Gijo and Antony (2014); Snee (2010)
	Poor linking of lean to employees' rewards	Yadav et al., (2018); Albliwi et al., (2014); Pedersen and Huniche (2011); Snee (2010)
	Poor linking between lean and strategic objectives	Albliwi et al., (2014); Antony et al., (2012); Antony et al., (2012); Pedersen and Huniche (2011)

In conclusion, it is clear that there are no fixed barriers for all sectors. Lean barriers differ from context to other and from industry to other. Organization's

capabilities, technology-bases barriers and cultural barriers (employees' culture) play vital role in shape in how the organization intend to implement lean concept and to what extent the organization has abilities and capabilities. Based on that, the organization decide to continue, postpone to certain time or refuse to implement lean initiative permanently (Yadav et al., 2018; Gupta et al., 2016 ;Albliwi et al., 2014).

4.3 Lean implementation barriers and prioritization in HSCM: from Saudi's perspective

Since health-care system differ from country to country, definitely HSCM practices differ depend on the health-care system. Also, culture (e.g. organizational culture) play crucial role in success lean initiative. Saudi healthcare organizations have won organizational culture that distinguish them from other worldwide health-care organization and make them have won barriers when attempt to implement lean concept in their supply chain. Different health-care system and different organizational culture make this study the first type of its kind which highlights barriers to lean implementation in hospital supply chain.

Although lean has been implemented in several western organisations for a decade, its implementation in the Middle Eastern countries in general and in Saudi Arabia in particular remains in the early phases(Albliwi et al., 2017). Thus, identifying lean implementation's barriers in HSCM has become a must to implement lean thinking successfully in Saudi context.

To discover lean implementing barriers in HSCM and make sure that these barriers are related to hospitals, Healthcare organisations were visited and 15 interviews were conducted with three different healthcare providers in Saudi Arabia to identify the lean implementation barriers from real-life scenario. Semi-structured interviews have been conducted to evaluate and understand the present situation more deeply in terms of barriers of lean in hospital supply chains in Saudi Arabia. The interviews were carried out with experienced employees who had qualified for example, LSSGB, LSSBB or LSSMBB or who participated in continuous improvement projects. Moreover, the issues and problems

identified in the literature review have been compared with the first-hand accounts of those qualified practitioners. Interviews with respondents were conducted in their hospitals. From the interviews, lean barriers were identified by the respondents. The main reasons behind focus on some barriers and neglect others are an individual barriers possesses different levels of significance which change with organisation, its priorities, its nature and its type(Yadav et al., 2018). Also, it is extremely difficult for healthcare organizations to overcome all of these barriers simultaneously(Yadav & Desai 2016).

The interview with respondents (experts) discovered many main barriers hospitals faced when the hospitals attempt to deploy lean approach. The following nine theme come from literature, field visiting (hospitals) and supported by interviewees' statements

- Existence of physicians' preferences, **B_1**
- Unpredictable patient demand, **B_2**
- Inadequate knowledge and Lack of understanding lean concept, **B_3**
- Identify waste in HSCM processes (delivering value to the patient), **B_4**
- Hospital culture and resistance to change, **B_5**
- Lack of hospital support, commitment and disbelief in Lean, **B_6**
- Scarcity of qualified human resources and lack of training, **B_7**
- Assessment of the required level of leanness, **B_8**
- Lack of effective communication and information sharing, **B_9**

All of these barriers will be elaborated in the following sections with highlight the relative importance for each barriers and effeteness of proposed solutions.

4.3.1 Existence of physicians' preferences (B_1)

In order to identify what the main barriers to lean implementation in hospital supply chain management, semi-structured interviews were conducted with experts. Participants indicated that physicians' preferences constitute real challenge for implementing lean thinking. For example, associate executive director for supply from hospital (X) stated that *"... clinical decision making: medical*

staff's preferences should be avoided to implement any continuous improvement initiatives such as lean thinking…"

Medical purchasing manager from hospital (Y) stated that *"…disagree between doctors about certain medication play role in obstructing the implementation of lean…"*

One of the ultimate goals of lean implementation is reducing the cost. Disagreement between medical staff plays a significant role in increasing medical supplies' cost. One of the major barriers that healthcare supply chain face is physicians' preferences. Due to physician's preferences and patient characteristics, process variability is becoming higher in the healthcare supply chain (Moons et al., 2018). According to Toba et al., (2008), Physician Preference Items (PPIs) constitute 40% of total medical supply spending for a hospital. Montgomery and Schneller (2007) defined PPIs as "those for which physicians have strong preferences and make the choice in hospital purchasing - typically not based on cost but rather on personal experience with the device and relationships with the vendor's sales representative."

It is believed that physicians exhibit change resistance. However, sometimes doctors opinion is valid (Neumann, 2003). Certain preferences by clinicians for medical supplies and variation in processes are adopted to ensure the safety of patients. However, these preferences increase HSCM cost. Recently, healthcare providers have become aware of the financial cost of allowing clinicians the independence to order whatever medical items they select (Toba et al., 2008).

"Physicians preferences" barrier can be overcome by physician buy-in, especially those clinical items that have high-cost medical product evaluation, and review committees or value-analysis committees have been recommended to overcome the issue (Neumann, 2003). This approach was successful in one of the largest healthcare organisations in the United State, which is Kaiser Permanente (KP). KP encourages physicians for buy-in and agreement. For instance, their purchase decision takes place based on team consensus. The compliance of this approach was more than 90% (Toba et al., 2008). Creating "standards and sourcing committee" can play a role in overcoming this problem. This committee consists of physicians, pharmacists, medical equipment experts and purchasing/sourcing representatives.

4.3.2 Unpredictable patient demand (B_2)

After conducting semi-structured interviews with experts. Respondents mentioned that it is difficult for hospital to identify patients demand accurately and it constitutes real barrier for implementing lean thinking. For example, demand planning and forecasting manager from hospital (Y) stated *that "...in healthcare context, it is difficult to predict customers' demand precisely..."*

Material management manager from hospital (Z) stated that *"It would be impossible at a certain point to predict the demand of patients ...it is too difficult"*

It is difficult for hospital supply chain decision makers to make sure that there are enough medicines and medical supplies for every patient's needs. Lean is less applicable due to unstable demand (Wilson, 2010). So, the medical supply will be either overstocked or in shortage; in both of these cases, hospital supply chain cost will be increased. Medicines shortages pose risks for patient health as a result of non-treatment, under-treatment and possible medication errors from attempts to substitute missing medicines. Medicine shortages have been increasing in recent years (Hedman, 2016). For example, in the USA, new medications shortages increased from 70 in 2006 to more than 267 in 2011. The total number of new and ongoing shortages crossed the 450 mark in 2012. International Pharmaceutical Federation (FIP) mentioned that shortages cost American hospitals US$ 416 million, i.e., US$216 million in labour costs and US$ 200 million to purchase more expensive alternatives (Hedman, 2016).

Bhakoo et al., (2012) mentioned the unanticipated lead-times of medical supplies and unexpected patient demand, especially in the case of emergencies. In a large survey conducted by European Association of Hospital Pharmacists (EAHP), 21% of hospital pharmacists mentioned experiencing a shortage of medicines on a daily basis and 45% of them mentioned experiencing it on a weekly basis. Pharmacists who participated in the interview mentioned that they could not manage the shortage most of the time; they reported that the shortages causes patients to suffer disruption to their treatment (EAHP, 2014).

Boutsioli (2013) mentioned that healthcare organisations' demand is unpredictable and can differ from hospital to hospital. Forecasting is not accurate and it is difficult to predict precisely. Hospitals policies, procedures and practices

can play a role in increasing demand variation. Lack of policies of hospital admissions (sometimes called preadmission policies and referral policies) can create a high variation of demand. As a result, the number of patients cannot be predicted accurately. Clear policies, procedures and practices should be implemented by hospitals to manage the demand of patients, especially the cases that can wait for some time without any serious harm. Moreover, using different mathematical models (such as a univariate model) can contribute significantly to control patients' demands (Boutsioli, 2013; Gupta & Potthoff, 2016).

Using information technology can minimize the uncertainty and the predictable demand in healthcare organisations. For example, using radio-frequency-identification (RFID). RFID allow the monitoring of the patients and provide information that can be used to identify patients' number and status amongst others. These data can be easily entered to a computer and then simulation models can be employed. By using such methods, healthcare providers can optimise the use of their resources and reduce variation in patients' numbers and therefore improve the forecasting process and reduce uncertainty (Gupta & Potthoff, 2016).

4.3.3 Inadequate knowledge and Lack of understanding lean concept (B_3)

During field study, interviewees indicated that inadequate knowledge and lack of understanding lean thinking constitute challenge for implementing lean thinking. For example, medical purchasing manager from hospital (Y) stated that "*…it is not clear what the aim of lean thinking in the hospitals nor is it clear what the supply chain wants to achieve*".

Medical equipment manager from hospital (Z) stated that *"…absence of the knowledge of lean approach is considered a real challenge for implementing lean initiative… Unfortunately, this problem is found in the healthcare sector in Saudi Arabia."*.

Lack of understanding impacts organisations in different sectors, e.g., the lack of understanding of managers on how to apply continuous improvement initiatives and their poor grasp on the implementation of lean techniques and tools in a

particular environment. In addition, many organisations have failed to earn any advantages from lean application due to the unclear understanding of leaders of lean performance and how to assess its impact on the performance (Karim & Arif-Uz-Zaman, 2013). Moreover, the lack understanding of how to begin and what should be conducted first (Nwabueze, 2012) as well as a lack of realizing the benefit or change that will occur after applying lean (Gurumurthy & Kodali, 2011) is another challenge.

Misunderstanding lean practices may create bad impression on managers. Further, many directors believe that lean implementation is costly, and its benefits are not worthy to invest in lean initiatives. So, a poor knowledge and misunderstanding by hospital supply chain decision makers are considered to be one of the biggest barriers (De Souza & Pidd (2011; Gurumurthy & Kodali 2011). By presenting a real-life scenario, such as lean success in another hospital and indicating how much healthcare organisations benefit from implementing lean in their processes may convince healthcare executives to adopt the lean approach. Well-trained and coached people are vital for implementing lean successfully (Albliwi et al., 2017). If healthcare SCM managers are trained and made to understand the knowledge for implementing lean, then they will be more likely to accept lean initiatives.

Jeyaraman and Kee Teo (2010) mentioned that using benchmark approach and narrating lean success stories can motivate managers to adopt the lean approach and attain what others have attained. This makes people in HSCM better understand lean approach benefits and become aware of lean's advantages. Psychogios et al., (2012) mentioned that insufficiency of awareness is a considerable challenge for any lean project, e.g., a lack of awareness of the benefits of lean and poor top management support

4.3.4 Identify waste in HSMC processes (delivering value to the patient) (B_4)

Identify waste in hospital supply chain management process is another barrier to lean implementation. Semi-structured interviews were conducted with experts. Participants indicated that physicians' preferences constitute real challenge for

implementing lean thinking. For example, medical warehouse manager from hospital (Y) stated that *"So far, the main problem which is facing hospitals and supply chain departments have not been accurately identified wastes in supply chain practices".*

Store manager from hospital (Z) stated that "*identifying value to patients is serious issue facing HSCM…*". One of the key barriers in the healthcare context is to manage and deal with the intangibility of waste emerging because of the difficulty to identify it" (Grove et al., 2010; Gupta et al., 2016). One of the main aims of lean implementation is to eliminate wastes from the processes. Process analysis should be used to identify waste in each process, and then waste can be eliminated during improvement steps (Radnor et al., 2006). Healthcare staff is struggling to identify key processes that do not add value to patients (Grove et al., 2010).

Interviewees suggested value stream mapping (VSM) to identify waste in healthcare supply chain processes. VSM or process mapping is highlighting many types of problems in day-to-day operations and processes. They supports lean initiative transformation by identifying waste (non-value-added) and value-added activities. VSM visualises wastes for elimination and areas for further improvement (Grove et al., 2010; Cottyn et al., 2011; Mostafa et al., 2013). Moreover, the 5S approach (sort, straighten, shine, standardise and sustain) plays a vital role in identifying and removing waste (non-added processes) from HSCM activities (Grove et al., 2010). Applying VSM and 5S need well-trained staff. Shortage of people who can implement lean tools successfully is another barrier.

4.3.5 Lack of hospital support, commitment and disbelief in Lean (B_5)

Field study showed that poor commitment and support from top management. Interviews were carried out with experts to identify the main barriers to lean implementation in hospital supply chain management. Participants indicated that lack of support and commitment and disbelief is considered challenge for implementing lean thinking. For example, purchasing and Tendering manager

from hospital (X) stated that *"... without top management support, it is impossible to deploy lean approach".*

Procurement and contract manager from hospital (Y) stated that *"... if the decision makers in hospitals do not strongly support continuous improvement projects, the projects definitely fail".*

One of the main reasons behind the failure of lean or any continuous improvement initiative is the poor commitment of top leadership. All directors in each level of the hospital should be persuaded that adopting lean is the right initiative. Decision makers at the hospital supply chain need to demonstrate strong commitment and full support in providing all lean implementation requirements such resources, employees training, budget and other needs that help, facilitate and accelerate lean implementation.

To overcome this challenge, building a lean dashboard at workplace facilitates both operators and managers to track the ongoing processes, reduce non value adding activities (NVA) and pay attention toward bottlenecks (Gremyr & Fouquet, 2012; Yadav et al., 2018). In addition, the senior management must be committed to improve the quality, include it within its objectives and strategic plan and regularly review the extent of its achievement. Moreover, leveraging previous lean implementation experience can also enhance hospital's commitment toward lean initiatives.

4.3.6 Hospital culture and resistance to change (B_6)

Visiting hospitals shows that hospital culture and resistance to change constitute barrier for implementing lean thinking in supply chain. For example, associate executive director for supply from hospital (X) stated that *"... resistance culture is the biggest issue in changing journey..."*

Associate executive director for logistic from hospital (Z) stated that *"... the absence of advocate/ supportive culture for change is considered a big issue in lean roadmap".*

Organisational culture is a key element in successful lean practices (Pakdil & Leonard, 2015). Bhasin (2011) claim that 80% of successful lean implementation is related to cultural issues. The culture of an organisation has the probability of creating resistance or restricting change efforts and may not be supportive to

initiative (McLean & Antony, 2014). Bhasin (2012) mentioned that culture change is one of the serious issues healthcare organisations are facing. Healthcare organisations need to alter their culture totally to guarantee successful lean adoption.

Albliwi et al., (2014) claimed that resistance to change is one of the most cause that lead to failure of lean implementation in the healthcare organisations. SCM in healthcare is suffering from the lack of process improvement culture (Moons et al., 2018). Such practices create a type of resistance to implementing lean initiatives in HSCM.

Organisational Culture is considered one of the most important factors in implementing lean in the Saudi context (Albliwi et al., 2017; Alkhoraif & McLaughlin, 2018). Sharing information about lean, effective communication and lean project success initiative stories can enhance lean culture and reduce resistance to change. Even though Saudi organisations lack the priority regarding training on lean six sigma yellow belt (LSSYB), many authors suggest all employees should be LSSYB certified. Attending awareness sessions such as LSSYB can play a vital role in changing organisational culture and lowering the level of change resistance (Albliwi et al., 2017).

Applying effective rewarding and recognition system (incentive) in healthcare organisation can be considered a motivational approach for implementing lean concept and facilitate change transformation. For example, bonus or monetary prize can facilitate implementation of lean (Brkic & Tomic, 2016).

4.3.7 Scarcity of qualified human resources and lack of training (B_7)

After conducting semi-structured interviews with experts. Respondents mentioned that lack and shortage of qualified and well-trained staff constitute real barrier for implementing lean thinking. For example, associate executive director for supply from hospital (Y) stated that *"Although there is training and qualified staff but hospital still suffers from shortage of high skilled employees and needs the intensive training which is required for implementing lean thinking".*

Associate executive director for logistic from hospital (Z) stated that *"... there is no training specifically about lean and its applications... hospital's staff need to know how to implement lean practically".*

Training is vital for the success of lean implementation in HSCM. No healthcare organisation can deliver high-quality patient satisfaction and safety and work process without well-trained employees. Lean implementation most likely requires different training than what is currently offered. During training sessions, many questions will be answered, and these answers will motivate employees to adopt and accept lean initiatives. These questions include why the lean project is necessary or needed, what the benefits of applying lean are, to what extent lean add value to patients. Taring is may be the first step toward lean implementation.

Large investments in training represent another problem for quality improvement programmes in healthcare(Antony et al., 2007). A healthcare organisation should invest in their employees' competencies to build and sustain lean implementation. The dependency on external lean consultant will be costly and not support lean sustainability. This is contrary and inconsistent with the objective of the lean concept.

Nwabueze (2012) mentioned that there are many issues related to executives, for example, poor investment in staff training and believing that training is just extra cost and waste of money and employees' time. Trained people drive change in the healthcare organisation so the staff should have the skills, knowledge and capabilities to lead the lean initiative and implement it properly. The presence of non-specialized staff in leadership positions who they do not believe in change and the concept of lean is a major obstacle to its successful application. This is due to poor training and lack of understanding of the concepts of continuous improvement such as lean.

4.3.8 Assessment of the required level of leanness (B_8)

During visiting hospitals, semi-structured interviews were conducted with experts. Interviewees indicated that assessment of required level of lean constitute challenge for implementing lean thinking. For example, associate executive

director for supply from hospital (X) stated that *"...measuring the maturity of level in terms of lean is a serious problem in supply chain practices"*.

Associate executive director for supply from hospital (Y) stated that *"... measuring the degree of leanness in supply chain operations is a real challenge facing decision makers in hospital"*.

Numerous and diverse organizations have implemented lean principles and practices, which concentrate on improving the efficiency of business processes by reducing cost, waste, consumptions and effort.

Presented model assessment tool to identify the gap between the present level of leanness and the desired leanness state so the healthcare organization can identify what can be improved. Almutairi et al., (2019) suggested model to enable decision makers in hospital supply chain to take suitable actions for improving lean implementation level For the healthcare institutions that are unable to determine their current or future leanness level, it is impossible to implement lean because they do not know where it exactly is and what the targeted level is in terms of lean (Bhasin, 2012, a,b). The lack of accurate criteria and precise attributes for determining the level of leanness required for the implementation of lean concept in the hospital supply chain result in a lack of clarity in the application of the lean concept. This barrier can be avoided by implementing leanness level assessment model (Jeyaraman & Teo, 2010).

4.3.9 Lack of effective communication and information sharing (B_9)

Field study revealed that lack of effective communication and information sharing. Interviews were carried out with experts to identify the main barriers to lean implementation in hospital supply chain management. Participants indicated that lack of support and commitment and disbelief is considered challenge for implementing lean thinking. For example, material management manager from hospital (X) stated that *"Unfortunately, there is no effective communication between departments and staff ... this means there is no sharing information in suitable time"*.

Medical warehouse manager from hospital (Y) stated that *"...without effective communication and information sharing between supply chain departments, lean implementation would be impossible"*.

In addition, poor communication between healthcare professional departments is another challenge in hospital setting. In the healthcare supply chain, the breakdown of effective/visual communication between the different departments/parties within the procurement process leads to dysfunctional supply chain (Al-Karaghouli et al., 2013). The lack of communication within the healthcare is a main challenge for the lean implementation (Antony et al., 2007; Grove et al., 2010). Poor communication may lead to increase in the time of delivery, raising the cost of medical items distribution, not meeting physicians' needs and reducing purchase of the right medical equipment (Al-Karaghouli et al., 2013).

To overcome this barrier, there is need to share information, work closely, and go against "silo working" (Not sharing information) by documenting all information and making it available on intranet (internal network). Communication can affect organisational culture in terms of lean implantation (Brkic & Tomic, 2016). Poor communication was observed in United Kingdom's healthcare system. Silo working (no sharing information) is usually expected in any organisation. This practice can hinder effective communication between parties while implementing continuous improvement initiatives (Grove et al., 2010).

Establishing effective and clear channels for communication at all healthcare SCM levels ensures the engagement of all the employees in the lean initiative, for example, using electronic channels rather than paperwork. These communication channels will help supply chain in healthcare organisations to solve issues related to the lack of communication.

4.4 Suggested Solutions for overcoming LSCM barriers

During visiting the hospitals, the interviews that held with participants also focused in identifying the suitable solutions to overcome lean implementation barriers. The suggested solutions identified as shown in Table 4.3. The validation of these solutions will be discussed in the following section. These barriers are interrelated and needs to be overcome. Figure 4.3 shows that there

is no direct mapping and the barriers are interrelated. Boundary line (dashed) shows all proposed solutions needs to be implemented in order to overcome all barriers. The barriers and their proposed solutions validated with experts from three hospitals. For example, associate executive director for supply from hospital (X) stated that *"If the hospital implement proposed solutions correctly the SCM departments is ready to start lean journey without obstacles".*

Table 4.3 Suggested Solutions to overcome Barrier

No		Suggested Solutions to overcome Barrier
S_1	S_{11}	Physicians buy-in.
	S_{12}	Creating "standards and sourcing committee"
S_2	S_{21}	Using information technology such as radio-frequency-identification (RFID)
	S_{22}	Clear policies, procedures and practices should be implemented by hospitals
S_3	S_{31}	Presenting a real-life scenario of lean success in another hospital.
	S_{32}	Well-trained HSCM managers to understand the knowledge for implementing lean
	S_{33}	Using benchmark approach
S_4	S_{41}	Applying value stream mapping and 5S
	S_{42}	well-trained HSCM staff for implementing lean tools
S_5	S_{51}	building a lean dashboard at workplace facilitates both operators and managers to track the ongoing processes, reduce non value adding activities
	S_{52}	pay attention toward bottlenecks
	S_{53}	Linking lean objectives with hospital strategic plan.
	S_{54}	leveraging previous lean implementation experience
S_6	S_{61}	Sharing information about lean,
	S_{62}	effective communication
	S_{63}	lean project success initiative stories
	S_{64}	Attending awareness sessions such as lean six sigma yellow belt
	S_{65}	Applying effective rewarding and recognition system (incentive)
S_7	S_{71}	investment in staff training
S_8	S_{81}	implementing leanness maturity assessment model
S_9	S_{91}	share information, work closely, and go against "silo working"
	S_{92}	documenting all information and making it available on intranet (internal network).
	S_{93}	Establishing effective and clear channels for communication at all healthcare SCM levels

Figure 4.4 shows driving (proposed solutions to overcome the barriers) and hindering (barriers) practices (force field analysis).

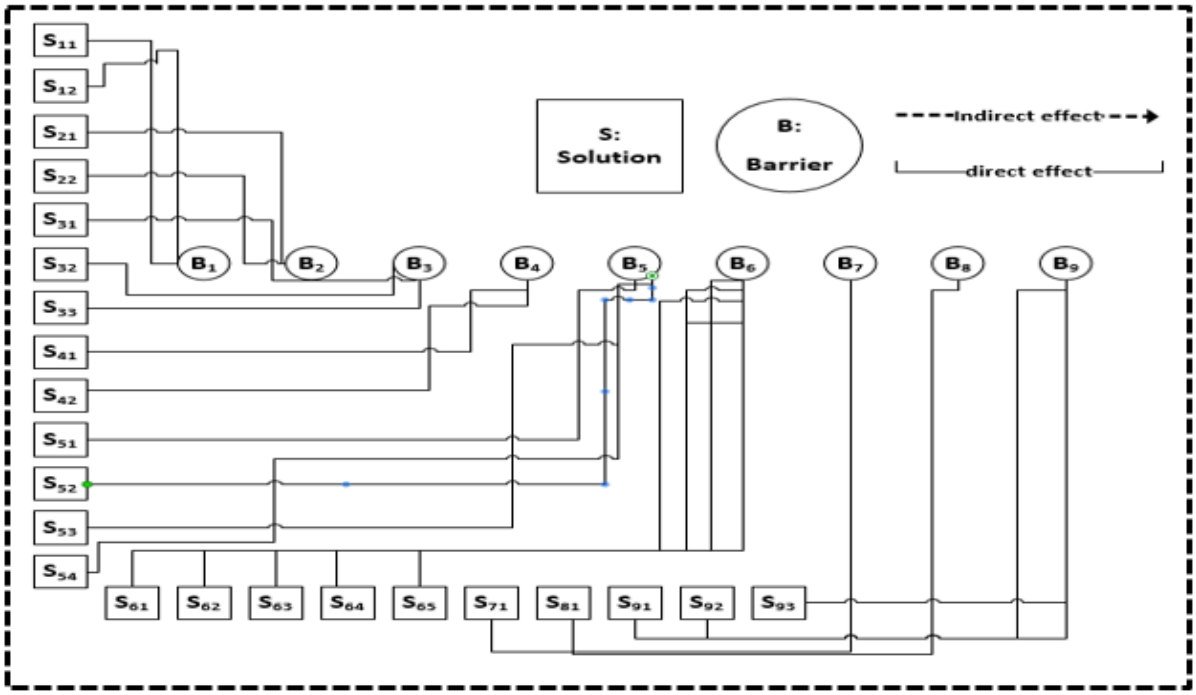


Figure 4.3 Relationship between Barriers and proposed solutions

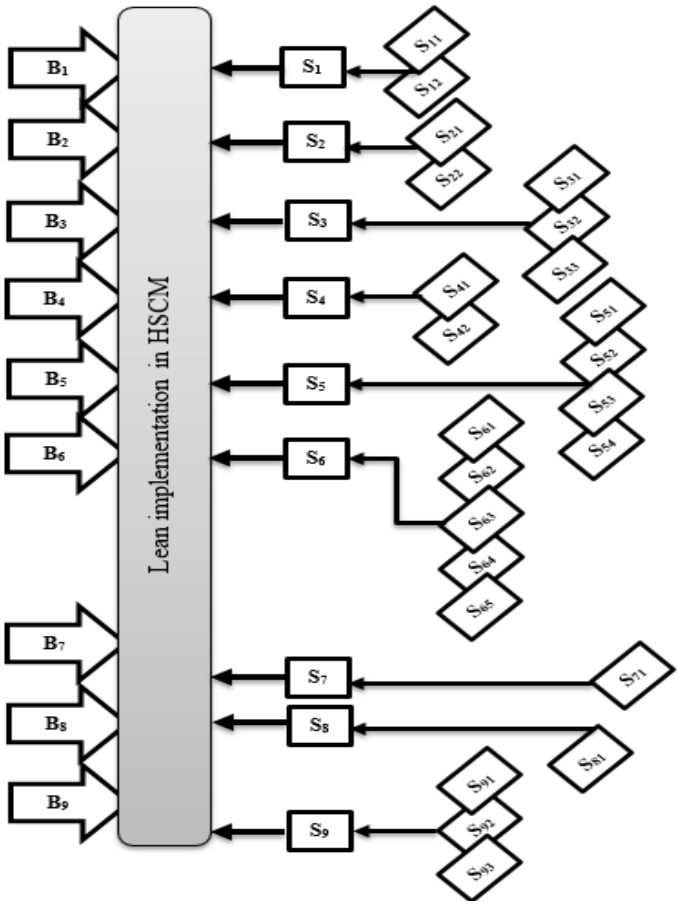


Figure 4.4 Force field analysis

4.5 Enablers and Factors for Successful Implementation of Lean in HSCM

First, it is important to understand what critical success factors **(**CSFs) are. Rockart (1979) defined CSFs as "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for an organization". Lönngren et al., (2010) defined CSFs as "the internal and external parameters which have an essential influence on a company's success or failure". CSFs needed by managers and has become necessary for implementing continuous improvement initiative. The hospitals must give careful and constant attention for these areas (CSFs) to reach the potential results. Failure to pay enough attention to areas of CSFs definitely will lead to less than desired findings. Many researchers asserted on the significance of investigating and examining such factors that take into its account critical for the effective application of any new initiatives of improvement (Moustfa, 2015).

To achieve effective supply chain and improve its performance in the healthcare context, there are many factors that should be taken into account (Kritchanchai, 2012). According to Chin et al., (2011) critical success factors assist organizations to reduce operational cost, maximize efficiency, increase system flexibility and company competitions and build strong customer and supplier relationship. In addition, according to Al-Aomar et al.,(2014) utilizing critical success factors to describe the performance gives worthy feedback information that can be utilized to track progress , diagnose potential issues, monitor performance.

Some researchers mention that the failure to achieve critical success factors in all decision-making levels definitely leads to dire consequences and can be devastating. Mohammadi (2013)mentioned that if the organizations failed to satisfy a limited number of area (CSFs), it will surely lead to the failure of the organizations, or even a disaster. In other words, to success the business, CSFs are the few main areas where "things must be used in the right way". The type of industry plays important role to generate CSFs. The concept CSFs can be

applied through different industry such as public-service, educational, or non-profit organization. In this research, the context is healthcare industry.

CSFs are different from context to context and from organization to organization based on organization's strategies, resources, capabilities and mission because of different operational domain(Caralli 2004; Mohammadi 2013). On other words, the CSFs are mainly depend on context and affected by cultural and environmental factors. Hospitals are under tremendous pressure to improve operational performance(Isack et al., 2018). In the healthcare sector, the importance of supply chain performance is rapidly growing and gaining the attention of both academics and practitioners alike. Hospital supply chain should be improved to enhance the overall hospital operational performance. Obviously, any imbalance in supply chain performance will inevitably lead to an imbalance in the performance of healthcare services as a whole According Mathur et al., (2018) supply chain in healthcare sector is different from the other sector and significantly effect on the performance of the healthcare providers. In order for a healthcare provider to succeed, there is the need to improve supply chain performance. One of the most important quality tools to achieve this is adopting lean. Prajogo and Olhager, (2012) mentioned that lean practices have a positive impact on supply chain performance.

Lean is an improvement approach that endeavour to improve speed, cost, quality, and customer satisfaction(Laureani & Antony 2017). In addition, lean approach is a substantial practice to improve quality in healthcare (Gijo et al., 2013). Today, organizations spend huge amounts of money in order to improve their performance and productivity in various fields. One of those fields is Supply chain management. A poor performance quality one of the main problems in supply chain management(Lai, Ngai, & Cheng, 2004; Sharahi & Abedian, 2009). So, in supply chain context, the improvement of performance is becoming must for those organizations looking for success.

Lean is somewhat a new concept in healthcare sector in Middle East in general and in Saudi Arabia in particular. According to Al-Balushi et al., (2014) the implementation of lean in healthcare sector is a relatively young area.

Understanding the enablers and success factors for any continuous improvement initiative is the foundation for the success before implementing any performance improvement initiative.

The factors extracted from reviewing literature and conducting field study (interviews) were grouped into five enablers. Enablers and success factors were developed for implementing lean practices successfully in hospitals supply chain management. The following sections will elaborate the five enablers and success factors related to each one.

1. Medical Top Management Responsibility

1.1 Hospital management support and commitment toward lean initiative

1.2 Hospital leadership

1.3 Patient safety as ultimate goal of a hospital (patient-oriented)

1.4 Hospital Culture

1.5 Understanding wastes in HSCM

2 HSCM Processes Management.

2.1 Medical purchasing processes

2.2 HSCM measurement of performance

2.3 Medical information exchange

2.4 smooth flow of medical item and information

2.5 Using value stream mapping

2.6 Adopting continuous improvement tools

2.7 Systematic measures for solving a problem (action plan)

3 Medical Human Resources

3.1 Accepting change by HSCM employees

3.2 Staff training (medical and non-medical)

3.3 HSCM employees and Physicians empowerment

3.4 Multi-skilled HSCM employees

3.5 Effective communication between HSCM departments

4 Consumer Relationship

4.1 On time delivery to patients

4.2 Medical team (i.e. Physicians) involvement

4.3 Buy-in between medical staff and Physicians Preference items

4.4 Patients / doctors feedback on delivery performance and cost

5 Supplier Relationship

5.1 Medical items arrive as per request (on time, right quantity)

5.2 Supplier lead time

5.3 Monitoring supplier performance

5.4 Supplier involvement

4.5.1 Medical Top Management Responsibility

The first lean enabler is top medical management/hospital leadership. This enabler include Hospital management support and commitment, Hospital leadership, Patient safety as ultimate goal of a hospital, Hospital Culture and Understanding wastes in HSCM. All these factors are considered to be important toward implementing lean initiative to achieve top medical management enabler.

4.5.1.1 Hospital management support and commitment toward lean initiative

Increased supportive commitment toward lean projects from top management is one of the main pillar to success lean initiatives. Hospital management commitment and support to give financial resource, training and other necessary needs is crucial for successful lean initiative(Grove et al., 2010; Abuhejleh et al., 2016).

4.5.1.2 Hospital leadership

Poor leadership is considered a key barrier for implementing lean within healthcare organizations(Grove et al., 2010). Laureani et al., (2013) assured that leadership is a critical factor in successful lean project. Style of leadership is another factor in success of continuous improvement initiative. According to Al-Borie & Abdulla, (2013) a majority of development initiatives are directed top-down and not bottom-up leadership style. Leaders must always take responsibility for the implementation of lean initiatives (Abuhejleh et al., 2016). Lack of leadership can be considered one of the main barrier for a lean implementation(Grove et al., 2010).

4.5.1.3 Patient safety as ultimate goal of a hospital (patient-oriented)

Patient-oriented (patient safety) is another factor should be focused. Since one principle of lean is identify value and value should be identified by the end user (patients), hospital should pay its attention to patients' needs and requirements. Nabelsi & Gagnon (2017)note that hospitals must become patient-oriented in order to achieve hospital mission and patient needs. The authors mention that "SCM can only be successful if it is truly patient-oriented" (patients' safety). Patient-oriented care processes require a supportive supply chain adhering to strong principles of fully-integrated and seamless inventory-sourcing processes. Implementing lean in healthcare can enhance patient safety, increase efficiency and quality by eliminating wastes from patients' workplace (Laureani et al., 2013).

4.5.1.4 Hospital Culture

Also culture is another critical factor for successful implementation of lean. Since the patient's safety is the ultimate goal for any healthcare provider, hospital leaders should enhance the culture of patient's Dobrzykowski et al., (2014) note that organizational culture plays a vital role in patient safety. Lillrank et al., (2011) mention, in healthcare settings, how the organizational culture leads to decreasing medical mistakes. Also, a study conducted on a large number of American hospitals shows the relationship between organizational culture and the reduction of medical errors.

Culture readiness is play critical role in success implementation of lean. Hospitals have to evaluate their culture preparedness prior to lean implementation. Hospital culture is a crucial factor in implementing lean, since culture either inhabits or facilitates lean projects implementation. In this research, hospital culture refers to "need and belief about ongoing improvement" (Noori, 2015)

4.5.1.5 Understanding wastes in HSCM

It is important to understanding of lean approach before applying and evaluating. In healthcare organizations understanding how lean works and to eliminate non-value-added activities is necessary for successful lean implementation

(Guimarães & Carvalho 2014;Radnor, 2010). Waste is anything (practice, activity, process) do not add value to the internal customer (such as medical department) or external customer (patient). It is important for hospital to identify the wastes' sources and hoe to eliminate it. The wastes can come in different forms:

- Overproduction: requesting medical items that are more than needed by patient
- Over processing or incorrect processing: more work more than is needed by patient such as excessive paperwork
- Waiting: wasted time waiting for the next step in process.
- Transportation: unnecessary movement of medical materials or information.
- Defect: any effect or waste caused by incorrect information or rework.
- Motion: any movement by HSCM employees such as walking.
- Excess inventory: excess material products not being processed.
- Unused employees: underutilization HSCM's employees talent, skills and knowledge. Not utilizing people's abilities such as no empowerment.

4.5.2 HSCM Processes Management

The lean concept of developing material (medical items), information and cash flow does not work properly without paying attention to hospital supply chain processes. HSCM Processes refers to all practices, activities or tasks required for secure medical material or service for make sure patients in safe mode. HSCM should be managed in efficient and effective method to satisfy patients and stakeholders. HSCM processes used to supply medical items to patients should be executed with zero non-value added (NVA) practices (or at least minimize NVA as much as possible) in order to minimize shortage in medical items, keep patients safe, reduce waiting time, reduce the Work in Progress (WIP), delivery time and other delays. Improving HSCM process is significant to create value, identify more wastes to remove from the whole system, respond to patients needs quickly and improve flow processes. In addition, improving hospital supply chain practices leads to reduce overall operational cost of hospital.

4.5.2.1 Medical purchasing processes

Improvements in medical purchasing processes lead to reduce overall supply chain cost. Ordering the right medical devices for daily processes puts pressure on hospitals to look for opportunities to deliver a high quality of patient care, and to improve supply chain operational efficiencies (Al-Karaghouli et al., 2013). For example, in the United Kingdom, the National Health Service (NHS) aims to achieve £1.2 billion in efficiency savings via improved procurement (Al-Karaghouli et al., 2013). The NHS (2011) notes that 30% of a hospital's budget is spent on procurement, so any tangible improvement in the medical purchasing process will lead to considerable cost savings.

4.5.2.2 HSCM measurement of performance

Lean plays a vital role in improvement of process performance resulting in increased patients' satisfaction (Laureani et al., 2013). Patient safety is important factor in HSCM. Measuring a hospital's SCM performance is required to accomplish the performance aim of patient safety (Supeekit et al., 2016). HSCM not only delivers medical items and services to patients, but also plays an important role in patient safety. Patient safety is the ultimate aim and main concentration of healthcare (Dobrzykowski et al., 2014). Improving HSCM performance can enhance patient safety by avoiding medical errors (Spagnol et al., 2013).

4.5.2.3 Medical information exchange

Information exchange is another process that enhance supply chain in hospital. Information exchange defined as "accurate and timely information interchange among those involved in the associated processes" (Mandal, 2017). The timely sharing of relevant information along the SC can dramatically reduce the "bullwhip effect" (Wei & Wang 2010). According to Blome et al., (2014) information exchange is forms are the very basis for effective coordination that forms the core of efficient hospital supply chain management.

4.5.2.4 Smooth flow medical item and information and effective communication

The coordination between all hospital supply chain departments and medical departments should be done in the proper way to avoid unexpected medicines demand. Laureani et al., (2013) mentioned that communication with all customers (internal, external) are play vital role in the success of the lean project. poor communication can be considered one of the main barrier for a lean implementation(Grove et al., 2010).

4.5.2.5 Using value stream mapping (VSM)

VSM is a tool "to visualise the opportunities allowed to improve the current process by converting waste into value from the customer's viewpoint". In healthcare, VSM helps staff identify chances to remove wastes from processes and therefore reduction in waiting time and delay (Abuhejleh et al., 2016). On other words, VSM is how value is delivered to a customer(Piercy & Rich 2009). VSM is "Identify the value stream starting from activities on the suppliers side to the end customers and expose waste" VSM is important to expose and eliminate wastes from SCM (Ugochukwu et al., 2012). VSM exposes non value added process in the current situation.

4.5.2.6 Adopting continuous improvement tools

Using continuous improvement techniques such as 5S, kaizen, 5whys (cause-effect diagram) etc. For example, 5S organizes workplace by apply 5S as mentioned in chapter two. Applying 5S in HSCM result to eliminate wastes from supply chain departments. Poor organized workplace can cause a delay.

4.5.2.7 Systematic measures for solving a problem (action plan)

Set a systematic steps and procedures to solve each problem is an important factor in success lean implementation in HSCM. Like other sector, healthcare sector faces many issues in SCM. Setting a clear action plan for every single issue can be play vital role in solving the issue quickly.

4.5.3 Medical Human Resource

Medical and non-medical staff related to the SCM are considered important factors when adopting any new change initiatives. In other words, without the effective participation and support of medical staff, lean practices in the hospital supply chain is useless.

4.5.3.1 Accepting Change by HSCM employees

HSCM employees are the main pillar in success any continuous improvement initiative. So, employees' readiness for accepting any change is considered a great indicator for successful lean implementation.

