Distinguishing mHealth from other health care alternatives in developing countries: a study on service characteristics

Author:
Motamarri, Saradhi

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Distinguishing mHealth from other Health Care Alternatives in Developing Countries: A Study on Service Characteristics

By

Saradhi Motamarri

Thesis submitted in fulfilment of the requirements
For the award of the Degree of Master of Philosophy

Supervisors

Pradeep Ray & Chung-Li Tseng

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Services in general and healthcare services in particular require proper planning and design so as to address patients' concerns and improve outcomes. In this context, mobile phone's wide spread penetration coupled with its versatility is transforming it as a significant delivery channel for healthcare services. Mobile Health (mHealth- healthcare using mobile phones) is expected to enhance the access to healthcare especially, in the developing world. Following the House of Quality (HoQ) for service design, the literature search identified significant gaps in comparatively assessing mHealth with the other conventional services. Such an analysis is important for the large scale adoption of mHealth.

To fill this gap, the current research has carried out a quantitative comparison of healthcare services, an important element of HoQ. The study explores the broad research questions: whether service alternatives are distinguishable from each other and if so, what factors contribute to the differentiation. A multiple discriminant analysis (MDA) is performed to understand patients' perceptions of various healthcare services: public hospital (PH), general practitioner (GP), traditional medicine (TM) and B2C mHealth service in a developing country.

***Ubiquity, information quality and value** have been identified to have significant influence on the patients' attitude towards healthcare services. mHealth is perceived by the patients as far more easy to use, useful and valuable than other service alternatives. These insights are incorporated into the HoQ model for healthcare service design. mHealth is found to be an effective alternative to serve the developing world where populations are marginally deprived of even basic healthcare services. Theoretical and practical relevance of these findings are analysed and some directions are provided for future research.*

Keywords: *mHealth, discriminant analysis, patients' perception, Quality Function Deployment (QFD), House of Quality (HoQ), ubiquity, information-quality, value, comparative analysis, health care services, developing countries, services design.*

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Publications Associated with this Thesis

Paper Title	Conference/ Journal	Year
Distinguishing m-Health from Other Health Care Systems in Developing Countries: A Study on Service Quality Perspective	CAIS Accepted for publication	2013
House-of-Quality and Comparative Assessment of Healthcare Services (book chapter)	Mobile Health (mHealth): Multidisciplinary Verticals, *to be published by Taylor & Francis (CRC Press)*	2013 (forth coming)
mHealth: A Better Alternative for Healthcare in Developing Countries	PACIS-2012 (ERA-A Conference)	Jul, 2012
The Status of Healthcare Service Delivery Systems Comparison, Mobile Health, and Healthcare Service Design	2nd Australian Symposium on Services Research and Innovation	Nov, 2012
Self-Management of Chronic Diseases Through mHealth	Journal of eHealth Technology & Applications, 10 (1)	2012
Cost Models for mHealth Intervention in Aged Care Diabetes Management	ACIS-2011 (ERA-A Conference)	Dec, 2011

Abstract

Services in general and healthcare services in particular require proper planning and design so as to address patients' concerns and improve outcomes. In this context, mobile phone's wide spread penetration coupled with its versatility is transforming it as a significant delivery channel for healthcare services. Mobile Health (mHealth-healthcare using mobile phones) is expected to enhance the access to healthcare especially, in the developing world. Following the House of Quality (HoQ) for service design, the literature search identified significant gaps in comparatively assessing mHealth with the other conventional services. Such an analysis is important for the large scale adoption of mHealth.

To fill this gap, the current research has carried out a quantitative comparison of healthcare services, an important element of HoQ. The study explores the broad research questions: whether service alternatives are distinguishable from each other and if so, what factors contribute to the differentiation. A multiple discriminant analysis (MDA) is performed to understand patients' perceptions of various healthcare services: public hospital (PH), general practitioner (GP), traditional medicine (TM) and B2C mHealth service in a developing country.

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Abbreviations Used in this Thesis

Abbreviation	Expansion	Page
AIHW	Australian Institute of Health and Welfare	3
ASI	American Supplier Institute	75
B2B	Business to Business	21
B2C	Business to Consumer	21
C-ACM	Communications of the Association for Computing Machinery	4
CHMI	Centre for Health Markets Research and Innovation	124
CIET	Canadian Institute for Energy Training	19
CR	Customer requirement	73
DA	Discriminant Analysis	23
DF	Discriminant function	81
DI	In-depth interview	61
DV	Dependent variable	80
EC	Engineering characteristic	73
eHealth	Electronic Health	16
FGD	Focus group discussion	61
GDP	Gross Domestic Product	71
GOe	Global Observatory for eHealth	28
GP	General practitioner	53
GPS	Global positioning system	29
GPRS	General packet radio service	29
HoQ	House of Quality	3
ICT	Information and Communications Technologies	14
IOM	Institute of Medicine	23
IS	Information Systems	5
ITIL	Information Technology Infrastructure Library	38
ITU	International Telecommunication Union	15
IV	Independent variable	80
MDA	Multiple discriminant analysis	6
MDG	Millennium development goals	22

Abbreviation	Expansion	Page
mHealth	Mobile Health	1
NCD	Non-communicable disease	18
NIC	National Intelligence Council	17
OGC	Office of Government Commerce	7
OM	Operations Management	5
PDA	Personal digital assistant	29
PH	Public Hospital	53
QFD	Quality Function Deployment	3
SAS	Statistical package from SAS Institute	80
SLC	Services Life Cycle	35
SMS	Short messaging service	29
SPSS	Statistical packages from IBM	80
SSC	Secondary School Certificate	91
TM	Traditional medicine	53
VoC	Voice of Customers	2
WHO	World Health Organisation	6

List of Key Terms and Definitions

Consumers or users or patients:

They are the ultimate users of services. However, the term also refers to the buyer or decision maker as well as the ultimate consumer (Kotler and Keller 2006).

Developing countries:

The nations which often have abundant natural resources but lack the capital, entrepreneurial and technical skills required to develop them. The average income per head and the standard of living in these countries is therefore far below that of the industrial nations (Worldbank 2004).

Discriminant Analysis (DA) or Multiple Discriminant Analysis (MDA):

Discriminant Analysis is a classification technique which helps in identifying the factors (or *independent variables*, IVs) that differentiate the cases into various categories of a categorical *dependent variable* (DV) (Hair et al. 2010; McLachlan 1992). When a DV has more than two categories the technique is referred to as Multiple Discriminant Analysis.

mHealth hotline service:

A personalised and interactive health service over a mobile phone in order to provide ubiquitous and universal access to medical information services to any patient (Ivatury et al. 2009).

Quality Function Deployment (QFD):

To address competitive challenges of the manufacturing sector Mizuno and Akao have developed tools and techniques that later came to be known as *Quality Function Deployment* (*QFD*) (Mazur 1993; Mizuno and Akao 1978). QFD has enabled to resonate the '*voice of the customer*' across the levels of the organisation end-to-end i.e., from planning to production.

House of Quality (HoQ):

House of Quality (HoQ) is a basic design tool. It is the first phase of QFD approach and is fundamental and of strategic importance (Chan and Wu 2005).

Service:

The application of specialized competences (knowledge and skills) through deeds, processes and performances for the benefit of another entity or the entity itself (Vargo and Lusch 2004).

