

# Chapter 1

## INTRODUCTION

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### 1.1 Introduction

Diabetes, a disease no longer associated with affluence, is on the rise across the globe (IDF, 2017). Diabetes has become a major health challenge in India in recent past (Joshi, 2015). The latest edition of Diabetes Atlas reports that over 82 million people in India are suffering from diabetes and this number is expected to increase in coming future (IDF, 2017). Rapidly changing socioeconomic demographics have put India at risk of the diabetes epidemic. Genetic predisposition combined with lifestyle changes associated with urbanization and globalization, all together contribute to the rapid rise of diabetes in India (Nakagami et al., 2003). The Indians are genetically at high risk of diabetes and there are lower thresholds for the effect of BMI on age-adjusted type 2 diabetes (T2D) prevalence rates among Indians. This scenario has put immense pressure on Indian healthcare system which is hardly prepared to face this humongous surge.

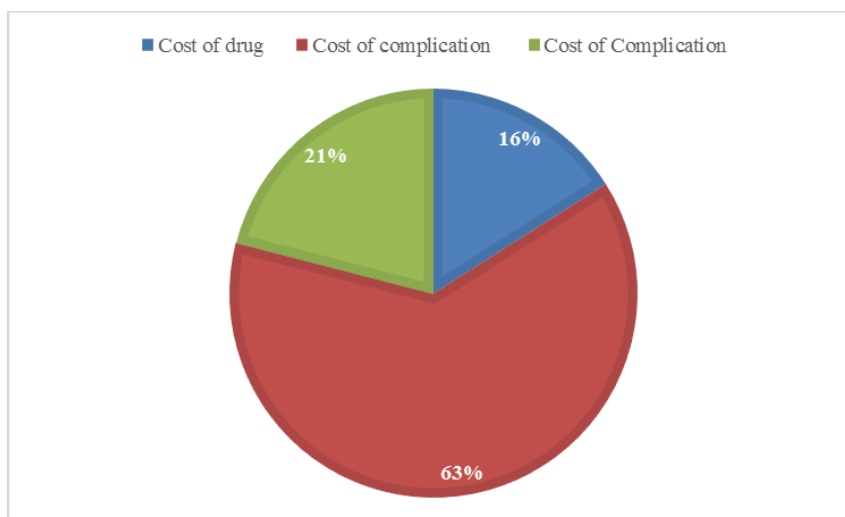
India has a vast health care system, but there remain many differences in quality between rural and urban areas as well as between public and private healthcare. The healthcare system in India is below par and already under a lot of pressure. Moreover, the system is designed to handle acute care and illness related to mother & child. Sixty percent of the ambulatory care is provided by the private player and is out of reach of the majority of the population. The quality of care is a major cause of concern in rural areas and situation is further aggravated by the presence of quacks in these areas.

## **1.2 Economic Burden of Diabetes**

To abate the rising prevalence of diabetes integrated effort is required in the direction of its prevention and control. However, these will not occur unless governments and public health planners are aware of the potential problem. With improvements in the diabetes management efforts, the prevalence of patients with complication is likely to increase as more people survive for longer after diagnosis (Amos et al., 1997). Thus the economic burden of diabetes is bound to increase in both of the cases. This scenario makes it imperative to reduce the waste in healthcare operation and apply lean strategies to reduce the economic burden of the disease.

An Indian study in the year 2013 reports the direct cost per person per year of diabetes in urban and rural India as ₹10,000 and ₹ 6260 respectively. Considering the inflation in healthcare in the recent year this figure would have further increased (Singh, 2013). Grover et al. (2005) conclude, that the total annual cost of care as ₹ 14,508. The largest proportion of the total cost was made up of direct costs (68%), followed by indirect costs (28.76%) and provider's costs (2.8%). They also conclude that the Drug cost is one of the highest components of the cost. The cost of hospitalization is highest among the patients at the advanced stage of the disease. The cost of medicine is one of the most important costs considering the chronic nature of the disease. The cost of hospitalization increases at an advanced stage of the disease (Kapur, 2007). A study estimates that 44% of the study population was hospitalized for diabetes-related complications. Singh (2013) reports, the annualized estimate of costs on hospitalization as ₹12,781. A cardiac event was the most common as well as the costliest cause of hospitalization followed by a non-healing wound like a diabetic foot.