4.5.3.2 Staff training (medical and non-medical)

Training hospital supply chain employees is essential to implementing the lean initiative. Human resources in hospitals can be improved by concentrating on training supply chain employees, while adopting job rotating systems to increase the ability of the employees to perform more than one role can help employees overcome issues related to quality (Womack & Jones 1996).

4.5.3.3 HSCM employees empowerment

Although the patients are the end users of each hospital, Physicians, nurses and medical engineers are responsible for actual demands therefore the corporation with them is very important to implement lean principle. Quickly response to patients' needs, accurate demand, minimize inventory, and eliminate the waste from the SCM process and cut cost cannot be done without collaboration of internal customer. Elsharydah et. al., (2020) mentioned that Cross-functional collaborations are important and necessary to the success of lean. Womack et al., (1990) assured the importance role of employees in adding value to the organization.

4.5.3.4 Multi-skilled HSCM employees

Employees who have multi-skilled can do a number of different work if needed. Multi-skilled workforce enable a hospital to easily adopt lean concept. Shortage

in well-trained employees is one of the most challenge for a hospital when it attempts to implement lean principle. So, multi-skilled employees can reduce this challenge by enabling them to do more than one type of task. However, to achieve this factor, hospital should investment in training.

4.5.4 Consumer Relationship

Because patients often rely on the advice of physicians, patients and physicians are considered as consumer. This enabler include: On time delivery to patients, Medical team (i.e. Physicians) involvement, Buy-in between medical staff and Physicians Preference items, Patients / doctors feedback on delivery performance and cost.

4.5.4.1 On time delivery to patients

This factor is considered one of the most important factor to make sure that patient safety is under control. Lean can improve healthcare delivery timely and accurately (Laureani et al., 2013). Many departments of hospital supply chain can play role in time delivery for each medical department in the hospital. For example, procurement, material management, store and medical equipment departments should work together to ensure on time delivery. Integration process between hospital supply chain is important to patient safety.

4.5.4.2 Medical team (i.e. Physicians) involvement

A willingness of the medical staff to implement lean transformation and a commitment to apply revised process improvement is crucial to the success of the lean initiative (Laureani et al., 2013). Physicians' involvement in continuous improvement is integral to implementing lean successfully within the supply chain. Toba et al., (2008) identified on the role of consumers as value co-creators in hospital supply chains.

4.5.4.3 Buy-in between medical staff and Physicians Preference items

Medical staff in different hospital departments, such as physicians or pharmacists, play vital roles in making sure the hospital supply chain is lean physician preference items (PPIs) constitute 40% of total medical supply

spending for a hospital (Toba et al., 2008) and this can be improved by physicians' buy-in. This is a main area for SC savings, especially with respect to the use of high-cost clinical items and changes in purchases (Toba et al., 2008). Disagreement between physicians, in terms of a certain type of medicine, slows supply chain processes and increases delivery lead time. Grove et al., (2010) assured that one of the main success factor for a lean transformation is leaders buy in at all levels of the hospital.

4.5.4.4 Medical staff feedback on delivery performance and cost

Opening environment of feedback can play role in improvement of delivery time and reduction of cost. For example, feedback from physicians about a certain medication can lead to change supplier or use another medication with lower price. In addition, consumer's feedback can enhance HSCM's performance and solve any problem.

4.5.5 Supplier Relationship

This enabler include four factors: Medical items arrive as per request (on time, right quantity), Supplier lead time, Monitoring supplier performance and Supplier involvement.

4.5.5.1 Medical items arrive as per request (on time, right quantity)

Laureani et al., (2013) mentioned that implementing lean can leading to the correct medical items (or service) at the right place and time as well as shortening the cycle time.

4.5.5.2 Collaboration with Supplier and medical items lead time

Hospital-supplier integration plays an important role in improving hospital supply chain performance (Chen et al., 2013). Additionally, hospital-supplier collaboration has an impact on hospital supply chain performance (Mandal 2017). Enhancing and creating long-term relationships with key suppliers contributes significantly to reducing fluctuation in demand and minimizing medicine shortage. Total lead time can delay medical items from reaching patients. Lead time can be reduced by identifying non-value adding processes in hospital. The lead time

during written communication process is another critical to the success of the lean project (Laureani et al., 2013).

4.5.5.3 Monitoring supplier performance

Hospitals should monitor, evaluate and visit (if necessary) of their main suppliers to overcome any potential risk and to encourage them to be part of lean project. Poor suppliers' performance can lead to serious results.

4.5.5.4 Adopting group purchasing organizations, GPOs

Medical purchases are the key purchases for any healthcare provider, as medical supplies can often constitute more than 40% of a hospital's operating cost. This cost can be improved through SCM practices (Nabelsi & Gagnon, 2017). Alliance with other healthcare providers is one of the most important factors to in reducing the total cost of medical supplies. Group purchasing organizations (GPOs) have provided significant cost saving opportunities for healthcare providers by taking advantage of economies of scale and purchasing from select suppliers/venders for many hospitals at once. GPOs can reduce hospital supply chain costs up to 15%. Hospital supply chain costs decreased for providers using GPOs, but group purchasing also helped to optimize the supply chain (Jacqueline & Belliveau 2017).

4.6 Chapter Summary

There is no easy and quick method to become a lean healthcare organisation. Toyota has taken over 50 years to implement continuous improvement approach throughout the whole company (Grove et al., 2010). In this study, nine key barriers were identified. These barriers are as follows: existance of physicians' preferences; unpredictable patient demand; inadequate knowledge and lack of understanding lean concept; identifying the type of waste through hospital supply chain processes (delivering value to the patient); lack of hospital support, commitment and disbelief in lean; organisational culture and resistance to change; scarcity of qualified human resources and lack of training; assessment of the required level of leanness and lack of effective communication and information sharing.

These barriers to successful lean implementation can be overcome with adopting many practices. Factors such as physicians' buy-in, using technology, hospital leadership support, improving organisational culture to reduce resistance to change, setting up a rewarding system to motivate people to accept the change, excellent communication, effective sharing of information, and train employees will enable the healthcare organisation to build its own lean philosophy based on patient value satisfaction and not simply implementing techniques and tools adopted from other industries. In general, lack trained of SCM employees in Saudi healthcare organisations was clearly observed and is consider the main issue by the decision makers in HSCM. This study coincides with study conducted by Albliwi et al., (2017).

5 Chapter Five: Leanness Assessment Model: Design and Development[2]

"You can't manage what you can't measure."

Peter Drucker

The aim of this chapter is to offer an innovative model to assess level of leanness in hospital supply chain management (HSCM) and to measure HSCM leanness index for each hospital. The model was validated via publication in a peer-reviewed journal and through three hospitals. This chapter is divided into many sections to achieve its aim as illustrated in Figure 5.1. This chapter addresses the third and fourth research objectives which are develop a model to assess healthcare supply chain management leanness and assess leanness index maturity of the healthcare supply chain management leanness.

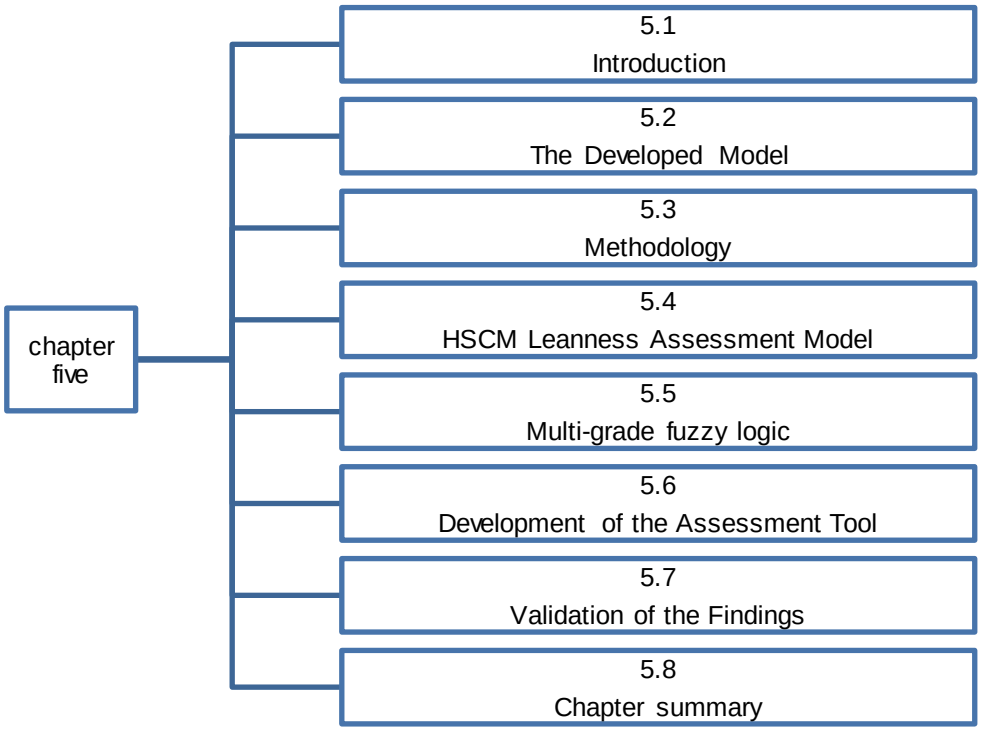


Figure 5.1 main sections of chapter five

[2] Part of chapter five has been published: Almutairi, A. Salonitis, K. and Al-Ashaab, A. (2019)"Assessing the leanness of a supply chain using multi-grade fuzzy logic: a health-care case study". International Journal of Lean Six Sigma, Vol. 10 Issue: 1, pp.81-105, https://doi.org/10.1108/IJLSS-03-2018-0027.

5.1 Introduction

Lean is a widely known approach to quality improvement. It was initially used in the manufacturing and automotive industries, although lately the healthcare industry has begun to apply lean principles (Moraros et al., 2016). Many researchers have pointed to the importance of supply chain management (SCM) and its role in preventing medical errors, improving healthcare-provider (hospital) performance, improving quality of care, decreasing waste, producing value-added operations and improving operational efficiencies (Al-Saa'da et al., 2013).

If an organisation cannot measure its progress, it cannot improve it. Pakdil and Leonard (2014) stressed that any organisation wishing to apply lean principles should develop a measurement tool with which to assess the level of leanness in that organisation and make sure that said tool works effectively. Leanness indicates what position the organisation is in in terms of being lean. Lean is an approach focused on maximising value while minimising waste. The UK National Health Service (NHS) has used a lean approach to achieve its strategic goals with a number of healthcare organisations (Antony et al., 2016). Antony et al., (2017) mentioned that it is necessary to apply continuous improvement approaches, such as lean, to ensure reliability, on-time delivery and quality at reduced overall costs.

However, before implementing any continuous improvement initiatives in a healthcare organisation, it is crucial to assess leanness in the supply chain management (SCM). Given that a healthcare organisation's SCM represents between 25% and 40% of its monthly budget, so the organisation must improve its SCM to ensure quality delivery of material and medications to clients or patients (Machado et al., 2014). This is why the present chapter seeks to develop a model with which to assess healthcare providers' SCM leanness. An organisation's lean readiness is critical when it comes to implementing lean practices. Moreover, the degree of lean readiness is important for determining

the extent to which lean implementation will succeed (Achanga et al., 2012). Figure 5.2 illustrates lean thinking (LT) assessment in general.

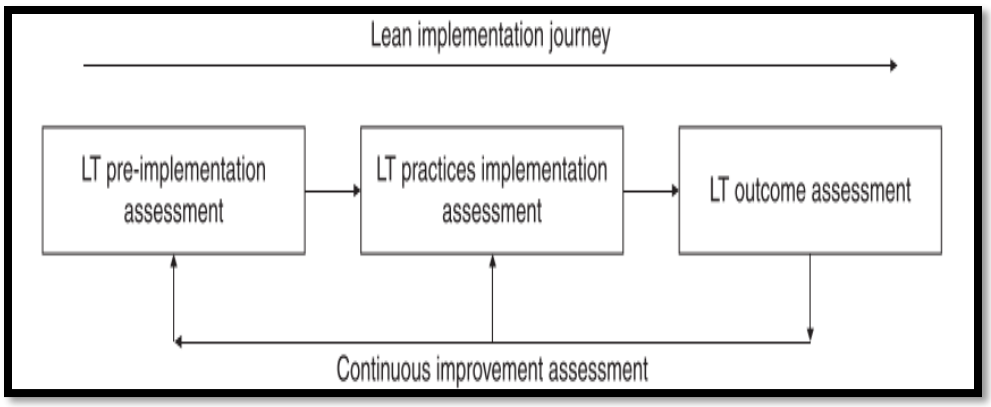


Figure 5.2 Lean Assessment Approach (Narayanamurthy and Gurumurthy, 2016)

Lean SCM is focused on reducing waste, reducing activities that do not add value, optimising processes, adding flexibility and searching for simplification. Well-defined lean SCM measurement increases the opportunity for success because it enables practitioners to see areas where performance can be improved, thus concentrating practitioners' attention on problem areas. Although lean implementation in a healthcare setting has become increasingly important in the existing body of research (Sobek & Lang, 2010), the question of "how much lean" there should be in a healthcare SCM has not been answered. Most of the frameworks for evaluating lean SCM have been restricted to particular non-healthcare sectors (Jasti & Kodali, 2015). Lega, Marsilio and Villa (2012) pointed out that there is a lack of research on SC performance in public healthcare institutions. Moreover, Vries and Huijsman (2011) stated that the supply chain is a crucial and ever-changing issue for healthcare administrators, and it impacts heavily on healthcare management. Lean approaches are effective and efficient quality improvement methodologies in several healthcare organisations (Roberts et al., 2017). Lean assessment

An up-to-date evaluation of leanness assists in determining the contribution of lean practices to improving an organisation's operational and financial performance (Narayanamurthy & Gurumurthy, 2016). According to Vidyadhar et al., (2016) to enable the systematic implementation of lean principles, an

organisation needs to perform a leanness assessment, which measures the extent to which the principles have been put into practice in each process. Cuthbertson and Piotrowicz (2011) stated that the supply chain is one of the processes that needs reviewing; SC performance should be evaluated to identify areas requiring further improvement.

Supeekit et al., (2016) employed DEMATEL-modified ANP to calculate weights for different performance aspects in the hospital supply chain. The authors asserted that using weights to measure performance can help healthcare decision-makers to identify which attributes need further improvement. Previous researchers have used a fuzzy-logic approach to overcome the ambiguity and vagueness associated with a leanness assessment (Vidyadhar et al., 2016). However, researchers have called for studies that examine the aspects of leanness in a healthcare setting (Narayanamurthy & Gurumurthy, 2016). For this reason, the present chapter attempts to fill said gap by developing a model for assessing leanness in the supply chain in a healthcare setting. Indeed, this model is the first of its kind in leanness assessment. Leanness assessment techniques enable a comprehensive audit of the performance of lean principles, and so are able to recognise lean improvements (Omogbai & Salonitis, 2016). According to Antony (2011) the concept of lean evolved from the Toyota Production System (TPS) during the 1950s. In lean, the focus is on eliminating waste to produce quicker flow, less variation, greater customer and shorter cycle time to add value (Sinclair, Phelps & Sadler, 2005). Under senior executives support, the results of the self-assessment can lead organisations to continuously improve their weaknesses (Kim et al., 2010).

The government of Saudi Arabia is making efforts to achieve its vision 2030 and implement continuous improvement initiatives, such as lean. The implementation of lean will lead to many benefits, such as cost reduction and elimination of non-value-added (NVA) activities. Lean assessment needs to be conducted to measure the level of implementation of lean in each process (Vidyadhar et al., 2016).

According to Omogbai and Salonitis (2016), lean attributes are either quantitative or qualitative. Table 5.1 shows both types and highlights their strengths and weaknesses.

Table 5.1 Qualitative and quantitative lean assessment framework

Framework/ model	Qualitative framework	Quantitative framework
Models	Quantitative lean index (Vimal & Vinodh, 2012)	Benchmarking (Ray et al., 2006)
	Balanced scorecard (BSC) (Seyedhosseini et al., 2011)	Value stream mapping (Abdulmalek & Rajgopal, 2007)
	Lean self-assessment tool (LESAT) (Nightingale & JH., 2002)	Quantitative lean index (Pakdil & Leonard, 2014)
Strengths	Lean attributes are easy to develop. Qualitative lean attributes can be generated for most lean practices. The use of linguistic terms ("high" or "low") to rate performance makes them easy to manage (Omogbai & Salonitis, 2016).	Lean performance allows to be mapped and tracked objectively and more regularly. The lean attributes can be statistically analysed (Omogbai & Salonitis, 2016).
Weakness	Self-assessment rating is open to bias. Qualitative lean attributes cannot be analysed statistically. Less informative and precise. Linguistic characterisations less specific than numerical ones (Zadeh 1975).	Data is not always easy to collect. Not all lean practices can be measured with quantitative lean attributes (Omogbai & Salonitis, 2016).

Developing a model for assessing lean in a service setting would be a unique contribution to the literature of lean philosophy. Some researchers have previously noted the need for studies to capture healthcare lean assessment aspects (Narayanamurthy & Gurumurthy, 2016). To overcome the ambiguity linked to lean assessment, the fuzzy approach has been used (Vidyadhar et al., 2016). Leanness assessment studies in the literature have taken many forms, e.g. leanness index (Wong et al., 2014), fuzzy leanness index (Vinodh & Chintha, 2011), assessing lean practices (Pedersen & Huniche 2011), assessing lean performance measures (Sezen et al., 2012), lean assessment framework (Guimarães & De Carvalho, 2014) and lean assessment instrument (Malmbrandt & Åhlström, 2013).

5.2 The developed model

The model and lean assessment tools are developed based on the literature review and the experts' opinions as shown in Figure 5.3. The aim of the assessment tool is to identify the gap between the present level of leanness and the desired leanness state so that the organisation can identify what can be improved, as mentioned in Chapter 4 (phase 2: assessment state). Moreover, the tool identifies both strengths and opportunity of improvement in supply chain practices.

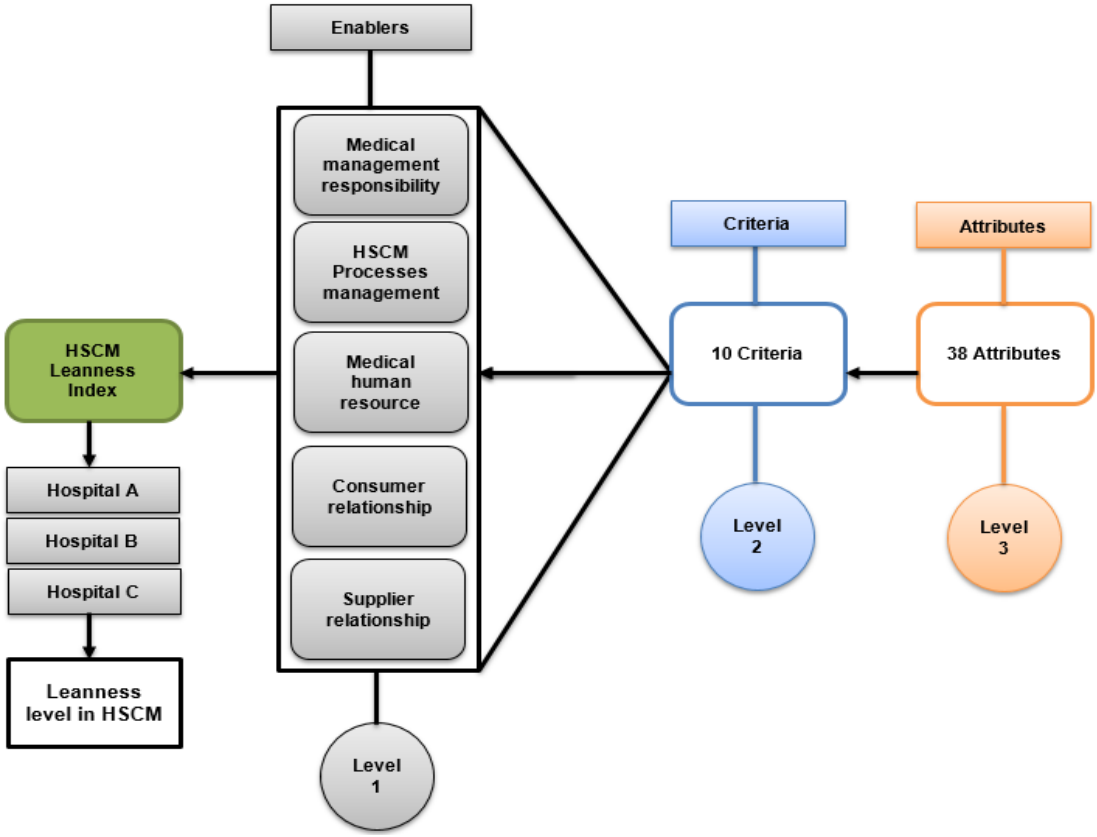


Figure 5.3 Developed model (Almutairi et al., 2019)

In addition, lean assessment is important because it is the most suitable starting point from which to identify potential improvement areas.

The model consists of three levels. The first level comprises five leanness enablers, while the second includes ten lean criteria, and the third consists of thirty-eight lean attributes.

5.2.1 Medical Management Responsibility

The first lean enabler is medical management responsibility. This enabler includes management support and commitment towards the lean journey. Senior executive managers must always take responsibility for the implementation of lean initiatives (Abuhejleh et al., 2016).

Style of leadership plays a vital role in the success of any continuous improvement initiative. According to Al-Borie and Abdulla (2013), a majority of development initiatives are directed top-down and not bottom-up. Increased supportive commitment towards lean projects from top management is one of the main pillars to the success of lean initiatives.

Patient-oriented is another factor which should be focused on. Since one principle of lean is to identify value and value should be identified by the end user (patients), hospitals should pay attention to patients' needs and requirements. Nabelsi and Gagnon (2017) noted that hospitals must become patient-oriented in order to achieve the hospital mission and meet patients' needs. The authors mentioned that "SCM can only be successful if it is truly patient-oriented". Patient-oriented care processes require a supportive supply chain which adheres to strong principles of fully-integrated and seamless inventory-sourcing processes.

Moreover, culture is another critical factor for the successful implementation of lean. Since the patient's safety is the ultimate goal for any healthcare provider, hospital leaders should enhance the culture of patients indeed. Dobrzykowski et al., (2014) noted that organisational culture plays a vital role in patient safety. Lillrank et al., (2011) further mentioned how, in healthcare settings, the organisational culture leads to a decrease in the number of medical mistakes. Moreover, a study conducted on a large number of American hospitals showed the relationship between organisational culture and the reduction of medical errors. In this research, organisational culture refers to "need and belief about ongoing improvement" (Noori, 2015).

5.2.2 HSCM Processes Management (operational excellence)

Improving hospital supply chain practices leads to reduced overall operational cost for the hospital. For example, improvements in medical purchasing processes lead to reduced overall supply chain cost. Ordering the right medical devices for daily processes puts pressure on hospitals to look for opportunities to deliver a high quality of patient care, and to improve supply chain operational efficiencies (Al-Karaghouli et al., 2013). For example, in the United Kingdom, the National Health Service (NHS) aims to achieve £1.2 billion in efficiency savings via improved procurement (Al-Karaghouli et al., 2013). The NHS (2011) has noted that 30% of a hospital's budget is spent on procurement, and so any tangible improvement in the medical purchasing process will lead to considerable cost savings.

Information exchange is another process that enhances the supply chain in a hospital. Information exchange has been defined as "accurate and timely information interchange among those involved in the associated processes" (Mandal, 2017). The timely sharing of relevant information along the SC can dramatically reduce the "bullwhip effect" (Wei & Wang, 2010).

The coordination between all hospital supply chain departments and medical departments should be conducted in the proper way, so as to avoid unexpected demand for medicines. According to Blome et al., (2014), information exchange forms the very basis for effective coordination, which in turn forms the core of efficient hospital supply chain management.

Patient safety is another important factor in HSC. Measuring a hospital's SCM performance is required to accomplish the performance aim of patient safety (Supeekit et al., 2016). HSC not only delivers medical items and services to patients, but also plays an important role in patient safety. Patient safety is the ultimate aim and main concentration of healthcare (Dobrzykowski et al., 2014). Improving HSC performance can enhance patient safety by avoiding medical errors (Spagnol et al., 2013).

5.2.3 Medical Human Resource

Medical and non-medical staff related to the supply chain are considered important factors when adopting any new change initiatives. In other words, without the effective participation and support of staff, lean practices in the hospital supply chain are useless. Womack et al., (1990) reiterated the importance of the role played by employees in adding value to the organisation. Training hospital supply chain employees are essential when it comes to implementing the lean initiative.

Human resources in hospitals can be improved by concentrating on training supply chain employees, while adopting job rotating systems to increase the ability of the employees to perform more than one role can help employees overcome issues related to quality (Womack & Jones, 1996). Disagreement between physicians, in terms of a certain.

5.2.4 Consumer Relationship

Because patients often rely on the advice of physicians, patients and physicians are considered to be consumers. Medical staff in other hospital departments, such as physicians or pharmacists, play vital roles in making sure the hospital supply chain is lean. Preference Items (PPIs) constitute 40% of total medical supply spending for a hospital (Toba et al., 2008) and this can be improved by physicians' buy-in. This is a main area for SC savings, especially with respect to the use of high-cost clinical items and changes in purchases (Toba et al., 2008). Physicians' involvement in continuous improvement is integral to successfully implementing lean within the supply chain. Toba et al., (2008) identified the role of consumers as value co-creators in hospital supply chain.

5.2.5 Supplier Relationship

Hospital-supplier integration plays an important role in improving hospital supply chain performance (Chen et al., 2013). Additionally, hospital-supplier collaboration has an impact on hospital supply chain performance (Mandal, 2017). Enhancing and creating long-term relationships with key suppliers

contributes significantly to reducing fluctuation in demand and minimising medicine shortage. Medical purchases are the key purchases for any healthcare provider, as medical supplies can often constitute more than 40% of a hospital's operating cost. This cost can be improved through SC practices (Nabelsi & Gagnon, 2017). Alliance with other healthcare providers is one of the most important factors in reducing the total cost of medical supplies. Group purchasing organizations (GPOs) have provided significant cost saving opportunities for healthcare providers by taking advantage of economies of scale and purchasing from select suppliers/venders for many hospitals at once. GPOs can reduce hospital supply chain costs by up to 15%. Hospital supply chain costs have decreased for providers using GPOs, but group purchasing has also helped to optimise the supply chain (Jacqueline & Belliveau, 2017).

5.3 HSCM leanness assessment model

5.3.1 Design of the assessment process

The lean HSCM assessment model provides the hospital with the HSCM leanness index.

This HSCM leanness index enables the hospital to identify the as-is (present) situation of how lean the HSCM is. By identifying the present situation, the hospital can identify the gap between the present situation and the to-be (required future state) situation. Figure 5.5 shows the main steps for assessing leanness level at HSCM.

By identifying the gap between how the lean hospital supply chain management is and how the lean hospital supply chain management should be, areas (e.g. processes) for further improvements can be identified. Therefore, an improvement plan and appropriate solutions can be developed to fill the gap and transform the hospital to a new level of lean. After the hospital successfully implements the proposed solutions, it should reassess HSCM level again using the developed lean HSCM assessment tool to take corrective actions if necessary. Additionally, causes and barriers that play a vital role in lower performance areas can be investigated.

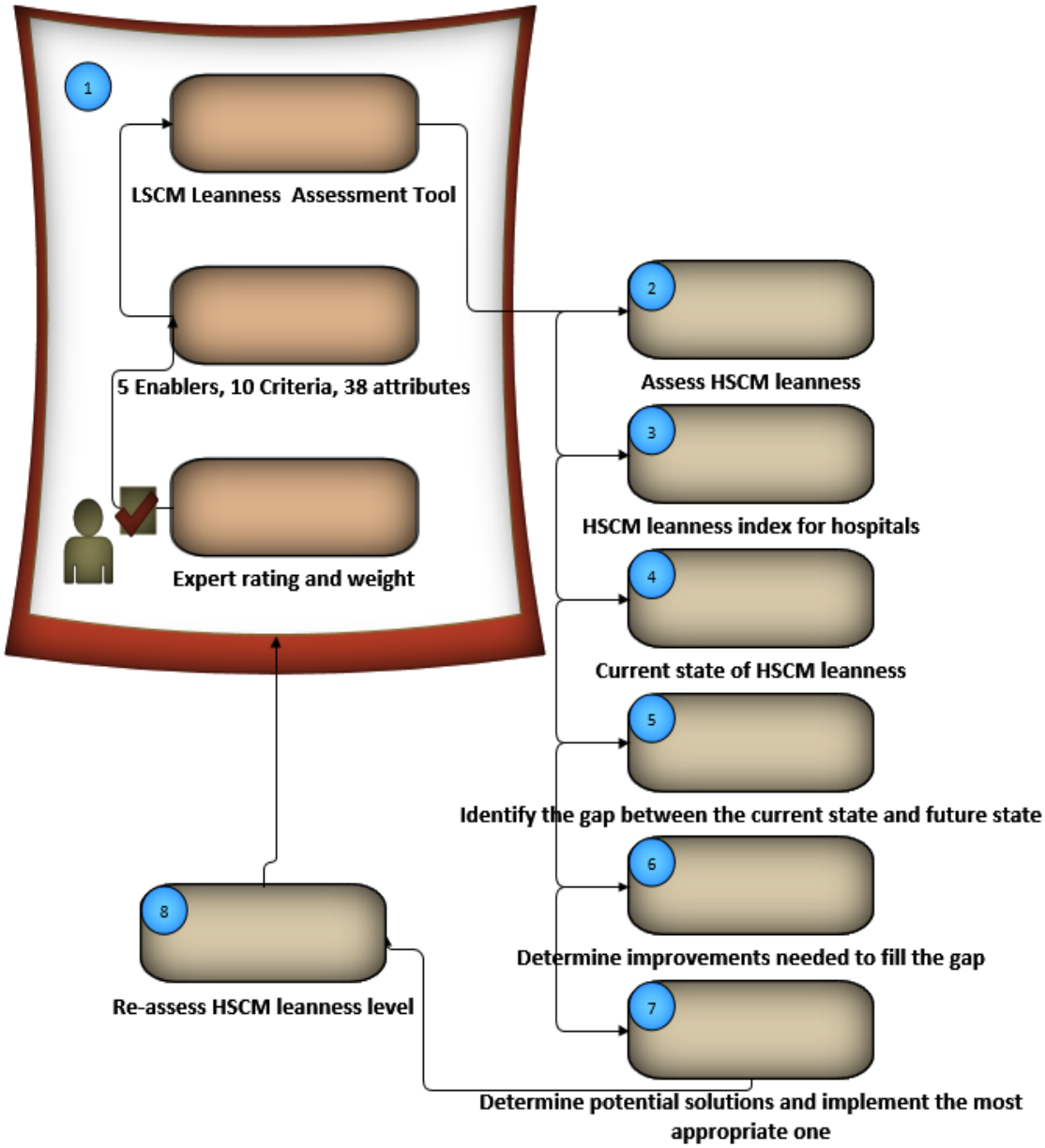


Figure 5.4 design of the process of leanness

5.4 Multi-grade fuzzy logic

There are various weighting approaches in the multi-criteria decision making method that use the judgment of experts and stakeholders to weight the effect of alternatives and categories (Myllyviita, Leskinen & Seppälä, 2014). Fuzzy logic is based on human logic, and takes advantage of knowledge with boundaries. Some of the concepts of fuzzy logic include probability distribution, linguistic variables, fuzzy if then, and fuzzy set (Vinodh & Chintha, 2011). Fuzzy logic is an

effective method with which to tackle the multi-attribute decision making issue when the given data is presented linguistically or is ambiguous (Klir & Yuan, 1995). Velasquez & Hester (2013) noted that fuzzy logic itself has proven to be an effective multi-criteria decision making method.

According to Yang and Li (2002), multi-grade fuzzy logic can be used to calculate leanness. There is no ideal methodology, but the fuzzy approach provides a useful way to deal with issues in which attributes of phenomena are vague and imprecise (Vinodh & Prasanna, 2011). Fuzzy multi-attribute is the core of determining the value of the weights for each measure/attribute, followed by a ranking process to select from the alternatives that have been given (Deni et al., 2013). One of the main issues in the qualitative research method is ambiguity, which may not be expressed numerically.

The main reason for using a multi-grade fuzzy approach is to avoid any fluctuation in variable values and simple calculations (Ganesh 2016). In addition, fuzzy logic takes the inadequate information into consideration and allows loose, imprecise input. Moreover, it allows for a few rules to encompass issues with great complexity (Balmat et al., 2011). In addition, this logic uses experts' judgment to weight the relative importance of each leanness in different enablers. The simplicity of fuzzy logic allows experts to enter the relative importance and weight of leanness straightforwardly. Multi-grade fuzzy logic has been used in different contexts. For example, Suresh and Patri (2017) employed fuzzy logic to assess agility in healthcare dispensary, while Vinodh and Prasanna (2011) used the same logic to evaluate agility in the supply chain at a single manufacturing company. Sustainability was assessed by using the same approach (Vinodh 2011). This approach has been used in another sector; indeed, Elnadi and Shehab (2016) and Vinodh and Vimal (2012) employed multi-grade fuzzy logic in the manufacturing industry. The leanness index has been assessed by using the same method as that presented by Vinodh and Chintha (2011). Although multi-grade fuzzy logic has been used for lean assessment in different sectors and contexts, leanness has not been used in the supply chain within a healthcare organisations. Table 5.2 shows Leanness assessment model based on multi grade fuzzy-logic.

Table 5.2 Leanness assessment model based on multi grade fuzzy-logic

Level 1 Lean enabler	Level 2 Lean criteria	Level 3 Lean attributes
1. Medical management responsibility	1.1 Hospital leadership	1.1.1 commitment by medical staff 1.1.2 Patient-oriented focus (patient safety) 1.1.3 Lean approach is driven by top hospital management 1.1.4 Adoption of information technology for hospital SC applications
	1.2 Hospital organizational culture	1.2.1 Culture of problem prevention and waste elimination in hospital 1.2.2 Culture of acceptance of change to enhance patient safety 1.2.3 The clear understanding of lean philosophy by hospital community 1.2.4 Hospital open to new ideas
2. HSCM Processes management	2.1 Process improvement	2.1.1 Existence of improvement team including physician, pharmacist or medical equipment engineer with an understanding of improvement tools 2.1.2 Processes of medical procurement 2.1.3 Information exchange/sharing across the hospital supply chain 2.1.4 Understanding problem solving tools to enhance patient safety 2.1.5 Waste identification and quantification of HSC processes
	2.2 Process streamline	2.2.1 Adoption of value stream mapping 2.2.2 Visual communication 2.2.3 Standardization of process 2.2.4 Jobs are pulled by each supply station from previous supply station 2.2.5 Supply medicine at the pull of the patients
3. Medical human resource	3.1 Employees proficiency	3.1.1 Multi-skilled medical staff 3.1.2 Culture of continuous improvement 3.1.3 Cross-functional collaboration
	3.2 Personnel involvement	3.2.1 Medical staff engagement 3.2.2 Regular meetings with medical staff 3.2.3 Hospital employees' ideas taken seriously
4. Consumer relationship	4.1 Consumer response	4.1.1 A well-defined voice of consumer (physicians/patients) (VOC) 4.1.2 Physician Preference Items (PPIs) 4.1.3 Physician buy-in
	4.2 Consumer involvement	4.2.1 Physician/patient feedback on quality, cost, time, and delivery performance 4.2.2 Physicians/patients participate in continuous improvement initiatives 4.2.3 Close contact with physicians to enable them to engage in continuous improvement projects 4.3.4 Engage physicians in forecasting planning processes
5. Supplier relationship	5.1 Supplier cost	5.1.1 Hospital-supplier integration 5.1.2 Incurred costs due to shortage of medicine 5.1.3 Medical purchasing
	5.2 Supplier delivery	5.2.1 Unpredictable patient demand 5.2.2 Medical supplies arrive on time and in the correct amounts 5.2.3 Minimize delivery lead times of medical supplies 5.2.4 Deliver urgent medicine when needed or in emergency cases

5.5 Development of the assessment tool

The calculation of the LSCM lean index mainly depends on the steps being linked to each other. For privacy and confidentiality reasons, the cases in the study will be referred to as hospital (X), hospital (Y) and hospital (Z). All three hospitals are tertiary care centres in Riyadh, Saudi Arabia. By following the same method of computing the HSCM leanness index adopted by Vinodh and Chintha (2011), the calculation of the HSCM leanness index goes through four steps that should be followed to assess leanness in HSCM:

1. Computing the weight (relative importance) for
    I. Enablers
    II. Criteria
    III. Attributes
2. Computing the index for each criterion.
3. Computing the indices for each enabler.
4. Computing hospital supply chain management leanness (HSCML).

The HSCM leanness index of a hospital is denoted by $\boldsymbol{I}$. The formula for the leanness index is given by equation no. (1):

$$\boldsymbol{I = W \times R}$$

Where:

W: Overall weight

R: Overall assessment factor

The assessment has been divided into five grades, since lean supply chain factors involve fuzzy determination, as shown in Table 5.4:

$\boldsymbol{I = \{10, 8, 6, 4, 2\}}$

Where:

Table 5.3 Scale of assessment

8.01 – 10	The HSCM implements lean practices in its processes and shares them internally and externally along the complete value chain.
6.01 – 8	The HSCM implements lean practices in all its processes and measures the results to implement improvement actions.
4.01 – 6	The HSCM implements lean practices in all its processes and achieves a basic level of implementation.
2.01 – 4	The HSCM is aware of the lean practices and is keen to implement them.
0.00 – 2	The HSCM does not implement lean practices in any supply chain processes.

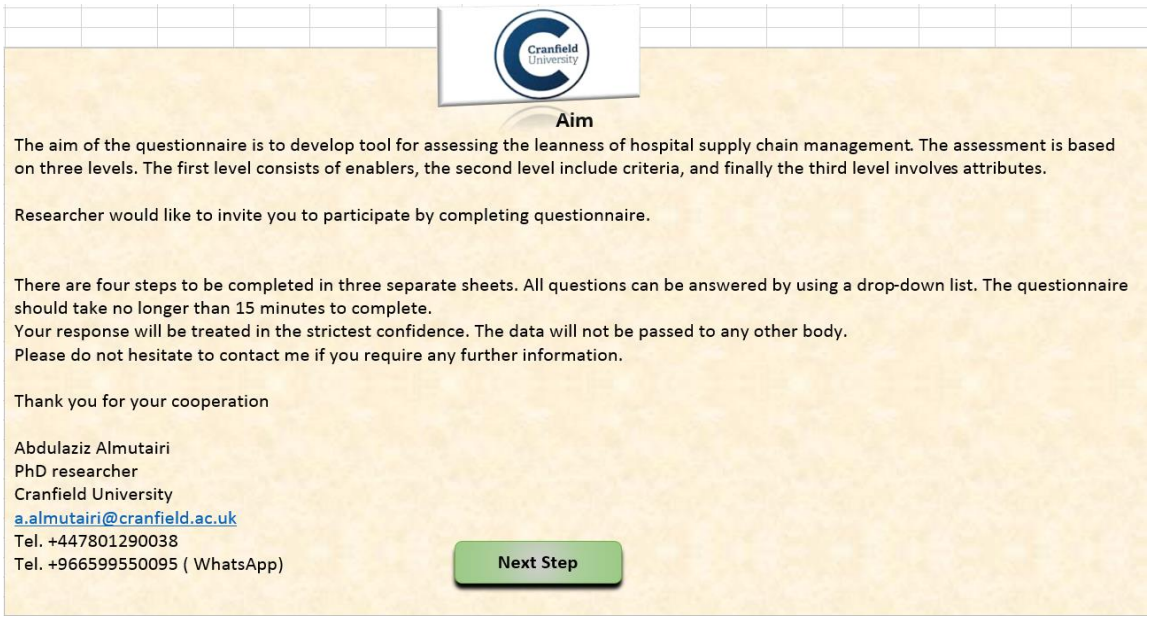


Figure 5.6 screenshot of introduction for assessing process

Five experts from each hospital (total = fifteen participants) were identified to participate in the assessment process based on their ability to participate and their experience. In the first Excel sheet, the aim of the assessment tool was explained clearly to all experts. Every expert was kindly asked to answer the Microsoft Excel assessment tool independently. A screenshot of the first window is presented in Figure 5.7.