Service quality or perceived service quality:

A consumer's (or patient's) judgment of, or impression about, an entity's overall excellence or superiority (Dagger et al. 2007).

Chapter 1: Introduction[1]

1.1 Overview (Research Problem, Rationale and Objectives)

Mobile wireless communications, over the last decade exponentially increased with the total worldwide subscriptions hovering above six billion. Interestingly, over this period the developing world leap frogged in adopting this technology and currently these countries account for over 75% of these subscriptions (ITU 2011). In contrast, healthcare services are in poor state in the developing world and to some extent healthcare is not a priority of the respective governments across the globe (Ivatury et al. 2009; Worldbank 2004). This *healthcare divide* between developed and developing nations cannot be bridged with the 20th Century medical practices (Economist 2012). The ubiquitous nature of mobile phones, greater penetration among the various strata of the population and their simplicity to use has triggered the emergence of a new delivery medium for healthcare services aptly referred to as *mobile health* or in short *mHealth* (WHO 2011).

Academic scholars have focussed on service quality in general and healthcare or mHealth in particular (Akter 2012). However, in the extant literature it is hard to find studies devoted to the antecedents of service quality, i.e., service design and service operation (Motamarri et al. 2012). In order for mHealth to be a formidable player in uplifting the healthcare delivery in the developing countries, it has to be ascertained that mHealth is positively perceived by its consumers i.e., patients and that it is viewed

[1] An abridged version of the thesis was presented at the PACIS-2012 Conference:
Motamarri, S.; Akter, S.; Ray, P.; Tseng, C.-L. (2012). mHealth: A Better Alternative For Healthcare In Developing Countries. PACIS-2012 Proceedings Paper 29. Ho Chi Minh City, Vietnam.

as a distinct form of healthcare service. This further calls for a comparative evaluation of different healthcare services in the market vis-à-vis mHealth. We are motivated by this vast opportunity to transform the healthcare delivery in the developing world through mHealth. Accordingly, this research is undertaken to understand how mHealth is perceived in comparison to other healthcare delivery systems. To deliver sustainable healthcare services, it is imperative to understand the factors that distinguish the different healthcare services from the perspective of the patients (Hauser and Clausing 1988; Keaveney 1995). Moving forward it is important to know how this comparative analysis acts as the *voice of the customer* (VoC) in evolving better healthcare services that meet the needs of patients (Akao 1997; Hauser and Clausing 1988; Mazur 1993; Mizuno and Akao 1978).

1.2 Research Questions

The review of healthcare services, mHealth, and healthcare delivery systems' status in developing countries, has brought to the forefront pertinent questions for healthcare services in general and mHealth in particular. Moving beyond service quality, the antecedents to service quality i.e., service design and service operation and differentiating characteristics of delivery systems are all important to bridge the *healthcare divide*. It is possible to draw a comparative analysis of existing healthcare services from a qualitative perspective. However, as the patients are the ultimate consumers of mHealth services, it is worthwhile to understand how patients perceive mHealth vis-à-vis other healthcare delivery systems. This has motivated us to pursue research to address the following research questions within the context of developing countries:

RQ1: Are the different healthcare services distinguishable from each other?
RQ2: If so, what factors contribute to the service differentiation? and
RQ3: Is mHealth distinct from other existing services?

The extant literature has presented a contrasting picture that the populations of the developing countries lack even basic healthcare advice, but they have become consumers to the mobile wireless communications. There is a tremendous gap between the demand for healthcare and supply (Economist 2012). mHealth is emerging to play a vital role in circumventing this huge gap in healthcare provision through affordable services delivered via mobile phones. Due to the extent of coverage and reach of the mobile phone, these services started serving not only under-served but unserved populations as well due to ubiquity and affordability of the mHealth services (Akter and Ray 2010; WHO 2011). Recognising this transformative impact of mobile phones in healthcare delivery, we hypothesise that in developing countries:

H_1: Patients differentiate different health care services.
H_2: Patients perceive mHealth as a distinct alternative over the other services.

The research identified that *House of Quality* as the conceptual framework. It furthermore guided in identifying *Multiple Discriminant Analysis* as the research method to analyse the research questions and thus address the hypotheses.

1.3 Research Scope and Theoretical Foundations

House of Quality (HoQ) is a basic design tool. It is the first phase of *Quality Function Deployment (QFD)* approach and is fundamental and of strategic importance for products/ service design (Chan and Wu 2005). HoQ inter-links customer requirements, their rankings, engineering characteristics, performance measures, competitive

products/ services and thereby elicits in a single diagram the areas of improvements required to win in the market (Chan and Wu 2002a; Chan and Wu 2005; Hauser 1993; Hauser and Clausing 1988). By propagating *Voice of the Customer (VoC)* across the organisation and across the technical specialities, QFD became the sole quality system to echo customer requirements in the process of products/services design (Mazur 1993). In practice, the HoQ is developed over an iterative process commonly referred to as *Hierarchy of HoQ Matrices*. Starting with customer needs and customer assessment of competitive products/ services, a series of HoQ Matrices are built where the output of preceding matrix becomes an input to the succeeding matrix.

The primary objective of this research is to identify the service characteristics of alternative healthcare services including mHealth and provide feedback to the service providers and planning agencies so that the quality of health services improve over time and deliver value to the society. The scope of the current research is limited to a subset of the theme of healthcare services design, i.e., evaluation of competing services. As such, this dissertation focuses on the *evaluation of competing services,* a segment of the HoQ Matrix. As a secondary goal, the research explores how the specific attributes that differentiate the alternate services can be successively cascaded in populating other segments of the HoQ Matrix to achieve well performing healthcare services.

1.4 Research Methodology

Healthcare services are essentially multi-disciplinary and service design encompasses many structured forms of learning. As such, this research is a multi-disciplinary undertaking combining the methodologies of both *Information Systems* and

Operations Management (IS and OM). The research hypotheses and the associated research questions require examination of group differences of health care service users i.e., patients. This can be achieved through a survey of patients who have used the services in question. By developing a model to relate the survey items and their specific rating by the patients of the respective service they have used, it is possible to see whether significant group differences are observable. Furthermore to have this comparison reliable and testable, all the survey participants need to answer the same set of questions. Thus hypotheses are being examined through a quantitative survey of patients. The investigation intends to a build a quantitative model to not only help in understanding the phenomenon but also serve as a predictive aid. Thus the current research conforms to *quantitative research paradigm*. Epistemologically and ontologically '*quantitative positivist*' paradigm naturally applies to this kind of investigation (Bhattacherjee 2012; Gregor 2006; Straub et al. 2004).

1.5 Research Contribution

The study is a significant step towards inter system comparison study within healthcare services from the perspective of patients. It provides a comparative assessment of mHealth with respect to other conventional healthcare delivery systems.

The *Services Life Cycle* model helps in visualising the different phases of service (emergence to retirement) that emanate from an unfulfilled need in the market place. It further helps in visualising the antecedents to service quality which has been heavily researched.

QFD and *HoQ* have been employed in manufacturing not only to echo the *voice of customer* across the organisation but also to address the mounting cost pressures. The current investigation made a preliminary attempt to compute the patients' evaluation of alternate healthcare services, a segment of HoQ to guide healthcare services design.