The healthcare insurance penetration in India is dismal. Singh (2013) in his paper provides the breakup of the cost of diabetes in India as ambulatory care constituting 65% cost whereas hospitalization cost is 35%. Yesudian et al. (2014) reports cost of drug 16%, general cost 63% and cost of complication 21% (Figure 1.6)



*Figure 1. 1: Breakup of the Cost of Diabetes*

According to an estimate, more than eighty percent of all health care costs are borne by individuals and their families from household income. The lower income group doesn't invest in the prevention of diabetes and can't afford the treatment at the advanced stage of the disease. This makes it imperative that government intervene to create the awareness about the disease in masses and provide affordable means to identify the disease at early stage. It is ironic that the poor result in paying a larger proportion of household income toward diabetes care. Direct expenses consume 27–34% of household incomes of rural and urban poor people while the middle-to-high income groups in rural and urban areas consume 5.0–12.6% and 4.8–16.9% of income respectively on diabetes care (Ali et al.2009). Year-on-year,

more and more people from the low-income group are falling into the trap of diabetes and prevalence of the diabetes is increasing in this group.

The number of people living with diabetes is increasing exponentially in India. The disease has become a major health challenge in the country in last decade (Joshi & Parikh, 2007). The chronic nature of the disease makes the treatment extremely costly. The cost of treatment of diabetes can be divided into two categories, namely direct and indirect cost (Jönsson, 2002). The direct cost includes the expenses related to treatment while indirect cost includes the loss of productivity. In addition to this cost, there is an intangible cost which includes reduced quality of life due to pain, anxiety, and stress (Bjork et al., 2000). The studies indicate that there has been a significant increase in the cost of diabetes management in the recent time (Kapur, 2007; Akari et al., 2013). With the progression of the disease, the cost of treatment increases many folds because of co-morbidities (Al-Maskari et al., 2010; Henriksson et al., 2000, Hogan et al, 2003). The studies suggest that the increasing cost of treatment results in low adherence to medication regime (Sokol et al., 2005; Ho et al, 2009). In a recent study, Roebuck et al. (2011) concluded that improved medication adherence by people with diabetes produced substantial medical savings as a result of reductions in hospitalization and emergency department use. India lags in healthcare infrastructure and a number of doctors and the beds-to-patients ratio is far below the World Healthcare Organization (WHO) guidelines. The Non-Government- Organization (NGO) can play an important role in bridging this gap. The NGO's have limited number of resources and need to optimally allocate the resources to maximize the social welfare.

## **Cost of Treatment**

There is an acute shortage of hospital beds and doctors in India and more than 50 percent of the ambulatory care is provided by the private players. The country has witnessed spiraling medical expenses in recent years. According to National Sample Survey Office (NSSO) report, consumer expenditure on healthcare in rural India increased from 6.6% in 2004-05 to 6.9 percent in 2011-2012, urban Indian's expenditure on medical care increased from 5.2% in 2004-05 to 5.5% in 2011-2012. The 70 % of this cost is constituted by medicine. Once diagnosed, the diabetes patient undergoes the treatment regime for rest of his life after, which results in high lifetime cost of treatment of diabetes. The average cost of treatment per diabetes patient per hospital admission, with and without multiple complications, is 314.15 (USD) and 29.1 (USD) respectively. Out of which 255.32 (USD) falls under the direct cost of treatment of the disease (Akari, 2013). Table 1.3, further provides the details of constituents of the direct cost of treatment of diabetes. From the Table, we can conclude that reducing the risk of hospitalization can significantly reduce the cost of treatment of the disease. There is evidence that the self- management education of the disease can help patients reducing the risk of hospitalization for diabetes and hence reduce the burden of diabetes (Norris, 2002). The other suggested measures in the literature are tax rebate and insurance coverage for the spending done on early detection of diabetes (Newhouse, 1992).

*Table 1. 1: Direct Medical Cost per Patient per Hospitalization*

<b>Component of Cost</b>	<b>Average Cost</b>	<b>Cost</b>
Lab Investigations	\$29.45	10.15 %
Medication for Diabetes	\$7.00	2.42 %
Medication for Co-morbidity	\$69.46	23.94 %
Hospitalization	143.75	49.56 %
Doctor's Consultation	40.37	13.93%

### **1.3 Healthcare Financing**

There are three main models for healthcare finance on the basis of their funding. The first one is the Beveridge model (Beveridge, 1998), which is based on taxation and has many public providers. The second is the Bismarck 'mixed' model (Vienonen & Wlodarczyk, 1993), funded by a mix of government and insurance providers. Finally, the 'Private Insurance model' in which the cost of the treatment is borne by the health insurance provider. Health insurance helps to spread the cost of treatment over a large time period. Properly designed and administered health insurance can act as a bridge between patients and providers, balancing quality care at reasonable costs (Srinivasan, 2001).