Figure 5.5 screenshot of general information excel sheet

After the participants finish reading the first window, they can easily move to the second window by simply clicking on the green button labelled “Next step”. Once they have clicked on this button, the second window will appear, as shown in Figure 5.8. On this screen the participants have to fill in the required information, e.g. hospital name, department, job title and number of years they have been involved in a continuous improvement project.

In the next window the participants are asked to state the relative importance (weight) of five enablers, as illustrated in Figure 5.9. The assessment tool was designed carefully to make sure that the results are validated. For example, the total weight must be 100%, and in cases where the total weight is more or less than 100, the “Error” will appear and the participant will understand that something went wrong. The participant will select his/her assessment by selecting from a drop-down list.

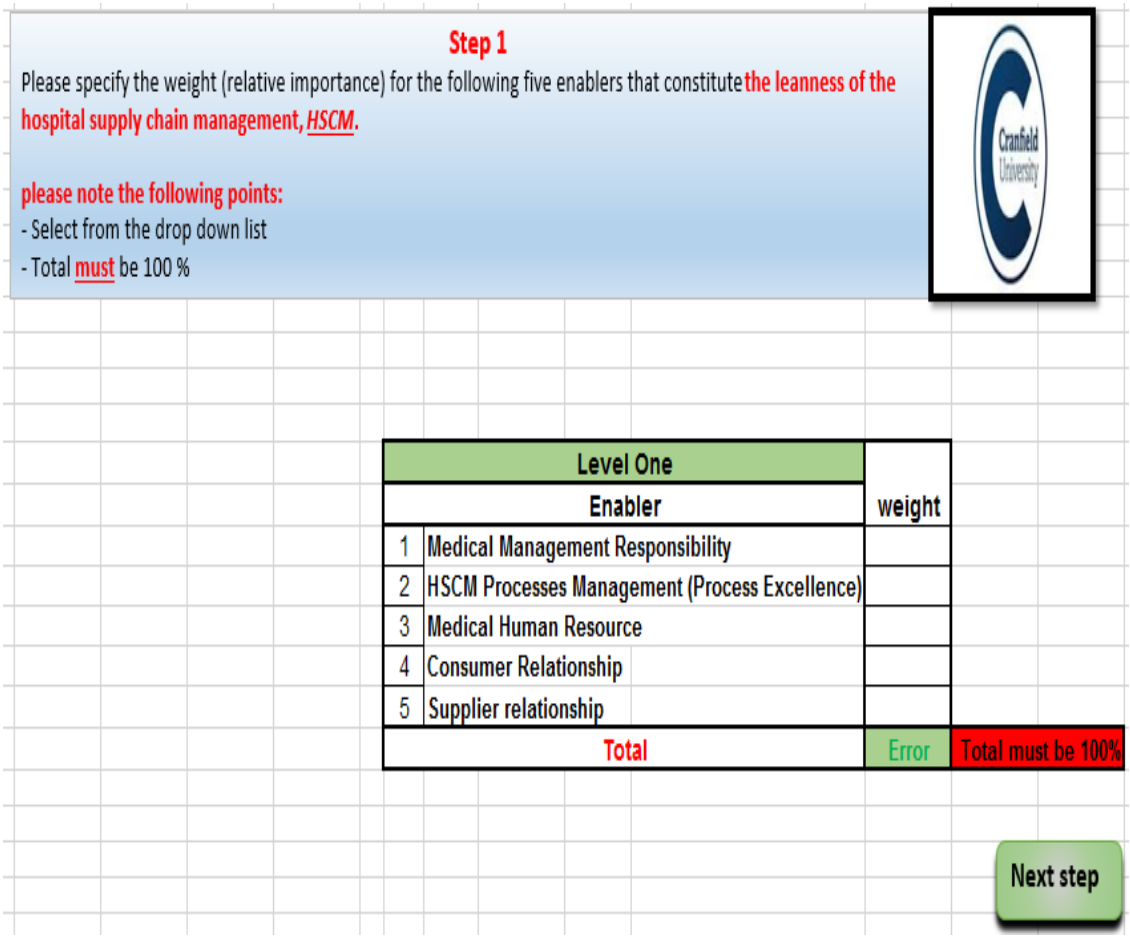


Figure 5.7 screenshot of Excel sheet for first step of assessment tool

After the participant makes sure that there is no mistake in the assessment process in the first step, the participant will move to the next Excel sheet by clicking “next step”, as shown in Figure 5.10. On this screen, the participants are asked to enter the weight for each criterion. As mentioned in the prior step, the total weight for each enabler MUST be 100%. An error message will appear in cases where the participant does not follow the rules.

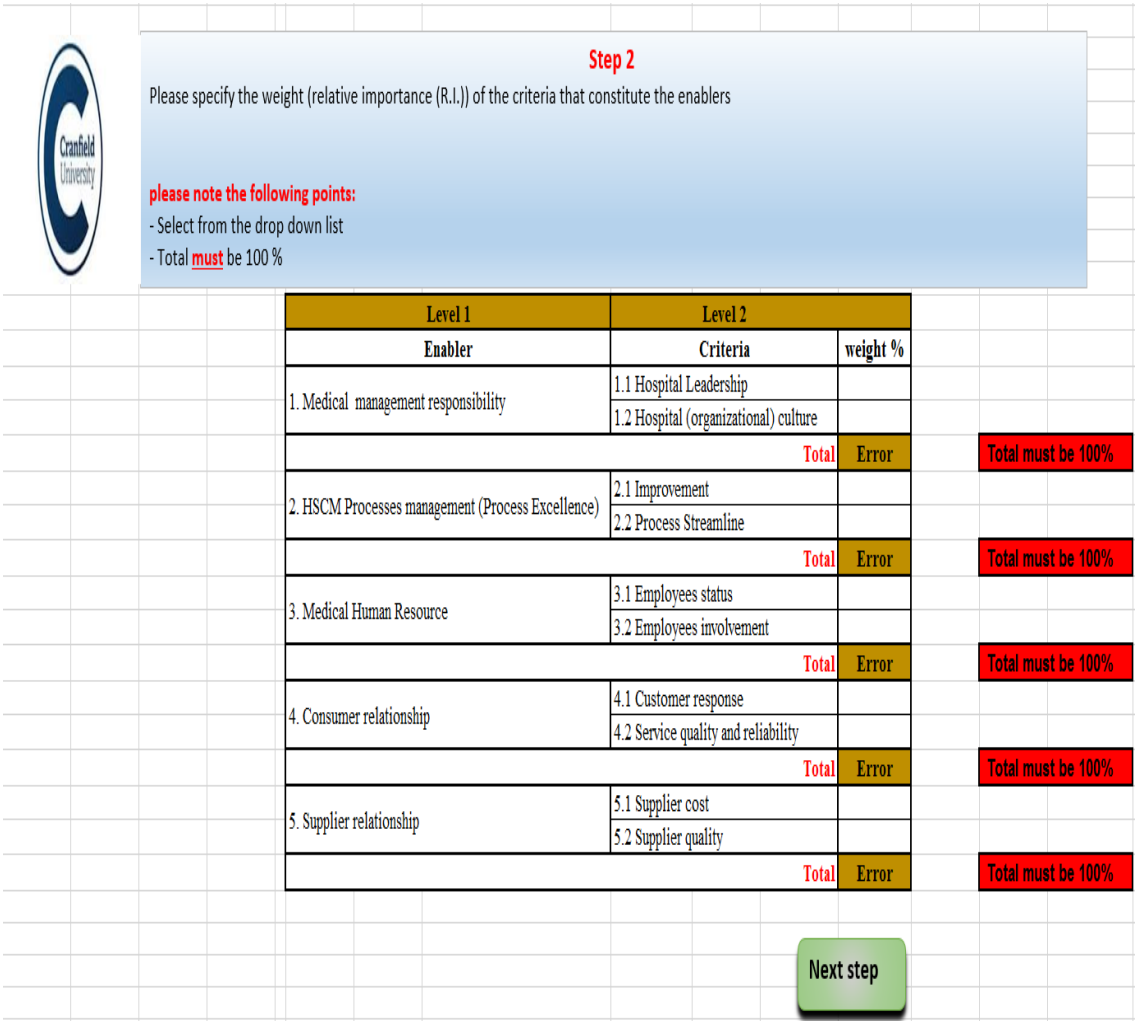


Figure 5.8 screenshot of Excel sheet for second step of assessment tool

After the participants make sure that there is no mistake in the assessment process, during the second step, participants will move to the next Excel sheet by clicking “next step”, as shown in Figure 5.10. On this screen, the participants are asked to enter the weight and assessment score for each attribute. As mentioned in the prior step, the total weight for each criterion MUST be 100%.

An error message will appear in cases where the participant does not follow the rules. The assessment score must be between 1 and 10.

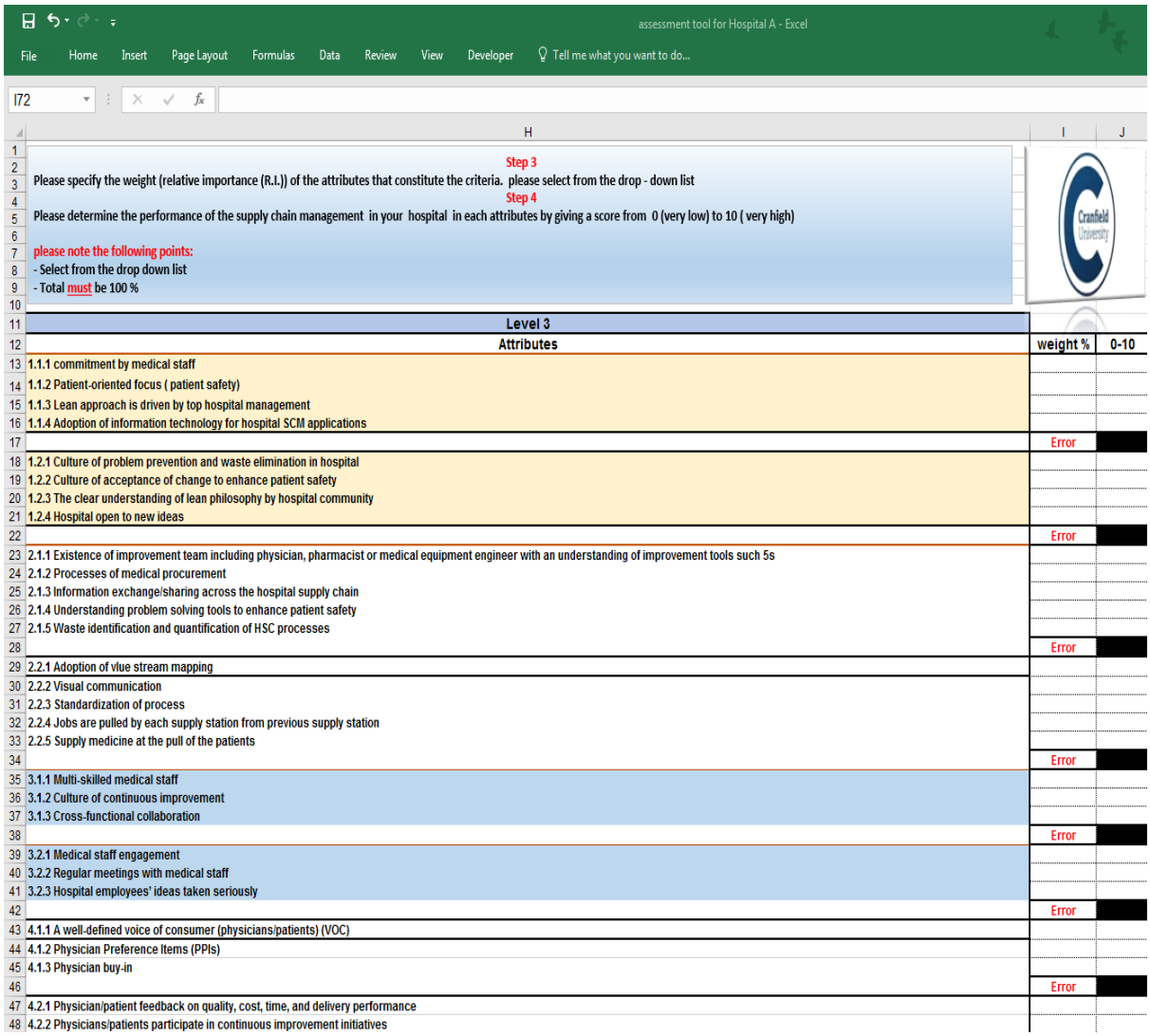


Figure 5.9 Screenshot of Excel sheet for third and fourth step of assessment tool

5.6 Validation of the developed model via case studies

Validation process will be discussed further in chapter seven.

5.7 Discussion on HSCM leanness assessment findings

Based on the leanness assessment process in the previous sections, it was noticed that the leanness indexes for HSCM in hospital (X), hospital (Y) and hospital (Z) were 3.69, 3.56 and 3.38 respectively. The indices for hospital (X),

hospital (Y) and hospital (Z) indicate that the hospital supply chain management in all hospitals are not lean, as shown in Table 5.5. A comparison between three hospitals was conducted, as illustrated in Table 5.6.

Table 5.4 HSCM leanness index

Hospital	HSCM Index
X	3.69
Y	3.56
Z	3.38

Table 5.5 Comparison between three hospitals

Enablers	Hospital					
	(X)		(Y)		(Z)	
	I	W	I	W	I	W
1. Medical management responsibility	3.71	30	3.49	25	3.69	30
2. HSCM process management	3.66	20	3.34	25	3.02	25
3. Medical human resource	3.79	20	3.44	20	3.19	25
4. Consumer relationship	3.53	20	3.72	25	3.44	10
5. Supplier relationship	3.75	10	3.82	5	3.59	10
1. Medical management responsibility	**(X)**		**(Y)**		**(Z)**	
	I	W	I	W	I	W
1.1 Hospital leadership	3.48	65	3.43	70	75	3.39
1.2 Hospital (organisational) culture	3.98	35	3.68	30	25	3.13
2. HSCM process management	**Hospital**					
	(X)		(Y)		(Z)	
	I	W	I	W	I	W
2.1 Process improvement	3.95	50	3.68	60	50	3.19
2.2 Process streamline	3.76	50	3.79	40	50	3.61
3. Medical human resource	**Hospital**					
	(X)		(Y)		(Z)	
	I	W	I	W	I	W
3.1 Employees' proficiency	3.50	50	2.95	60	3.45	65
3.2 Personnel involvement	3.64	50	3.68	40	3.31	35
4. Consumer relationship	**Hospital**					
	(X)		(Y)		(Z)	
	I	W	I	W	I	W
4.1 Consumer response	3.63	30	3.31	40	3.01	40
4.2 Consumer involvement	3.60	70	3.50	60	2.64	60
5. Supplier relationship	**Hospital**					
	(X)		(Y)		(Z)	
	I	W	I	W	I	W
5.1 Supplier cost	3.53	60	3.68	50	3.93	50
5.2 Supplier delivery	3.93	40	3.85	50	3.25	50

5.7.1 Hospital (X)

The HSCM leanness index for hospital (X) was 3.69, which means that HSCM practices are not lean. Enablers in hospital (X) have different levels of importance. The most important enabler is medical management responsibility, with 30%.

From Table 5.6, it can be seen that hospital (X) should focus on all enablers, but should start with a consumer relationship, because this has the lowest index, specifically 3.53. Many further measures were suggested in Chapter 4 to improve the enablers.

5.7.2 Hospital (Y)

The HSCM leanness index for hospital (Y) was 3.56, which means that HSCM practices are not lean. Enablers in hospital (Y) have different levels of importance. The most important enablers are medical management responsibility, HSCM process management and consumer relationship, all with weights of 25%. As seen in Table 5.6, hospital (Y) should focus on all enablers, but should start with a HSCM process management (operation excellence), because this has the lowest index, specifically 3.34. Many further measures were suggested in Chapter 4 to improve the enablers.

5.7.3 Hospital (Z)

The HSCM leanness index for hospital (Z) was 3.38, which means that HSCM practices are not lean. Enablers in hospital (Z) have different levels of importance. The most important is medical management responsibility, with 30%. As seen in Table 5.6, hospital (Z) should focus on all enablers, but should start with HSCM process management (operation excellence), because this has the lowest index, specifically 3.02. Many further measures were suggested in Chapter 4 to improve the enablers. Validation of the results will be discussed further in detail in chapter seven.

5.8 Chapter summary

In this chapter, an introduction to leanness was presented. In addition, the research methodology used for developing the assessment was illustrated. The HSCM assessment tool was developed and validated in two different ways, practically and academically. The model was divided into three levels: five enablers, ten criteria and thirty-eight attributes. Four steps were employed for computing the leanness index. The leanness index was calculated for three hospitals and evaluated the extent to which HSCM processes in these hospitals

are lean. Opportunities for further improvements were identified and introduced. Following this, the five main enablers, namely Medical management responsibility, HSCM process management, Medical human resource, Consumer relationship and Supplier relationship, were assessed. Five experts from each hospital participated in the assessment process. The HSCM leanness level for each hospital was revealed by experts, who agreed that the enablers need further improvement if lean principles are to be implemented. Following this, a discussion on the three hospitals' assessment findings was conducted.

6 Chapter Six: A framework for implementing lean in healthcare supply chain management[3]

The main aim of this chapter is to display a framework that can be employed to implement lean principles in healthcare supply chain management (HSCM). To achieve the aim of this chapter successfully, many sections have been introduced with a view to fulfilling the chapter's aim as shown in Figure 6.1. This chapter addresses the fifth research objective which is develop a framework for the implementation of lean principles in supply chains management in healthcare organizations.

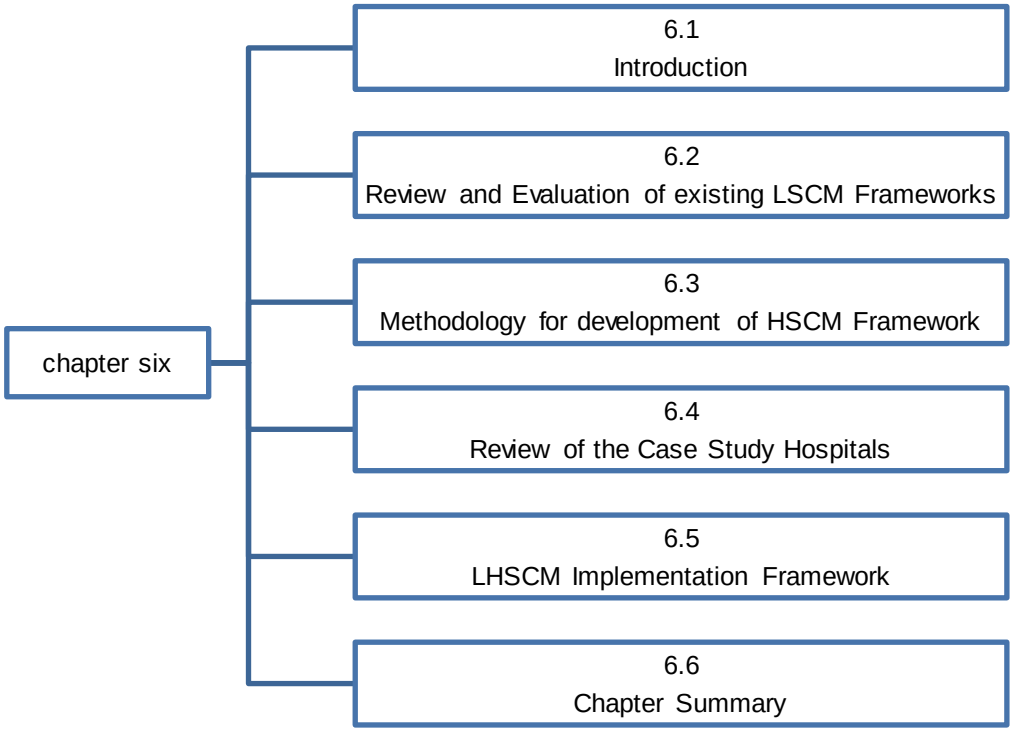


Figure 6.1 main sections of chapter six

[3] Part of chapter six has been published: Almutairi, A. Salonitis, K. and Al-Ashaab, A. (2019)" a framework for implementing lean principles in the supply chain at healthcare organizations: From Saudi Arabia's perspective" International Journal of Lean Six Sigma.

6.1 Introduction

A massive number of non-value-added process are executed within healthcare supply chain management (SCM) activities. Implementing lean concept can improve on-time delivery and reduce the amount of resources and time spent in the processes and other activities of an organization, with an assurance on eliminating every type of wastage(Anvari et al., 2011). Many organizations have adopted lean concept because of the advantages that can be achieved from the application of this concept. Lean principles are helpful to identify and eliminate waste actions throughout the SCM activities (Jasti & Kurra, 2017). Several organizations including healthcare organizations have considerable difficulty in implementing lean concept. In spite of the lean approach has been implemented in the service sector and manufacturing sector, few organizations have achieved the satisfied findings(Baker 2002).

Despite the lean has been implemented in in both sectors; service and manufacturing sector, few organizations have gained the desired results(Bhasin & Burcher, 2006). For example, Kotter (1996) mentioned that only 30% of all continuous improvement initiative implemented are successful. This means that 70% of changes programmes were failed. The high percentage of lean implementation fail has assured by Eaton (2010) and he stated that 75% of continuous improvement programmes fail.

Whilst several tries have been made to develop an effective framework for implementing lean in the service sector and manufacturing sector, none of the existing frameworks or models have attempted to develop a framework for implementing lean in SCM in healthcare context especially for Middle East and Gulf region context and there is no framework in line with Saudi context. Many authors have mentioned that there is a shortage of studies focusing on SCM continuous improvement (Hong et al., 2012; Al-Saa'da et al., 2013; Piotrowicz & Cuthbertson 2015).

Under conditions of massive percentage of lean implementation fail and lack of studies, there is need to build a well-defined framework for enhance lean practices and make sure that lean concept implemented successfully in HSCM.

Almutairi et al., (2019) mentioned that there is no framework which has been developed for SCM in the healthcare sector.

Consequently, this chapter aims to develop a framework that can be adopted to implement lean principles in the HSCM and transfer lean practices to the HSCM activities where applicable in Saudi context.

6.2 Review and evaluation of existing LSCM frameworks

This study seeks to develop an appropriate LSCM framework that suits the Saudi healthcare setting with a combination of in-detail review of existing LSCM frameworks and experts' opinion from Saudi healthcare sector study. First, it is important to know and understand what a framework is within a research context. Based on the literature, there is no consensus on the dentition of a framework. The term framework is a very popular term used in a vague way, and thus it does not have a clear-cut definition. Several sources use the framework in the place of a model or vice versa (Jasti & Kodali 2016). According to Miles & Huberman (1994), a conceptual framework is defined as "a visual or written product, one that "explains, either graphically or in narrative form, the main things to be studied and the key factors, concepts, or variables and the presumed relationships among them."

Found & Rich (2007) suggested a lean supply chain (LSC) framework after conducting a survey. This study applied empirical research to find out the applicability of the suggested LSC framework, but did not include validity and reliability analysis. Further, researchers have developed LSC frameworks to fulfill the requirements of the manufacturing industry (Jayaram et al., 2008). Lee et al., (2011) developed a framework to investigate the innovation of supply chain in the healthcare sector to improve organizational performance. The data was collected from 243 clinics in South Korea (large hospitals, more than 100 beds), and the hypotheses were examined utilizing structural equation modeling. The results showed that there was a positive relationship between the innovation of supply chain factors and organizational performance. The design of supply chain innovation has a considerable effect on the choice of collaboration with improved supply chain efficiency, suppliers, and enhancement of quality management practices. However, the research was limited to the hospital's size.

Pasutham (2012) developed a framework for integrated performance supply chain in three case studies within the Thai manufacturing sector. These include integration of upstream (suppliers relationship management) with downstream (customer relationship management) and within a firm (internal supply chain management). However, the framework was suitable within the Thai context and was affected by context and culture. Furthermore, policy makers in healthcare cannot be disregarded, as the framework cannot work properly if the regulators and all players in healthcare do not embrace the same practices and standards. Kritchanchai (2012) developed a supply chain framework for the healthcare sector in Thailand. The framework focused on co-ordination and operations within healthcare players, integrated with government of healthcare policy in the public sector. Three projects were conducted during this study. The results showed that SCM is a new concept in Thailand and is still in its infancy in healthcare.

Lega et al., (2013) developed a framework to evaluate and measure supply chain processes in the healthcare sector and applied it on Italian NHS. The study showed that there was an urgent need to quickly respond to changes in demand. In addition, due to the levels of variability, it is difficult to predict the demand of some medical departments, such as emergency and intensive care units (ICU). Furthermore, the criteria of warehouse management in the manufacturing sector are not suitable to be used in the healthcare sector (Lega et al., 2013). Finally, any problem in supply chain processes can lead to critical patient damage. Machado et al., (2014) proposed framework to implement lean concept in Brazilian hospitals through change of culture. Anand & Kodali (2008) developed a conceptual framework resulting in two concepts, including lean and agile. The proposed framework helped organizations in transforming from traditional supply chain into lean supply chain and was developed based on judgmental processes in the manufacturing context. However, the framework is not validated through case studies. Table 6.1 summarises LSCM frameworks

Table 6.1 Summarizing LSCM frameworks

Author(s)(year)	Sector	Country	validation	limitation
Found & Rich (2007)	Manufacturing / packaging	UK	panel of experts	Lean supply chains Limited to packaging. Focus only on just in time
Jayaram et al., (2008)	Automotive	North America	panel of experts	The conceptual framework examined effect of lean practices on financial performance and building relationship.
Anand & Kodali (2008)	Manufacturing	India	panel of experts	The framework only attempts to evaluate the relationship between SC performance and LSCM practices
Lee et al., (2011)	Healthcare	USA	structural equation modelling	The framework focused on quality management practices more than lean practices and its impact in organizational performance
Pasutham (2012)	Food/ chemical/ textile	Thailand	panel of experts	One of the drawback of this framework is developed for Manufacturing sector
Kritchanchai (2012)	Healthcare	Thailand	Focus group	The framework propose use standardizing medication code to improve hospital supply chain.
Lega et al., (2013)	Healthcare	Italy	panel of experts	The framework concentrated on evaluation of SC performance more than implementing lean concept. The framework ignore evaluation of patient value (satisfaction)
Machado et al., (2014)	Healthcare	Brazil	N/A	The framework attempts to implement lean through change organizational culture.

Agwunobi & London (2009) pointed out that the use of lean for improving high-volume purchasing and SCM in the healthcare sector lower prices saving a significant amount of money and improves healthcare. Moreover, a low purchasing level leads to a reduction of inventories and therefore, saves money. Aronsson et al., (2011) developed a framework by combining SCM and lean philosophy in the healthcare context. The framework used lean and agility in the hospital supply chain setting. Furthermore, a case study approach at one of the largest hospitals in Sweden has been adopted. The framework focused on

organizational transparency and teamwork and the study shows that using a lean concept in supply chain at hospitals potentially works well for patient flow in hospitals.

Godinho Filho et al., (2014) presented the implementation of lean techniques in healthcare in the surgery department of a Brazilian hospital. The proposed lean approach is based on a set of nested improvement cycles that are employed to continuously improve the value chain. The findings of the implementation illustrated improvement in savings in cost capacities and cycle time. Another important improvement was a significant reduction by 94% in the index of delayed surgeries due to the lack of materials and a reduction in post-surgery infection. Garcia (2017) wondered how lean management principles could be used to improve patient satisfaction scores and reduce wait time. Using lean methodology and implementing a PDSA (Plan, Do, Study, Act) cycle has shown to have a significantly reduced procedure cycle time and improved patient satisfaction. Implementation of lean principles leads to increased patient satisfaction by improving cycle times for procedure room turnover, developing methods to anticipate work ahead of time and improving overall cycle times. In conclusion, although there are many frameworks that addressed lean implementation in SCM, most of these frameworks are limited to certain industries such as manufacturing, food, small-medium enterprise (SMEs) or construction while other focus on in a specific region such as Taiwan and Portuguese.

It can be noted that all previous frameworks addressed either a single part in SCM (Gunasekaran et al., 2001; Chan & Qi, 2003;Gunasekaran et al., 2004 ; Huang et al., 2005; Bhagwat & Sharma, 2007; Robb et al., 2008; Lin & Li, 2010) or focused on non-healthcare sector (Bhagwat & Sharma (2007; Pasutham, 2012). Other researchers focused on the importance and the benefits gained from improving SCM performance such as preventing medical errors, improving healthcare provider (hospital) performance, decreasing waste, producing value added operations, improving operational efficiencies and helping to improve quality of care (Ford & Scanlon, 2007; Mustaffa & Potter, 2009; Kumar, Ozdamar, & Zhang, 2008; White & Mohdzain, 2009). Many authors mentioned that there is

scarcity of studies concentrated on SCM performance improvement (Mustaffa and Potter, 2009a; Gopal & Thakkar 2012; Piotrowicz & Cuthbertson 2015; Hong et al., 2012; Al-Saa'da et al., 2013) while many tries have been made to create a helpful framework for improve SCM in different sectors, none of the present frameworks have attempted to develop framework for improving SCM by integrating lean and SCM within healthcare settings generally in the Middle East and especially in Saudi Arabia or gulf region.

6.3 The case study hospitals

Due to the privacy and confidentiality and agreement with targeted hospitals, the hospitals' names will not be mentioned throughout this thesis and will be called as hospital (X), (Y) and (Z).

6.3.1 Hospital (X): case 1

Hospital (X) is one of the oldest hospital in Saudi Arabia and working under ministry of health. It plays vital role of the patients' safety and secure healthcare in local community. It has 1400 bed capacity and many major hospitals and medical centres. These hospitals include Pediatrics Hospital, Maternity and General Hospitals as well as Charity Kidney Centre and the Dental Centre. More than 8,000 employees of different nationalities work with hospital (X). SCM departments in hospital (X) includes: medical supply, capital equipment, purchasing and tendering, store and material management. After interviewing key employees from these departments, it was noted that lean concept is well known and they know where lean practices can be implemented in SCM. Hospital (X) started to implement lean principle in HSCM. However, the lean project "died in its cradle" and actually was failed as mentioned by Interviewees. The reasons behind are lack of commitment and support from top management and disbelief in lean benefits (barrier 5) and shortage in well trained employees (barriers 7). These barriers will discussed with more details in chapter five.

Because there is no available framework for implementing lean in hospital SCM, hospital (X) committed some mistakes that lead to fail lean project. Neglecting hospital readiness (phase 1 from the developed framework) has critical role in failure of lean implementation before launching. Also, lack of culture of change is

another mistake. In addition, lack of well-trained employees is another reason for failure of lean initiative in hospital (X).

6.3.2 Hospital (Y): case 2

Hospital (Y) is include many medical centres and hospital and serves local community. The hospital does not accept patient directly. Patient needs referral letter to admit in this hospital except emergency case. It has 1500 bed capacity and more than 9000 employees. Usually it called medical city not a hospital. SCM departments in hospital (Y) includes: material planning, catalogue and standardisation, procurement and contracts, warehouse, property transfer, distribution and coordination department. There is some trials to deploy initiative projects, however, it were not institutionalized. Lack of systematic and clear steps to adopt continuous improvement initiative was clear so there is no actual starting any continuous improvement project. One of the most issue in this case study is disbelieve of lean concept and its great benefits. So this hospital should starts with top management toward commitment of implementing lean principle in SCM. A few employees in this hospital have knowledge about lean and its application in healthcare sector. Most barriers will for this hospital will elaborate in chapter five**.**

6.3.3 Hospital (Z) case 3

Hospital (Z) also include many healthcare centres and hospitals and serve thousands patients. This hospital has no intention to adopt lean initiative due to disbelieve of hospital leaders by lean benefits. Although there are many employees who have good knowledge in terms of lean and its advantages, the decision makers do not support such initiatives. The hospital has 1200 bed capacity and more than 7000 staff. SCM departments in this hospital are the same

From investigating the current lean practices in all hospitals SCM, the following points were noticed:

- In general, there is no commitment and support by hospital leadership toward implementing lean practices in SCM for many reasons. For example, inadequate knowledge in terms of lean, lack of training, disbelief in lean and believe that lean just waste of money.

- Poor vision about lean project and its applications in healthcare context.
- Lack of linking continuous improvement initiatives with hospital strategy.
- There are a few number of people who have solid background in terms of lean implementation or continuous improvement initiative.
- Although there is training department, there is a clear lack of training programme especially on-job training.
- In spite of total quality management (TQM) department is one of the most important department, there is no body specialized in lean or lean six sigma. Some TQM employees Certified Professional in Healthcare Quality® (CPHQ).
- Although the importance of supply chain management in hospitals, less attention has been made compared to medical departments in terms of performance improvement.
- Difficulty to find out which processes in SCM do not add value to patients.
- In all hospitals, no employee has lean six sigma master black belt or other qualified certificate in continuous improvement area.
- Lack of effective communication was clear between SCM internal departments and external departments.
- Although all hospitals have accredited by Joint Commission International Accreditation and The Saudi Central Board for Accreditation of Healthcare Institutions standards, lean approach has not implemented in spite of existing wastes in processes.
- Organizational culture and moving to lean organization (change resistance) is one of the most barrier to deploy lean concept in healthcare context. Change initiatives need a clear framework to implement the change successfully.

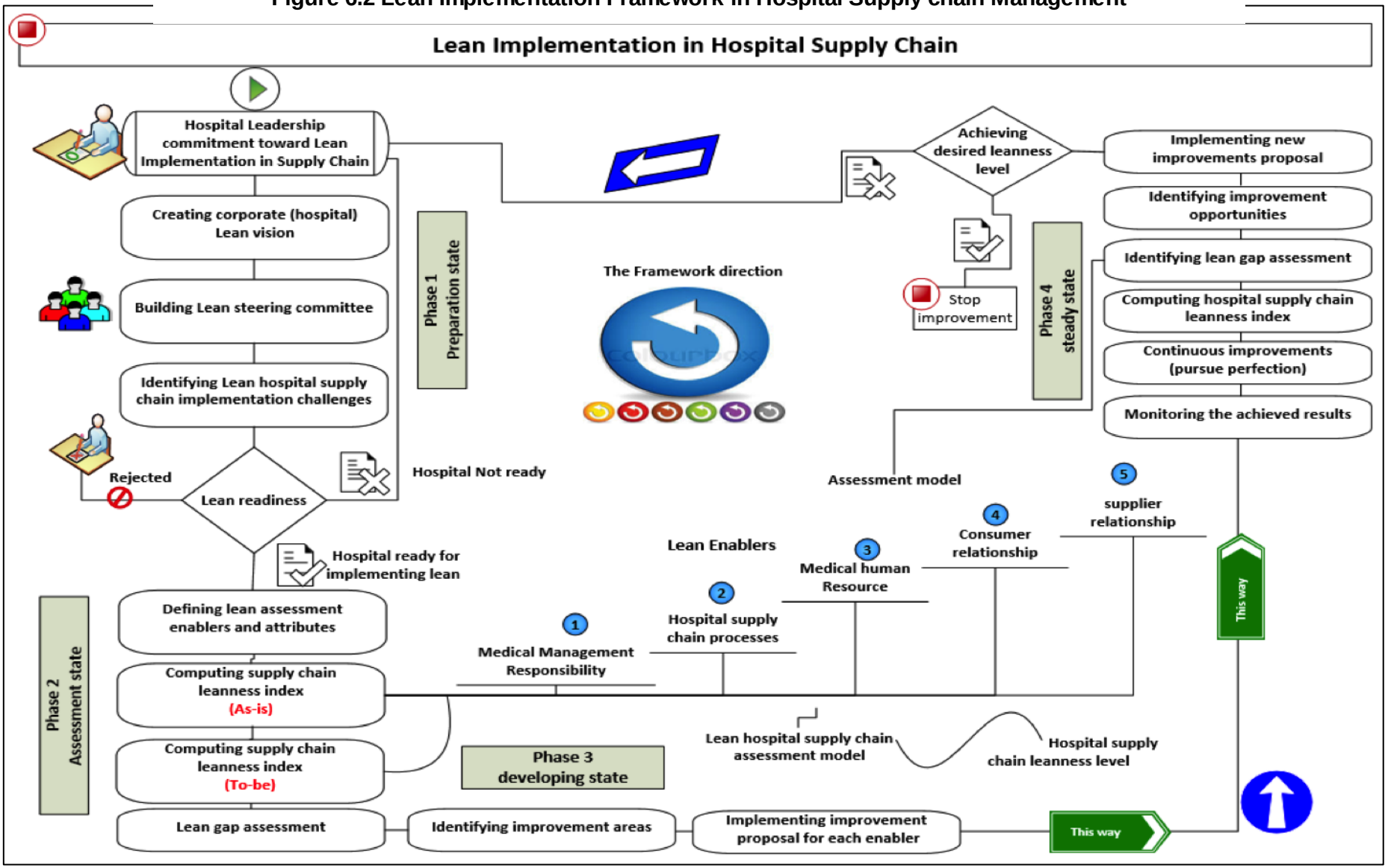
6.4 LHSCM implementation framework

Proposed lean Hospital supply chain management (LHSCM) implementation framework is built on four stages and each stage should be completed successfully before moving on to the next stage. Figure 6.4 shows the overview of stages of implementation. Thus, the four phases are:

- Phase One: Preparation state

- Phase Two: Assessment of the current state in terms of lean
- Phase Three: Developing the desired future state in terms of lean
- Phase Four: Steady (sustainable) state of new actions taken

Figure 6.2 Lean Implementation Framework in Hospital Supply chain Management



6.4.1 Phase 1: Preparation (readiness) state

"Before anything else, preparation is the key to success"

Alexander Graham Bell

Before initiating any lean implementation project, the decision makers should prepare their healthcare organizations to accept these changes and make them ready to contribute to its success with the new approach. Like other continuous

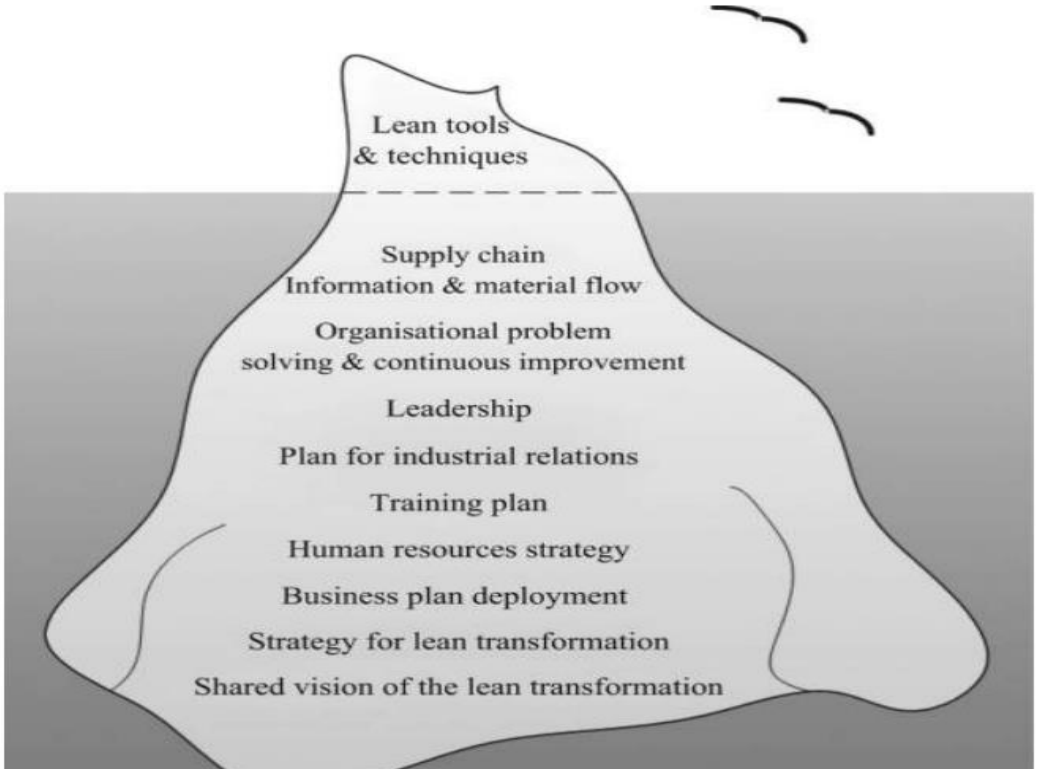


Figure 6.3 the iceberg model of lean implementation (Grove et al., 2010)

improvement initiatives, lean needs a fertile ground for success. According to Achanga et al., (2012) an organization's lean readiness is critical for implementing lean practices. The degree of lean readiness is important for determining to what extent lean implementation will succeed.