The study proves Multiple Discriminant Analysis (MDA)'s usefulness in comparative analysis of service alternatives. This investigation is also a significant move in applying an established and popular classification technique from the realms of Marketing Research and Pattern Recognition into *Information Systems & Operations Management Research and Practice*.

Some authors noted that there has not been a concrete demonstration of cost-effectiveness of mHealth initiatives. Contrary to these notions, this research has empirically established that patients perceive that mHealth is cost effective and delivers better value over the other conventional systems.

mHealth and expansion of its role will certainly benefit the society and, as will be shown later, patients consider that mHealth is of superior value than other alternatives. We thus hope policy makers will start recognising and leveraging on mHealth. Furthermore this study provides a case for positive experience and patients' acceptance of mHealth to the organisations like the World Health Organisation (WHO) and Centre for Health Markets Research and Innovation (CHMRI) in their ongoing efforts of promoting better healthcare in developing countries.

1.6 Research Limitations

This study has some limitations. The *Discriminant Analysis (DA)* Model depicts the patients' perspective at a point in time as the data is collected through a cross-sectional survey. The data collection might not have covered all geographies within Bangladesh. It is possible that the user perceptions may change over time (temporal validity), due to continual changes that happen in the market place. It is worthwhile to examine the temporal validity of the model through on-going surveys. The model reflects that of a developing world, particularly with reference to Bangladesh. It is worthwhile to examine the model for other geographical settings to ensure locational transferability. It also has to be noted that mHealth is a complimentary form of service rather than a replacement to conventional services. The study focuses on the commonalities of services offered by the alternative healthcare forms.

1.7 Future Research

Future research will focus on enhancing the current HoQ model with the computation of performance targets (Figure 3.2), and then cascade these outcomes towards development of process characteristics, sub-process characteristics and function specifications and function targets (Figure 3.3). The lowest level of QFD Matrix in essence is the operational characteristics and operational targets.

The outcome of the DA model for healthcare services can also be viewed as patients' perception of service operation. The three dimensions and the associated 11 factors are to be ingrained in *services design* in order to improve *services operation*. ITIL is developed by the United Kingdom's Office of Government Commerce (OGC) as a

response to systematically execute services management in a five phase model. ITIL is the de-facto industry standard for IT Services Management (OGC 2007). Thus it is possible to integrate higher phases of QFD Matrices to the ITIL Operational Framework, in order to aid in the *health care services design* as well as *operations*.

1.8 Structure of the Thesis

The thesis is organised into six chapters including this introductory chapter that provides a bird's-eye-view of the entire research investigation. Table 1.1 summarises the remaining chapters and the next sub-sections provide a brief summary of each chapter.

Table 1.1: Structure of the Thesis

Chapter	Contents
Chapter 1 Introduction	• Problem definition, rationale, objectives • Research questions • Scope and theoretical foundation • Methodology • Contribution • Structure of the thesis
Chapter 2 Literature Review	• Growth of mobile communications • Healthcare services quality in developing countries • Services, Quality, Services Life Cycle • Emergence of mHealth • Need for Healthcare services design framework • Study domain, Research themes
Chapter 3 Conceptual Framework: QFD and HoQ	• Comparative analysis of healthcare systems • Defining mHealth • mHealth & service quality challenges • Qualitative study • Research hypotheses and questions • QFD and HoQ • Scope of current research
Chapter 4 Research Methodology	• Research philosophy • Research method: discriminant analysis • Research context and quantitative study • Sampling and data collection
Chapter 5 Analysis and Findings	• Demographic analysis • Discriminant analysis model, interpretation • Hypotheses testing and review of research questions • HoQ Model for healthcare service design
Chapter 6 Discussion and Conclusions	• Research objective • Summary of findings • Contribution of the study – theory and practice • Limitations and future directions • Conclusions

1.8.1 Chapter 2: Literature Review

This chapter looks at the overwhelming growth of mobile wireless communications across the world, especially in developing countries. It portrays the contrasting state of affairs with healthcare status in the developing world. From the perspective of services science, healthcare services characteristics are analysed, and moves on to service quality and services life cycle. In developing countries, mobile health or mHealth

(delivery of healthcare services through mobile phones) is emerging as an alternative delivery system to obviate the healthcare challenges. The extant literature points to the necessity for a healthcare service design framework and leads to the development of the broad opportunities for the research and highlights the research domain and theme. The chapter is concluded with a summary.

1.8.2 Chapter 3: Conceptual Framework – QFD and HoQ

The objective of this chapter is to develop the conceptual framework within which the broad research questions set forth in the previous chapter are investigated. It argues for the need of a comparative assessment of mHealth with respect to the alternative healthcare systems. It provides a definition of mHealth within the purview of the current investigation. The chapter looks at qualitative comparison of alternative healthcare services. The discussion forms the necessary backdrop to develop the research hypotheses the investigation aims to test and the associated research questions that are addressed. Then it reviews Quality Function Deployment (QFD) and House of Quality (HoQ) as they form conceptual basis for the research. The chapter also discusses QFD Matrices in the context of healthcare services, and delineates the scope of the current research task. The chapter is concluded with a summary.

1.8.3 Chapter 4: Research Methodology

In continuation to the conceptual framework HoQ introduced in previous chapter and the delimited research scope, this chapter discusses on the appropriate research method. Discriminant Analysis, a multi-variate classification technique that facilitates the quantitative comparative assessment of service alternatives is discussed. Then it

the discussion moves on to the survey instrument, survey location, and methodology to collect patient perception data to test the model.

1.8.4 Chapter 5: Analysis and Findings

This chapter focuses on the analysis of the survey data collected. The data analysis utilises SPSS statistical package. Demographic analysis of the data is performed to find out the characteristics of the respondents and total sample and number of valid cases. Qualitative analysis of the data is performed through histograms. Based on the recommended procedures to conduct DA, the dataset is validated for the satisfactory conformance to underlying assumptions, like sample size validation etc. Then it moves on to the analysis of the discriminant functions and their validity. The DA model is tested for classification accuracy. As a next logical step, the investigation will test the hypotheses and seek answers to the research questions. Finally the outputs of DA are utilised in the building the HoQ model for the healthcare service design. The chapter is concluded with a brief summary of the analysis and findings.

1.8.5 Chapter 6: Discussion and Conclusions

This chapter discusses the empirical findings from the perspective of research objectives, hypotheses and research questions. The theoretical, practical, and methodological contributions of the research are highlighted. Limitations of the current study and opportunities for future research are outlined. Finally, the chapter concludes with a brief summary of the work, its relevance in alleviating the healthcare divide and significant tasks ahead for the worldwide community to enhance healthcare services across the world.

Essentially the research found support to the premise that patients distinguish different healthcare service as different, and mHealth is found to be the preferred alternative. The service differentiation occurs along the dimensions of ubiquity, information-quality and value. Given the mobile phone's wide spread adoption in the developing countries, mHealth appeals to be an alternative that can alleviate the healthcare challenges faced by these countries and help in substantially altering the healthcare provision status in the developing countries.