India has one of the largest private health sectors in the world, with over 80 percent of ambulatory care being supported through out-of-pocket expenses (Duggal, 2007; Gangolli et al., 2005). Out-of-pocket (OOP) expenditure on health care has significant implications for poverty in many developing countries (Berman et al., 2010). In India, three-fourths of the

healthcare expenses are supported by out-of-pocket spend. The government spending on healthcare has been paltry as a percentage of GDP when we compare it with other developing and developed countries. India spends only 5% annual gross domestic product (GDP) on health care which is far below international average (Prinja et al., 2012).

As the earlier sections of the thesis suggest the diabetes patient needs, affordable and quality health care, self-management education and insurance coverage to meet the cost of diabetes management. The government in India has not been able to develop adequate infrastructure and support to manage the sudden surge in a number of diabetes patients (Patil et al., 2002). Despite recent thrust to improve the healthcare infrastructure in India, inequalities related to socioeconomic status, geography, and gender still persists. This situation is further aggravated by high out-of-pocket expenditures (Balarajan et al., 2011).

### **Role of an NGO in Healthcare**

Nonprofit organizations can be registered in India as a Society, under the Registrar of Societies (Society Act 1860) or as a Trust, by making a Trust deed, or as a Section 8 Company, under the Companies Act, 2013 (Ganesh, 2005). They can work in the capacity building, policy shaping or ensure long-term results in healthcare areas. They work in partnership with communities, health institutions, donors, academicians, and governments to achieve these results. An NGO funds its activities through international funding, government funding, local philanthropy, and income-generating activities. NGOs carry out a range of projects including emergency management and relief; health care research; designing and implementing alternative funding and insurance schemes; mobilization, advocacy and raising awareness, health campaigns, protection of patient's right and balancing private players

interest. NGO's can fill the gap in diabetes care by working in areas like disease awareness, free consultation, check-up camps and providing funding for the diabetic patients not able to meet the healthcare expenses. They can also work for bringing transparency and efficiency in healthcare supply chain so that medicine reaches patients at affordable cost. Thus, we can say that NGO's can bridge that gap between demand and supply of diabetes care, but they need to efficiently utilize the scarce resources available at their disposal to maximize the welfare of the patients (Delisle et al., 2005).

### **Resource Allocation in Healthcare**

Healthcare resources are limited and demand exceeds supply, hence allocation becomes a big challenge. In case of private healthcare providers, the allocation is resolved on the basis of the ability to pay. The allocation on basis of ability to pay is against the principle of healthcare equity (Kluge et al., 2007). The next section discusses the various approaches to resource allocation found in the literature.

### **Hippocratic Model**

According to this model, the focus of medical action revolves around the physician-patient encounter. It establishes a fiduciary relationship between the physician and the patient, which means that the physician's duty toward the individual patient overrides all other considerations except insofar as these affect the physician's ability to fulfill her or his patient-related duties (Veatch, 2003; Beauchamp & Childress, 2001; Tauber, 2005).

### **Social Service Model**

This model sees the health care in much broader perspective and considers medicine as one among several social enterprises of which the overall purpose is to advance the well-being



of members of society (Cruess, 2006; Bernardin, 1996). In this approach, the allocation issues assume an entirely different nature. Although the physician-patient encounter still remains an element of fiduciary duty, that element is limited by the constraints pertaining to social welfare maximization (Daniels, 1985; Freidson, 1988).

## **Business Model**

This model considers health care as neither a fiduciary undertaking nor as a health-oriented profession that operationalizes society's duty to do the best for its members (Hui, 2005). The healthcare provider ethically works for the value maximization of its shareholder (Carroll et al., 2006).

### **1.4 Forecasting the Prevalence of Diabetes**

Diabetes prevalence has suddenly increased in India. The health infrastructure in the country is inadequate to address this sudden surge in the demand. The diabetes management in India is plagued with numerous challenges like a number of qualified healthcare professional and basic facilities. This situation require planning of additional capacity for management of chronic disease like diabetes in India. For effectively managing the disease the government and healthcare professionals need to forecast the prevalence of the disease in near future.