Iceberg model (Figure 6.5) shows there are many determinants that should be taken into account (starting from bottom of the iceberg) to make sure the success of lean implementation. Decision makers in healthcare organizations attempt to adopt the success of other industries without understanding lean philosophy. Without serious preparation of healthcare organizations for implementing lean approach, the failure will be the end (Grove et al., 2010). Willing to change and

readiness for adopting lean initiative should be identify in healthcare setting strategic agenda. This will play role in sustain lean implementation(Al-Balushi et al., 2014). The steps (activities) in this stage should be addressed successfully before moving to the next stage.

6.4.1.1 Activity 1: Commitment toward lean implementation by hospital leadership

Hospital's top management's commitment plays a vital role in the success of lean implementation. Hospital leadership is important in terms of facilitating the necessary requirements to allow lean implementation and willingness to be connected with problems during the implementation stage. Executives are in charge of actualizing the real involvement of hospital staff in a lean initiative and facilitating the needed resources to allow lean implementation. In terms of resources needed for lean implementation, involvement and training for hospital employees should be provided in a lean initiative. Senior managers should be willing to show their support and commitment for any lean initiative whenever problems arise(Al-Balushi et al., 2014). As well, an increased supportive commitment towards lean projects from the top management is one of the main pillars of successful lean initiatives. In this stage, the hospital's top management provides assistance when any problems over lean implementation appear. As well, they support the goal of prompting necessary attitudes from all hospital levels to encourage successful lean implementation. Hospital leaders must show an interest in and allow the availability of needed resources to ensure forward movement of lean projects, which reinforces its position in a hospital setting. Without sustained and visible support from hospital leaders, lean initiatives cannot be implemented in healthcare settings (Pampanelli et al., 2014; Alves & Alves, 2015; Tsironis & Psychogios 2016;Kader Ali, 2016 ;Cherrafi et al., 2016;Albliwi et al., 2017).

6.4.1.2 Activity 2: Create Hospital Lean Vision

Executives should link lean initiatives with organizational visions and strategic goals to show that people confirm their visible commitment and serious support towards lean initiatives. Hospitals' senior managers need to set forth a clear lean

vision and mission that indicates hospital goals for performance improvement. The hospital's vision should be translated into lean strategies and goals and communicated to supply chain employees, medical staff (physicians, pharmacists, and medical engineers), as well as medical suppliers by the use of a hospital's website, periodicals, or other social media. This allows them to imagine and visualize the hospital's mission, lean culture and commitments of the hospital (Spagnol et al., 2013; Antony 2014; Shokri et al., 2016). Linking lean with the strategic objectives of the healthcare context is important in terms of requirements, justification, clarification, support, commitment and willing to change before and during lean implementation(Al-Balushi et al., 2014).

6.4.1.3 Activity 3: Build Lean Steering Committee

Forming a lean steering committee is considered the cornerstone of success of lean implementation. This committee is comprised of representatives from different departments, such as top management, front-line employees, and quality management. The main roles of a steering committee are building a lean team, making sure lean team members have sufficient knowledge in terms of lean, how to implement it and identifying the appropriate lean tools and techniques suitable for the nature of hospital supply chain, changing the culture, and identifying lean resistors. Also, steering a committee provides the required and necessary lean training to the staff of the hospital. In addition, the issue that needs to be solved should be clearly identified before embarking on the lean journey(Sanders & Karr, 2015). In the case of lean experts being unavailable within the hospital, the hospital can be assisted by external lean experts, along with giving lean training courses for employees who need them. In addition, a qualified steering committee is responsible for assessing supply chain leanness levels and identifying the main barriers of lean initiative implementation. Also, a steering committee (lean team) would help hospital senior executives establish a corporate lean vision and then translate it into action plans. Lean teams should publicize the lean vision and guide lean objectives in an effective way. Moreover, the committee is responsible for improving organizational culture. Lean practices should be linked to organizational missions and strategy, where lean approaches

become part of the organizational culture (Hines et al., 2008; Jeyaraman & Kee Teo 2010; Radnor & Bucci 2011; Burgess & Radnor 2013)

6.4.1.4 Activity 4: Identify Lean Implementation Challenges

The next step in this stage is to identify lean implementation challenges. Identifying implementation barriers before applying lean is important and can help a hospital to evaluate its ability and capabilities in implementing lean effectively or not. Barriers prohibit lean implementation from successful (Grove et al., 2010). A steering committee then identifies the main barriers and gains the approval of the senior management that all the issues facing the implementation of lean initiatives can be treated. Continuity without the approval of decision makers may cause the failure of lean implementation. The main reason for this step is to make sure that all barriers can be resolved in the future. In some cases and due to the lack of a hospital's capabilities, a hospital cannot overcome some of the barriers in its current situation. In this case, lean initiatives are postponed until the barriers are resolved (Kim et al., 2006; D'Andreamatteo et al., 2015). After verifying, the steps in this stage are working effectively the hospital can then move on to the next stage.

After achieving these steps, the decision makers at healthcare organization should ask themselves "is our organization ready to implement lean principles?" After finishing this phase, the healthcare organization will be able to ready "readiness" implement lean and now should move to the second phase. More details about lean implementation barriers will discuss in chapter five.

6.4.2 Phase 2: lean assessment state

After establishing the commitment and support from hospital's senior management, building a qualified lean team, linking lean with the hospital's vision, resolving all lean implementation challenges, and then steering the committee; the lean implementation team can then move on to the second stage. This stage is considered to be a diagnostic tool for hospitals in terms of lean and can determine the actual level of lean implementation. In light of this diagnosis, areas that need further improvements will be identified. This stage enables supply chain in hospitals to define the actual gap between the current situation and the

desired outcomes. This stage requires a thorough audit to document what is actually happening in a hospital by interviewing experienced supply chain employees (Almutairi et al.,2019). Before visiting hospitals, there is a need to achieve all the steps in stage one.

The implementation of lean and the assessment of leanness are different from industry to industry and from one organization to another because they depend on its situation and conditions. This means that there is no agreed step by step or roadmap to leanness level and lean implementation (Anvari et al., 2011). Lean implementation is not clear-cut of actions or steps that should be strictly followed for every lean implementation because every organization has its own systems, culture, policies and type of waste; thus, a customized approach is widely accepted.

6.4.2.1 Activity 1: define lean assessment attributes

This activity can be considered the most critical step of the framework because it is directly related to the evaluation of the current situation in terms of lean. After making sure all barriers can be overcome, the steering committee should evaluate and assess the SCM leanness level using the developed assessment model. The assessment model of hospital supply chain management (HSCM) leanness level includes five lean enablers. These enablers are medical management responsibilities, HSC processes management, medical human resources, consumer relationships and supplier relationships.

The HSCM Leanness Assessment Model (HSC-LAM) was developed based on main three levels (Almutairi et al.,2019) This model will elaborate in (chapter 6).

- The first level includes fie lean enablers
- The second level contains ten criteria
- The third level consists of thirty eight attributes

The first task that should be performed in this activity is identifying the correct factors that achieve lean goals. Failure to correctly identify lean enablers, success factors and attributes and overcome lean barriers can lead to the failure of lean implementation. This can be achieved through lean champions, lean six sigma black belt (LSSBB) holders, as well as lean six sigma master black belt (LSSMBB) certified or qualified teams from different departments(Jeyaraman &

Kee Teo 2010). The second task is to make sure all assessment model elements lead to real-life improvements and achieve patients' needs and requirements. This task can be performed by supply chain decision makers in cooperation with their stakeholders. There are many tools that can be used to perform this task, such as brainstorming, focus groups, benchmarking or others (Almutairi et al., 2019) .The purpose of this step is to generate ideas and take opinions and feedback from different angles.

6.4.2.2 Activity 2: compute SCM leanness index

After developing the HSC Leanness Assessment Model, a mathematical calculation can be performed through software, such as Microsoft Excel, by the committee steering (improvement team) or lean champions. The value of the leanness index is considered the real step toward the improvements. After quantifying the leanness level, decision makers in hospital supply chain are numerically aware of their healthcare organizations' position in terms of lean. The computation of HSC leanness index contributes significantly in the success of lean implementation because it works as a diagnostic tool for lean performance and helps hospital leaders to take corrective actions. Also, the leanness index is considered the real starting point for applying lean in HSC (Almutairi et al., 2019). After accomplishing phase one and two, the healthcare organization can move to the third phase. Computing SCM Leanness Index for each hospital will elaborate in (chapter 5).

6.4.3 Phase 3: lean developing state

Identifying a gap between "what is' and "what should be" and the desire to take corrective actions is considered to be the main step towards success. Value stream mapping can be used for identifying current and future state (Mostafa et al., 2013). Improving lean enablers' performance is considered the main aim of this stage by capturing the best methods and practices that enable a hospital to implement lean successfully in the SCM.

6.4.3.1 Activity 1: lean gap assessment

Almutairi et al., (2019) assured that lean assessment at SCM in healthcare organizations is gaining vital importance and before implementing lean initiatives.

It is crucial to assess leanness in the SCM practices. After determining the HSCM leanness level by computing leanness index, the steering committee is responsible for identifying future levels of lean. Determining the lean current level and identifying the lean future state will enable lean champions / steering committee from proposing improvement actions. Lean gap assessment can be achieved by evaluation the current situation in the organization in order to identify weakness (wastes) to implement lean by using value stream mapping (Mostafa et al., 2013). The lean future state depends on the hospital's vision, strategic plans and availability of resources (human, financial, technical, infrastructure, stakeholders) and can be calculated by using the developed model (Phase 2: Activity: 1). The proposed actions fill the gap between the current state and future state and move the hospital supply chain from one position to another towards operational excellence.

6.4.3.2 Activity 2: identify improvement areas

Almutairi et al., (2019) mentioned that lean assessment is the most appropriate starting point to identify potential improvement areas. As a result of the previous step, the lean implementation committee has the ability to determine the gap between the current situation and the desired future state. The leanness level index in supply chain will enable the steering committee to identify the areas that need further improvements and develop improvement actions with respect to the five lean enablers. Now, the steering committee (lean champions) understanding the current situation in terms of lean have all the information about how lean the hospital supply chain is. After identifying leanness level, the committee is ready to improve the five lean hospital supply chain enablers and adopt the appropriate lean tools to improve and enhance each enabler in light of the hospital's vision, strategy, capabilities and ability to overcome lean implementation challenges. Identifying improvement areas (opportunities) supports lean transformation by eliminating wastes (Cottyn et al., 2011). After accomplishing phase one and two, the healthcare organization can move to the third phase.

6.4.4 Phase 4: steady (sustainable) state

Stabilizing the new way of operations is a crucial point and should be under concentration. Keeping the new proposal's improvements running continuously in operation is considered a step forward to achieve a new level of lean.

6.4.4.1 Activity 1: monitoring the achieved results (lean monitoring)

Lean monitoring (sustaining) is recommended to make sure that lean implementation on the track and works as planned (Mostafa et al., 2013). In this stage, the first step is monitoring the lean implementation. The monitoring process is making sure that the implementation on lean hospital supply chain is going the right way. The main purpose of the monitoring process is sustainability of lean implementation over the long term. In this step, the real (actual) performance is measured in terms of lean and compared against the target goals (desired lean level). This monitoring process plays a vital role in making sure the lean implementation is done as planned and to take corrective actions if the implementation process deviates from its course. Frequent assessment and communication on lean results will provide the chance to identify potential opportunity for improvement (Jeyaraman & Kee Teo 2010). This step works as auditing process to make sure that all achieved actions are under control.

6.4.4.2 Activity 2: continuous improvement (pursue perfection)

Continuous improvement should be implemented to attain certain level of lean implementation (Mostafa et al., 2013). Again, the steering committee (implementation committee) will use the lean HSC assessment model to measure the real (actual) performance attained and compares the outcomes with initial findings from the first stage. The obtained feedback from this stage enables the hospital to take corrective actions in case of deviation during the implementation process. Also, hospital work practices must use continuous improvement tools achieve the endless pursuit of perfection. Reijula and Tommelein (2012) mentioned that using "Kaizen" in hospital work processes is necessary to achieve the "endless pursuit of perfection"

6.4.4.3 Activity 3: computing HSC leanness index (to-be) and (as-is)

The steering committee will use the lean HSCM assessment model again (Phase 2; Activity1) to measure the real (actual) performance attained and compare the outcomes with initial findings from the second phase (Phase 2; Activity 2). The obtained feedback from this stage enables the hospital to take corrective actions in case of deviation during the implementation process. Almutairi et al., (2019) proposed leanness index model for computing leanness index for HSC. By using the developed HSCM assessment model, current and future state leanness can be evaluated.

6.4.4.4 Activity 4: identify lean gap assessment

Again, after identifying the lean level (second round, the first one was in Phase 3; Activity 1) and comparing it with lean level in the previous phase, supply chain decision makers in a hospital can implement improvement actions, which are identified in the next step. Identifying lean gap can be attained by assessing (AS-IS) and (To-BE) situation (Mostafa et al., 2013).

6.4.4.5 Activity 5: identify improvement opportunities

By identifying the areas that need further improvement through the model that was developed in Phase 2, the proposed improvements for lean enablers could be the following and based on either literature or experts' suggestions:

The first lean enabler in HSCM is medical management responsibility (MMR) (hospital leadership). This enabler can be improved by several steps. Since a majority of development initiatives in healthcare sector are directed top-down and not bottom-up, this kind of leadership should be improved by changing leadership style to a bottom-up leadership approach. Such an approach will encourage employees to strongly participate in lean projects a majority of development initiatives are directed top-down and not bottom-up. Leaders should refer to personnel and look to them as associates. Leading by example is another way to improve leadership style. In addition, MMR can be enhanced by management commitment (MC) Al-Borie & Abdulla (2013),

MC can be improved by the introduction of quality policies and by conducting management reviews. Linking lean implementation with organization vision and

strategic goals is considered critical point in success of lean implementation. Also, increase supportive commitment toward lean projects from top management is one of the main pillar to success lean initiatives. The second organizational area which needs further improvement is patient-oriented. The hospitals must become patient-oriented in order to achieve hospital mission and patient needs. SC can only be successful if it is truly patient-oriented. Patient-oriented care processes require a supportive supply chain adhering to strong principles of fully-integrated and seamless inventory-sourcing processes. SCM and inventory automation are necessary for lean patient-oriented processes. This organizational area can be improved by clearly identifying patients' needs and linking these needs with the hospital strategic goals. One of the main factor that contribute significantly in success lean initiative is culture. (Nabelsi & Gagnon 2017).

Hospital culture (HC). Since the patient's safety is the ultimate goal for any healthcare provider, hospital leaders should enhance patient's safety culture. HC plays a vital role in patient safety (Dobrzykowski et al., 2014). Lillrank et al., (2011) mentioned, in healthcare settings, how the organizational culture leads to decreasing medical mistakes. Also, a study conducted on a large number of American hospitals shows the relationship between organizational culture and the reduction of medical errors. In this research, HC refers to "need and belief about ongoing improvement" (Noori 2015). This area can be improved, starting with top management. Patient safety starts with a transformational leadership, which in turn leads to the formation of a culture of safety, the adoption of patient safety plans, and to development in patient safety outcomes. This enhances the culture of patient safety**.** The significance of HC in the supply chain is undeniable. There are two main reasons for focusing on HC. First, HC plays a significant role in SCM. Second, HC is more intractable than other factors, such as information or technology. According to Schilke & Cook (2014), HC shapes the attitude of staff with respect to risk-taking, teamwork and information sharing. Appropriate organizational culture improves trust and inter-firm associations. Resistance to change is one of the most feature of HC. HC can be facilitated by using one of

the most common organizational change model which was developed by Kotter. More details how to overcome HC barrier will elaborate in chapter 5

The second enabler that needs further improvement is Hospital SC processes management (HSCPM). HSCPM can be attained by creating the department, such as Business Process Streamlining Department (BPSD) that is responsible for continuous improvements processes. This department is linked directly to the Chief Executive Officer (CEO) or executive general manager for supply. This intervention was suggested by interviewees during focus groups. A form improvement team, which might include physicians, pharmacists or medical equipment engineers working closely with SC decision makers, is necessary to improve SC processes. The improvements can be done through medical procurement processes. Ordering the right medical devices for daily processes puts pressure on hospitals to look for opportunities to deliver a high quality of patient care, and to improve supply chain operational efficiencies. Redesigning supply chain processes by implementing Business Process Re-engineering (BPR) will improve workflow, reduce cost, and improve quality. For example, link procurement department directly with CEO in organizational chart (normally under supply chain department). Also, redesigning the OC to reduce the number of decision-making levels will contribute significantly to accelerating the purchasing process.

Information exchange in hospital supply chains is another area that need more improvement. The timely sharing of relevant information along the SC can dramatically reduce the “bullwhip effect”. The coordination between all HSCM departments and medical departments should be done in the proper way to avoid unexpected medicines demand. Information exchange forms are the very basis for effective coordination that forms the core of efficient hospital SCM. Also, prompt information exchange plays a vital role in meeting patients’ needs. Information exchange relationship between healthcare providers is necessary to achieve desirable patient outcomes. These actions may improve information exchange throughout HSCM if implemented properly(Blome et al., 2014).

Process streamlining (PS). PS in HSCM can be improved by adopting value stream mapping and visualizing communication. The implementation of lean

methodology in healthcare, and using value stream mapping (VSM), can deliver value for customers (in this case, patients) by eliminating waste and providing value-added services at a reasonable cost. This will help organizations save, and make them sustainable in this sector. Also, VSM has been used as a lean SCM tool to reduce lead time and cost, and to enhance quality (Mostafa et al., 2013; Wee & Wu 2009).

In the healthcare supply chain, the breakdown of effective communication between the different departments/parties within the procurement process has led to dysfunctional. The lack of communication within the healthcare sector is one of the main barriers for lean implementation(Grove et al., 2010). Communication can be improved by exchanging information between the different departments/parties involved to improve purchase of the correct medical devices needed for daily operations, to minimize the cost of distribution, and to reduce time of delivery, while meeting doctors' and surgeons' needs(Al-Karaghouli et al., 2013).

The third lean enabler in HSCM is medical human resource (MHR). Medical staff related to the supply chain is considered important factors when adopting any new change initiatives. In other words, without the effective participation and support of staff, lean practices in the hospital supply chain are useless. The importance role of employees in adding value to the organization. Human resources in hospitals can be improved by concentrating on training supply chain employees, while adopting job rotating systems to increase the ability of the employees to perform more than one role can help employees overcome issues related to quality. Training HSCM employees is essential to implementing the lean initiative. Also, empowering HSC staff to take suitable actions and minimize centralization will improve decision making at the lowest level of supply chain employees. Empowerment of HSCM increases motivation and productivity(Womack & Jones 1996). The performance of lean supply chain management not only depends on decisions taken by executive managers, but also on the execution method and the involvement of hospital employees in the implementing process(Jasti & Kurra 2017). To implement lean successfully, the hospital need to engage medical and non-medical employees in the

implementation process through hire well trained, provide lean training courses; empower all employees in change process.

The fourth lean enabler that needs improvement is the customer relationship. Because patients often rely on the advice of *physicians,* patients can consider as end user while *physicians can considered as "surrogate consumer" and at the end both of them are considered to be consumers.* Many authors mentioned that consumer rather than customer especially in SCM context (Chopra & Meindl 2010; Omar et al., 2010; Al-Saa'da, Abu Taleb, Abdallat, et al., 2013). Chopra and Meindl (2010) mentioned that SCM "deals with the management processes of flows of goods, information and funds among supply chain partners in order to satisfy consumer needs in an efficient way".

Medical staff in other hospital departments, such as physicians, medical equipment engineers, or pharmacists, plays vital roles in making sure the hospital supply chain management is lean. Disagreement between physicians, in terms of a certain type of medicine, slows supply chain processes and increases delivery lead time. Physician Preference Items (PPIs) constitute 40% of total medical supply spending for a hospital (Toba et al., 2008) and this can be improved by physicians' buy-in. This is a main area for SC savings, especially with respect to the use of high-cost clinical items and changes in purchases. Physicians' involvement in continuous improvement is very important to implementing lean successfully via the supply chain. The role of consumers as value co-creators in hospital supply chains. Also, this enabler can be improved by increasing medical staff such as physicians' involvement. It was clear from field study that medical staff not get involved in any HSCM activities.

The fifth lean enabler that needs improvement is supplier relationship. Hospital-supplier integration plays an important role in improving hospital supply chain performance. Hospital-supplier collaboration has an impact on hospital supply chain performance (Chen et al., 2013). Enhancing and creating long-term relationships with key suppliers contributes significantly to reducing fluctuation in demand and minimizing medicine shortage. Medical purchases are the key purchases for any healthcare provider, as medical supplies can often constitute

more than 40% of a hospital's operating cost. This cost can be improved through SC practices (Nabelsi & Gagnon 2017).

Alliance with other healthcare providers is one of the most important factors to reducing the total cost of medical supplies. Group purchasing organizations (GPOs) have provided significant cost saving opportunities for healthcare providers by taking advantage of economies of scale and purchasing from select suppliers/venders for many hospitals at once. GPOs reduce hospital supply chain costs up to 15%. Hospital supply chain costs decreased for providers using GPOs, but group purchasing also helped to optimize the supply chain. Kwon et al., (2016) indicate that GPOs manage more than 70% of healthcare expenditures.

One of the main reasons GPOs are advantageous is that they have a global network of suppliers, which gives healthcare organizations the leverage to access more suppliers. Also cooperation between healthcare organizations play vital role in reducing the overall cost of healthcare provider. Recent developments demonstrate the extent to which SC is gaining the attention of hospital leaders. GPOs have provided significant cost saving chances for healthcare providers by taking advantage of economic scale in purchasing from select suppliers / venders for several hospitals at once(Toba et al., 2008). Using GPOs help hospitals in provides cost savings and streamlines purchasing process.

Most departments turn to a GPO to find main suppliers and negotiate contracts; others use the stockless approach, calling on medical supply distributors to deliver medical products directly to nursing stations. The responsiveness of suppliers is a sensitive point for hospitals, as any delay of medical supplies constitutes a possible threat to patients' lives. Lead-times of medical supplies and unpredictable patient demand are key points that should be dealt with seriously. Also, working with other healthcare systems which is not working under Saudi Ministry of Health such as health services at Ministry of Defence and health services at Ministry of Interior. Integration between these different healthcare systems will lead to save a huge amount of money. Since Saudi Arabia (SA) apart from GCC, hospital in SA can benefit from GPO concept to reduce the

medical items cost and absolutely adopting this approach will lead to reduce significant amount of cost.

Medical shortages (MS) are another factor which is very important for healthcare providers. Medicine and equipment shortages have been increasing in recent years (Hedman, 2016). MS put patient health at risk, and possible medication errors, non-treatment and under-treatment can result from attempts to substitute missing medicines. Shortages of medicines and technologies can be avoided by improving coordination between countries, while an end-to-end approach across the healthcare system is needed to mitigate the impact on patients and public health. Global healthcare leaders will be required to move forward on priority problems/issues for improving access to needed medicines in healthcare systems and will need to develop an approach to market shaping in collaboration with global partners. In addition, work with partners such as global industry representatives and professional associations to develop good standards practices in managing shortages. Moreover, information technology systems that facilitate the collection of information need additional support(Hedman, 2016).

6.4.4.6 Activity 6: implementing improvement proposal

During the monitoring of the actual achievement, the hospital will be able to identify influencing factors that may impact the implementation process and take actions if necessary for any unexpected situation. Without a monitoring process on lean implementation, the lean implementation may fail. At the end of this stage, the implementation process either goes back to the first stage if the level of lean has not be achieved or remains on the desired level by monitoring the process. After accomplishing four phases, the healthcare organization can implement lean successfully.

6.5 Chapter Summary

In this chapter, a framework for implementing lean principles in healthcare supply chain management was developed. Introduction about the significance of developing lean framework in HSCM was presented. Then, review and evaluation the state-of-the-art literature was conducted. After that, methodology for development of HSCM Framework was illustrated based on prior studies and

industrial practices collected from three hospitals. Next, there are three hospitals were participated in this study and all of them from Saudi Arabia. Due to confidentiality and privacy, hospitals was called hospital (X), (Y) and (Z). Then, lean HSCM framework implementation was structured in four phases:

- Phase One: Preparation state
- Phase Two: Assessment of the current state in terms of lean
- Phase Three: Developing the desired future state in terms of lean
- Phase Four: Steady (sustainable) state of new actions taken

7 Chapter seven: validation of the framework

7.1 Introduction

The aim of this chapter is to validate the main results of this study. The main sections of this chapter illustrated below in Figure 7.1. This chapter addresses the sixth research objective which is validate the research outcomes via case studies and evaluated through experts' judgement.

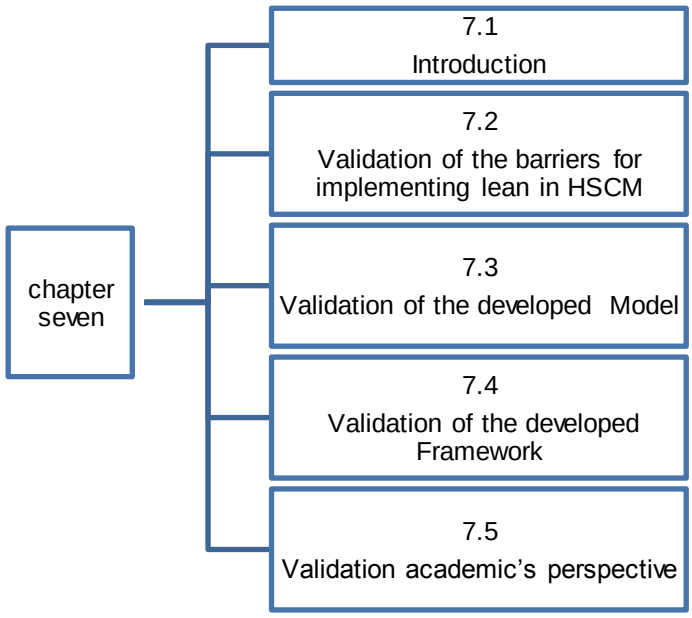


Figure 7.1 main sections of chapter seven

7.2 Validation of the barriers for implementing lean in HSCM

Rating system will enable participants to identify the relative importance of the main barriers that hinder lean implementation. Also, the participants were asked to validate the lean implementation barriers by asking the questions shown in Table 7.1. Table 7.2 shows proposed solutions. Additionally, respondents were asked to indicate to what extent the listed barriers represent the real obstacles for implementing lean and to what extent proposed solutions help healthcare organization in overcome of lean challenges.

Table 7.1 Question was asked Experts for prioritization Process for validation purpose

Question
To what extent do you believe that lean barriers represent the real obstacles for implementing lean? *To what extent the proposed solutions significantly and effectively contribute to overcome lean implementation barriers in HSCM?* **Where:** ***(1 = least Important, 2 = less Important, 3 = Important, 4 = Very Important, 5 = Extremely Important)*** ***(1 = least effective, 2 = less effective, 3 = effective, 4 = Very effective, 5 = Extremely effective)***

- Existence of physicians' preferences, $\mathbf{B_1}$
- Unpredictable patient demand, $\mathbf{B_2}$
- Inadequate knowledge and Lack of understanding lean concept, $\mathbf{B_3}$
- Identify waste in HSCM processes (delivering value to the patient), $\mathbf{B_4}$
- Hospital culture and resistance to change, $\mathbf{B_5}$
- Lack of hospital support, commitment and disbelief in Lean, $\mathbf{B_6}$
- Scarcity of qualified human resources and lack of training, $\mathbf{B_7}$
- Assessment of the required level of leanness, $\mathbf{B_8}$
- Lack of effective communication and information sharing, $\mathbf{B_9}$

Table 7.2 proposed solutions

No		Suggested Solutions to overcome Barrier
S_1	S_{11}	Physicians buy-in.
	S_{12}	Creating "standards and sourcing committee"
S_2	S_{21}	Using information technology such as radio-frequency-identification (RFID)
	S_{22}	Clear policies, procedures and practices should be implemented by hospitals
S_3	S_{31}	Presenting a real-life scenario of lean success in another hospital.
	S_{32}	Well-trained HSCM managers to understand the knowledge for implementing lean
	S_{33}	Using benchmark approach
S_4	S_{41}	Applying value stream mapping and 5S
	S_{42}	well-trained HSCM staff for implementing lean tools
S_5	S_{51}	building a lean dashboard at workplace facilitates both operators and managers to track the ongoing processes, reduce non value adding activities
	S_{52}	pay attention toward bottlenecks
	S_{53}	Linking lean objectives with hospital strategic plan.
	S_{54}	leveraging previous lean implementation experience

S_6	S_{61}	Sharing information about lean,
	S_{62}	effective communication
	S_{63}	lean project success initiative stories
	S_{64}	Attending awareness sessions such as lean six sigma yellow belt
	S_{65}	Applying effective rewarding and recognition system (incentive)
S_7	S_{71}	investment in staff training
S_8	S_{81}	implementing leanness maturity assessment model
S_9	S_{91}	share information, work closely, and go against "silo working"
	S_{92}	documenting all information and making it available on intranet (internal network).
	S_{93}	Establishing effective and clear channels for communication at all healthcare SCM levels

Table 7.3 importance of barriers and effectiveness proposed solutions

Expert, E_i	Barriers, B_i (importance)									Solutions, S_i for Barriers, B_i (effectiveness)								
Hospital,H_i	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9
H_XE_1	3	3	3	4	4	5	5	4	5	4	4	5	5	4	5	5	3	3
H_XE_2	2	2	4	4	4	5	5	4	3	5	3	5	5	4	3	4	5	5
H_XE_3	3	3	4	4	5	4	5	5	4	5	4	4	5	5	5	4	5	5
H_XE_4	2	2	3	3	5	4	5	4	4	4	5	5	5	5	5	4	4	5
H_XE_5	2	3	4	4	4	5	4	4	5	5	4	5	4	5	4	5	5	4
H_YE_6	3	4	3	5	4	5	5	4	4	4	4	5	4	5	4	5	4	5
H_YE_7	3	2	5	3	3	4	5	5	5	4	5	4	5	5	4	5	4	5
H_YE_8	3	3	3	4	4	5	5	5	4	5	4	5	5	4	5	5	5	4
H_YE_9	2	2	4	4	5	5	5	4	5	5	4	4	5	5	5	5	5	5
H_YE_{10}	3	3	3	5	4	5	5	5	4	5	4	5	5	4	3	4	5	5
H_ZE_{11}	3	2	4	4	4	4	4	4	5	4	4	4	5	5	4	5	4	5
H_ZE_{12}	4	3	3	5	5	5	5	5	5	5	4	5	5	5	5	4	5	4
H_ZE_{13}	3	4	3	4	3	4	5	4	4	4	5	4	5	5	4	5	5	4
H_ZE_{14}	3	3	4	5	4	5	4	4	5	4	5	5	5	5	4	5	4	5
H_ZE_{15}	4	2	3	4	3	5	5	5	5	5	5	5	4	4	5	5	4	5
Total	43	41	53	62	61	70	72	66	67	68	64	70	72	70	65	70	67	69
Average	2.87	2.73	3.53	4.13	4.07	4.67	4.80	4.40	4.47	4.53	4.27	4.67	4.80	4.67	4.33	4.67	4.47	4.60

E_i = Experts participated; B_i = Barrier importance; S_i = Solution effectiveness; $H_{X,Y,Z}$ = particpated hospiatls

It is clear from Table 7.3 that the most important barrier faces healthcare organizations when they attempt to deploy lean initiative in their supply chain is Scarcity of qualified human resources and lack of training with priority (importance) of 4.80. Most participants agreed that absence of well-trained employees constitute the most challenge to start lean journey. Some respondents mentioned that without qualified people, it is impossible to start lean project.

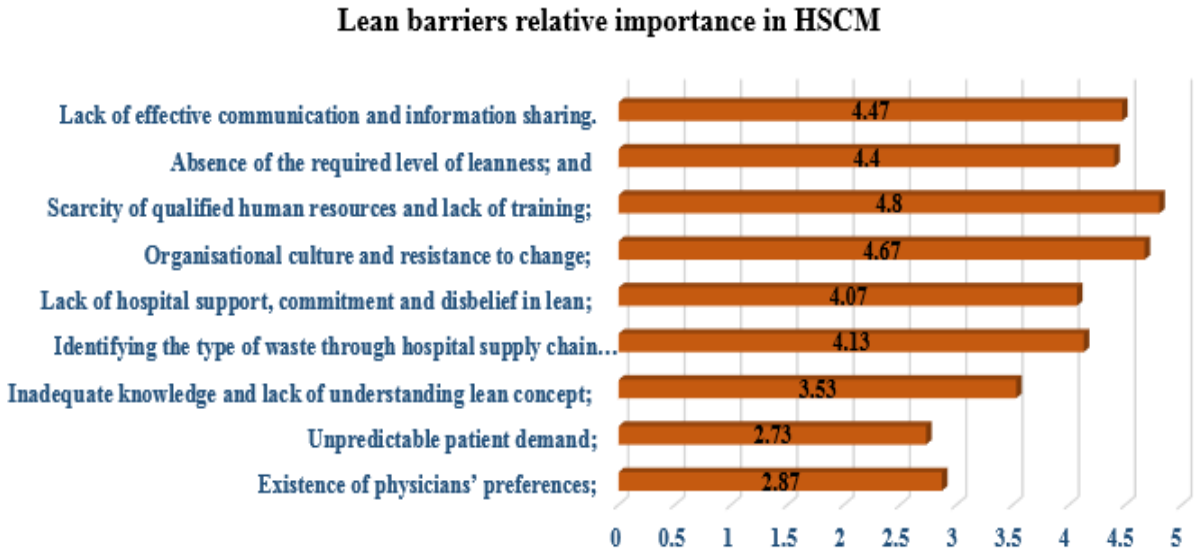


Figure 7.2 Relative importance for lean barriers in HSCM

This followed by Organizational culture and resistance to change, Lack of effective communication and information sharing, assessment of the required level of leanness and Identify type of waste through HSCM processes (delivering value to the patient) with relative prioritise of 4.67, 4.47, 4.40 and 4.13 respectively. Figure 7.2 represents relative prioritise (importance) of lean barriers in HSCM. Based on interviewees, the proposed solutions can contribute effectively to overcome the barriers. For example, to overcome Scarcity of qualified human resources and lack of training challenge, the suggested solutions can overcome this barriers with 96%. Figure 7.3 show to what extent proposed solutions can effectively overcome barriers when lean implementing in SCM.

7.3 Validation of the developed model

After calculating the leanness index in SCM and identifying opportunities for further improvement for all of the hospitals, the work was validated in different ways.

7.3.1 Validation by using multi-grade fuzzy logic

The validation of the developed model was conducted at three large Saudi hospitals, as mentioned previously. For confidentiality reasons, the hospitals will

be called hospital (X), hospital (Y) and hospital (Z). After gathering all the required data from the respondents of the hospitals, the assessment of leanness in SCM processes in each hospital was started.

7.3.1.1 HSCM leanness assessment of hospital (X)

There are four steps which were followed for assessing leanness in the hospitals, as seen below:

Step (1) Calculating the weight (relative importance) for each enabler, criterion, and attribute.

Step (2) Calculating the index belonging to each criterion.

Step (3) Calculating the indices belonging to each enabler.

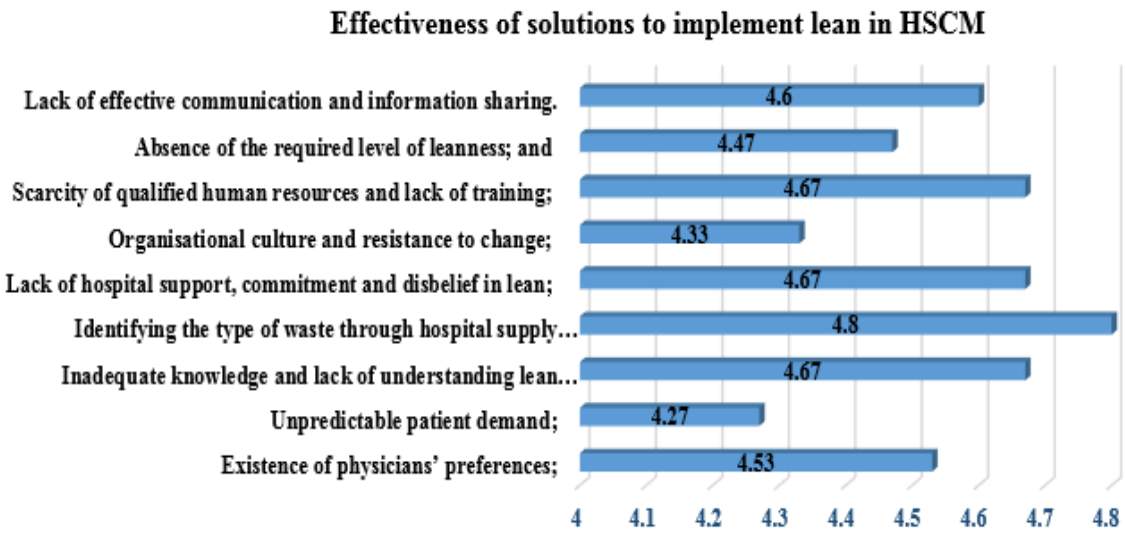


Figure 7.3 effectiveness of proposed solutions

Step (4) Calculating HSCM leanness Index for hospital (X).

Due to the small sample size, the mean was not used, and instead the median was used in computing the weight in order to avoid the impact of the outliers and sensitivity to extreme points related to the mean. The **median formula** is {(n + 1) ÷ 2}, where "n" is the number of items in the set. By computing the median for each enabler, the weight (relative importance) of each enabler was calculated. For instance, the weights given by the experts for the medical management responsibility leanness enabler were: 20%, 30%, 30%, 20% and 30%.