1.9 Summary

The objective of this chapter, *Introduction*, is to provide an overview of the research investigation, '*Distinguishing mHealth from other Healthcare Alternatives in Developing Countries: A Study on Service Characteristics*.' The chapter has briefly touched on the research problem, rationale for the study, objectives and scope of the research. Healthcare services and services design are by nature multi-disciplinary, and as such combines the knowledge from both the disciplines of IS & OM. Following this the specific questions and hypothesis that the research will attempt to address, the research paradigm and method to aid in the process are discussed. Outcomes of the research analysis and their implications for both theory and practice, limitation of the current research and opportunities for future research are presented. A brief discussion and conclusions of the research endeavours are summarised.

The next chapters will focus on the literature review, context of healthcare service and mobile health (mHealth), and progressively move on to the research questions, methodology, data analysis, model construction, discussion of the results and

summary of the contributions of the work, i.e., enhancement of healthcare services design and provision, especially in the developing world.

Chapter 2: Literature Review[2]

2.1 Chapter Overview

This chapter looks at how three distinct aspects play a pivotal role in addressing a significant shortcoming of the developing world, i.e. the provision of healthcare to the underserved and unserved segments across the globe. The three aspects are: the advent of ICT/ Mobile Communications, quality of healthcare services in the developing world and services science. The structure of this discussion is portrayed in Figure 2.1.

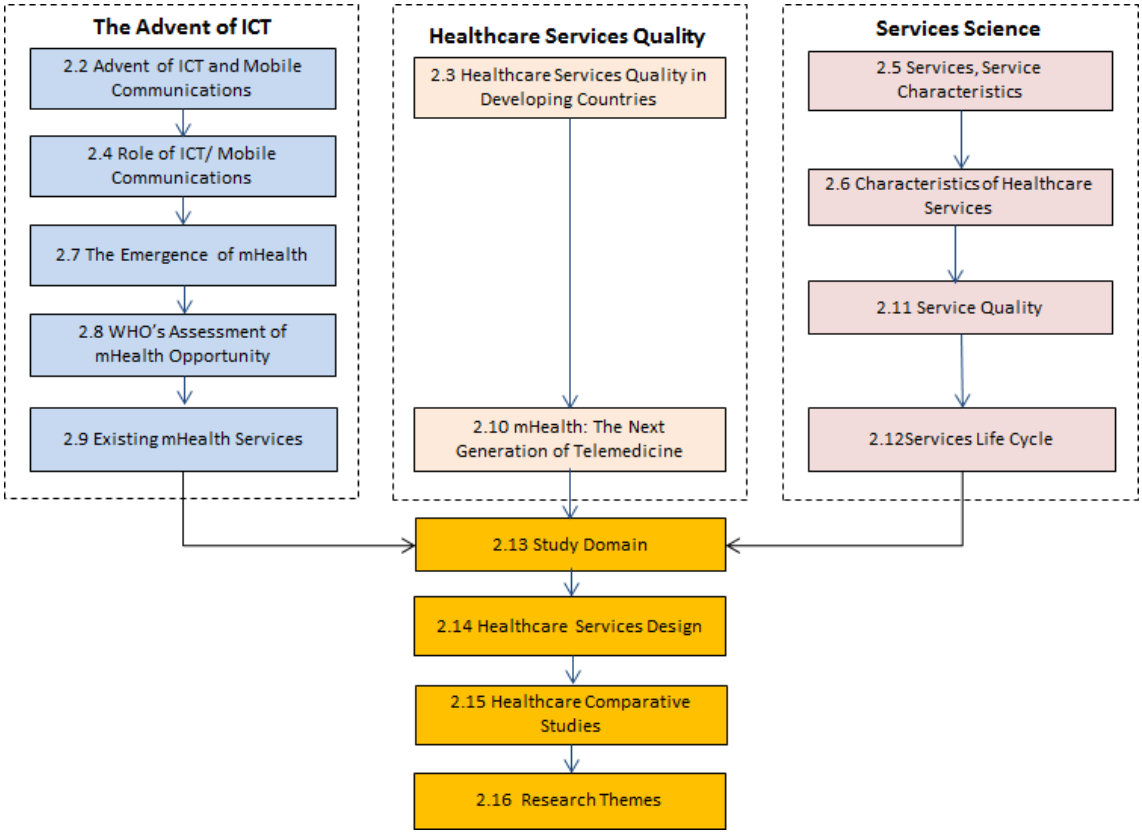

Figure 2.1: Structure of Chapter 2

[2] A segment of this chapter has been presented at 2nd Australian Symposium on Services Research and Innovation:
Motamarri, S.(2012). Status of Health Care Services, Mobile Health, and Health Care Service Design.

As reflected in Figure 2.1, the discussion traces how the overwhelming growth in ICT/ mobile communications (2.2), the depressed state of healthcare in the developing world (2.3, 2.10), and how *Mobile Health or mHealth* is emerging to leverage the wireless communications as a medium to play a complimentary role in conventional healthcare delivery systems (2.4, 2.7). It provides an assessment of existing mHealth applications (2.8, 2.9). At the same time, services science provides a contextual background to understand special characteristics of healthcare services (2.5 2.6), and how the extant literature is highly devoted to *service quality* (2.11). In order to fulfil the mHealth dream to provide universal access to healthcare, the discussion turns to the *services life cycle* which emphasises the need to focus on the antecedents to service quality, i.e. *service design* (2.12).

From a holistic view, these seemingly distinct flows of extant literature converge in triangulating the study domain (2.13). Furthermore, the lessons from the extant literature emphasise the timely need for a healthcare services design framework (2.14) and which in turn brings to light a significant gap in the literature, i.e. a comparative analysis of mHealth vis-à-vis with conventional healthcare services (2.15). Assimilating this multi-disciplinary undertaking, and the nature of mHealth vis-à-vis conventional healthcare, assists us in defining the focus for this research undertaking (2.16). Thus this chapter lays the foundation in defining the theme and scope of this research, waiting to be refined in Chapter 3.

2.2 Advent of ICT and Mobile Communications

The service industry, including healthcare services is transforming with the new powerful, anytime and anywhere accessible delivery channels: the internet and

wireless mobile communications. This is a direct consequence of advances in *Information and Communications Technologies* (ICT). The internet had played a dominant role in resource rich countries resulting in a *digital divide* between the developed and developing nations. However, this situation is drastically altering due to the exponential growth of mobile wireless communications in developing nations (ITU 2011). As per the GSM Association wireless signals which cover over 85% of the world's population, far beyond the reach of the electrical grid (WHO 2011).

Global mobile subscriptions have topped six billion, a nine fold increase from 0.7 billion in 2000 (ITU 2011) as shown in Figure 2.2. In developing countries, wireless communications is the fastest growing sector (Banks and Burge 2004; Free et al. 2010; ITU 2003) and it overtook fixed line communications. The developing world has a surprising share of over 75% of these subscriptions or close to 4.5 Billion. The International Telecommunication Union (ITU) also observes that the growth in mobile phones outweighs a slow increase in the adoption of computers in this part of the world as can be observed from the contrasting growths shown in Figure 2.3.