Traditionally the tools used for forecasting of the disease are diagrammatic logic models and epidemiological forecasting models. These tools are not capable of addressing the dynamic complexity of diabetes. The policy makers should adopt an integrated system-wide approach to prevention and management of diabetes. The tools like system dynamics modeling can be used for forecasting the prevalence of diabetes in near future.

## **1.5 Facility Planning in Healthcare**

For efficient and effective healthcare delivery, preventive health care programs become very important (Zhang et al., 2009). Unfortunately, the facilities for the early detection are rarely available at the lower centers in India and patients are referred to higher centers only after the disease has progressed to an advanced stage (McGorry et al., 2007). The logistic planning for the network has a direct impact on the whole system's efficiency (Shariff et al., 2012). Thus, facility and logistic planning play an important role in health service planning, as it directly affects the healthcare cost and accessibility (Rahman & Smith, 1999).

Decentralization is the process of distributing or dispersing functions, powers, people or things away from a central location or authority. The decentralization increases the accessibility at the same time results in poor control and utilization. Even in decentralized systems, the role of the central body can be very important to contain health expenditure. Thus there is a need for a middle-path between complete decentralization and centralized control in healthcare services.

## **1.6 Healthcare Quality**

Healthcare industry is facing the dual challenge of health care quality and patient satisfaction. Healthcare services are difficult to evaluate as the credence attributes values are high. The patients don't possess the medical knowledge adequate to assess the performance of healthcare services (Fowdar, 2005). There is a debate about how health care quality should be evaluated. While some authors feel patient perceptions are valuable healthcare quality indicators, others contend that health service quality should be evaluated by experts (Naidu, 2009).

Considering the intangible nature of the service, measuring its quality is an uphill task. The only way to measure it is by measuring the consumer's perception of quality which is very subjective in nature.

The healthcare delivery in case of a chronic disease like diabetes is complex and more involving. According to Oermann & Templin (2000), the most important indicators of healthcare quality to the consumer are the expertise of healthcare provider, being able to communicate and spending enough time with the patients. Another research done by Brown and Swartz (1989) identified, 'professional credibility', 'professional competence' and 'communication' as factors significant in evaluating the service quality in case of the healthcare.

Diabetes is a physiological state of persistent high glucose level in blood. The progression of the disease involves various complications like retinopathy, nephropathy, neuropathy, cardiac problem and diabetic foot. The studies show that physician's communication skill and participatory decision-making style are strongly associated with diabetes management. The diabetes specialty clinic delivers a better quality of diabetes care than a general medical clinic. The knowledge of diabetes care and system resources becomes necessary to deliver good quality of diabetes care (Ho et al., 1997).

### **1.7 Background and Motivation**

The Health Infrastructure in India is inadequate and the country spends less than five percent of GDP on healthcare. Moreover, eighty percent of the healthcare spending is out-of-pocket and a serious ailment drive people into poverty. The traditional healthcare infrastructure is created for acute illness and for disease related to mother and child .There is a need of

forecasting the prevalence of the disease for effective planning. There is also a need of a well-planned healthcare infrastructure to tackle the growth of chronic disease like diabetes, metabolic disorder, respiratory disease and cardiovascular complications. There is a tradeoff between availability and affordability in case of healthcare. The increasing availability at any cost can move health care out of reach of the majority of the healthcare. There is need of cautious decentralization of healthcare to achieve availability as well as resource utilization. To effectively manage the healthcare supply chain it should be matched with appropriate supply chain strategy. The existing methods of matching healthcare supply chain with supply chain strategies may not work in case of chronic care. There is a need to develop a customized method for matching supply chain strategies in case of chronic disease like diabetes.

The patients adhere to medication regimen if they find utility in the service provided. The inclusion of service attributes which are neither critical nor have utility for the patients can increase the cost of care and hence results in non-adherence of medication. There is need to assess the utility of diabetic patients for different service attributes. The literature suggests that quality is one of the most important criteria for selection of a healthcare provider but there is the unavailability of a similar study in the Indian context. Considering the importance of quality in health care delivery, there is a need for quality assessment framework for diabetes care in the Indian context.