By using the median, the weight (relative importance) for medical management responsibility leanness was determined to be 30%. By adopting the same procedures, the weight (relative importance) for the remaining enablers was calculated for all the experts from hospital (X), as shown in Figure 7.4

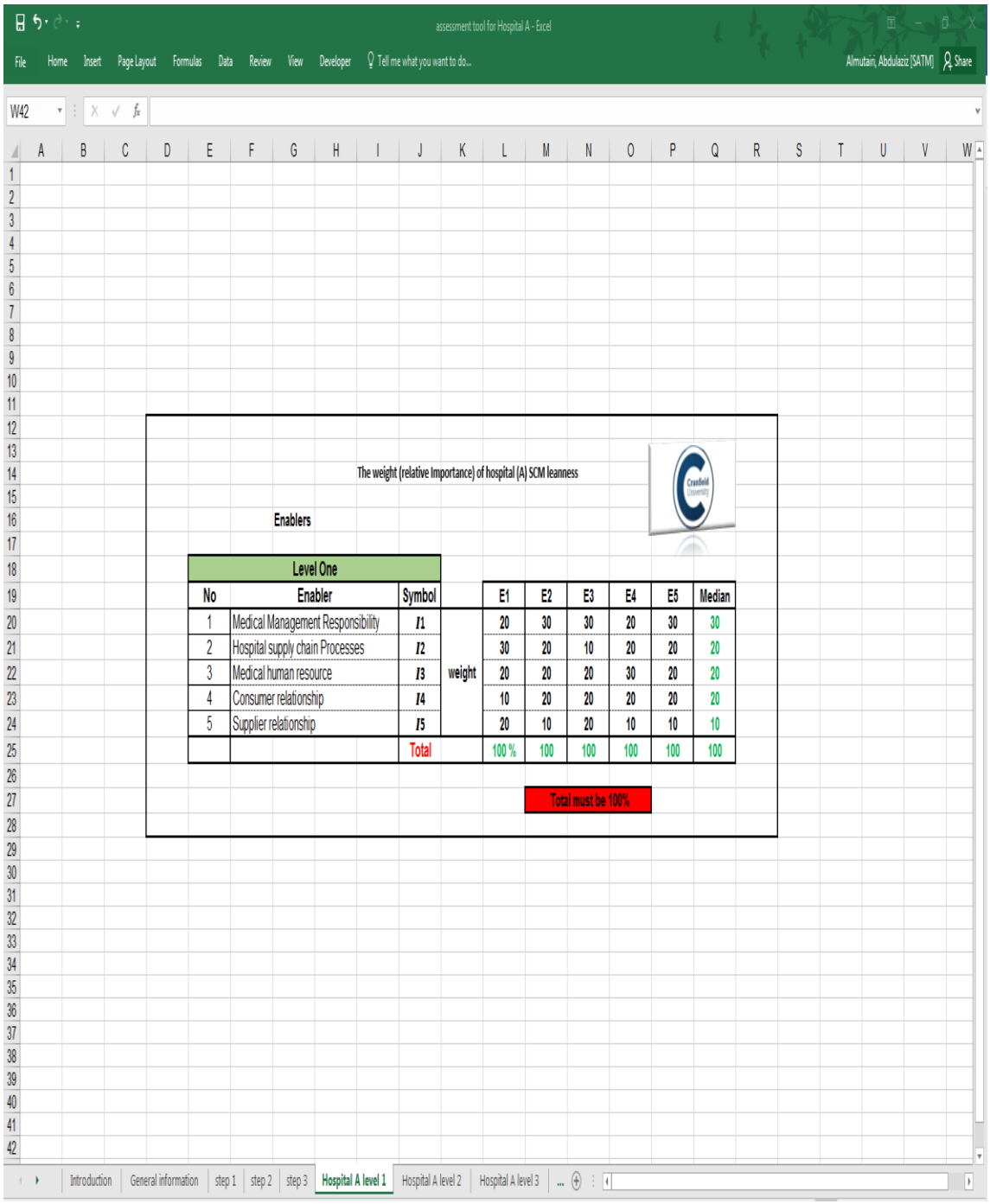
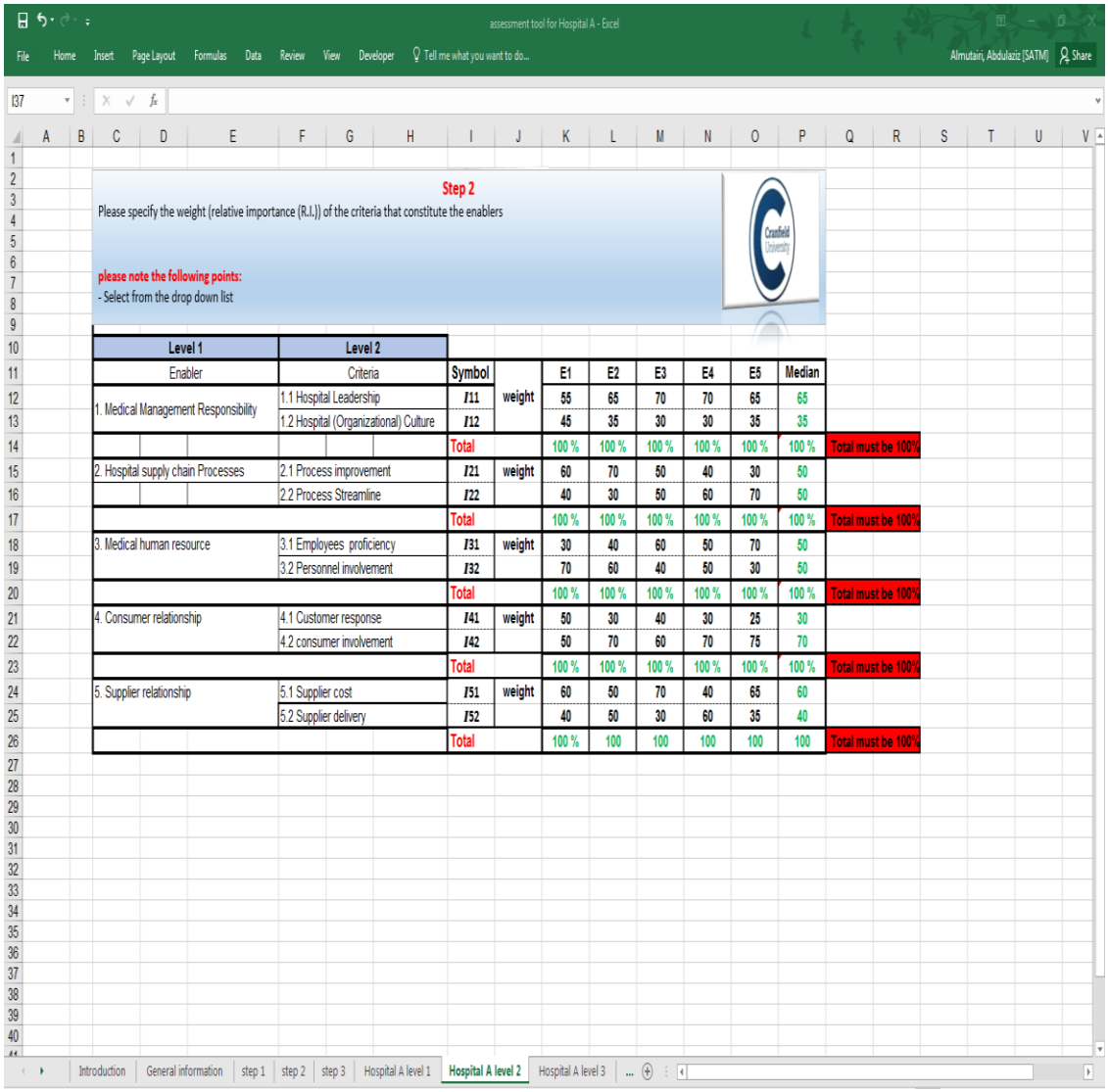


Figure 7.4 Screenshot of Excel sheet for assessing weight for each enabler



Step 2

Please specify the weight (relative importance (R.I.)) of the criteria that constitute the enablers

please note the following points:

- Select from the drop down list

Level 1	Level 2	Symbol		E1	E2	E3	E4	E5	Median	
Enabler	Criteria									
1. Medical Management Responsibility	1.1 Hospital Leadership	I11	weight	55	65	70	70	65	65	
	1.2 Hospital (Organizational) Culture	I12		45	35	30	30	35	35	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
2. Hospital supply chain Processes	2.1 Process improvement	I21	weight	60	70	50	40	30	50	
	2.2 Process Streamline	I22		40	30	50	60	70	50	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
3. Medical human resource	3.1 Employees proficiency	I31	weight	30	40	60	50	70	50	
	3.2 Personnel involvement	I32		70	60	40	50	30	50	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
4. Consumer relationship	4.1 Customer response	I41	weight	50	30	40	30	25	30	
	4.2 consumer involvement	I42		50	70	60	70	75	70	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
5. Supplier relationship	5.1 Supplier cost	I51	weight	60	50	70	40	65	60	
	5.2 Supplier delivery	I52		40	50	30	60	35	40	
		Total		100 %	100	100	100	100	100	Total must be 100%

Figure 7.5 Screenshot of Excel sheet for assessing weight for each criterion

The second step in the assessment is computing the weight (relative importance) for each criterion by also calculating the median. For instance, the weights given by the experts for the hospital leadership criterion were: 55%, 65%, 70%, 70% and 65%, as illustrated in Figure 7.5. Therefore, the weight of the hospital leadership criterion was computed to be 65% using the median**.** By employing the same approach it was possible to calculate the rest of the data for all experts. Using the same procedures, the third step in the assessment is computing the weight (relative importance) for each attribute by calculating the median and, finally, the experts provided assessment scores for each attribute. Figure 7.6 and Figure 7.7 show this process respectively. After organising the data, as shown in Table 7.4 the calculation was started.

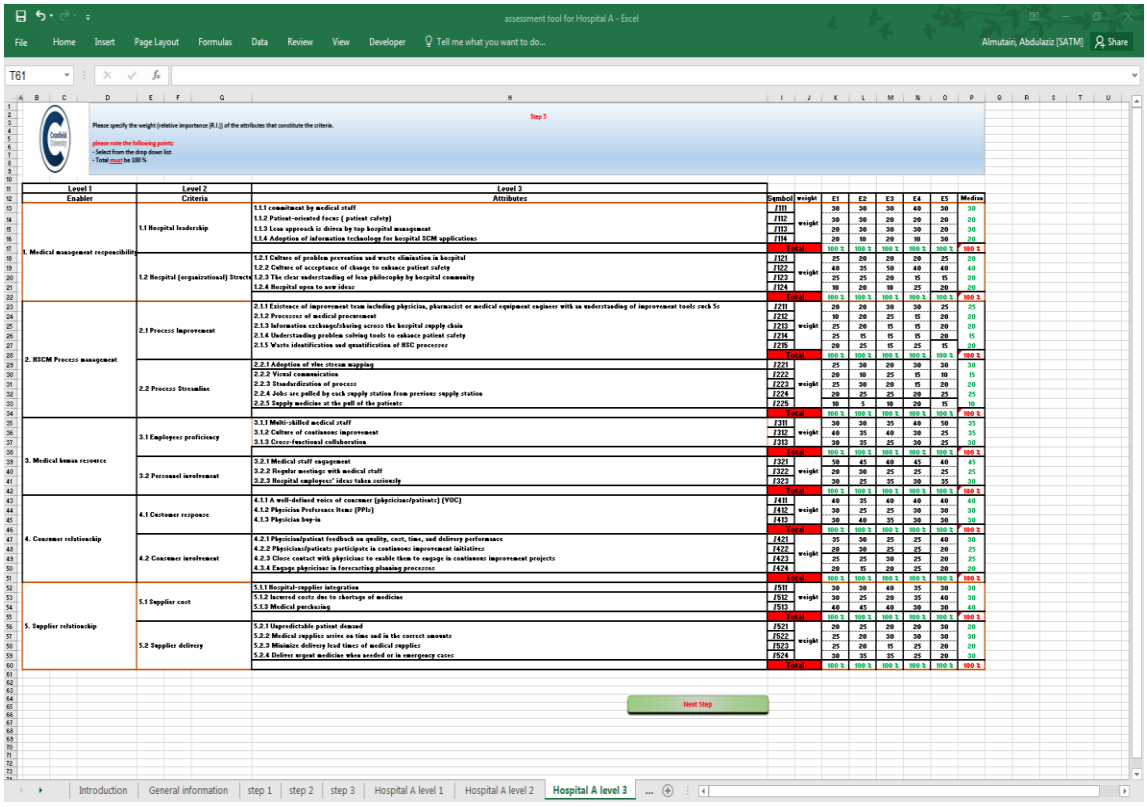


Figure 7.6 Screenshot of Excel sheet for assessing scores

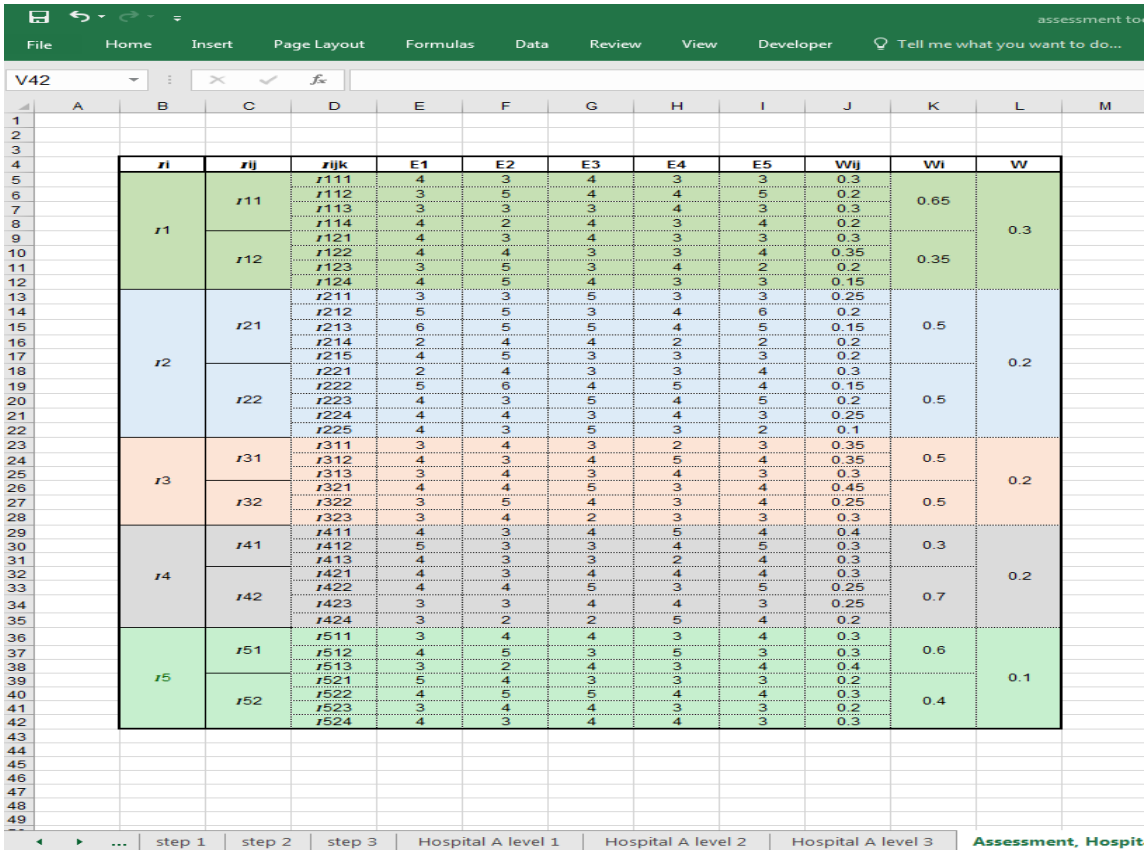


Figure 7.7 Screenshot of Excel sheet for assessing weight for attributes

Table 7.4 Assessment scores and weights for hospital (X)

Hospital (X)										
I_i	I_{ij}	I_{ijk}	E_1	E_2	E_3	E_4	E_5	W_{ij}	W_i	W
I_1	I_{11}	I_{111}	4	3	4	3	3	0.3	0.65	0.30
		I_{112}	3	5	4	4	5	0.2		
		I_{113}	3	3	3	4	3	0.3		
		I_{114}	4	2	4	3	4	0.2		
	I_{12}	I_{121}	4	3	5	3	3	0.3	0.35	
		I_{122}	5	5	3	4	6	0.35		
		I_{123}	6	4	5	4	5	0.2		
		I_{124}	2	4	5	3	4	0.15		
I_2	I_{21}	I_{211}	4	5	3	3	3	0.25	0.50	0.20
		I_{212}	5	5	3	4	6	0.2		
		I_{213}	6	5	5	4	5	0.15		
		I_{214}	2	4	4	2	2	0.2		
		I_{215}	4	5	3	3	3	0.2		
	I_{22}	I_{221}	2	4	3	3	4	0.3	0.50	
		I_{222}	5	6	4	5	4	0.15		
		I_{223}	4	3	5	4	5	0.2		
		I_{224}	4	4	3	4	3	0.25		
		I_{225}	4	3	5	3	2	0.1		
I_3	I_{31}	I_{311}	3	4	3	2	3	0.35	0.50	0.20
		I_{312}	4	3	4	5	4	0.35		
		I_{313}	3	4	3	4	3	0.3		
	I_{32}	I_{321}	4	4	5	3	4	0.45	0.50	
		I_{322}	3	5	4	3	4	0.25		
		I_{323}	3	4	2	3	3	0.3		
I_4	I_{41}	I_{411}	4	3	4	5	4	0.4	0.30	0.20
		I_{412}	5	3	3	4	5	0.3		
		I_{413}	4	3	3	2	4	0.3		
	I_{42}	I_{421}	4	3	4	4	4	0.3	0.70	
		I_{422}	4	4	5	3	5	0.25		
		I_{423}	3	3	4	4	3	0.25		
		I_{424}	3	2	2	5	4	0.2		
I_5	I_{51}	I_{511}	3	4	4	3	4	0.3	0.60	0.10
		I_{512}	4	5	3	5	3	0.3		
		I_{513}	3	2	4	3	4	0.4		
	I_{52}	I_{521}	5	4	3	3	3	0.2	0.40	
		I_{522}	4	5	5	4	4	0.3		
		I_{523}	3	4	4	3	3	0.2		
		I_{524}	4	3	4	4	3	0.3		

Legend:

I_i = Enabler index;

I_{ij} = Criterion index;

I_{ijk} = Attribute index;

E_i = Experts participated in the assessment;

W_{ij} = Attribute weight;

W_i = Criterion weight;

W = Enabler weight

The computation pertaining to 'hospital leadership' criterion is illustrated as follows:

Weights pertaining to the hospital leadership criterion W_{11} = (0.3, 0.2, 0.3, and 0.2) and the assessment scores for the same criterion are given by the following matrix by using the formula below:

$$I_{ij} = R_{ij} \times W_{ij}$$

$$\mathbf{R_{11}} = \begin{bmatrix} 4 & 3 & 4 & 3 & 3 \\ 3 & 5 & 4 & 4 & 5 \\ 3 & 3 & 3 & 4 & 3 \\ 3 & 2 & 4 & 3 & 4 \end{bmatrix} \times [\mathbf{0.3} \quad \mathbf{0.2} \quad \mathbf{0.3} \quad \mathbf{0.2}]$$

$$\boldsymbol{I_{11}} = [\mathbf{3.5} \quad \mathbf{3.2} \quad \mathbf{3.7} \quad \mathbf{3.5} \quad \mathbf{3.6}]$$

Using the same principle, the following indices relating to the reset lean criterion were calculated, as illustrated in Table 7.5

Table 7.5 Indices of the Criteria

Symbol	E_1	E_2	E_3	E_4	E_5	$E_{Average}$
I_{11}	3.50	3.20	3.70	3.50	3.60	3.48
I_{12}	4.45	4.30	4.00	3.15	3.70	3.98
I_{21}	4.10	4.15	4.20	3.35	4.10	3.50
I_{22}	3.55	4.00	3.75	3.75	3.75	3.76
I_{31}	3.35	3.65	3.35	3.65	3.35	3.50
I_{32}	3.45	4.25	3.85	3.00	3.70	3.64
I_{41}	4.30	3.00	3.40	3.80	4.30	3.63
I_{42}	3.55	3.05	3.85	3.95	4.00	3.60
I_{51}	3.30	3.50	3.70	3.60	3.70	3.53
I_{52}	4.00	4.00	4.10	3.60	3.30	3.93

After computing Indices of the Criteria, the index for enablers was calculated by using the following formula: $I_i = R_i \times W_i$

For example, the computation for medical management responsibility was made using the formula $\boldsymbol{I_1} = \boldsymbol{R_1} \times \boldsymbol{W_1}$ and followed the steps set out below:

Medical management responsibility,

$$\boldsymbol{I_1} = \begin{bmatrix} 3.5 & 3.2 & 3.7 & 3.5 & 3.6 \\ 3.8 & 4.2 & 3.4 & 3.2 & 3.2 \end{bmatrix} \times (0.65,\ 0.35)$$

$\boldsymbol{I_1} = (3.83,\ 3.59,\ 3.81,\ 3.38,\ 3.64)$

Using the same principle, the following indices relating to the reset lean enablers were calculated, as illustrated in Table 7.6.

Table 7.6 Indices of the enablers

Hospital (X)						
	E_1	E_2	E_3	E_4	E_5	$E_{Average}$
I_1	**3.83**	**3.59**	**3.81**	**3.38**	**3.64**	**3.65**
I_2	**3.83**	**4.08**	**3.98**	**3.55**	**3.93**	**3.87**
I_3	**3.40**	**3.95**	**3.60**	**3.33**	**3.53**	**3.56**
I_4	**3.78**	**3.04**	**3.72**	**3.91**	**4.09**	**3.70**
I_5	**3.58**	**3.70**	**3.86**	**3.60**	**3.54**	**3.66**

The last step was to calculate the overall value of the leanness index in HSCM in hospital (X) by using the following formula: $I = R \times W$

$$\boldsymbol{I} = \begin{bmatrix} 3.83 & 3.59 & 3.81 & 3.38 & 3.64 \\ 3.83 & 4.08 & 3.98 & 3.55 & 3.93 \\ 3.40 & 3.95 & 3.60 & 3.33 & 3.53 \\ 3.78 & 3.04 & 3.72 & 3.91 & 4.09 \\ 3.58 & 3.70 & 3.86 & 3.60 & 3.54 \end{bmatrix} \times (0.3,\ 0.2,\ 0.2,\ 0.2,\ 0.1)$$

$\boldsymbol{I} = (3.71,\ 3.66,\ 3.79,\ 3.53,\ 3.75)$

$$\boldsymbol{I_{average}} = \frac{1}{5}(3.71 + 3.66 + 3.79 + 3.53 + 3.75)$$

$\boldsymbol{I_{average}}$ = **3.69** $\in$ (2.01 – 4)

Table 7.7 Enablers, weights and indices in hospital (X)

Enabler	Weight	Index
Medical Management Responsibility	**30%**	**3.71**
HSCM Processes Management	**20%**	**3.66**
Medical Human Resource	**20%**	**3.79**
Consumer Relationship	**20%**	**3.53**
Supplier Relationship	**10%**	**3.75**

The overall leanness index for HSCM processes at hospital (X) is approximately 3.7, which falls in the range of 2.01 – 4 on the scale of assessment. Table 7.7 shows weight and indices for enablers. The overall leanness index in the HSCM process at hospital (X) indicates that:

The HSCM does not implement lean practices in any supply chain processes

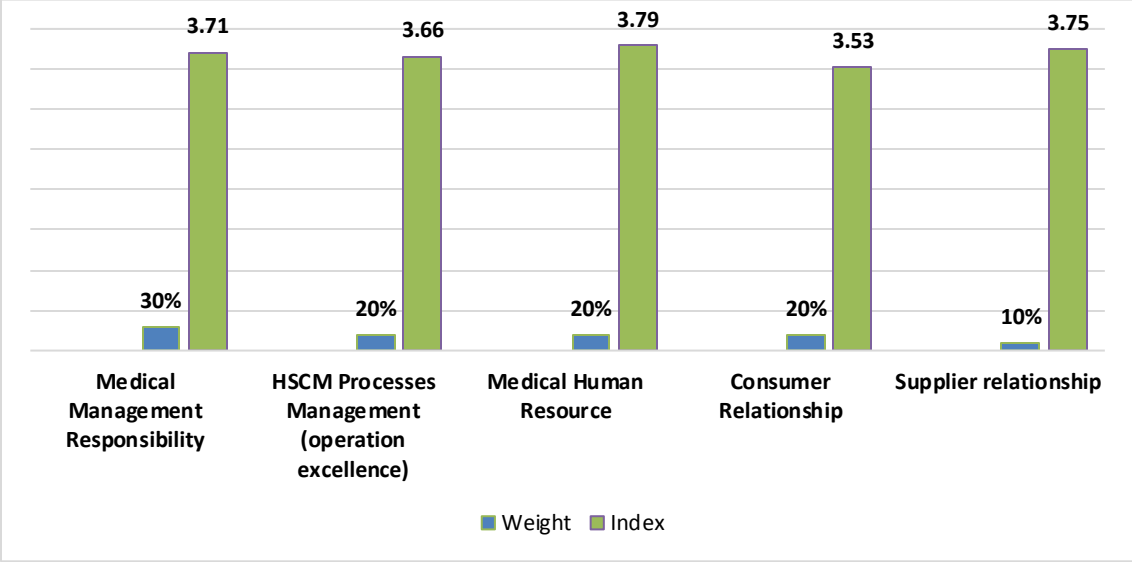


Figure 7.8 indices and weights for hospital (X) enablers

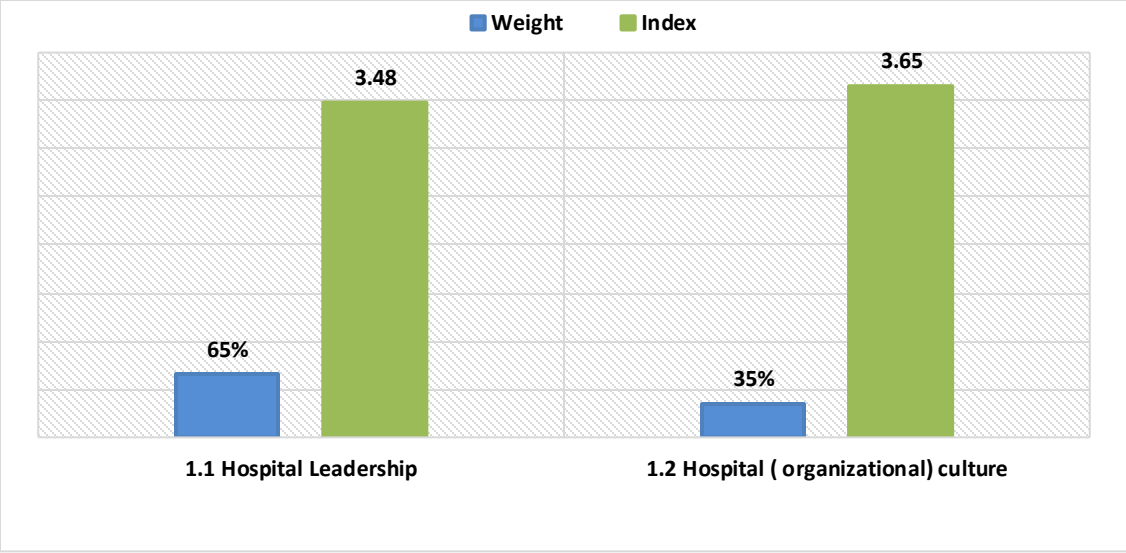


Figure 7.9 indices and weights for medical management responsibility in hospital (X) enablers

For hospital (X), it was noticed from Figure 7.8 that medical management responsibility is the most important enabler, with a weight of 30% and an index of 3.71, while the least important is supplier relationship, with a weight of 10% and an index of 3.75. The remaining enablers, namely HSCM process management, medical human resources and consumer relationship have the same importance, which is 20% with different indices. All the weights and indices computed for hospital (X) enablers and criteria are illustrated in Figures 7.9, 7.10, 7.11, 7.12 and 7.13 respectively.

More details for HSCM activities at hospital (X) will be elaborated on later in this chapter.

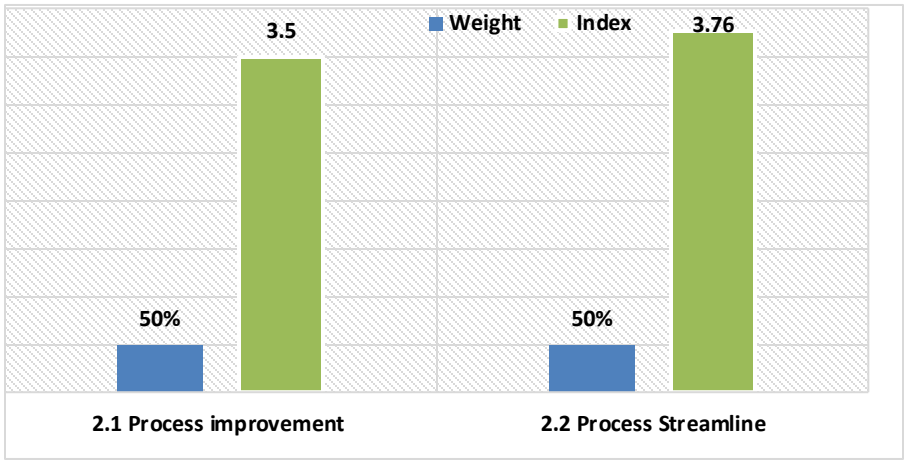


Figure 7.11 Indices and weights for HSCM process management in hospital (X)

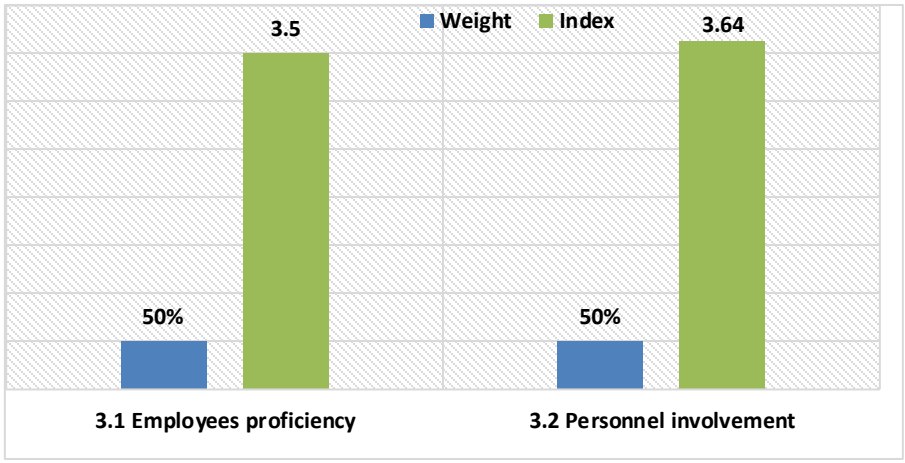


Figure 7.10 indices and weights for medical human resource in hospital (X)

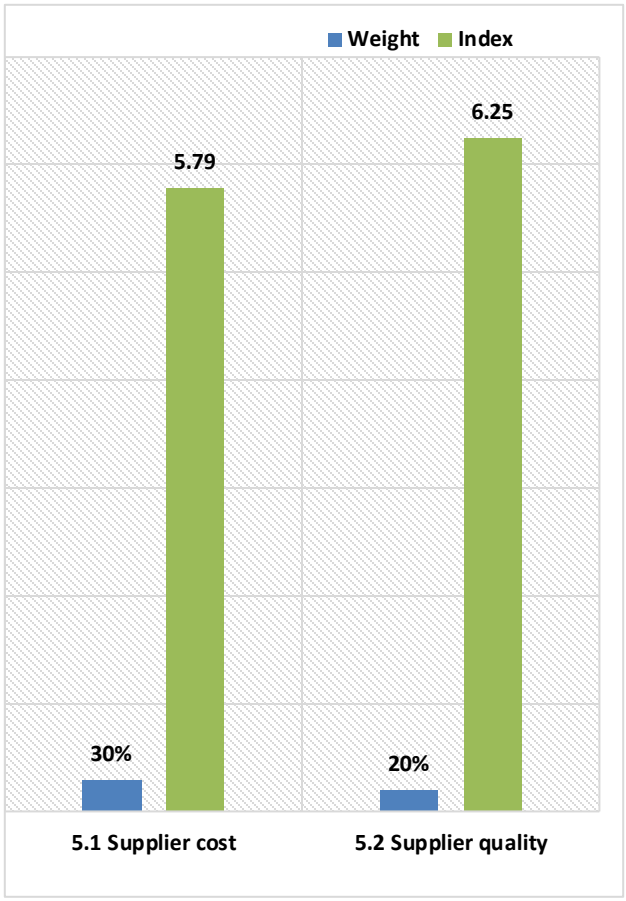


Figure 7.13 Indices and weights for supplier relationship in hospital (X)

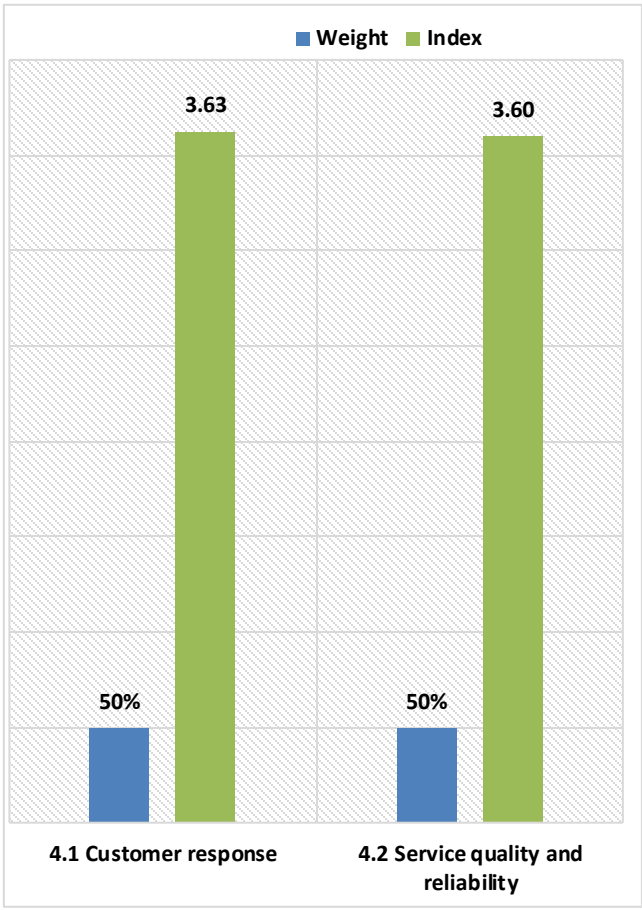


Figure 7.12 Indices and weights for consumer relationship in hospital (X)

7.3.1.2 HSCM leanness assessment of hospital (Y)

As mentioned previously, there are four steps which were followed for assessing leanness in the hospitals, as set out below:

Step (1) Calculating the weight (relative importance) for each enabler, criterion, and attribute.

Step (2) Calculating the index belonging to each criterion.

Step (3) Calculating the indices belonging to each enabler.

Step (4) Calculating the HSCM Leanness Index for hospital (Y)

By following the same steps mentioned in computing the HSCM leanness index for hospital (X) in the previous section, the median was calculated for each enabler. Following this, the weight for each enabler was also computed. For example, the relative importance (weights) for medical management responsibility were: 20%, 25%, 25%, 20% and 30%. By calculating the median, it was found that the weight for medical management responsibility was 25%, as illustrated in Figure 7.14. By using the same method, the weight for the remaining enablers was calculated for all the experts from hospital (Y).

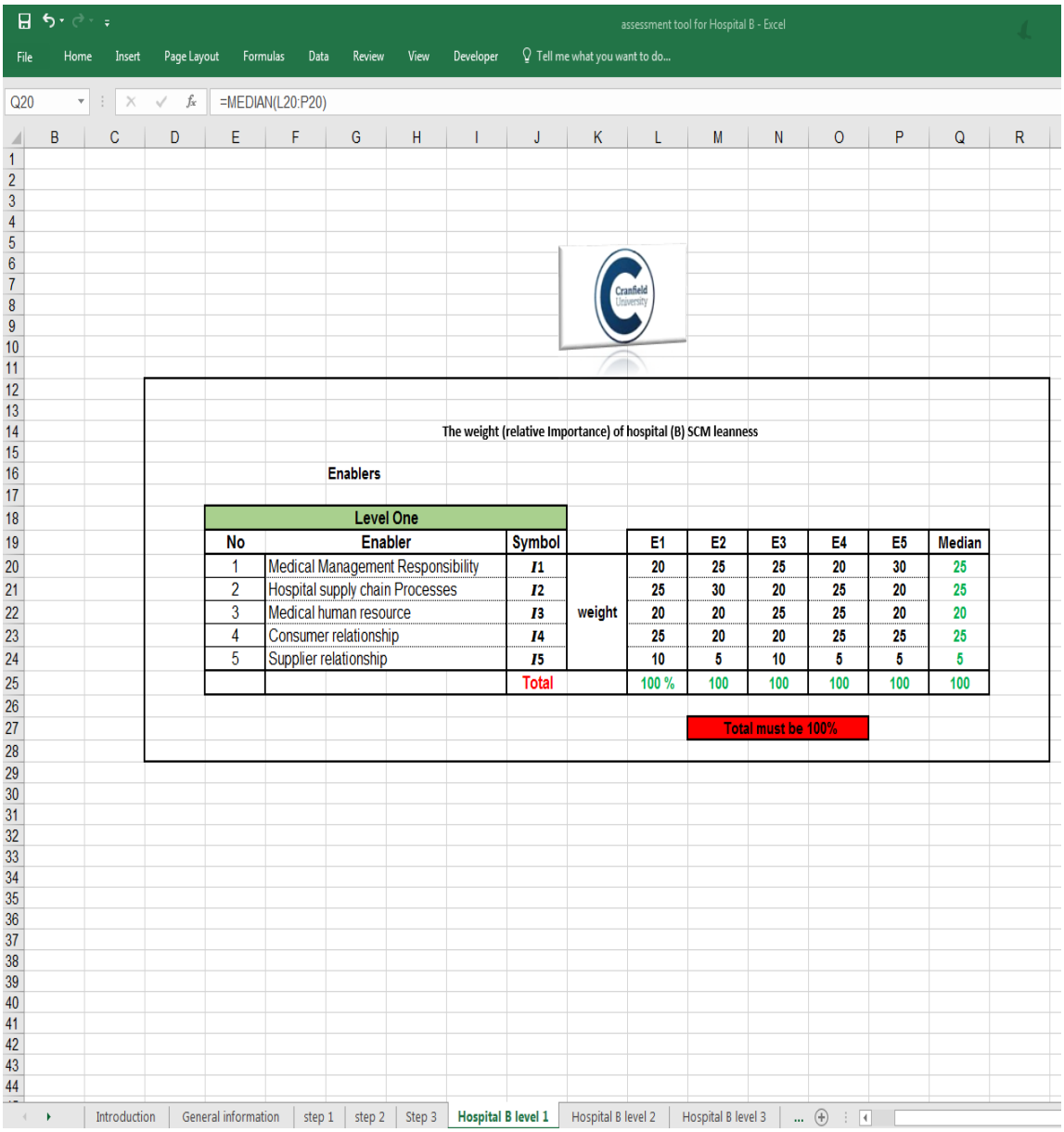
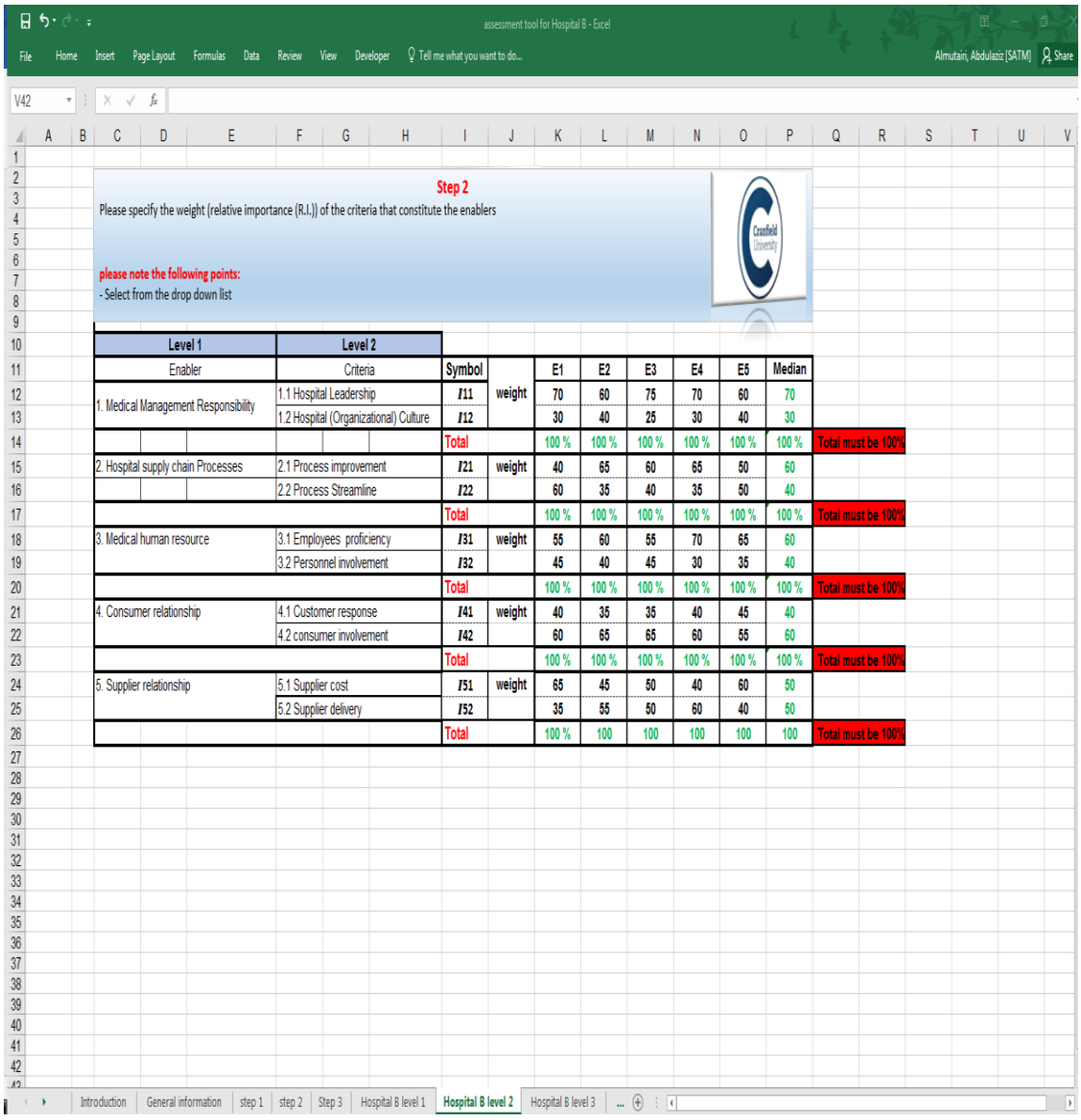


Figure 7.14 Screenshot of Excel sheet for assessing weight for each enablers

Following this, the second level of the assessment will appear, as shown in Figure 7.15, and the weight for each criterion is calculated. For example, the relative importance (weights) provided by hospital (Y) experts for the medical management responsibility criterion were: 70%, 60%, 75%, 70% and 60%. As mentioned previously, the relative importance of the medical management responsibility criterion was computed to be 70% using the median.