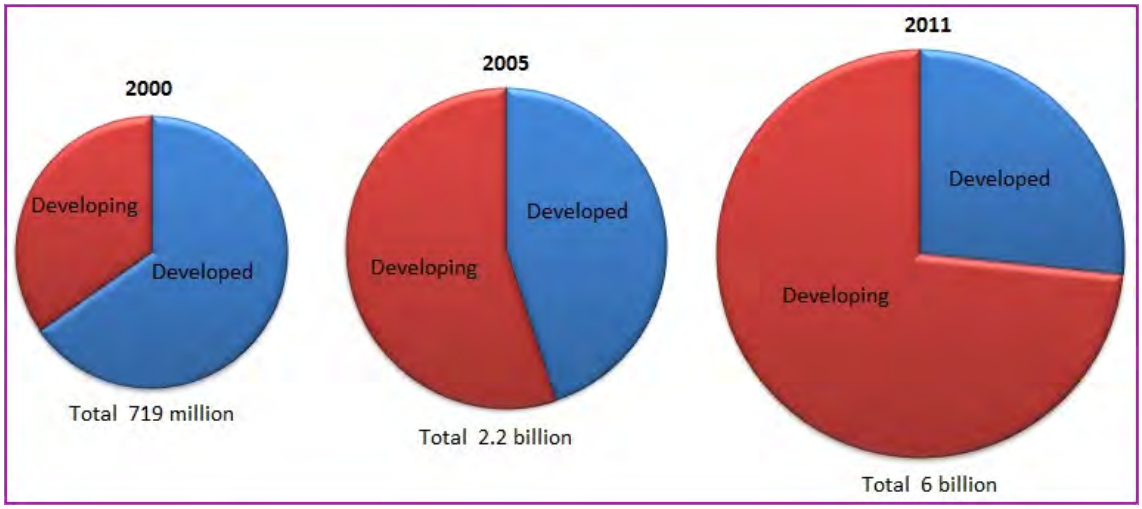

Figure 2.2: Mobile Cellular Subscriptions (2000 – 2011)
Source: (ITU 2011)

ICT has had crucial role in transforming several industrial segments like: banking/finance, manufacturing, commerce, logistics, services etc., and it has improved the general productivity of these sectors of the economy. However, there is enormous potential for its transformative role in the health sector (Agarwal et al. 2010; Economist 2012). Ever since the invention of telecommunication, there has been a certain degree of its application in the medical sector. The advent of the internet in the mid-nineties has given impetus to many researchers to apply these innovations in improving the health care delivery. These efforts have culminated into the development of '*Telemedicine,*' '*Telehealth*' and '*Electronic Health or eHealth*' (Bashshur et al. 2011; Bashshur et al. 2000; Moore 1999).

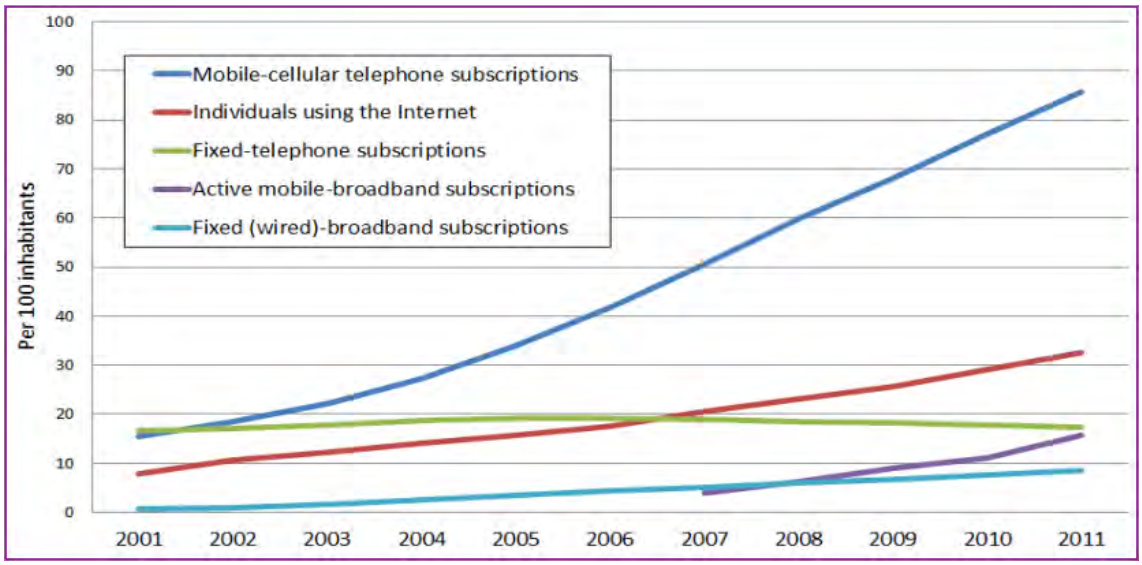

Figure 2.3: Global ICT Developments (2000 – 2011)
Source: (ITU 2011)

2.3 Healthcare Services Quality in Developing Countries

Despite the amazing penetration of wireless mobile technology in the developing world, the state-of-affairs with respect to education and health remain very unsatisfactory. Health systems in low- and middle-income countries have many

hurdles in providing basic healthcare that is affordable and covers their subjects (Lewis et al. 2012). The health service system in the developing world is on a depressing path, with a deadly combination of limited access to care, uneven quality and high costs (Porter and Teisberg 2006). It is a startling fact that populations of the developing nations are in possession of mobile devices, while they still struggle for access to basic healthcare, as is apparent from the selected healthcare system indicators shown in Table-2.1 (Ivatury et al. 2009; Sharma 2012; WHO 2012). Poor people are yet to travel several kilometres to avail basic medical services (Worldbank 2004).

Table 2.1: Sample Health System Indicators for Selected Countries
Source: (WHO 2012)

Country	Births attend by skilled health personnel (%)	Hospital beds per 10,000 population	Physicians per 10,000 population
	2005-11	2005-11	2005-10
Bangladesh	27	3	3
India	50	9	6.5
Mexico	95	16	19.6
Pakistan	45	6	8.1
Russia	100	97	43.1
United Kingdom*	99	33	27.4
United States	99	30	24.2

*(Ivatury et al. 2009)

The National Intelligence Council (NIC) prepared a typology map, Figure 2.4 depicting the healthcare system status across the world (NIC 2003). It has classified the healthcare system into five categories: excellent, good, fair, poor and unstable. A majority of countries are rated fair or below. It is also clear that for these countries, healthcare is not even a priority of their respective governments. The World Health Organization's (WHO) health indicators show a large divide in health care between

developed and developing nations (Andaleeb 2000; Ivatury et al. 2009) which the author terms as *'**healthcare divide**.'*

Assessing the overall situation in terms of healthcare services in developing countries, the World Bank did an elaborate analysis, and was very dissatisfied with the state-of-affairs. They summarised that:

> *"Services are falling because… they are inaccessible and prohibitively expensive. But even when accessible, they are often dysfunctional, extremely low in technical quality, and extremely unresponsive to the needs of a diverse clientele."* (Worldbank 2004)