### **1.8 Objective of the Research Work**

There is sudden surge in prevalence of diabetes in recent years. For effectively planning to meet this sudden surge there is a need for forecasting the prevalence of diabetes in the near future. Considering the complexity of the diabetes management, the system dynamics modeling was found appropriate for simulating the demand. The policy measures were

proposed and tested using the system dynamics model. Once the demand is forecasted there should be effective facility planning for meeting the demand. This study proposes and used a facility planning method using a case of the Varanasi city. The study also proposes the method for the decentralization decision in case of diabetes care. Literature suggests that healthcare supply chain should be lean as well as agile and to achieve these objectives there should be good supply chain partnership. This research proposes a two-step rule-based method (TRBM) for implementation of lean, leagile and agile strategy in healthcare. In the last but not the least, this research explores the patient's utility for various service attributes of the diabetes care and proposes a customized framework for the assessment of quality in diabetes care. The five research objectives of the thesis can be summarized as below:

6. Developing a System Dynamics model for prevention and control of diabetes in Varanasi
7. Developing decentralization, facility planning, and logistics strategy for diabetes care in Varanasi
8. Implementing leagile strategy in diabetes care
9. Assessing patient's utility for various service attributes in diabetes care
10. Developing a quality assessment and implementation framework for diabetes care

### **1.9 Novelty of the Proposed Research Work**

In the literature review, it is found that majority of the research done in the healthcare facility planning and service design is done in the context of western countries. Moreover, these research are focused on disease like Tuberculosis, Cancer and emergency care only. There is lack of similar studies done for chronic care in the Indian context. In best of our knowledge,

there is a complete absence of any Indian study using system dynamics modeling for prevalence, prevention, and control of diabetes in India. In this research, we have proposed a new method for decentralization decision making in case of diabetes care. The research further proposes a milk-run connecting the central facility with the remote nodes. This study is first of its kind proposing a framework for leagility implementation using five criteria namely: demand variability, lead-time variability, criticality, cost, and perishability. The study calculates the utility of patients for different health care attributes in case of diabetes care and this study is first of its kind to do so in the Indian context. The study concludes that quality is most important criteria for the selection of a hospital, even in an economically backward area like Varanasi. In the last but not the least this study proposes a customized quality assessment framework for diabetes care in India.

In this research work, the gap areas for diabetes management in India were identified and measures were proposed and elaborated using the case study of Varanasi city or a diabetes specialty clinic situated in Varanasi. The method proposed in this research are easy to implement and can be easily adapted for another chronic disease like asthma, HIV, and tuberculosis.

### **1.10 Organization of the thesis**

The thesis is divided into eight chapters where the first chapter is a general introduction to the research work. The chapters 3 to 7 include the research related to the various objectives of the study. The last chapter summaries the study and discuss the future scope of the work.

## **Chapter 2: Literature Review**

This chapter discusses various literature related to the research work and identifies the gap areas in diabetes management in India. The literature review is divided into following five sections:

1. Prevalence, Prevention, and Control of Diabetes
2. Facility Planning, Logistic Strategies, and Resource Allocation
3. Lean, Agile and Leagile Strategy implementation
4. Patient's Utility for Service Attributes in Diabetes Care
5. Healthcare Quality Assessment for Diabetes Care

## **Chapter 3: Prevalence, Prevention, and Control of Diabetes**

This chapter deals with the development of a system dynamics model for prevalence, prevention, and control of diabetes in Varanasi. The model was developed to explain the growth of diabetes since 2017 and portray possible future through 2050. The model simulations suggest characteristic dynamics of the diabetes population, including unintended increases in diabetes prevalence due to diabetes control, the inability of diabetes control efforts alone to reduce diabetes-related deaths in the long-term, and significant delays between prevention effort and improvement in diabetes outcomes.

The simulation model gives the prevalence of diabetes in Varanasi for the years 2030 as 0.52 million and 35.64 %. The study suggests involving 520 specialized doctors for management of diabetes in the city to achieve a ratio of one doctor per thousand population. The research examines the effect of the control efforts by using a ramped increase in the key performance variable over ten years.

The results conclude that in spite of the proposed policy measures the diagnosed diabetes population will decrease while undiagnosed diabetes population will increase and then decrease. Total population suffering from diabetes will increase irrespective of the policy measures, hence only option before policymakers is to tackle diabetes at prediabetes stage and make preventive and curative healthcare available at affordable cost. The method suggested by the study can be easily adapted for developing the similar models for other chronic diseases like Asthma, Chronic Obstructive Pulmonary Disease (COPD) and Tuberculosis.