Figure 7.16 and Figure 7.17 illustrate all of the weights (relative importance) calculated for the enablers, criteria and attributes as well as all the assessment scores of each attribute given by experts from hospital (Y).



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V42

Step 2

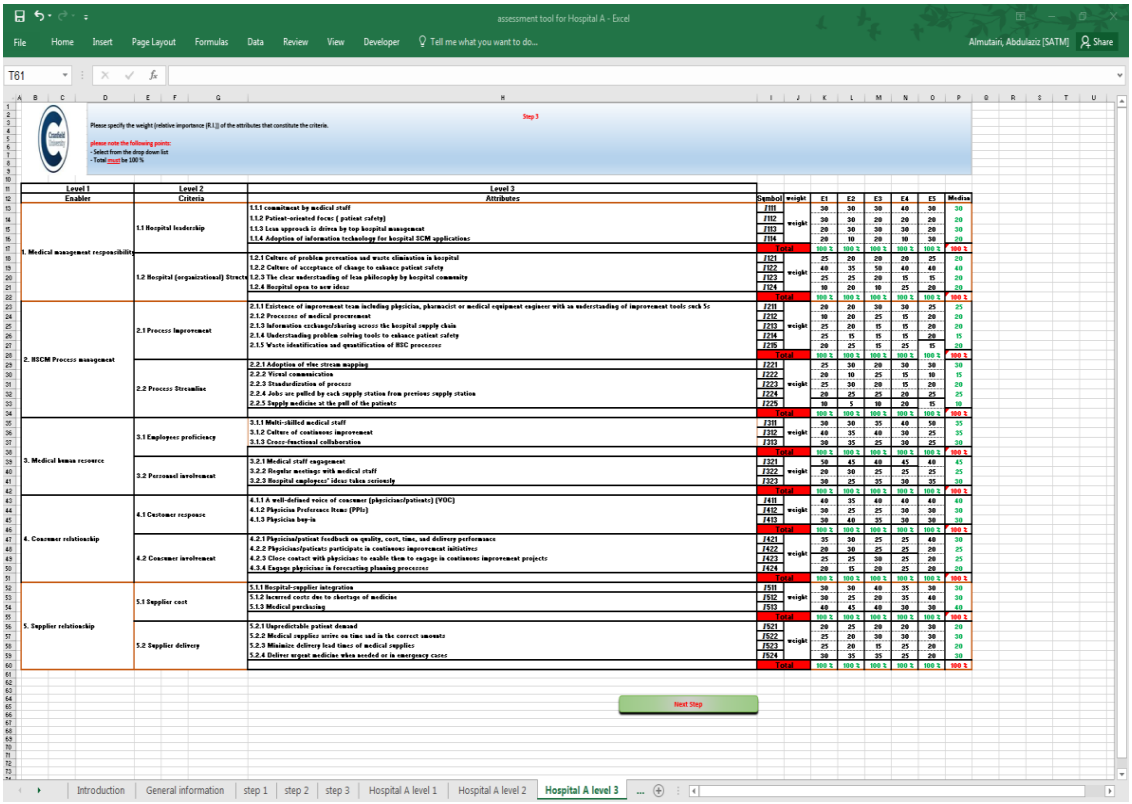
Please specify the weight (relative importance (R.I.)) of the criteria that constitute the enablers

please note the following points:
- Select from the drop down list

Level 1	Level 2										
Enabler	Criteria	Symbol		E1	E2	E3	E4	E5	Median	
1. Medical Management Responsibility	1.1 Hospital Leadership	I11	weight	70	60	75	70	60	70	
	1.2 Hospital (Organizational) Culture	I12		30	40	25	30	40	30	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
2. Hospital supply chain Processes	2.1 Process improvement	I21	weight	40	65	60	65	50	60	
	2.2 Process Streamline	I22		60	35	40	35	50	40	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
3. Medical human resource	3.1 Employees proficiency	I31	weight	55	60	55	70	65	60	
	3.2 Personnel involvement	I32		45	40	45	30	35	40	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
4. Consumer relationship	4.1 Customer response	I41	weight	40	35	35	40	45	40	
	4.2 consumer involvement	I42		60	65	65	60	55	60	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
5. Supplier relationship	5.1 Supplier cost	I51	weight	65	45	50	40	60	50	
	5.2 Supplier delivery	I52		35	55	50	60	40	50	
		Total		100 %	100	100	100	100	100	Total must be 100%

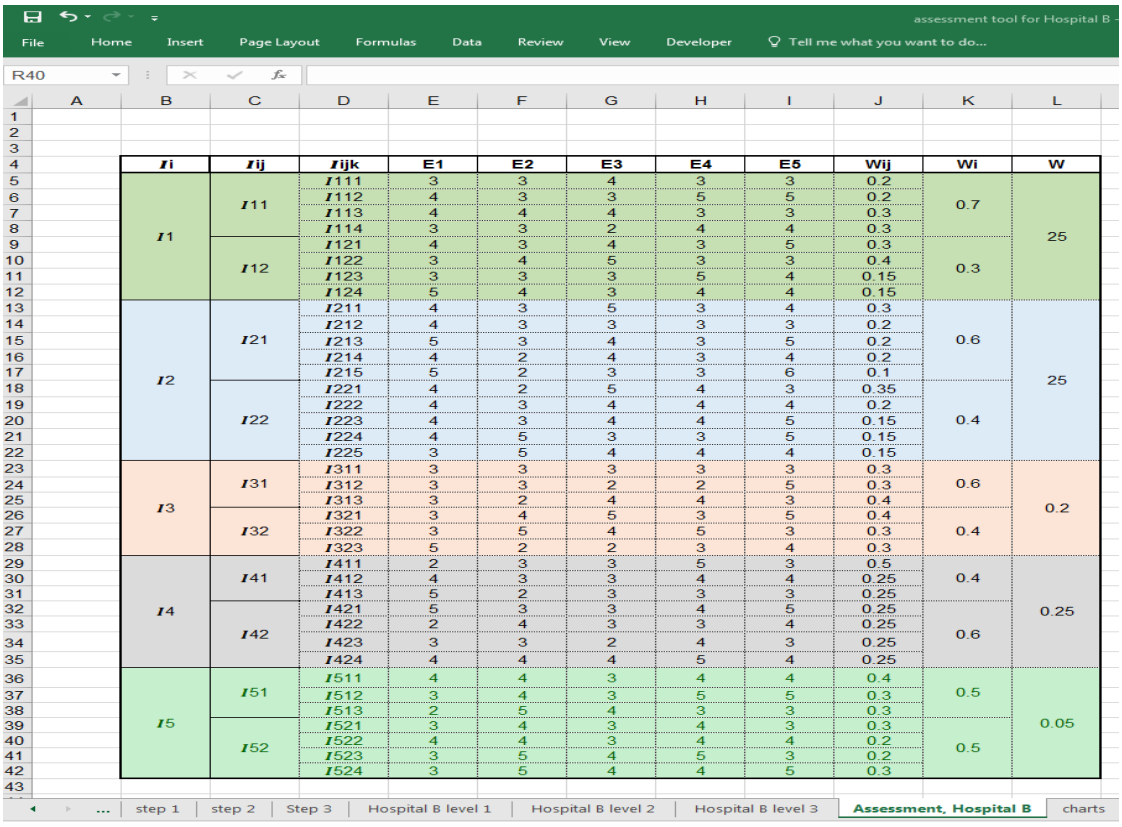
Introduction | General information | step 1 | step 2 | Step 3 | Hospital B level 1 | Hospital B level 2 | Hospital B level 3

Figure 7.15 Screenshot of Excel sheet for assessing weight for each criterion



Level 1 Enabler	Level 2 Criteria	Level 3 Attributes	Symbol	weight	E1	E2	E3	E4	E5	Median
1. Medical management responsibility	1.1 Hospital leadership	1.1.1 commitment by medical staff	I111	weight	30	30	30	40	30	30
		1.1.2 Patient-oriented focus (patient safety)	I112		30	30	20	20	20	20
		1.1.3 Lean approach is driven by top hospital management	I113		20	30	30	30	20	30
		1.1.4 Adoption of information technology for hospital SCM applications	I114		20	10	20	10	30	20
			Total		100 %	100 %	100 %	100 %	100 %	100 %
	1.2 Hospital (organizational) Structu	1.2.1 Culture of problem prevention and waste elimination in hospital	I121	weight	25	20	20	20	25	20
		1.2.2 Culture of acceptance of change to enhance patient safety	I122		40	35	50	40	40	40
		1.2.3 The clear understanding of lean philosophy by hospital community	I123		25	25	20	15	15	20
		1.2.4 Hospital open to new ideas	I124		10	20	10	25	20	20
			Total		100 %	100 %	100 %	100 %	100 %	100 %
2. HSCM Process management	2.1 Process Improvement	2.1.1 Existence of improvement team including physician, pharmacist or medical equipment engineer with an understanding of improvement tools such Six	I211	weight	20	20	30	30	25	25
		2.1.2 Processes of medical procurement	I212		10	20	25	15	20	20
		2.1.3 Information exchange/sharing across the hospital supply chain	I213		25	20	15	15	20	20
		2.1.4 Understanding problem solving tools to enhance patient safety	I214		25	15	15	15	20	15
		2.1.5 Waste identification and quantification of HSC processes	I215		20	25	15	25	15	20
			Total		100 %	100 %	100 %	100 %	100 %	100 %
	2.2 Process Streamline	2.2.1 Adoption of vlue stream mapping	I221	weight	25	30	20	30	30	30
		2.2.2 Visual communication	I222		20	10	25	15	10	15
		2.2.3 Standardization of process	I223		25	30	20	15	20	20
		2.2.4 Jobs are pulled by each supply station from previous supply station	I224		20	25	25	20	25	25
		2.2.5 Supply medicine at the pull of the patients	I225		10	5	10	20	15	10
			Total		100 %	100 %	100 %	100 %	100 %	100 %
3. Medical human resource	3.1 Employees proficiency	3.1.1 Multi-skilled medical staff	I311	weight	30	30	35	40	50	35
		3.1.2 Culture of continuous improvement	I312		40	35	40	30	25	35
		3.1.3 Cross-functional collaboration	I313		30	35	25	30	25	30
			Total		100 %	100 %	100 %	100 %	100 %	100 %
	3.2 Personnel involvement	3.2.1 Medical staff engagement	I321	weight	50	45	40	45	40	45
		3.2.2 Regular meetings with medical staff	I322		20	30	25	25	25	25
		3.2.3 Hospital employees' ideas taken seriously	I323		30	25	35	30	35	30
			Total		100 %	100 %	100 %	100 %	100 %	100 %
4. Customer relationship	4.1 Customer response	4.1.1 A well-defined voice of customer (physicians/patients) (VOC)	I411	weight	40	35	40	40	40	40
		4.1.2 Physician Preference Items (PPIs)	I412		30	25	25	30	30	30
		4.1.3 Physician buy-in	I413		30	40	35	30	30	30
			Total		100 %	100 %	100 %	100 %	100 %	100 %
	4.2 Customer involvement	4.2.1 Physician/patient feedback on quality, cost, time, and delivery performance	I421	weight	35	30	25	25	40	30
		4.2.2 Physician/patients participate in continuous improvement initiatives	I422		20	30	25	25	20	25
		4.2.3 Close contact with physicians to enable them to engage in continuous improvement projects	I423		25	25	30	25	20	25
		4.2.4 Engage physicians in forecasting planning processes	I424		20	15	20	25	20	20
			Total		100 %	100 %	100 %	100 %	100 %	100 %
5. Supplier relationship	5.1 Supplier cost	5.1.1 Hospital-supplier integration	I511	weight	30	30	40	35	30	30
		5.1.2 Incurred costs due to shortage of medicine	I512		30	25	20	35	40	30
		5.1.3 Medical purchasing	I513		40	45	40	30	30	40
			Total		100 %	100 %	100 %	100 %	100 %	100 %
	5.2 Supplier delivery	5.2.1 Unpredictable patient demand	I521	weight	20	25	20	20	30	20
		5.2.2 Medical supplies arrive on time and in the correct amounts	I522		25	20	30	30	30	30
		5.2.3 Minimize delivery lead times of medical supplies	I523		25	20	15	25	20	20
		5.2.4 Deliver urgent medicine when needed or in emergency cases	I524		30	35	35	25	20	30
			Total		100 %	100 %	100 %	100 %	100 %	100 %

Figure 7.17 Screenshot of Excel sheet for assessing weight for attributes



Ii	Iij	Iijk	E1	E2	E3	E4	E5	Wij	Wi	W
I1	I11	I111	3	3	4	3	3	0.2	0.7	25
		I112	4	3	3	5	5	0.2		
		I113	4	4	4	3	3	0.3		
		I114	3	3	2	4	4	0.3		
	I12	I121	4	3	4	3	5	0.3	0.3	
		I122	3	4	5	3	3	0.4		
		I123	3	3	3	5	4	0.15		
		I124	5	4	3	4	4	0.15		
I2	I21	I211	4	3	5	3	4	0.3	0.6	25
		I212	4	3	3	3	3	0.2		
		I213	5	3	4	3	5	0.2		
		I214	4	2	4	3	4	0.2		
		I215	5	2	3	3	6	0.1		
	I22	I221	4	2	5	4	3	0.35	0.4	
		I222	4	3	4	4	4	0.2		
		I223	4	3	4	4	5	0.15		
		I224	4	5	3	3	5	0.15		
		I225	3	5	4	4	4	0.15		
I3	I31	I311	3	3	3	3	3	0.3	0.6	0.2
		I312	3	3	2	2	5	0.3		
		I313	3	2	4	4	3	0.4		
	I32	I321	3	4	5	3	5	0.4	0.4	
		I322	3	5	4	5	3	0.3		
		I323	5	2	2	3	4	0.3		
I4	I41	I411	2	3	3	5	3	0.5	0.4	0.25
		I412	4	3	3	4	4	0.25		
		I413	5	2	3	3	3	0.25		
	I42	I421	5	3	3	4	5	0.25	0.6	
		I422	2	4	3	3	4	0.25		
		I423	3	3	2	4	3	0.25		
		I424	4	4	4	5	4	0.25		
I5	I51	I511	4	4	3	4	4	0.4	0.5	0.05
		I512	3	4	3	5	5	0.3		
		I513	2	5	4	3	3	0.3		
	I52	I521	3	4	3	4	3	0.3	0.5	
		I522	4	4	3	4	4	0.2		
		I523	3	5	4	5	3	0.2		
		I524	3	5	4	4	5	0.3		

Figure 7.16 Screenshot of Excel sheet for assessing scores

Table 7.8 Assessment Scores and Weights for Hospital (Y)

Hospital (Y)										
I_i	I_{ij}	I_{ijk}	E_1	E_2	E_3	E_4	E_5	W_{ij}	W_i	W
I_1	I_{11}	I_{111}	3	3	4	3	3	0.20	0.70	0.25
		I_{112}	4	3	3	5	5	0.20		
		I_{113}	4	4	4	3	3	0.30		
		I_{114}	3	3	2	4	4	0.30		
	I_{12}	I_{121}	4	3	4	3	5	0.30	0.30	
		I_{122}	3	4	5	3	3	0.40		
		I_{123}	3	3	3	5	4	0.15		
		I_{124}	5	4	3	4	4	0.15		
I_2	I_{21}	I_{211}	4	3	5	3	4	0.30	0.60	0.25
		I_{212}	4	3	3	3	3	0.20		
		I_{213}	5	3	4	3	5	0.20		
		I_{214}	4	2	4	3	4	0.20		
		I_{215}	5	2	3	3	6	0.10		
	I_{22}	I_{221}	4	2	5	4	3	0.35	0.40	
		I_{222}	4	3	4	4	4	0.20		
		I_{223}	4	3	4	4	5	0.15		
		I_{224}	4	5	3	3	5	0.15		
		I_{225}	3	5	4	4	4	0.15		
I_3	I_{31}	I_{311}	3	3	3	3	3	0.30	0.60	0.20
		I_{312}	3	3	2	2	5	0.30		
		I_{313}	3	2	4	4	3	0.40		
	I_{32}	I_{321}	3	4	5	3	5	0.40	0.40	
		I_{322}	3	5	4	5	3	0.30		
		I_{323}	5	2	2	3	4	0.30		
I_4	I_{41}	I_{411}	2	3	3	5	3	0.50	0.40	0.25
		I_{412}	4	3	3	4	4	0.25		
		I_{413}	5	2	3	3	3	0.25		
	I_{42}	I_{421}	5	3	3	4	5	0.25	0.60	
		I_{422}	2	4	3	3	4	0.25		
		I_{423}	3	3	2	4	3	0.25		
		I_{424}	4	4	4	5	4	0.25		
I_5	I_{51}	I_{511}	4	4	3	4	4	0.40	0.50	0.05
		I_{512}	3	4	3	5	5	0.30		
		I_{513}	2	5	4	3	3	0.30		
	I_{52}	I_{521}	3	4	3	4	3	0.30	0.50	
		I_{522}	4	4	3	4	4	0.20		
		I_{523}	3	5	4	5	3	0.20		
		I_{524}	3	5	4	4	5	0.30		

Legend:

I_i = Enabler index;

I_{ij} = Criterion index;

I_{ijk} = Attribute index;

E_i = Experts participated in the assessment;

W_{ij} = Attribute weight;

W_i = Criterion weight;

W = Enabler weight

After organising the data, as shown in Table 7.8, the calculation was started. Weights pertaining to the hospital leadership criterion W_{11} = (0.2, 0.2, 0.3, and 0.3) and the assessment scores for the same criterion are given by the following matrix through using the formula set out below:

$$\boldsymbol{I_{ij}} = \boldsymbol{R_{ij}} \times \boldsymbol{W_{ij}}$$

$$\mathbf{R_{11}} = \begin{bmatrix} 3 & 3 & 4 & 3 & 3 \\ 4 & 3 & 3 & 5 & 5 \\ 4 & 4 & 4 & 3 & 3 \\ 3 & 3 & 2 & 4 & 4 \end{bmatrix} \times [\mathbf{0.2} \quad \mathbf{0.2} \quad \mathbf{0.3} \quad \mathbf{0.3}]$$

$$\boldsymbol{I_{11}} = [\mathbf{3.5} \quad \mathbf{3.3} \quad \mathbf{3.2} \quad \mathbf{3.7} \quad \mathbf{3.7}]$$

Using the same principle, the following indices relating to the reset lean criteria were calculated, as illustrated in Table 7.9

Table 7.9 Indices of the Criteria

Symbol	E_1	E_2	E_3	E_4	E_5	$E_{Average}$
$\boldsymbol{I_{11}}$	**3.50**	**3.30**	**3.20**	**3.70**	**3.70**	**3.43**
$\boldsymbol{I_{12}}$	**3.60**	**3.55**	**4.10**	**3.45**	**3.90**	**3.68**
$\boldsymbol{I_{21}}$	**3.80**	**3.60**	**3.70**	**3.60**	**4.00**	**3.68**
$\boldsymbol{I_{22}}$	**3.85**	**3.25**	**4.20**	**3.85**	**3.95**	**3.79**
$\boldsymbol{I_{31}}$	**3.60**	**3.00**	**3.90**	**3.90**	**4.20**	**3.60**
$\boldsymbol{I_{32}}$	**3.60**	**3.70**	**3.80**	**3.60**	**4.10**	**3.68**
$\boldsymbol{I_{41}}$	**3.50**	**2.70**	**3.00**	**4.10**	**3.30**	**3.33**
$\boldsymbol{I_{42}}$	**3.50**	**3.50**	**3.00**	**4.00**	**4.00**	**3.50**
$\boldsymbol{I_{51}}$	**3.10**	**4.30**	**3.30**	**4.00**	**4.00**	**3.68**
$\boldsymbol{I_{52}}$	**3.20**	**4.50**	**3.50**	**4.20**	**3.80**	**3.85**

After computing Indices of the Criteria, the index for the enablers was calculated by using the following formula: $I_i = R_i \times W_i$

For example, the computation for medical management responsibility was made using the formula $\boldsymbol{I_1} = \boldsymbol{R_1} \times \boldsymbol{W_1}$ and followed the steps set out below:

Medical management responsibility:

$$\boldsymbol{I_1} = \begin{bmatrix} 3.5 & 3.3 & 3.2 & 3.7 & 3.7 \\ 3.6 & 3.55 & 4.1 & 3.45 & 3.9 \end{bmatrix} \times (0.70, 0.30)$$

$$\boldsymbol{I_1} = (3.53, 3.38, 3.47, 3.63, 3.76)$$

Using the same principle, the following indices relating to the reset lean enablers were calculated, as illustrated in Table 7.10

Table 7.10 indices of the enablers

	Hospital (Y)					
	E_1	E_2	E_3	E_4	E_5	E Average
I_1	3.53	3.38	3.47	3.63	3.76	3.55
I_2	3.82	3.46	3.90	3.70	3.98	3.77
I_3	3.24	3.04	3.38	3.30	3.80	3.35
I_4	3.40	3.20	3.00	4.10	3.70	3.48
I_5	3.15	4.40	3.40	4.10	3.90	3.79

The last step is to calculate the overall value of the leanness index in HSCM at hospital (X) by using the following formula: $I = R \times W$

$$\boldsymbol{I} = \begin{bmatrix} 3.53 & 3.38 & 3.47 & 3.63 & 3.76 \\ 3.82 & 3.46 & 3.90 & 3.70 & 3.98 \\ 3.24 & 3.04 & 3.38 & 3.30 & 3.80 \\ 3.40 & 3.20 & 3.00 & 4.10 & 3.70 \\ 3.15 & 4.40 & 3.40 & 4.10 & 3.90 \end{bmatrix} \times (0.25,\ 0.25,\ 0.2,\ 0.25,\ 0.05)$$

$$\boldsymbol{I} = (3.49,\ 3.34,\ 3.44,\ 3.72,\ 3.82)$$

$$\boldsymbol{I}_{average} = \frac{1}{5}(3.49 + 3.34 + 3.44 + 3.72 + 3.82)$$

$\boldsymbol{I}_{average}$ = **3.56** ∈ (2.01 – 4)

Table 7.11 enablers, weights and indices in hospital (Y)

Enabler	Weight	Index
Medical Management Responsibility	25%	3.49
HSCM Processes Management	25%	3.34
Medical Human Resource	20%	3.44
Consumer Relationship	25%	3.72
Supplier Relationship	5%	3.82

Table 7.11 shows weight and indices for enablers. The overall leanness index for HSCM processes in hospital (Y) is approximately 3.6, which falls in the range of 2.01 – 4 on the scale of assessment; the overall leanness index in the HSCM process in hospital (Y) indicates that:

The HSCM does not implement lean practices in any supply chain processes

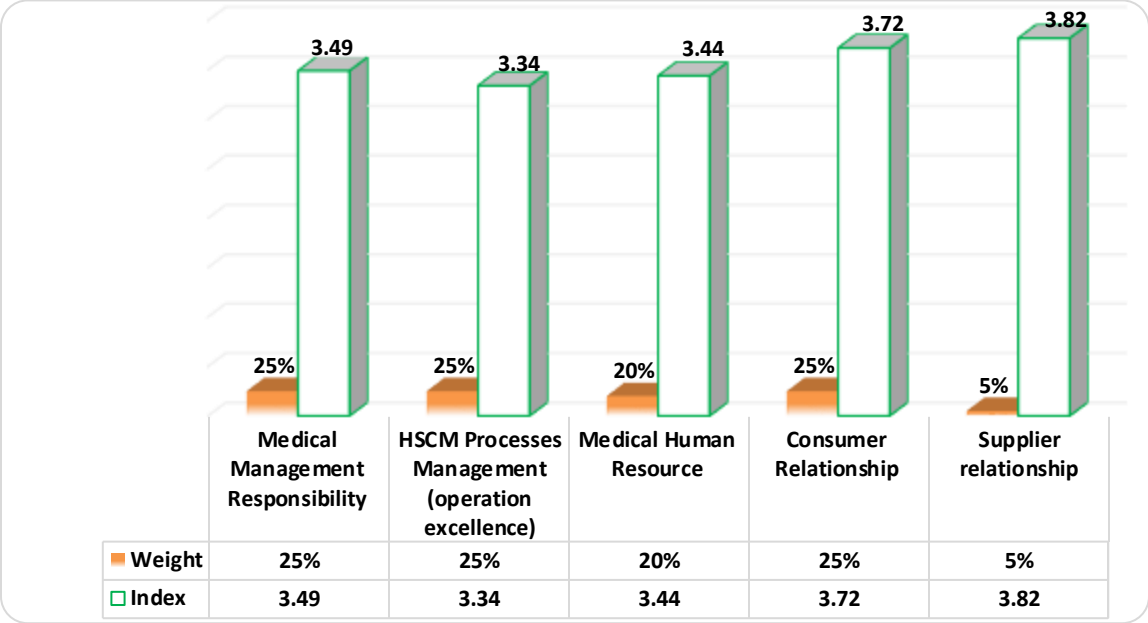


Figure 7.19 Indices and weights for hospital (Y) enablers

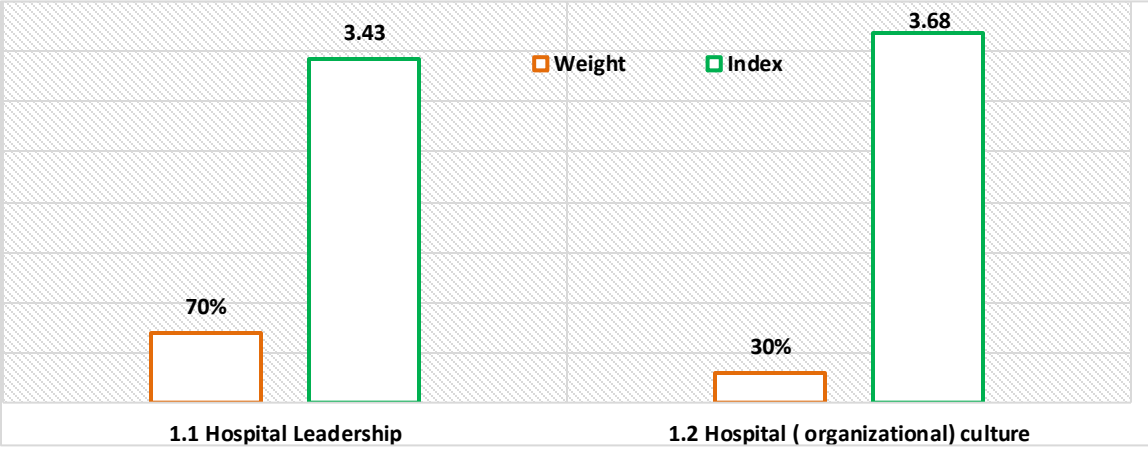


Figure 7.18 indices and weights for medical management responsibility in hospital (Y)

All the weights and indices computed for hospital (Y) enablers and criteria are illustrated in Figures 7.18, 7.19, 7.20, 7.21, 7.22 and 7.23 respectively.

For hospital (Y), it was noticed from Figure 7.17 that medical management responsibility, HSCM process management and consumer relationship are important, with a weight of 25% and indexes of 3.49, 3.34 and 3.44 respectively. The least important enabler is supplier relationship, with a weight of 5% and an index of 3.82. The medical human resources option has an importance of 20%.

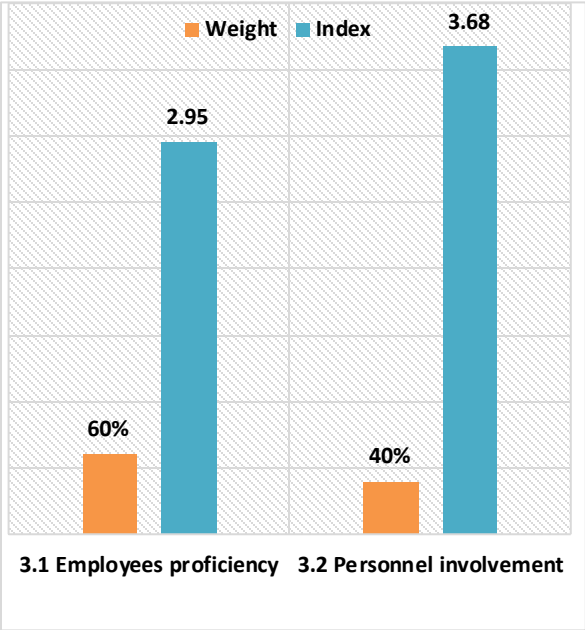


Figure 7.21 Indices and weights medical human resources in hospital (Y)

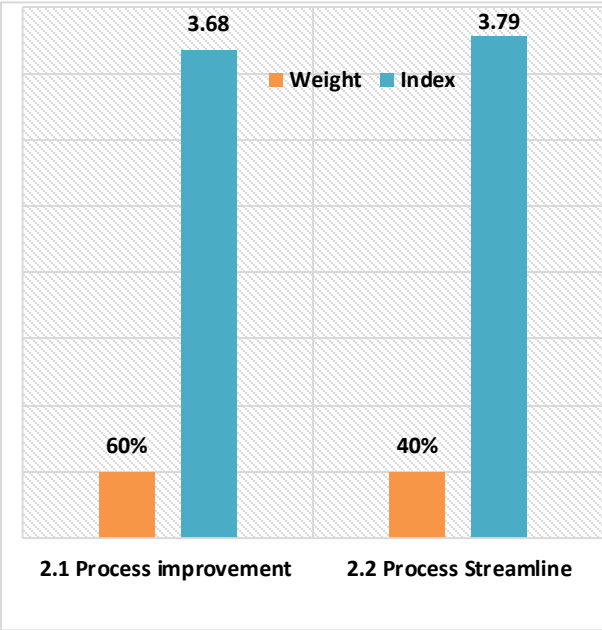


Figure 7.20 Indices and weights for HSCM process in hospital (Y)

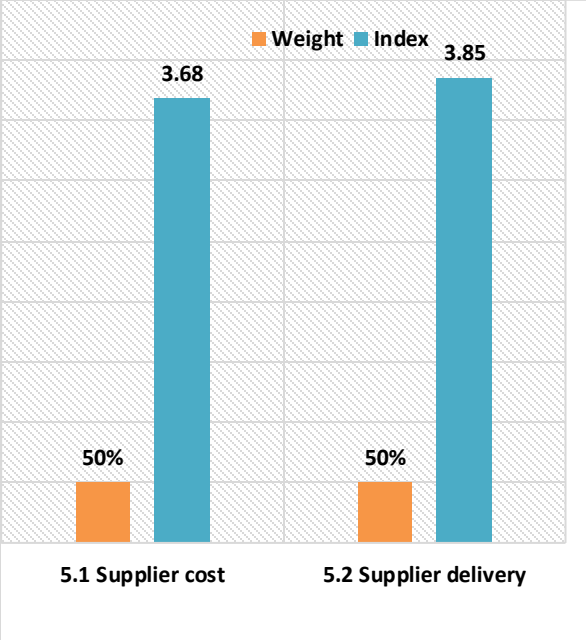


Figure 7.23 indices and weights for supplier relationship in hospital (Y)

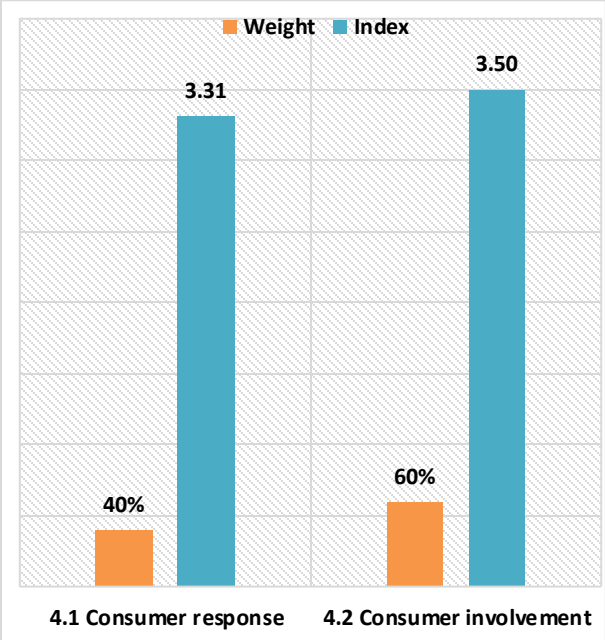


Figure 7.22 indices and weights for consumer relationship in hospital (Y)

7.3.1.3 HSCM Leanness Assessment of Hospital (Z)

As mentioned previously, there are four steps which were followed for assessing leanness in the hospitals, as set out below:

- ***Step (1) Calculating the weight (relative importance) for each enabler, criterion, and attribute.***
- ***Step (2) Calculating the index belonging to each criterion.***
- ***Step (3) Calculating the indices belonging to each enabler.***
- ***Step (4) Calculating HSCM Leanness Index for hospital (Z).***

By following the same steps mentioned in computing the HSCM leanness index for hospital (X) and hospital (Y) in the previous sections, the median was calculated for each enabler, as illustrated in Figure 7.24. Following this, the weight for each enabler was also computed. For example, the relative importance (weights) for medical management responsibility were: 30%, 25%, 25%, 10% and 10%. By calculating the median, it was found that the weight for medical management responsibility was 30%, as illustrated in Figure 7.25. By using the

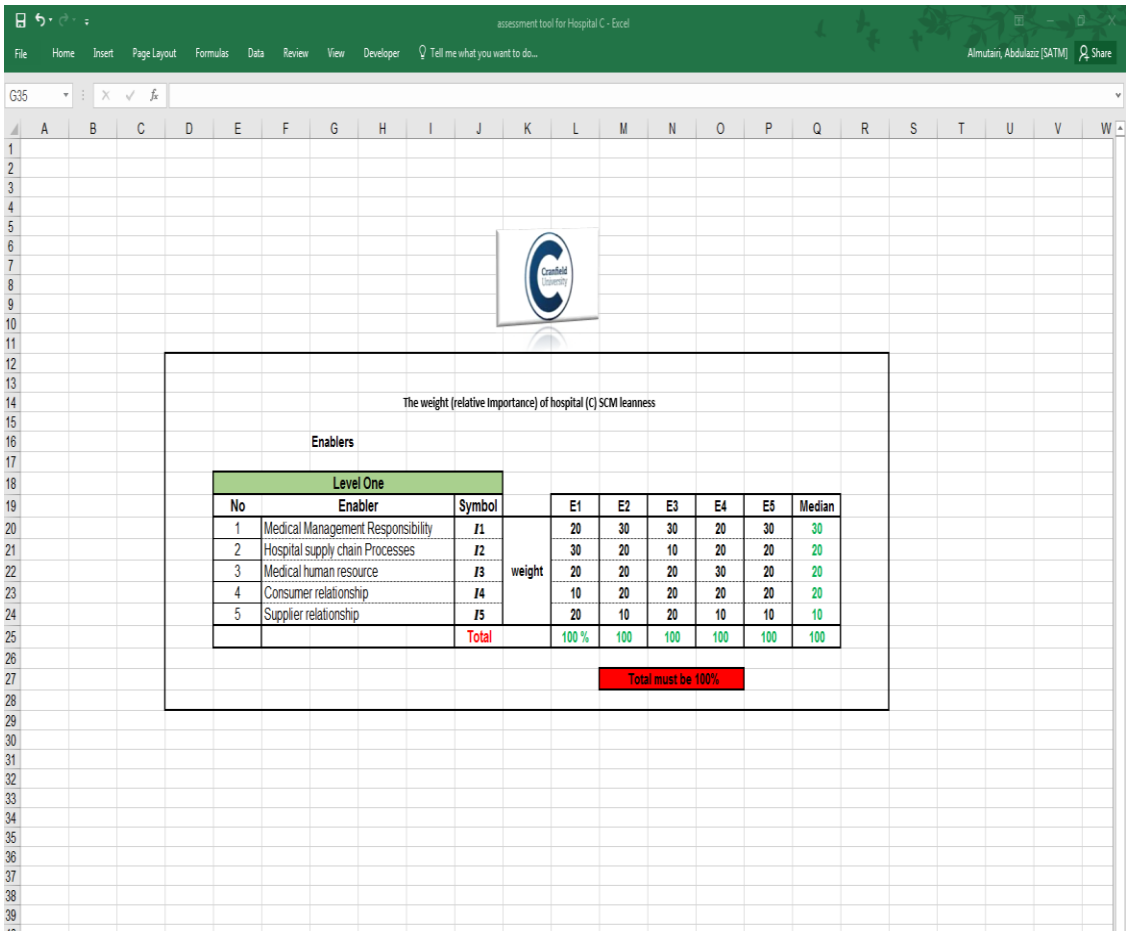
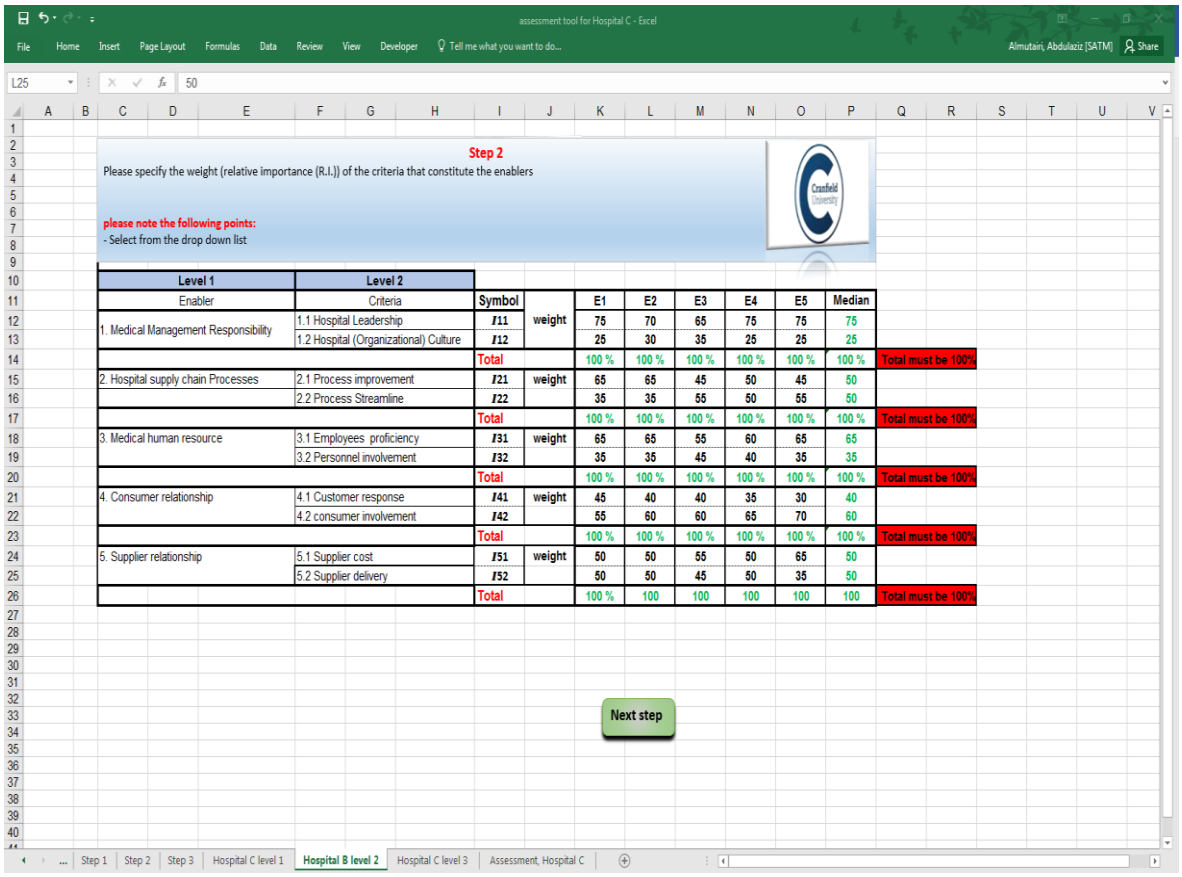


Figure 7.24 Screenshot of Excel sheet for assessing weight for each enabler

same method, the weight for the remaining enablers was calculated for all the experts from hospital (Z).