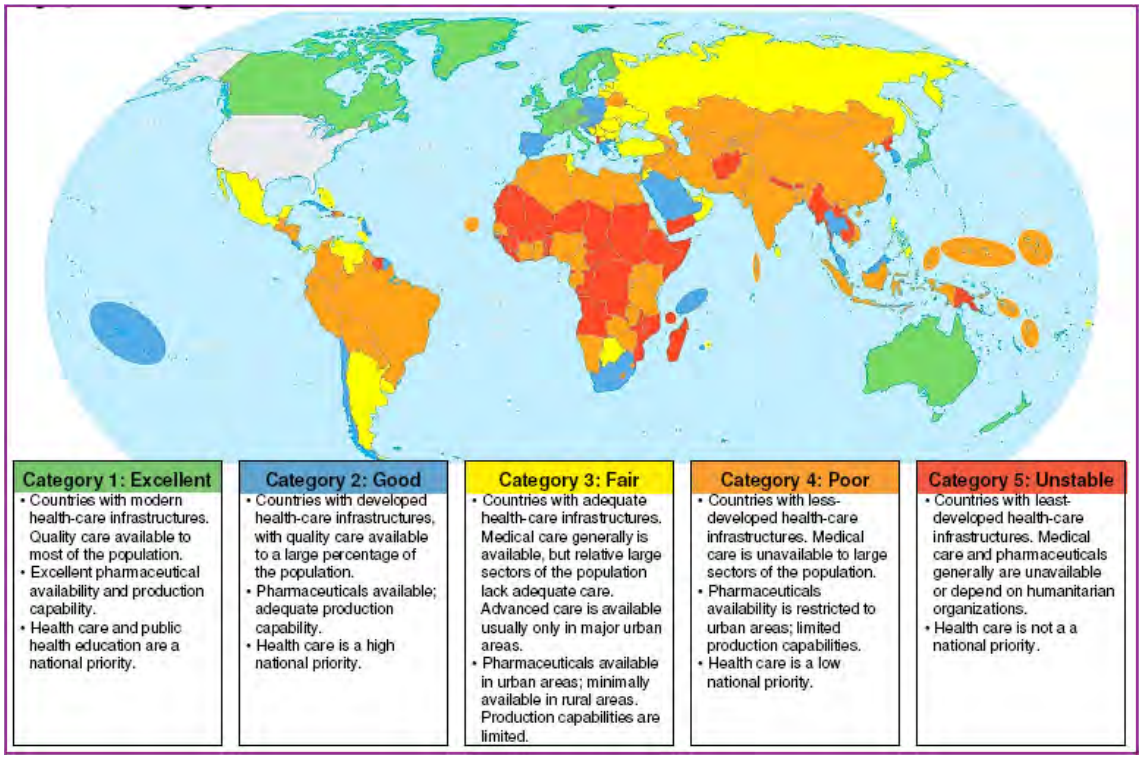

Figure 2.4: Typology of Countries by Health Care Status
Source: (NIC 2003)

In its latest report, '*World Health Statistics: 2012*' (WHO 2012), the WHO estimates that there were 57 million deaths in 2008, of which 36 million (63%) were due to non-communicable diseases (NCDs). Sadly 80% of these deaths due to NCDs occurred in

low- and middle-income countries (WHO 2012). Furthermore, a high proportion (48%) of all NCD deaths occur under the age of 70 in poor countries vs. 26% in developed nations. In sub-Saharan Africa, Eastern Europe and parts of Asia there is an extremely large probability of dying from an NCD between the ages of 30 and 70 as shown in Appendix B. The WHO estimates that the average per capita expenditure on health varies significantly between the rich and poor countries, i.e., US$4,692 to US$25. With such low levels of funding, poor countries cannot ensure universal access to even a very limited set of health services. Thus richer countries with lower disease burden consume more health resources than poor countries with higher disease burdens (GSMA 2012).

2.3.1 Healthcare Service Delivery Indicators for Bangladesh

In Bangladesh, there is one Registered Physician on average, for every 4,000 people (Grameenphone 2006). The ratio is much higher in rural areas where 80% of the population lives. These areas lack clinics, hospitals, health facilities and registered medical practitioners (Yahya et al.). The Canadian Institute for Energy Training (CIET) under the project *Bangladesh Health and Population Sector Programme 1998-2003*, compiled an interesting assessment report, *The Third Service Delivery Survey 2003* (Cokroft et al. 2003). The report provided detailed information on the health care delivery systems in Bangladesh. Table 2.2 provides a snapshot of some of the delivery system indicators. Unqualified practitioners are the major providers of curative healthcare and that Traditional Medicine practice is highly prevalent in Bangladesh with 60% of the population subscribing to it. Based on the reviews presented earlier on Bangladesh health care status, it is no surprise that the public hospitals cost twice that

of a traditional medicine, and private practice costs four times of the traditional practice.

Table 2.2: Health Care Service Delivery Indicators for Bangladesh
Source: (Cokroft et al. 2003)

Sl No	Service Delivery Indicator	Public	Private	Traditional
1	Treatment service users used (%)	13	27	60
2	Median waiting time (minutes)	30	20	5
3	Mean cost paid to provider (in Taka)	188	451	100
4	User satisfaction with service provider behaviour (%)	56	91	90

The public service is highly inaccessible. It is supposed to be free of cost, but due to the ill social practice of *baksheesh,* it costs twice that of visiting a traditional practitioner to the average Bangladeshi patient (Andaleeb 2000). The mean waiting times are also worse with public services in comparison to traditional and private providers. It is interesting to note from these indicators that the average patient satisfaction with traditional or private service is twice that of public service.

Andaleeb (2008) in his work on children's healthcare in Bangladesh, summarises that the overall status of the health sector's performance is in a poor state, due to lack of: medicines, separate consultation rooms, water, electricity, poor quality of medicines and apathy of healthcare workers and extra payments for supposedly free services. Based on the user satisfaction survey, he suggests that nurses must provide service that is: good, prompt, caring, helpful, assures confidence, and finally demonstrates expertise in order to alter the patients' image of them. When coming to doctors he suggests that they need to demonstrate expertise, respond to queries, foster confidence and be available to the patients. He concludes that by making the customers' voice publicly available, it will exert some social pressure on healthcare

workers and influence behavioural changes or else even children will be neglected of basic care.

2.4 The Role of ICT/ Mobile Communications

Thanks to the phenomenal innovation in mobile communications technologies in the last decade, the developing world has leap-frogged fixed line communications that facilitated in narrowing down the global digital divide (Free et al. 2010). Furthermore, continual technological innovation is fuelling a rapid increase in mobile device capabilities and functionalities coupled with decrease in device costs.

Along with the advances in internet technologies there is a corresponding impetus in various industries to leverage the internet as an additional or in some instances as the sole delivery channel to offer products/ services which has led to the emergence of *electronic commerce* in two different modes, popularly known as *Business to Business* (B2B) *and Business to Consumer* (B2C). Healthcare is still catching up in the race with other sectors even in the developed world, in transforming itself to leverage the flexible and accessible internet, and wireless communications channels (Agarwal et al. 2010; PWC 2010).

Fortunately, the wide spread adoption of mobile phones in the developing world is offering a viable, cost-effective and ubiquitous channel to deliver healthcare services. We believe that progressively, mobile technologies will play a vital complimentary role not only in raising the bar of healthcare in these counties but may also help in achieving the *millennium development goals* (MDG) set by the WHO (HIMSS 2012; Ivatury et al. 2009; Mechael 2009; WHO 2011). In order to realise this goal, the mobile

healthcare services (mHealth) need to adopt a rational approach across the services life cycle in fulfilling the market opportunity.