#### **Chapter 4: Decentralization Facility Planning and Logistic Strategies**

This chapter discusses the facility planning and logistics and decentralization strategies for the Varanasi city. The objective of the research is to identify the location for the central facility and then plan a Milk-Run connecting the central facility with the remote locations. This study classifies the components of diabetes management in two categories namely “central facility only” and “remote facility” using Multi-Attribute Utility Theory (MAUT). There is an assumption that this classification will result in better utilization of resources hence the reduced cost of care. The study concluded that Hospitalization, Neuropathy Detection, Pathology, Pharmacy should be kept at the central facility while other components of care like consultancy, Foot Care, Eye Care, Exercise and Diabetes Education, and Medical Nutrition Therapy should be kept at the remote facility. The study uses nonlinear programming method for identification of central facility and found Chetganj, a location in the center of the city, as the location for the central facility. In the last, the research uses Traveling –Salesman-Problem method for identifying the milk-run route connecting this facility with remote locations. The sequence of the nodes traveled during Milk-Run is:



- ▶ Chetganj-Kotwali-Jaitpura-Adampura-Chowk- Dashashwamedh-Nagwa-Khojwan-Bhelupur-Sigra-Nadesar-Shivpur-Sikraul.

### **Chapter 5: Leagile Strategy Implementation in Diabetes Care**

This chapter discusses a method for identification of best-fit supply chain strategy in case of diabetes care. The study finds out that simple classification on the basis of demand and lead-time variability proposed in the extant literature is not adequate to address the complexity of the healthcare supply chain. The study uses secondary research and expert interview to divide the inventory into eleven homogeneous groups. The study uses Multi-Dimensional Scaling (MDS) method for exploring the dissimilarities of these groups on criteria other than demand and lead time variability. The study then uses focus group discussion to identify three additional criteria for the classification of the supply chain strategy namely criticality, cost, and perishability. Based on these additional dimensions this study proposes a two-step rule-based approach for selection of the best supply chain strategy for the diabetes care.

### **Chapter 6: Patient's Utility for Healthcare Service Attributes**

This chapter of the thesis deals with the identification of patient's utility for various service attributes in the context of diabetes care. The study uses focus group discussion to identify the important attributes for the diabetes care and then uses conjoint analysis to calculate the patient's utility for various service attributes. The study randomly selects 301 patients from a diabetes specialty clinic in Varanasi. The result of the study shows that quality is most important criteria for selection of a hospital followed by waiting time. The least important criteria for selection of a diabetes clinic was the distance of the hospital.

## **Chapter 7: Quality Assessment and Implementation for Diabetes Care**

This chapter of the thesis proposes and uses a framework for assessment and implementation of quality in a healthcare organization. The research also proposes and uses a framework for assessment and implementation of quality in a healthcare organization. First of all, the study identifies eighteen attributes using focus group discussion as: Quality of Clinical Care, Quality of Investigation, Cost of Medicine, Length of Stay, Professional Flexibility, Practitioner's Attitude, Administrative Staff's Attitude, Waiting Time, Facility Availability, Access, Grievance Handling Time, Medical Record Keeping, Hospital Infection Control, Privacy, Waste Disposal Policy, Process Flexibility, Cost of Consultancy, and Cost of Investigation. The high correlation among the variable suggested us to perform factor analysis to reduce the list of variables. The six factors identified after the factor analysis were: Employee Attitude Factor, Care Delivery Factor, Cost of Care Factor, Cleanliness and Privacy Factor, Customer Relationship Factor and Process Flexibility Factor.

Then the study uses Interpretive Structural Modeling(ISM) for identifying and summarizing relationship among these factors related to the quality of diabetes care. The ISM Model identifies employee attitude as the most important factor in the implementation of quality practices in a healthcare organization. In the last Analytic Hierarchy Process (AHP) was used to calculate the priority weights of these factors. The study found the weights for the factors as Employee Attitude (0.337), Care Delivery (0.337), Cost of Care (0.164), Cleanliness & Privacy (0.039), Customer Relationship (0.084) and Process Flexibility (0.039).

## **Chapter 8: Summary and Conclusions**

The concluding chapter 8 concludes major finding of the study, along with its contribution, limitation, and scope for future research.

Finally, this thesis forecasts the prevalence of diabetes in near future in chapter 3. The 4<sup>th</sup> and 5<sup>th</sup> chapter of the study deals with facility planning and supply chain strategies respectively. The chapter 6 uses conjoint analysis for designing the healthcare services for diabetes. The study identifies quality as the most important factor in healthcare and chapter 7 provides a framework for quality assessment and implementation in case of diabetes care.