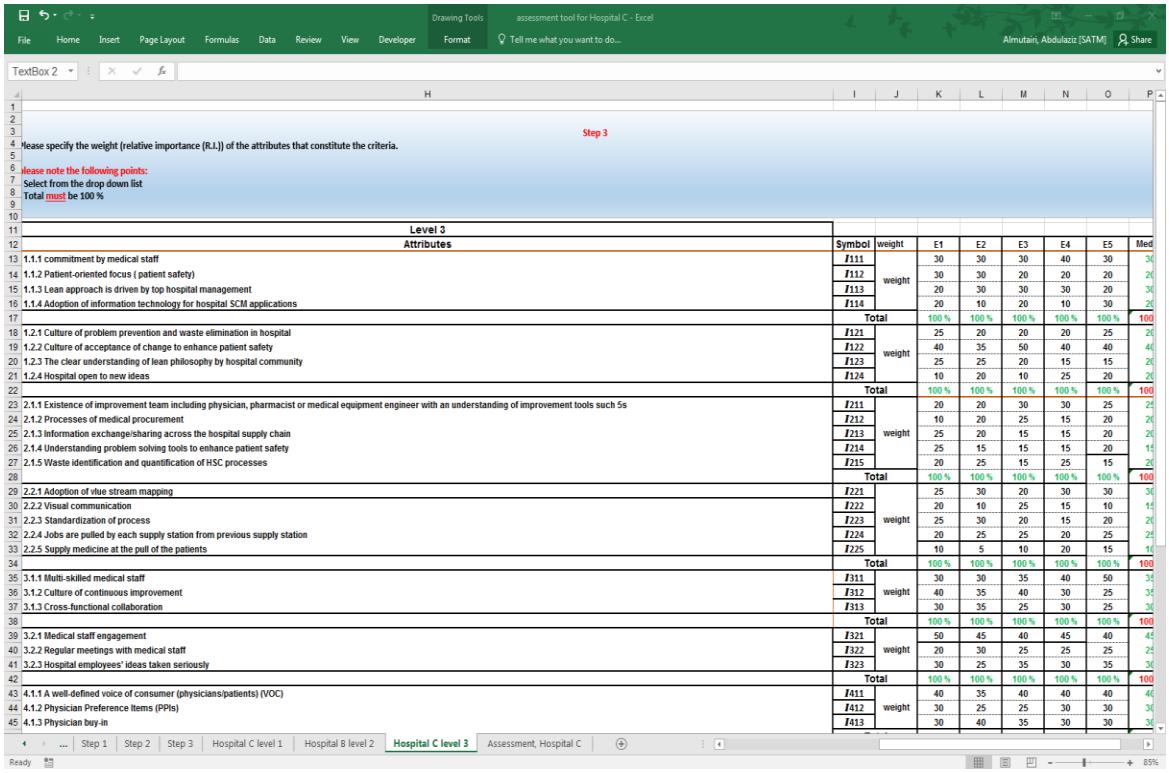
Following this, the second level of the assessment will appear, as shown in Figure 7.25; at this point, the weight for each criterion is calculated. For example, the relative importance (weights) provided by hospital (Y) experts for the medical management responsibility criterion were: 75%, 70%, 65%, 75% and 75%. As mentioned previously, the relative importance of the medical management responsibility criterion was computed using the median and found to be 75%.

Using the same method, the weight (relative importance) for each attribute was computed. At the end, all of the assessment scores given by each expert were gathered, as shown in Figure 7.26. After organising the data, as shown in Figure 7.27, the calculation was started.



Level 1	Level 2	Symbol		E1	E2	E3	E4	E5	Median	
Enabler	Criteria									
1. Medical Management Responsibility	1.1 Hospital Leadership	I11	weight	75	70	65	75	75	75	
	1.2 Hospital (Organizational) Culture	I12		25	30	35	25	25	25	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
2. Hospital supply chain Processes	2.1 Process improvement	I21	weight	65	65	45	50	45	50	
	2.2 Process Streamline	I22		35	35	55	50	55	50	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
3. Medical human resource	3.1 Employees proficiency	I31	weight	65	65	55	60	65	65	
	3.2 Personnel involvement	I32		35	35	45	40	35	35	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
4. Consumer relationship	4.1 Customer response	I41	weight	45	40	40	35	30	40	
	4.2 consumer involvement	I42		55	60	60	65	70	60	
		Total		100 %	100 %	100 %	100 %	100 %	100 %	Total must be 100%
5. Supplier relationship	5.1 Supplier cost	I51	weight	50	50	55	50	65	50	
	5.2 Supplier delivery	I52		50	50	45	50	35	50	
		Total		100 %	100	100	100	100	100	Total must be 100%

Figure 7.25 Screenshot of Excel sheet for assessing weight for each criteria



Step 3

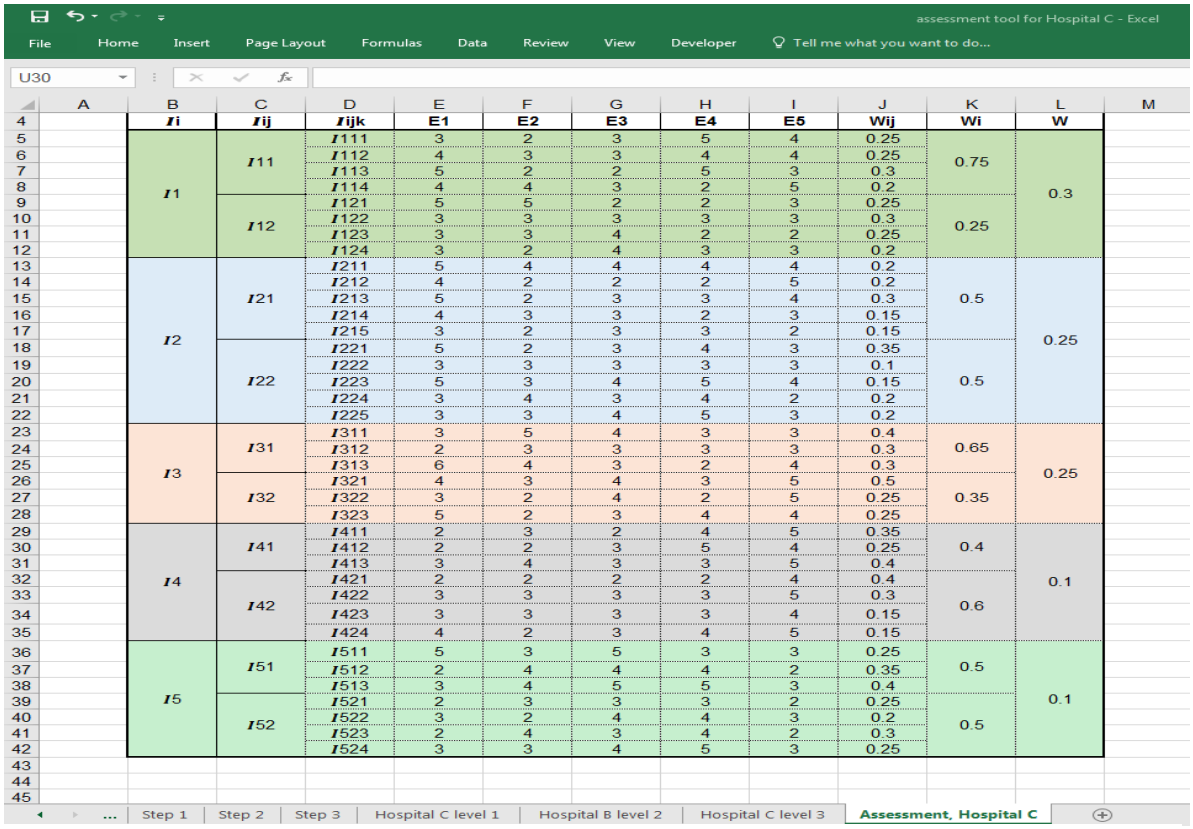
Please specify the weight (relative importance (R.I.)) of the attributes that constitute the criteria.

Please note the following points:
Select from the drop down list
Total must be 100 %

Level 3 Attributes	Symbol	weight	E1	E2	E3	E4	E5	Med
1.1.1 commitment by medical staff	I111		30	30	30	40	30	3
1.1.2 Patient-oriented focus (patient safety)	I112	weight	30	30	20	20	20	2
1.1.3 Lean approach is driven by top hospital management	I113		20	30	30	30	20	3
1.1.4 Adoption of information technology for hospital SCM applications	I114		20	10	20	10	30	2
	Total		100 %	100 %	100 %	100 %	100 %	100
1.2.1 Culture of problem prevention and waste elimination in hospital	I121		25	20	20	20	25	2
1.2.2 Culture of acceptance of change to enhance patient safety	I122	weight	40	35	50	40	40	4
1.2.3 The clear understanding of lean philosophy by hospital community	I123		25	25	20	15	15	2
1.2.4 Hospital open to new ideas	I124		10	20	10	25	20	2
	Total		100 %	100 %	100 %	100 %	100 %	100
2.1.1 Existence of improvement team including physician, pharmacist or medical equipment engineer with an understanding of improvement tools such 5s	I211		20	20	30	30	25	2
2.1.2 Processes of medical procurement	I212		10	20	25	15	20	2
2.1.3 Information exchange/sharing across the hospital supply chain	I213	weight	25	20	15	15	20	2
2.1.4 Understanding problem solving tools to enhance patient safety	I214		25	15	15	15	20	1
2.1.5 Waste identification and quantification of HSC processes	I215		20	25	15	25	15	2
	Total		100 %	100 %	100 %	100 %	100 %	100
2.2.1 Adoption of vlue stream mapping	I221		25	30	20	30	30	3
2.2.2 Visual communication	I222		20	10	25	15	10	1
2.2.3 Standardization of process	I223	weight	25	30	20	15	20	2
2.2.4 Jobs are pulled by each supply station from previous supply station	I224		20	25	25	20	25	2
2.2.5 Supply medicine at the pull of the patients	I225		10	5	10	20	15	1
	Total		100 %	100 %	100 %	100 %	100 %	100
3.1.1 Multi-skilled medical staff	I311		30	30	35	40	50	3
3.1.2 Culture of continuous improvement	I312	weight	40	35	40	30	25	3
3.1.3 Cross-functional collaboration	I313		30	35	25	30	25	3
	Total		100 %	100 %	100 %	100 %	100 %	100
3.2.1 Medical staff engagement	I321		50	45	40	45	40	4
3.2.2 Regular meetings with medical staff	I322	weight	20	30	25	25	25	2
3.2.3 Hospital employees' ideas taken seriously	I323		30	25	35	30	35	3
	Total		100 %	100 %	100 %	100 %	100 %	100
4.1.1 A well-defined voice of consumer (physicians/patients) (VOC)	I411		40	35	40	40	40	4
4.1.2 Physician Preference Items (PPIs)	I412	weight	30	25	25	30	30	3
4.1.3 Physician buy-in	I413		30	40	35	30	30	3

Step 1 | Step 2 | Step 3 | Hospital C level 1 | Hospital B level 2 | Hospital C level 3 | Assessment, Hospital C

Figure 7.27 Screenshot of Excel sheet for assessing weight for attribute



Ii	Iij	Iijk	E1	E2	E3	E4	E5	Wij	Wi	W
I1	I11	I111	3	2	3	5	4	0.25	0.75	0.3
		I112	4	3	3	4	4	0.25		
		I113	5	2	2	5	3	0.3		
		I114	4	4	3	2	5	0.2		
	I12	I121	5	5	2	2	3	0.25	0.25	
		I122	3	3	3	3	3	0.3		
		I123	3	3	4	2	2	0.25		
		I124	3	2	4	3	3	0.2		
I2	I21	I211	5	4	4	4	4	0.2	0.5	0.25
		I212	4	2	2	2	5	0.2		
		I213	5	2	3	3	4	0.3		
		I214	4	3	3	2	3	0.15		
		I215	3	2	3	3	2	0.15		
	I22	I221	5	2	3	4	3	0.35	0.5	
		I222	3	3	3	3	3	0.1		
		I223	5	3	4	5	4	0.15		
		I224	3	4	3	4	2	0.2		
		I225	3	3	4	5	3	0.2		
I3	I31	I311	3	5	4	3	3	0.4	0.65	0.25
		I312	2	3	3	3	3	0.3		
		I313	6	4	3	2	4	0.3		
	I32	I321	4	3	4	3	5	0.5	0.35	
		I322	3	2	4	2	5	0.25		
		I323	5	2	3	4	4	0.25		
I4	I41	I411	2	3	2	4	5	0.35	0.4	0.1
		I412	2	2	3	5	4	0.25		
		I413	3	4	3	3	5	0.4		
	I42	I421	2	2	2	2	4	0.4	0.6	
		I422	3	3	3	3	5	0.3		
		I423	3	3	3	3	4	0.15		
		I424	4	2	3	4	5	0.15		
I5	I51	I511	5	3	5	3	3	0.25	0.5	0.1
		I512	2	4	4	4	2	0.35		
		I513	3	4	5	5	3	0.4		
	I52	I521	2	3	3	3	2	0.25	0.5	
		I522	3	2	4	4	3	0.2		
		I523	2	4	3	4	2	0.3		
		I524	3	3	4	5	3	0.25		

Step 1 | Step 2 | Step 3 | Hospital C level 1 | Hospital B level 2 | Hospital C level 3 | Assessment, Hospital C

Figure 7.26 Screenshot of Excel sheet for assessing scores

Table 7.12 Assessment Scores and Weights for Hospital (Z)

I_i	I_{ij}	I_{ijk}	E_1	E_2	E_3	E_4	E_5	W_{ij}	W_i	W
I_1	I_{11}	I_{111}	3	2	3	5	4	0.25	0.75	0.30
		I_{112}	4	3	3	4	4	0.25		
		I_{113}	5	2	2	5	3	0.30		
		I_{114}	4	4	3	2	5	0.20		
	I_{12}	I_{121}	5	5	2	2	3	0.25	0.25	
		I_{122}	3	3	3	3	3	0.30		
		I_{123}	3	3	4	2	2	0.25		
		I_{124}	3	2	4	3	3	0.20		
I_2	I_{21}	I_{211}	5	4	4	4	4	0.20	0.50	0.25
		I_{212}	4	2	2	2	5	0.20		
		I_{213}	5	2	3	3	4	0.30		
		I_{214}	4	3	3	2	3	0.15		
		I_{215}	3	2	3	3	2	0.15		
	I_{22}	I_{221}	5	2	3	4	3	0.35	0.50	
		I_{222}	3	3	3	3	3	0.10		
		I_{223}	5	3	4	5	4	0.15		
		I_{224}	3	4	3	4	2	0.20		
		I_{225}	3	3	4	5	3	0.20		
I_3	I_{31}	I_{311}	3	5	4	3	3	0.40	0.65	0.25
		I_{312}	2	3	3	3	3	0.30		
		I_{313}	6	4	3	2	4	0.30		
	I_{32}	I_{321}	4	3	4	3	5	0.50	0.35	
		I_{322}	3	2	4	2	5	0.25		
		I_{323}	5	2	3	4	4	0.25		
I_4	I_{41}	I_{411}	2	3	2	4	5	0.35	0.40	0.10
		I_{412}	2	2	3	5	4	0.25		
		I_{413}	3	4	3	3	5	0.40		
	I_{42}	I_{421}	2	2	2	2	4	0.40	0.60	
		I_{422}	3	3	3	3	5	0.30		
		I_{423}	3	3	3	3	4	0.15		
		I_{424}	4	2	3	4	5	0.15		
I_5	I_{51}	I_{511}	5	3	5	3	3	0.25	0.50	0.10
		I_{512}	2	4	4	4	2	0.35		
		I_{513}	3	4	5	5	3	0.40		
	I_{52}	I_{521}	2	3	3	3	2	0.25	0.50	
		I_{522}	3	2	4	4	3	0.20		
		I_{523}	2	4	3	4	2	0.30		
		I_{524}	3	3	4	5	3	0.25		

Legend:

I_i = Enabler index;

I_{ij} = Criterion index;

I_{ijk} = Attribute index;

E_i = Experts participated in the assessment;

W_{ij} = Attribute weight;

W_i = Criterion weight;

W = Enabler weight

After organising the data, as shown in Table 7.12, the calculation was started. Weights pertaining to the hospital leadership criterion W_{11} = (0.25, 0.25, 0.3, and 0.2) and the assessment scores for the same criterion are given by the following matrix through using the formula set out below:

$$\boldsymbol{I_{ij}} = \boldsymbol{R_{ij}} \times \boldsymbol{W_{ij}}$$

$$\mathbf{R_{11}} = \begin{bmatrix} 3 & 2 & 3 & 5 & 4 \\ 4 & 3 & 3 & 4 & 4 \\ 5 & 2 & 2 & 5 & 3 \\ 4 & 4 & 3 & 2 & 5 \end{bmatrix} \times [\mathbf{0.25} \quad \mathbf{0.25} \quad \mathbf{0.3} \quad \mathbf{0.2}]$$

$$\boldsymbol{I_{11}} = [\mathbf{3.5} \quad \mathbf{3.3} \quad \mathbf{3.2} \quad \mathbf{3.7} \quad \mathbf{3.7}]$$

Using the same principle, the following indices relating to the reset lean criteria were calculated, as illustrated in Table 7.13

Table 7.13 Indices of the Criteria

Symbol	E_1	E_2	E_3	E_4	E_5	$E_{Average}$
$\boldsymbol{I_{11}}$	4.05	2.65	2.70	4.15	3.90	3.39
$\boldsymbol{I_{12}}$	3.50	3.30	3.20	2.50	2.75	3.13
$\boldsymbol{I_{21}}$	4.35	2.55	3.00	2.85	3.75	3.19
$\boldsymbol{I_{22}}$	4.00	2.85	3.35	4.25	2.95	3.61
$\boldsymbol{I_{31}}$	3.60	4.10	3.40	2.70	3.30	3.45
$\boldsymbol{I_{32}}$	4.00	2.50	3.75	3.00	4.75	3.31
$\boldsymbol{I_{41}}$	2.40	3.15	2.65	3.85	4.75	3.01
$\boldsymbol{I_{42}}$	2.75	2.45	2.60	2.75	4.45	2.64
$\boldsymbol{I_{51}}$	3.15	3.75	4.65	4.15	2.65	3.93
$\boldsymbol{I_{52}}$	2.45	3.10	3.45	4.00	2.45	3.25

After computing Indices of the Criteria, the index for enablers was calculated by using the following formula: $I_i = R_i \times W_i$

For example, the computation for medical management responsibility was made using the formula $\boldsymbol{I_1} = \boldsymbol{R_1} \times \boldsymbol{W_1}$ and followed the steps set out below:

Medical management responsibility:

$$\boldsymbol{I_1} = \begin{bmatrix} 4.05 & 2.65 & 2.70 & 4.15 & 3.90 \\ 3.50 & 3.30 & 3.20 & 2.50 & 2.75 \end{bmatrix} \times (0.75, 0.25)$$

$\boldsymbol{I_1}$ = (3.91, 2.81, 2.83, 3.74, 3.61)

Using the same principle, the following indices relating to the reset lean enablers were calculated, as illustrated in Table 7.14

Table 7.14 indices of the enablers

Hospital (Z)						
	E_1	E_2	E_3	E_4	E_5	E Average
I_1	3.91	2.81	2.83	3.74	3.61	3.38
I_2	4.18	2.70	3.18	3.55	3.35	3.39
I_3	3.74	3.54	3.52	2.81	3.81	3.48
I_4	2.61	2.73	2.62	3.19	4.57	3.14
I_5	2.80	3.43	4.05	4.08	2.55	3.38

The last step is to calculate the overall value of the leanness index in HSCM at hospital (X) by using the following formula: $I = R \times W$

$$\boldsymbol{I} = \begin{bmatrix} 3.91 & 2.81 & 2.83 & 3.74 & 3.61 \\ 4.18 & 2.70 & 3.18 & 3.55 & 3.35 \\ 3.74 & 3.54 & 3.52 & 2.81 & 3.81 \\ 2.61 & 2.73 & 2.62 & 3.19 & 4.57 \\ 2.80 & 3.43 & 4.05 & 4.08 & 2.55 \end{bmatrix} \times (0.30,\ 0.25,\ 0.25,\ 0.10,\ 0.10)$$

$$\boldsymbol{I} = (3.69,\ 3.02,\ 3.19,\ 3.44,\ 3.59)$$

$$\boldsymbol{I}_{average} = \frac{1}{5}(3.69 + 3.02 + 3.19 + 3.44 + 3.59)$$

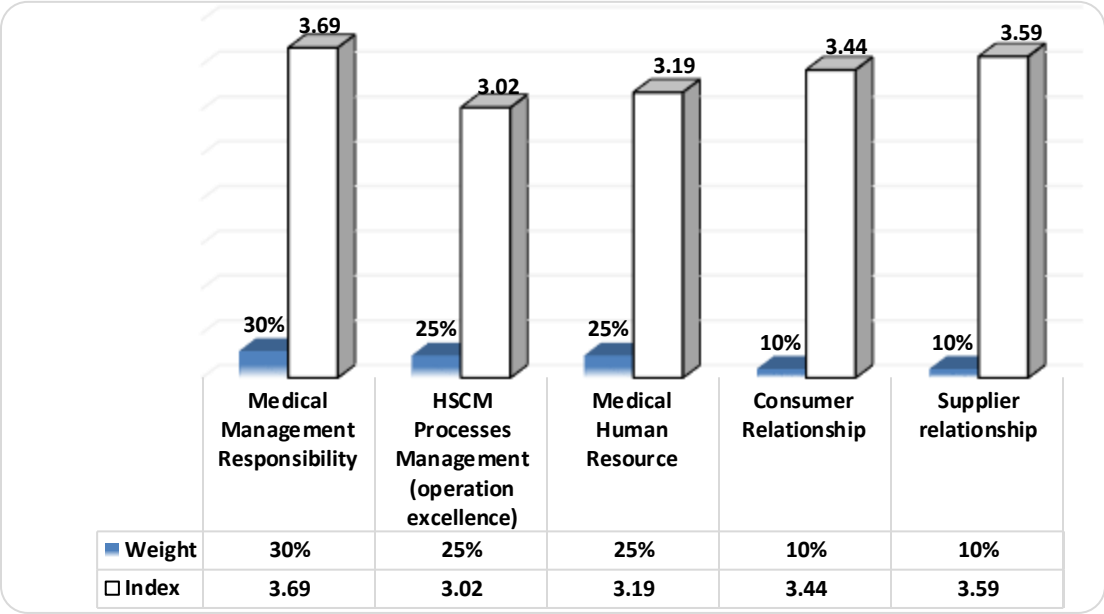
$\boldsymbol{I}_{average}$ = **3.38** ∈ (2.01 – 4)

Table 7.15 enablers, weights and indices in hospital (Z)

Enabler	Weight	Index
Medical Management Responsibility	30%	3.69
HSCM Processes Management	25%	3.02
Medical Human Resource	25%	3.19
Consumer Relationship	10%	3.44
Supplier Relationship	10%	3.59

Table 7.15 shows enablers weights and indices for hospital (Y). The overall leanness index for HSCM processes in hospital (Z) is approximately 3.4, which falls in the range of 2.01 – 4 on the scale of assessment; the overall leanness index in the HSCM process at hospital (Z) indicates that:

The HSCM does not implement lean practices in supply chain processes



	Medical Management Responsibility	HSCM Processes Management (operation excellence)	Medical Human Resource	Consumer Relationship	Supplier relationship
Weight	30%	25%	25%	10%	10%
Index	3.69	3.02	3.19	3.44	3.59

Figure 7.28 indices and weights for hospital (Z) enablers

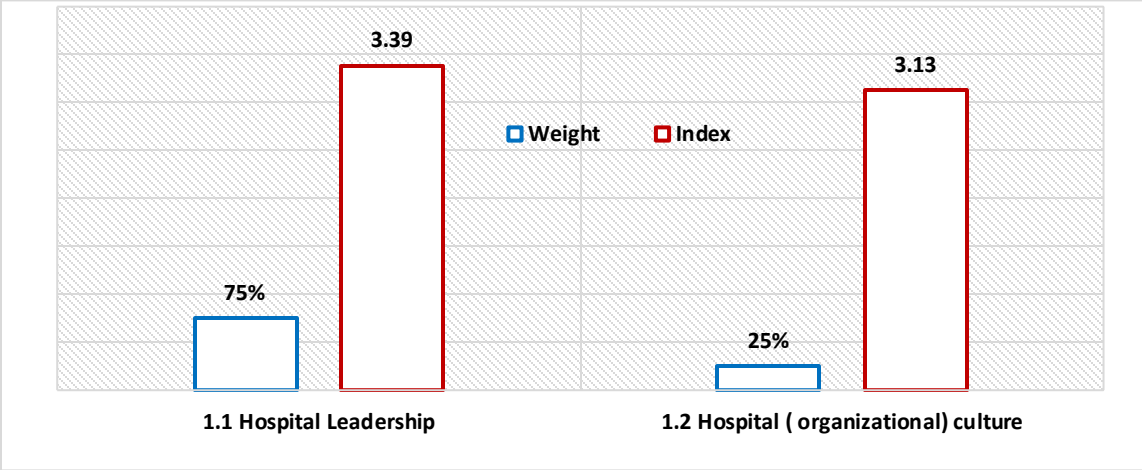


Figure 7.29 Indices and weights for medical management responsibility in hospital (Z)

With regards hospital (Y), it was noticed from Figure 7.28 that medical management responsibility has the most importance, with a weight of 30% and an index of 3.69. HSCM process management and medical human resource have the same importance with 25% and indexes of 3.02 and 3.19 respectively.

Consumer relationship and supplier relationship have the least important enablers, with a weight of 10% and indexes of 3.44 and 3.59 respectively.

All the weights and indices computed for hospital (Z) enablers and criteria are illustrated in Figures 7.28,7.29, 7.30, 7.31, 7.32, and 7.33 respectively.

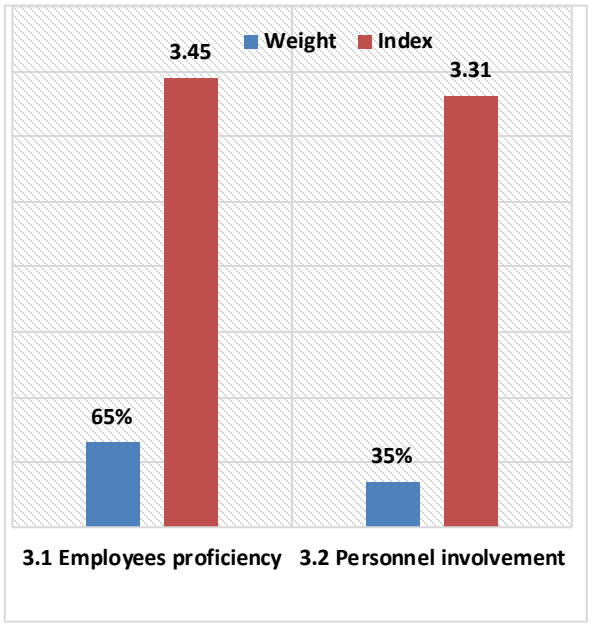


Figure 7.31 Indices and weights medical human resources in hospital (Z)

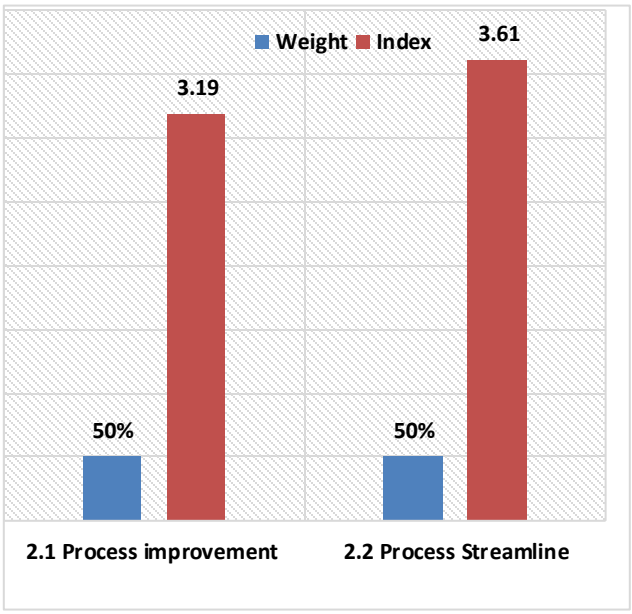


Figure 7.30 Indices and weights for HSCM process in hospital (Z)

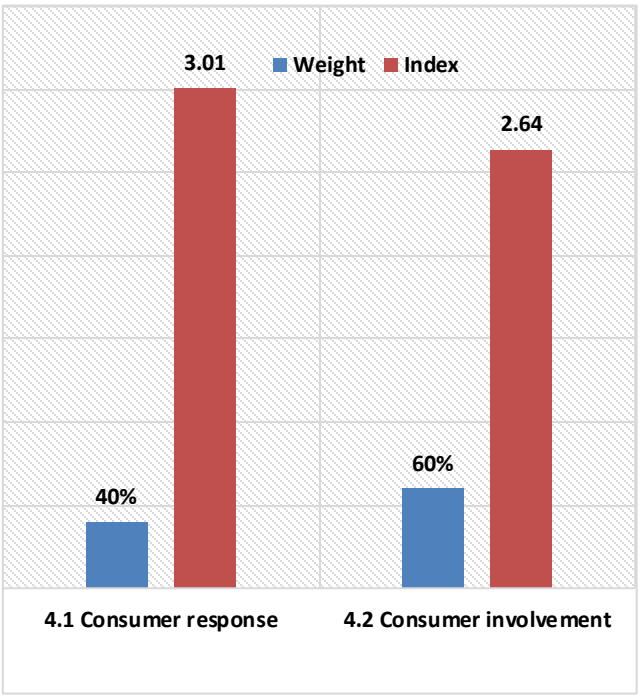


Figure 7.33 Indices and weights for consumer relationship in hospital (Z)

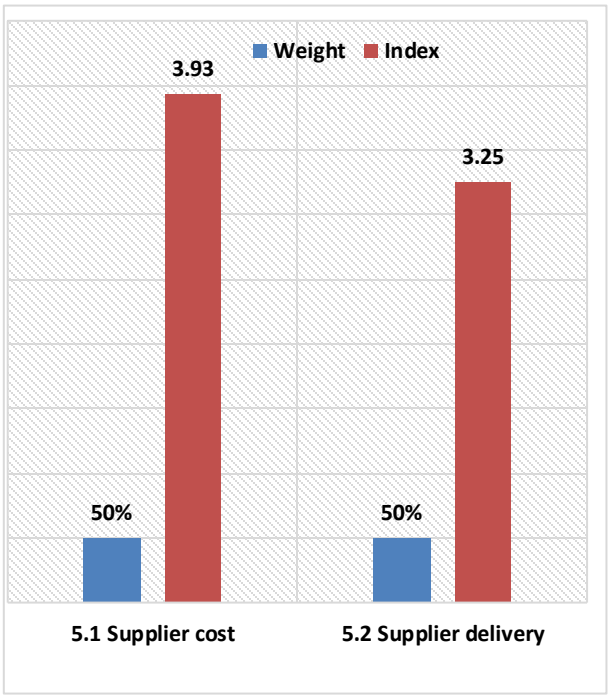


Figure 7.32 Indices and weights for supplier relationship in hospital (Z)

7.3.2 Validation by practitioners

After calculating the HSCM leanness index for the three hospitals and identifying opportunities for further improvement, a group discussion was held with experts who participated in the process of assessment. The main purpose of this discussion was to present the computed index and to discuss opportunities for further improvement, while also validating whether or not the findings reflect the real-life scenario in each hospital. To achieve this, the experts discussed three main points.

Q1. To what extent does the index calculated reflect the reality in the HSCM process?

Q2. To what extent do the improvement opportunities reflect the current state of the HSCM?

Q3. Are there any items that should be included in, or excluded from, the assessment tool?

For example, the associate executive director for supply from hospital (X) mentioned that: *"The assessment tool of the HSCM index was computed clearly and easily and definitely reflects the real-life scenario in the HSCM practices. The tool helps us in identifying wastes in our processes and then we can eliminate them. I believe the assessment tool visualises where the bottlenecks are".*

Furthermore, the demand planning and forecasting manager from hospital (Y) stated: *"I am so much to find such a tool that helps us in saving our resources by eliminating non-added-value processes. We are a patients-focused organisation so saving our resources means saving people's lives. This assessment is a useful tool in terms of letting us know where HSCM practices are and answering a very important question, is our work wasting our resources?"*

For example, the material management manger from hospital (Z) said: *"Now we can cut wastes and cost in our process. The assessment tool developed by the researchers is a great tool that can be employed in our hospital to identify areas for further improvement. One of the greatest advantages of this tool is that it can be used repetitively many times to move towards operational excellence".*

7.3.3 Validation by Academia

After the work was criticised and revised by industrial experts, it was also reviewed and criticised by referees from a leading journal. For example, one of the referees commented on the work by saying:

"This research has a high degree of originality. Little published research exists on this topic. It is worthy of publication. The research does a good job of reviewing and applying the appropriate literature. The methodology of the research is based on the development of a model that is then validated by five identified experts. The results of the research are clearly stated and analysed appropriately. The research clearly addresses a gap in the current body of research and identifies implications for the future application of the research. The research is fairly well written".

This work was peer-reviewed and published in the *international journal of lean six sigma* under the title *"assessing the leanness of a supply chain using multi-grade fuzzy logic: a health-care case study"*; it was published by Emerald Publishing Limited with the DOI 10.1108/IJLSS-03-2018-0027. Publication is one of the most reliable validation strategies, due to feedback and criticism. This approach is called research dissemination, as mentioned in Chapter 3.

7.4 Validation of the developed framework

7.4.1.1 Qualitative validation

Using experts' opinions for the validation of the approach is common and used by many researchers (Haq & Boddu 2014). The framework was developed and finalized by working cooperatively with three healthcare organizations. There were 15 respondents that participated in the focus group process. Group discussions were held to capture experts' feedback and to check the validity of the framework. Group discussions were conducted in each hospital and validity-centred sessions were held about the following point: "To what extent the LHSC framework phases, activities and lean enablers considered to be vital for successfully implementing lean in SCM in healthcare organizations?" After making 25 minutes presentations (on average) to each HSCM experts as illustrated Figure 7.34, overall comments were summarised in Table 7.16.