2.5 Services, Service Characteristics

The exchange of goods and services is an essential intertwined aspect of human activity. In contrast to goods which can be felt and seen in physical form, services have distinct characteristics. As such services are considered to be *intangible* activities to fulfil wants (Bateson 1979; Shostack 1977). Gronroos (2000) takes forward the early notions on services, and redefines services as "processes that consist of a set of activities which take place in interactions between a customer and people, goods and other physical resources, systems and/ or infrastructures representing the service provider and possibly involving other customers, which aim at solving customers' problems." As the economic activity of services spans several disciplines, many scholars have provided meaningful extensions and definitions. The view of processes, time-perishability, near-simultaneous exchange of production of consumption and co-production of value also are all important aspects that distinguish services from goods (Fitzsimmons and Fitzsimmons 2011; Lovelock and Wirtz 2010b; Zeithaml 1985). Kotler and Keller (2006) recognise that unlike goods, services do not result in any ownership after the exchange. However, they summarise that the economic activity of service provides benefits to a consumer by bringing a desired change in his or her status at a specific time and place.

Extending the definition of service by emphasising value over utility, Vargo and Lusch (2004) define service as "the application of specialised competencies (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or

the entity itself." Differing from these viewpoints Alter (2008) defines services as "acts performed for others, including the provision of resources that others will use." IBM Research (2012) defines "service is a provider/ client interaction that creates and captures value." Thus from the extant literature it is apparent that academia as well as industry progressively attest the creation of value over intangibility. In summary, this study relies on the unifying ideas of Vargo & Lusch, and Alter which synthesise service as a process to provide benefits to others using resources (e.g., skills, competences and platforms or technologies) (Akter 2012).

2.6 Characteristics of Healthcare Services

Intangibility, inseparability, variability, perishability, customer participation and no ownership are the fundamental characteristics of services (Lovelock and Wirtz 2010b). Naturally these characteristics drew enormous research attention in the extant literature. Asides these unstructured complexities, healthcare services are distinct in the sense that they deal with human life and have a wide impact on the global economies (Berry and Bendapudi 2007).

In the US the national health expenditure is estimated at US$2.5 trillion in 2009 (IOM 2010). In Australia the expenditure on healthcare for 2010-11 is estimated to be A$130.3 billion (AIHW 2012b). The apex bodies of these countries, the *Institute of Medicine* (IOM) as well as the *Australian Institute of Health and Welfare* (AIHW) are highly concerned about the escalating costs of healthcare. Most of the developed nations have enjoyed improved life expectancies as a result of the continual improvements in healthcare. As consequence these economies are subjected to aging population, and associated increase in chronic disease proportions (AIHW 2011; IOM

2012; PC 2011b). Mounting consumerism, the invention of new treatment technologies and an aging population is fuelling the growth in the healthcare sector (Dagger et al. 2007; Ludwig et al. 1993; O'Connor et al. 1994), and as a result, the health care services sector is one of the fast growing segments of the global economy as the costs of healthcare are escalating across the world (AIHW 2012a; Berry and Bendapudi 2007; Dagger et al. 2007; Economist 2012; IOM 2010; PC 2011b; WHO 2012).

While service characteristics received significant attention from healthcare researchers, the distinct nature of healthcare services requires additional factors like people-based, equipment-based etc., to be factored in (Akter 2012). Analysing similar contexts, Akter (2012) synthesised the extant literature and proposed a service classification scheme as shown in Table 2.3. The scheme provides interesting insights into the nature of health services and their importance to various stakeholders. In paraphrasing the extant literature and basing on this classification scheme, Akter (2012; pp28-29) attempts to distinguish health services from other services as:

> "Health care service is predominantly categorised as high contact service which is provided by people, dependent on experience properties, and the value is added by interaction. Some scholars highlight that health services are dependent on a high degree of interaction, and a large number of consumers use these services. Health care services are both labour and skill intensive, contributing to considerable variability in performance from one clinician to another. The variability is not just in the service style and communication skills of clinicians but also in their technical skills. Health services are intangible and perishable. Health service is a 'credence service' as it is difficult to judge its performance even after consumption. Overall, these characteristics indicate that it is necessary to evaluate the performance of any health service using patients' perceptions. Patient perceptions are inherently meaningful and shall be the primary focus within the health care system, as they are powerful drivers of outcomes important to various

other stakeholders. Finally, it is important to conceptualise patient perceptions of health service quality and uncover what drives those perceptions."

These conclusions present the distinctive nature of healthcare services, and emphasise the need to study on the service quality of mHealth. While service quality is important, we argue that its antecedents are even more important. At the same time, it is also equally important to assess how patients perceive other competing services too, not just mHealth. These are the additional drivers that motivated us to research the distinguishing characteristics of mHealth from other healthcare services from the perspective of patients, and how these outcomes can be cascaded in order to enhance one of the antecedents of service quality, i.e., service design.

2.7 The Emergence of mHealth

The potential of mobile phones to deliver various health care services attracted researchers and facilitated the emergence of mHealth (Bashshur et al. 2011). mHealth is transforming healthcare in developing countries by serving the unserved as a result of the failure of the traditional delivery channels (Akter and Ray 2010). In the healthcare sector in developing countries, mHealth is a transformative service system for shifting the care paradigm from crisis intervention to promoting wellness, prevention and self-management (Kaplan and Litewka 2008). As a sub-segment of electronic health (eHealth), mHealth is emerging as a significant contender for the delivery of health services (Ganapathy and Ravindra 2009; Mishra et al. 2009). This transformation is driven by the dramatic growth in mobile phones. The affordability, ubiquity and ever increasing capabilities of mobile phones are responsible for it gaining popularity as an alternate delivery medium for healthcare services. This leads to the

emergence of *Mobile health* or *mHealth.* Mobile phones offer easy accessibility, personalized solutions and location based services (Akter and Ray 2010).

Table 2.3: Nature of Health Services in Service Classification Scheme
Source: (Akter 2012)

Author	Proposed Classification	Comments on Health Service
(Shostack 1977)	Tangibility vs. intangibility	Health care is a highly intangible service
(Sasser et al. 1978)	Pure good vs. pure service	Health care is a pure service
(Thomas 1978)	Primarily equipment-based: automated, monitored by unskilled operator, monitored by skilled operator	Traditional health services are people-based (skilled), however, mHealth services are technology-based
(Chase 1978)	Primarily people based: unskilled labour, skilled labour, professional staff	Health services are delivered by professional staff
(Zeithaml 1981)	Search vs. experience vs. credence	Health services are based on credence properties, i.e., it is harder to assess its quality even after consumption
(Kotler 1980)	High contact vs. low contact	Health services are high contact services, therefore, consumer input influences service quality
(Lovelock 1983)	The nature of service act (tangible vs. intangible); relationship with customers (continuous, discrete, membership, no formal relationships); customisation and judgement in service delivery; nature of demand in relation to supply; methods of service delivery (single or multi-site, provider's or customer's premises)	Generally, health services are intangible and highly customised; mHealth or eHealth services are ubiquitous
(Schmenner 1986)	Degree of interaction and customisation (high vs. low); degree of labour intensity (high or low)	Health services depend on higher degrees of interaction
(Silvestro et al. 1992)	Volume of customers: high, medium or low	Health services are consumed by a large number of customers
(Booms and Bitner 1981)	Self-service, interpersonal service, remote services	For health services over electronic platform, front office and back office influence quality
(Lovelock and Yip 1996)	People processing services, possession processing services, information processing services	Health services are typically people processing services
(Berry and Bendapudi 2007)	Intangibility, inseparability, perishability, variability	Health services are labour and skill intensive

Globally the mobile wireless networks expanded massively and they were able to provide wide spread coverage to the remotest corners and at times, to geographically inaccessible locations. In some parts of the world where the wired-phone was never heard of, today the populations have adopted mobile phones with ease. The ready availability of low cost mobile phones makes it a formidable platform for healthcare delivery. The mobile technology can scale well to handle the healthcare challenges with its low cost and simplicity to use (Akter and Ray 2010).