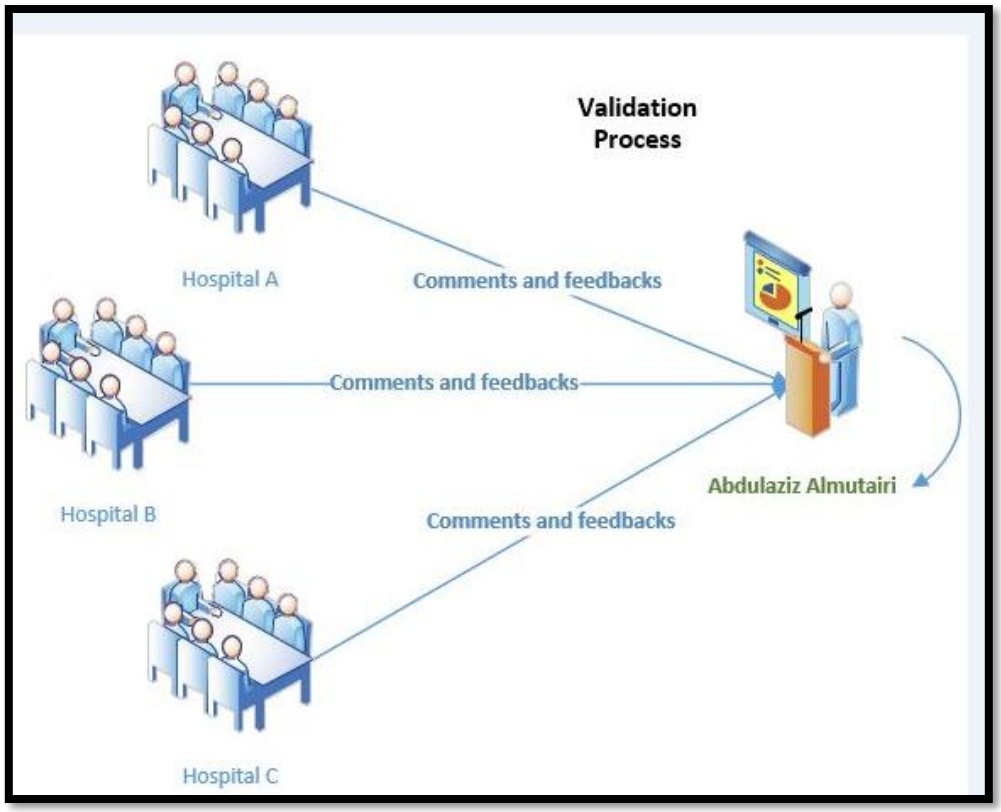


Figure 7.34 Group discussion process

Table 7.16 Focus Group feedback

Hospital	Group's comments overview
X	It is an applicable and helpful framework. All of the hospital supply chain departments could implement lean successfully if they follow phases and take into account lean enablers and lean challenges. Also, the framework is useful in identifying the waste in SCM practices. The hospital should ensure that their people are ready to implement the lean initiative.
Y	The sequence of the phases within the framework enable the stages of lean implementation to be visualized. Decision makers in SCM should prepare their staff on how to use and implement lean tools, and select suitable techniques for this implementation.
Z	The framework is applicable if SCM staff have sufficient knowledge along with strong relationships with customers and supplier, which will enable them to effectively implement lean within the supply chain practices. There is need to train HSCM staff for lean implementation instead of relying of external consultant

7.4.1.2 Quantitative (statistical) validation

In order to test the acceptance of a "framework for implementing lean principles in a supply chain at healthcare organizations", t-tests were carried out. Managers from HSCM were asked the following questions for quantitative validation purpose. Participants were asked to give each question number from 0 to 10: (10 indicates applicable) as illustrated in Figure 7.35 and Table 7.17

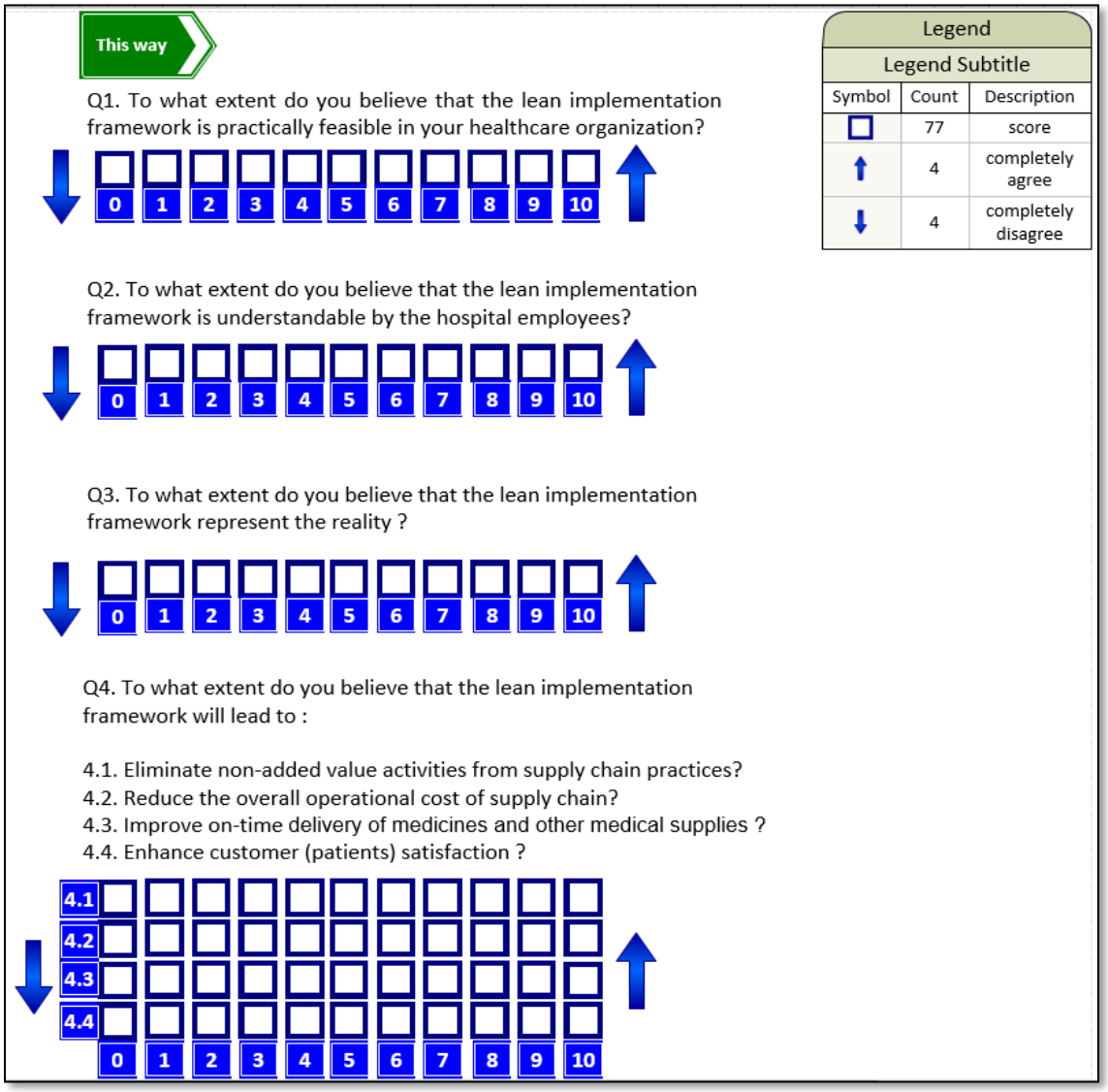


Figure 7.35 validation form

Table 7.17 validation questions

No	Question
1	To what extent do you believe that the lean implementation framework is practically feasible in your healthcare organization?
2	To what extent do you believe that the lean implementation framework is understandable by the hospital employees?
3	To what extent do you believe that the lean implementation framework represent the reality?
4	To what extent do you believe that the lean implementation framework will lead to: 4.1. Eliminate non-added value activities from supply chain practices? 4.2. Reduce the overall operational cost of supply chain? 4.3. Improve on-time delivery of medicines and other medical supplies? 4.4. Enhance patients / physicians satisfaction?

After experts answering the above questions, T-Test was conducted at 95% confidence interval. For all hospital, two trials were used. First trial was supposed each question will be implemented 100% (10 in the scale) as shown in Table 7.20, 7.23 and 7.26.

P-value is either less or bigger than the chosen significance level (in this study 0.05)

- If *p*-value ≤ 0.05) indicates strong evidence against the null hypothesis, so you reject the null hypothesis.
- If *p*-value > 0.05 indicates weak evidence against the null hypothesis, so you fail to reject the null hypothesis.

One-Sample T: Hospital (X)

Table 7.18 Descriptive statistics

Sample		N	Mean	St Dev	SE Mean	95% CI for μ
Hospital (X)	Q1	5	8.400	0.548	0.245	(7.720, 9.080)
Q2		5	8.400	0.894	0.400	(7.289, 9.511)
Q3		5	8.200	0.837	0.374	(7.161, 9.239)
Q4.1		5	8.400	0.548	0.245	(7.720, 9.080)
Q4.2		5	8.400	0.894	0.400	(7.289, 9.511)
Q4.3		5	8.800	0.447	0.200	(8.245, 9.355)
Q4.4		5	8.800	0.837	0.374	(7.761, 9.839)

Table 7.20 T-test for hospital (X) at μ = 10

Null hypothesis		H_0: μ = 10	
Alternative hypothesis		H_1: μ ≠ 10	
Sample		T-Value	P-Value
Hospital (X)	Q1	-6.53	0.003
Q2		-4.00	0.016
Q3		-4.81	0.009
Q4.1		-6.53	0.003
Q4.2		-4.00	0.016
Q4.3		-6.00	0.004
Q4.4		-3.21	0.033

Table 7.19 T-test for hospital (X) at μ = 9

Null hypothesis		H_0: μ = 9	
Alternative hypothesis		H_1: μ ≠ 9	
Sample		T-Value	P-Value
Hospital (X)	Q1	-2.45	0.070
Q2		-1.50	0.208
Q3		-2.14	0.099
Q4.1		-2.45	0.070
Q4.2		-1.50	0.208
Q4.3		-1.00	0.374
Q4.4		-0.53	0.621

μ: mean of Hospital (X) Q1, Q2, Q3, Q4.1, Q4.2, Q4.3, Q4.4

After running the software (Minitab®), first trial was failed for all hospitals, then the second trial was supposed. The second trial was 90% (9 in the scale) as shown in Table 7.19, 7.22 and 7.25.

One-Sample T: Hospital (Y)

Table 7.21 Descriptive Statistics

Sample		N	Mean	StDev	SE Mean	95% CI for μ
Hospital (Y)	Q1	5	8.600	0.548	0.245	(7.920, 9.280)
Q2		5	8.800	0.837	0.374	(7.761, 9.839)
Q3		5	8.400	0.548	0.245	(7.720, 9.080)
Q4.1		5	8.400	0.548	0.245	(7.720, 9.080)
Q4.2		5	8.200	0.837	0.374	(7.161, 9.239)
Q4.3		5	8.600	0.548	0.245	(7.920, 9.280)
Q4.4		5	8.400	0.894	0.400	(7.289, 9.511)

Table 7.23 T-test for hospital (Y) at μ = 10

Null hypothesis		H_0: μ = 10	
Alternative hypothesis		H_1: μ ≠ 10	
Sample		T-Value	P-Value
Hospital (Y)	Q1	-5.72	0.005
Q2		-3.21	0.033
Q3		-6.53	0.003
Q4.1		-6.53	0.003
Q4.2		-4.81	0.009
Q4.3		-5.72	0.005
Q4.4		-4.00	0.016

Table 7.22 T-test for hospital (Y) at μ = 9

Null hypothesis		H_0: μ = 9	
Alternative hypothesis		H_1: μ ≠ 9	
Sample		T-Value	P-Value
Hospital (Y)	Q1	-1.63	0.178
Q2		-0.53	0.621
Q3		-2.45	0.070
Q4.1		-2.45	0.070
Q4.2		-2.14	0.099
Q4.3		-1.63	0.178
Q4.4		-1.50	0.208

μ: mean of Hospital (Y) Q1, Q2, Q3, Q4.1, Q4.2, Q4.3, Q4.4

One-Sample T: Hospital (Z)

Table 7.24 Descriptive Statistics

Sample		N	Mean	StDev	SE Mean	95% CI for μ
Hospital (Z)	Q1	5	8.200	0.837	0.374	(7.161, 9.239)
Q2		5	8.400	0.894	0.400	(7.289, 9.511)
Q3		5	8.600	0.548	0.245	(7.920, 9.280)
Q4.1		5	8.400	1.140	0.510	(6.984, 9.816)
Q4.2		5	8.400	0.894	0.400	(7.289, 9.511)
Q4.3		5	8.000	1.225	0.548	(6.479, 9.521)
Q4.4		5	8.200	0.837	0.374	(7.161, 9.239)

Table 7.26 T-test for hospital (Z) at μ = 10

Null hypothesis		H_0: μ = 10	
Alternative hypothesis		H_1: μ ≠ 10	
Sample		T-Value	P-Value
Hospital (Z)	Q1	-4.81	0.009
	Q2	-4.00	0.016
	Q3	-5.72	0.005
	Q4.1	-3.14	0.035
	Q4.2	-4.00	0.016
	Q4.3	-3.65	0.022
	Q4.4	-4.81	0.009

Table 7.25 T-test for hospital (Z) at μ = 9

Null hypothesis		H_0: μ = 9	
Alternative hypothesis		H_1: μ ≠ 9	
Sample		T-Value	P-Value
Hospital (Z)	Q1	-2.14	0.099
	Q2	-1.50	0.208
	Q3	-1.63	0.178
	Q4.1	-1.18	0.305
	Q4.2	-1.50	0.208
	Q4.3	-1.83	0.142
	Q4.4	-2.14	0.099

μ: mean of Hospital (Z) Q1, Q2, Q3, Q4.1, Q4.2, Q4.3, Q4.4

In hospital (X), (Y) and (Z) and based on experts' opinion, it noticed from Table 7.19, 7.22 and 7.25 , that p-value for all questions exceed the 0.05 **(**95% confidence interval) which mean the null hypothesis has been accepted. This indicates that the successful of lean implementation in HSCM is 90 % from experts' perspective.

7.5 Validation academic's perspective

For example one of referee commented when researcher submitted the paper to the one of leading-journal:

"An interesting research and this is a study of healthcare processes in Saudi with a focus on lean ops. A good breadth of literature is considered with appropriate methodology. Implications for research, practice is an interest to academics and practitioners".

Another referee commented as: *"This research is* ***Good Work*** with ***Originality***"

This work was peer-reviewed and published in international journal of lean six sigma under title: ***A framework for implementing lean principles in the supply chain management at healthcare organizations: Saudi's perspective.*** Publication is one of the most reliable validation strategy due to feedback and criticism. This approach called research dissemination as mentioned in chapter three.

7.6 Chapter Summary

As mentioned earlier in this chapter. The goal of this chapter is to validate the outcomes of this research project. The barriers for implementing lean in HSCM were validated through experts' judgement, the developed model was validated by using multi-grade fuzzy logic and case studies and the developed framework was validated qualitatively, quantitatively (statistically) and from academic's perspective. Five experts from each healthcare organization participated in the validation process.

8 Chapter Eight: Discussion and Conclusions

8.1 Introduction

This last chapter seeks to present the research outcomes and discuss them methodically as illustrated in Figure 8.1. In addition, conclusions based on this study's findings are presented below.

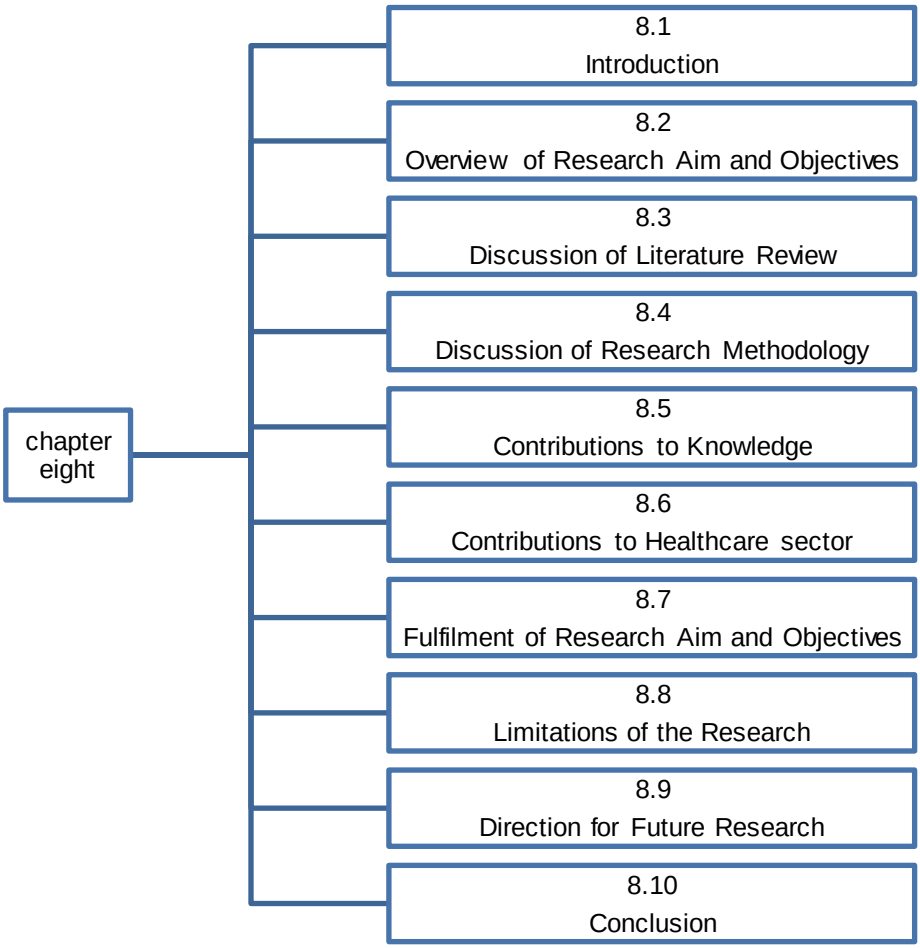


Figure 8.1 main sections of chapter eight

8.2 Overview of Research Aim and Objectives

This section recapitulates the research's aim and objectives. The aim was given in chapter one as to develop a framework for implementing lean thinking in supply chain management in healthcare organisations. To achieve this goal, six objectives were set:

- To understand the best practices of supply chains in healthcare settings via a comprehensive literature review (Chapter Two)
- To determine the main enablers and barriers for healthcare organisations seeking to implement lean practices in supply chains (Chapter Four)
- To develop a model to assess supply chain leanness in healthcare organisations (Chapter Five)
- To create a leanness index for supply chains in healthcare organisations (Chapter Five)
- To develop a framework for the implementation of lean principles in supply chain management in healthcare organisations (Chapter Six)
- To validate this research's outcomes based on expert judgement (Chapter Seven)

8.3 Discussion of Literature Review Findings

A review of the literature on lean implementation highlighted multiple points:

- A great number of organisations have attempted to follow lean principles in their processes, but few lean initiatives have been successful.
- Lean implementation is difficult and challenging, so great effort is required to embark on the lean journey.
- The implementation process differs between industries and countries due to varying cultural patterns.
- Organisational culture plays a vital role in the building and developing of lean implementation frameworks.
- Most recent studies have reported that the number of manufacturing organisations that have implemented lean practices is much higher than the number of service organisations that have deployed this strategy.
- Few studies have been conducted in healthcare organisational contexts versus other service organisations.
- Little effort has been made to identify the barriers and enablers of implementing lean practices in healthcare supply chain management (HSCM).
- No existing study has focused on how lean HSCM is overall in developing countries, especially in Saudi Arabia.

- No prior research has sought to test whether leanness can be assessed in healthcare contexts by applying a leanness index to HSCM processes.
- Lean implementation in healthcare organisations is still a promising field of research that needs further investigation.

8.4 Discussion of Research Methodology

As mentioned previously in Chapter Three, this research used a quantitative approach in some areas, but the primary methodology is qualitative. The research included conducting semi-structured interviews with 15 experts from 3 different hospitals in Saudi Arabia. A focus group was used to validate the results. The data were collected from various sources to reduce bias as much as possible. In addition, structured analysis was conducted to identify the relative importance of – and prioritise – lean implementation barriers and the most effective solutions proposed. Next, the main results were presented to participants to validate the findings and reduce possible bias.

A lean implementation framework was then developed in four phases:

- Phase 1: Understanding the context
- Phase 2: Developing research strategies
- Phase 3: Conducting data collection and creating the framework
- Phase 4: Validating the results

The leanness assessment model was constructed by following the same steps. The model's purpose was to identify what level of leanness can be achieved by five lean enablers in HSCM or, in other words, to what extent HSCM processes are lean. To identify barriers in implementing lean practices in HSCM, four further phases were followed to achieve this study's aim:

- Phase 1: Reviewing the literature
- Phase 2: Visiting healthcare organisations (i.e. field studies)
- Phase 3: Conducting structured interviews
- Phase 4: Validating the results

8.5 Contributions to Existing Knowledge

On a theoretical level, this research's findings add considerable value to the field's existing body of knowledge by providing a fuller understanding of how healthcare organisations implement lean principles in their supply chain management. This study's results include a framework that should facilitate hospitals' implementation of lean practices in HSCM. In addition, key challenges, primary enablers and success factors in this process were identified.

Although extensive research has been conducted on leanness models, the literature does not yet include an instrument that can be used to assess organisations' level of HSCM leanness. The present study developed a novel HSCM leanness assessment model that can evaluate how lean HSCM practices are. Identifying the degree of leanness already present can open managers' eyes to weak areas in their HSCM. This assessment tool can also support the continuous improvement of projects and facilitate the application of lean concepts in HSCM. By applying this model, hospitals can identify both their desired and required leanness levels.

8.6 Contributions to practitioner (Healthcare sector)

HSCM practitioners should benefit from this research's findings. The proposed framework's implementation could contribute significantly to improving supply chains' overall performance and work quality by reducing cost, eliminating waste and ensuring on-time delivery. In addition, flows of medical items and information can be strengthened, thereby diminishing patients' waiting time, avoiding shortages of necessary medical items and increasing consumer safety.

Little attention has been paid to healthcare providers' implementation of lean t in developing countries. This study, therefore, created a new framework for implementing lean principles in HSCM in Saudi, which appears to be the first of its kind. This framework could help decision makers incorporate lean practices successfully into HSCM.

Although lean concepts are widely applied in developed countries, few researchers have focused on how healthcare organisations are implementing lean principles in developing countries. No prior study has identified lean

implementation barriers in HSCM in developing countries, especially in Saudi Arabia. This study is thus the first to seek to reduce barriers to implementing lean practices in this country's healthcare supply chains. More specifically, no existing research has highlighted barriers to lean hospital supply chain management despite how important these organisations are in healthcare settings.

The barriers identified and their proposed solutions are thus tailored to meet the specific needs of Saudi healthcare organisations, including how lean barriers can be overcome by Saudi healthcare providers. This research's results also contribute to filling gaps in the literature by proposing ways to overcome lean implementation barriers in HSCM, as well as expanding the existing knowledge about successful lean implementation in hospital settings. The proposed method of addressing these barriers more directly could assist HSCM decision makers to implement lean principles more successfully in supply chain activities.

8.7 Fulfilment of Research Aim and Objectives

Chapter One defined this study's aim and objectives. The following subsections summarise how each objective has been achieved.

8.7.1 Objective One

To understand the best practices of supply chains in healthcare settings via a comprehensive literature review

This objective was addressed in **chapter two** by reviewing the state of the art of research on HSCM and lean practices and examining real life practices based on visits to three Saudi healthcare organisations. After combining these two sources of information, the following points were highlighted:

- Most lean implementation research has been carried out in the manufacturing sector, and few studies have focused on the service sector.
- Most studies have been conducted in developed countries, while only a few have involved developing countries.
- Lean implementation is a daunting task and even more difficult in the service sector, so many organisations have failed to implement lean practices for many reasons, such as failing to prepare adequately for lean

implementation and ignoring lean barriers before starting on the lean journey.

- Identifying the level of leanness in healthcare organisations is important in order to elucidate each organisation's position with regard to lean practices, but the literature reveals a shortage of knowledge in this area.
- Although extensive research has been carried out on lean principles and supply chain management, the integration of these two concepts, especially in healthcare, has not been addressed adequately in the Middle East, in general, and Saudi Arabia, in particular.
- The literature shows that too few studies have focused on accurately determining how lean concepts can be implemented in supply chain management, especially in healthcare contexts.
- Although multiple studies have been conducted of lean practices in the service sector, no model has been developed to assess the degree of leanness in HSCM.
- Even though lean enablers, factors and barriers play a crucial role in lean practices' success or failure in the healthcare sector, these elements have not yet been investigated in terms of HSCM.
- While many researchers have sought to build a helpful framework for lean implementation in the service sector, none have focused specifically on HSCM.

8.7.2 Objective Two

To determine the main enablers and barriers for healthcare organisations seeking to implement lean practices in supply chains

This objective was addressed in **chapter four**. Nine barriers and five enablers were identified based on the literature review and expert interviews. Which barriers hospitals should first meet was also determined by drawing on the experts' experience and knowledge. The main enablers are medical management responsibilities, HSCM process management (i.e. operational excellence), medical human resources, consumer relationships and supplier

relationships. In addition, the barriers to lean implementation were identified as follows:

- Physicians' existing preferences
- Unpredictable patient demands
- Inadequate knowledge and a lack of understanding of lean concepts
- Identification of types of waste throughout HSCM processes that hinder the delivery of value to patients
- A lack of hospital support and commitment, as well as disbelief in lean principles
- Organisational culture and resistance to change
- A scarcity of qualified human resources and a lack of training
- The assessment of required levels of leanness
- A lack of effective communication and information sharing

The most important barrier healthcare organisations face when they attempt to deploy lean initiatives in their supply chain management is a scarcity of qualified human resources and a lack of training. This barrier was given a priority (i.e. importance) of 4.80 out of 5, as mentioned in Chapter Four.

8.7.3 Objectives Three and Four

To develop a model to assess supply chain leanness and create a leanness index for healthcare organisations

These two objectives were addressed in **chapter five**. A new model was developed to assess how lean hospitals' supply chain management is. This model provides the basis for an HSCM leanness index. By applying this model, managers can identify which HSCM processes need further improvement and where waste occurs. The model consists of 5 enablers, 10 criteria and 38 attributes. The index can be used to produce a score that indicates to what extent HSCM practices in healthcare organisations are lean, partially lean or not lean.

8.7.4 Objective Five

To develop a framework for implementing lean principles in healthcare organisations' supply chain management.

This objective was addressed in **chapter six.** The framework developed should enable decision makers in healthcare organisations to implement lean HSCM practices. To achieve this objective, four steps were followed: understanding the context, developing research strategies, collecting data and developing a framework and validating the results. The proposed framework consists of four phases. Each phase includes many steps taken to achieve the entire phase. The four phases are as follows:

- Phase One: Preparing for lean implementation
- Phase Two: Assessing the current state of lean practices
- Phase Three: Developing a vision of the desired future level of leanness
- Phase Four: Maintaining a steady (i.e. sustainable) rate of new lean initiatives

8.7.5 Objective Six

To validate the research outcomes based on expert judgement

To achieve this objective was addressed in **chapter seven**. Three Saudi hospitals were visited, and 15 experienced and knowledgeable experts were interviewed. The proposed model was also validated by peer reviewers and published in the *International Journal of Lean Six Sigma* under title 'assessing the Leanness of a Supply Chain Using Multi-grade Fuzzy Logic: a Healthcare Case Study'. The article was published by Emerald Publishing Limited with DOI 10.1108/IJLSS-03-2018-0027. Publication is one of the most reliable validation strategies due to the feedback process involved. This step is referred to as 'research dissemination' in Chapter Three.

8.8 Limitations of the Research

The limitations of this study's findings present opportunities for future researchers to investigate lean activities in other Saudi industries and Middle East countries. Although the proposed model was validated for only a few healthcare

organisations, the expert interviewed indicated that similar results can be expected throughout the healthcare sector in Saud Arabia. This research's results thus confirm previous studies' reports that lean practices are still in the early stages of implementation in Saudi Arabia.

Although, the developed framework will help decision makers in healthcare organization for implementing lean thinking in supply chain context, this study has its limitation. This study focused on health-care organizations, which were selected from hospitals operated by the Ministry of Health and only those hospitals that are accredited by both the Saudi Central Board for Accreditation of Healthcare Institutions and the Joint Commission International. The framework is limited to Saudi health care.

8.9 Direction for Future Research

As all research does, the current study had some limitations, which could be the basis for future research agendas. For example, more case studies should be investigated to strengthen the present findings. Moreover, this research was conducted in public healthcare organisations managed by the Saudi Ministry of Health. Other healthcare providers operated by different health systems (e.g. hospitals run by the Ministry of Defence and Ministry of Interior) need to be examined for other systems' impacts on levels of lean implementation. Because the present study was limited to data gathered on public healthcare organisations in Saudi Arabia, the current findings should be validated for other developing countries to ensure that the proposed model works consistently in different contexts. In this way, the model could be applied in healthcare organisations in different developing countries.

Finally, this research focused on organisations that have already been accredited by both the Saudi Central Board for Accreditation of Healthcare Institutions and the Joint Commission International. Examining the relationship between accreditation by institutions that monitor quality and the level of lean implementation in healthcare organisations could be one more research question worth answering. Data were also gathered from three large Saudi hospitals, so future studies may want to investigate implementations of lean concepts in other service sector organisations and make comparisons to healthcare institutions.

8.10 Conclusion

The assessment of leanness in healthcare organisations is becoming of increasingly vital importance. The present study thus developed an innovative model for evaluating the level of leanness of healthcare organisations' supply chains. The model was validated by five knowledgeable, experienced healthcare provider employees. The supply chains' leanness was calculated for selected healthcare organisations based on the factor weightings (i.e. relative importance) and scores assigned by experienced staff from Saudi healthcare organisations. Subsequently, further improvements were made to the model as suggested by the experts consulted in order to evaluate better the implementation of lean practices in supply chains. The final supply chain index identifies the gap between the organisations' current situation and their desired state, thereby assisting managers by deepening their understanding and identifying attributes needing further improvement.

Currently, hospitals strive to improve their performance and reduce costs by applying lean principles. To implement lean concepts successfully, lean enablers and success factors need to be identified. Previously, the enablers for implementing lean practices in HSCM had not been investigated in the Middle East, in general, and Saudi Arabia, in particular. Most prior studies extracted their lists of enablers and factors from the manufacturing sector or the service sector in developed countries. No previous research has focused on lean enablers in hospital supply chains in the Middle East or Saudi Arabia. Therefore, the literature revealed a need to identify a set of enablers and factors that could be more suitable for this country's hospital supply chains.

Lean principles are applicable to HSCM, but lean implementation and transformation requires enablers and success factors that allow organisations to imitate previously successful implementations in healthcare. These enablers are specifically medical management responsibility, HSCM process management, medical human resources, consumer relationships and supplier relationships. In conjunction with success factors, these enablers facilitate healthcare organisations' adoption of continuous improvement projects.

No easy or quick methods have been found for becoming a lean healthcare organisation. For instance, Toyota has taken over 50 years to implement a continuous improvement approach throughout the entire company (Grove et al., 2010). In the present study, nine key barriers to lean implementation were identified. These obstacles to successful implementation can be overcome by adopting many lean practices. Physicians' buy-in, appropriate technology and hospital leadership support can transform organisational cultures in order to reduce resistance to change.

This process needs to include developing excellent communication, effective information sharing, employee training programmes and reward systems to motivate individuals to accept changes. All of these strategies enable healthcare organisations to build their own lean philosophy based on valuing patient satisfaction and not simply implementing techniques and tools adopted by other industries. Overall, a clear lack of trained supply chain management employees was observed in Saudi healthcare organisations, which should be considered the main issue decision makers need to address in HSCM.

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APPENDICES

Appendix (A)

Introduction:

At the beginning I would like to express my thanks for agreeing to participate in this research. This research aims to develop a framework for implementing lean thinking in hospital supply chain management (HSCM). Your participation and valuable comments will help the researcher to develop the framework and therefore help hospital to deploy lean thinking. The researcher will provide you research's findings.

Regarding the interview, I'm interested in your opinion about the implementation of lean thinking in HSCM. Therefore, I want to discuss with you questions related to the aim of this research.

Please do not hesitate for further information.

Abdulaziz Almutairi
PhD researcher
Cranfield University
a.almutairi@cranfield.ac.uk
almutairiam@gmail.com
Tel. +447801290038
Tel. +966599550095 (WhatsApp)

General information:

Please read the questions carefully and answer them as appropriate:

	Appropriate Answer
Hospital	……
Departement	Excutive director
	Medical supply
	Capital equipment
	Purchasing and Tendering
	Store / warehouse
	Material management
	Other,please specify……
Experience	1-5
	6-10
	11-15
	16-20
	More than 21
continouos improvement project(s) involved	1
	2
	3
	More than 3
accreditation certificate	CBAHI
	JCI
	Other,please specify……

Semi-Structured Questionnaire

8. Do you believe implementing lean thinking will improve/enhance the HSCM processes?
9. Do you think there are improvements needed in the HSCM processes?
10. What is driving your hospital toward becoming lean?
11. What are the factors contributing to the success of lean thinking in the HSCM processes?
12. What are the barriers to implementing lean thinking in the HSCM processes?
13. What solutions may have required to overcome the current barriers?
14. Is there any aspect (factors to success, barriers), which you feel is important for the topic and the research have not covered?

Structured Questionnaire

For each of the following statements listed below, please tick the box that indicates your opinion of its importance to supply chain processes in your organization?

importance	*Last important*	*Less important*	*important*	*Very important*	*Extremely Important*
effectiveness	*last effective*	*less effective*	*effective*	*Very effective*	*Extremely effective*
Rate	1	2	3	4	5

Q1. To what extent do you believe that:

- ***Lean barriers represent the real obstacles for implementing lean in HSCM***
- ***The proposed solutions significantly and effectively contribute to overcome lean implementation barriers in HSCM?***

No	Barrier	Barrier's importance					Solution's effectiveness				
		1	2	3	4	5	1	2	3	4	5
1	Existence of physicians' preferences										
2	Unpredictable patient demand;										
3	Inadequate knowledge and lack of understanding lean concept;										
4	Identifying the type of waste through hospital supply chain processes (delivering value to the patient);										
5	Lack of hospital support, commitment and disbelief in lean;										
6	Hospital culture and resistance to change										
7	Scarcity of qualified human resources and lack of training										
8	Assessment of the required level of leanness;										
9	Lack of effective communication and information sharing										

No		Suggested Solutions to overcome Barrier
S_1	S_{11}	Physicians buy-in.
	S_{12}	Creating "standards and sourcing committee"
S_2	S_{21}	Using information technology such as radio-frequency-identification (RFID)
	S_{22}	Clear policies, procedures and practices should be implemented by hospitals
S_3	S_{31}	Presenting a real-life scenario of lean success in another hospital.
	S_{32}	Well-trained HSCM managers to understand the knowledge for implementing lean
	S_{33}	Using benchmark approach
S_4	S_{41}	Applying value stream mapping and 5S
	S_{42}	well-trained HSCM staff for implementing lean tools
S_5	S_{51}	building a lean dashboard at workplace facilitates both operators and managers to track the ongoing processes, reduce non value adding activities
	S_{52}	pay attention toward bottlenecks
	S_{53}	Linking lean objectives with hospital strategic plan.
	S_{54}	leveraging previous lean implementation experience
S_6	S_{61}	Sharing information about lean,
	S_{62}	effective communication
	S_{63}	lean project success initiative stories
	S_{64}	Attending awareness sessions such as lean six sigma yellow belt
	S_{65}	Applying effective rewarding and recognition system (incentive)
S_7	S_{71}	investment in staff training
S_8	S_{81}	implementing leanness maturity assessment model
S_9	S_{91}	share information, work closely, and go against "silo working"
	S_{92}	documenting all information and making it available on intranet (internal network).
	S_{93}	Establishing effective and clear channels for communication at all healthcare SCM levels

Structured Questionnaire

What are the main enablers for the potential successful implementation of lean in HSCM processes?

No	Enablers	1	2	3	4	5
1	**Medical Management Responsibility**					
2	**HSCM Processes Management**					
3	**Medical Human Resources**					
4	**Consumer relationship**					
5	**Suppliers relationship**					

What are the main factors related to Medical Management Responsibility enabler in HSCM processes?

No	factors	1	2	3	4	5
1	**Hospital management support and commitment toward lean initiative**					
2	**Hospital leadership**					

3	Patient safety as ultimate goal of a hospital (patient-oriented)					
4	Hospital Culture					
5	Understanding wastes in HSCM					

What are the main factors related to HSCM Processes Management enabler in HSCM processes?

No	factors	1	2	3	4	5
1	Medical purchasing processes					
2	HSCM measurement of performance					
3	Medical information exchange					
4	smooth flow of medical item and information					
5	Using value stream mapping					
6	Adopting continuous improvement tools					
7	Systematic measures for solving a problem (action plan)					

What are the main factors related to Medical Human Resources enabler in HSCM processes?

No	factors	1	2	3	4	5
1	Accepting change by HSCM employees					
2	Staff training (medical and non-medical)					
3	HSCM employees and Physicians empowerment					
4	Multi-skilled HSCM employees					
5	Effective communication between HSCM departments					

What are the main factors related to consumer relationship enabler in HSCM processes?

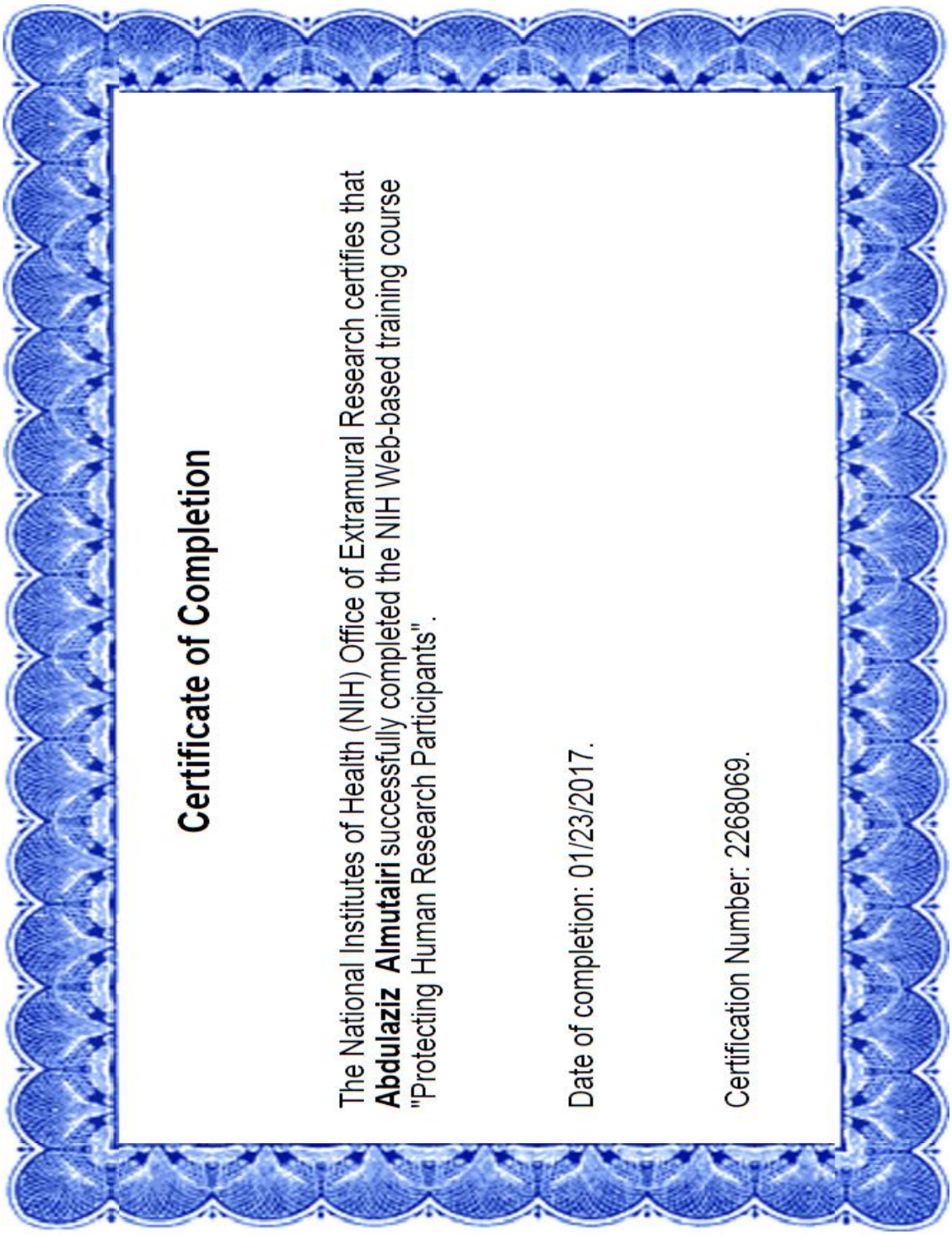
No	factors	1	2	3	4	5
1	On time delivery to patients					
2	Medical team (i.e. Physicians) involvement					
3	Buy-in between medical staff and Physicians Preference items					
4	Patients / doctors feedback on delivery performance and cost					

What are the main factors related to supplier relationship enabler in HSCM processes?

No	factors	1	2	3	4	5
1	Medical items arrive as per request (on time, right quantity)					
2	Supplier lead time					
3	Monitoring supplier performance					
4	Supplier involvement					

Appendix (B)

The National Institutes of Health (NIH) Office of Extramural Research.



Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Abdulaziz Almutairi** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 01/23/2017.

Certification Number: 2268069.