Electronic Health (eHealth) encompasses any form of health service rendered electronically. *Mobile Health* (mHealth) is a specific case of eHealth where the delivery of service depends on the wireless cellular technology. With the ongoing innovations in communications technologies and availability of a wide variety of devices at affordable prices to the individual users, the mHealth frontiers are ever expanding. The UN Foundation and Vodafone Foundation report in 2009 (Vital Wave Consulting 2009) has presented 6 categories of applications based on mobile technology for the healthcare sector, namely:

1. education and awareness,
2. helpline,
3. diagnostic and treatment support,
4. communication and training for healthcare workers,
5. disease and epidemic outbreak tracking,
6. remote monitoring and remote data collection

Mobile phones are anticipated to serve as the universal patient terminal in telemedicine scenarios as well as a data collection and monitoring device in the self-management of diabetic patients (Giménez-Pérez et al. 2002).

Free et al. conducted a systematic review protocol of mHealth technologies exploring the effectiveness of mobile phones for health and health services (Free et al. 2010). By reviewing various publications since 1990, they have collated useful evidence of mHealth interventions. The review comprehensively looked at publications that incorporated mobile communications technology or computing to enhance health, health service or quality. They have grouped the publications into 3 broad categories:

1. Interventions designed to improve diagnosis, investigation, treatment, monitoring, and management of disease;
2. Interventions to deliver treatment or disease management programs to patients, and health promotion; and
3. Interventions to improve health care processes e.g., appointment attendance, result notification, and vaccination reminders.

2.8 WHO's Assessment of mHealth Opportunity

The WHO's Global Observatory for eHealth (GOe) completed a global survey on the status of mHealth among its 114 Member States. The majority i.e., 83% of the Member States are reported to be offering at least one type of mHealth service (WHO 2011). What was viable technically but not operationally in the past now is becoming a possibility. In view of this evolving and expanding role, mHealth is defined to encompass the spectrum of services possible by GOe as (WHO 2011):

> *mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. mHealth involves the use and capitalization on a mobile phone's core utility of voice and short messaging service (SMS) as well as more complex functionalities and applications including general packet radio service (GPRS), third and fourth generation mobile telecommunications (3G and 4G systems), global positioning system (GPS), and Bluetooth technology.*

Based on the most established mHealth interactions between the health system and the public and within the health system, GOe had asked the member countries to provide their input as per the following mHealth categories:

1. Communication between individuals and health services
2. Communication between health service and individuals
3. Consultation between health care professionals
4. Inter-sectoral communication in emergencies
5. Health monitoring and surveillance; and
6. Access to information for health care professionals at point of care.

Globally, the most frequently reported mHealth initiative is call centres/ health care telephone help lines (59%). The next important categories are: emergency toll-free telephone services (55%), emergencies (54%), and mobile telemedicine (49%). These mHealth initiatives share utilisation of the common characteristic: mobile phones, i.e., voice functionality. The results are summarised in Figure 2.5. This exhibit also reflects the maturity of the mHealth initiatives (i.e., established, pilot, informal, none given) across the world.

GOe also analysed mHealth initiatives by WHO region (Africa, Eastern Mediterranean, Western Pacific, Europe, South-East Asia, and Americas) to find out any regional trends. Health call centres/ health care telephone help lines were one of the two most common initiatives across all WHO regions. Except in Africa where infrastructure is still evolving, health call centres are the most frequently reported initiative. GOe's further analysis of the data by the World Bank Income group (High Income, Upper-middle, Lower-middle, and Low Income) too confirmed that Health call centres/Health care telephone help lines were the most popular initiatives across all income groups.

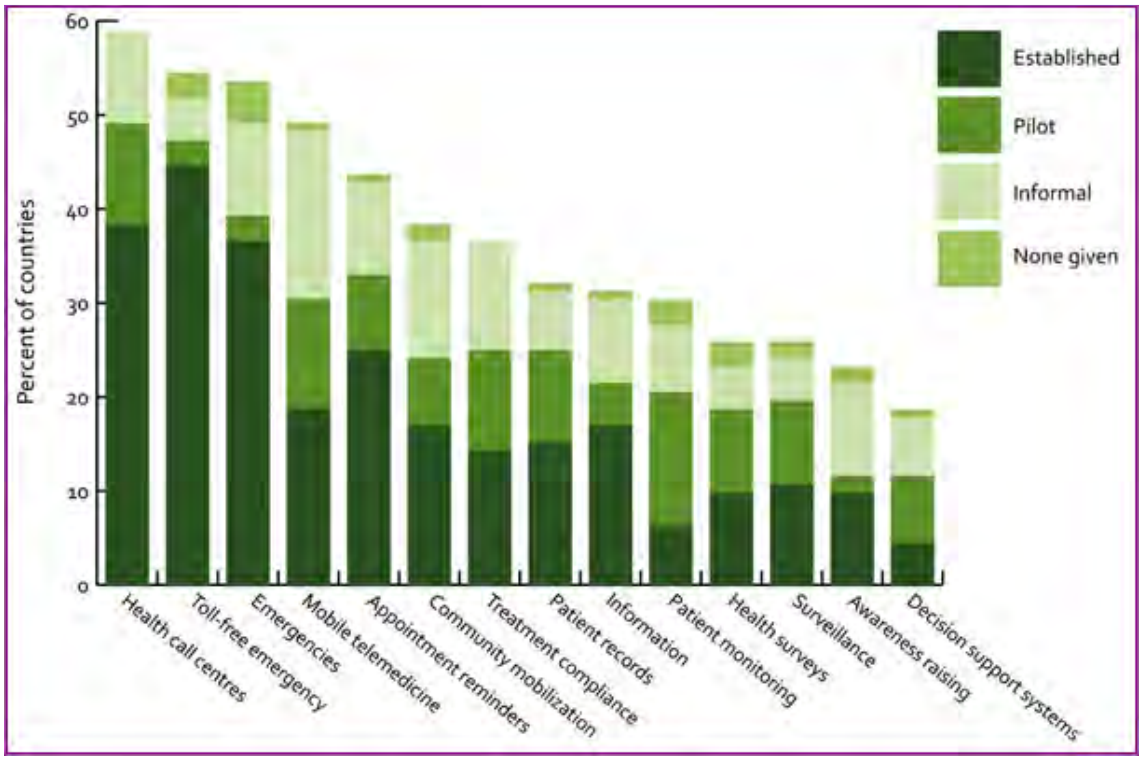

Figure 2.5: Adoption of mHealth Initiatives and Phases, Globally
Source: (WHO 2011)

GOe observed that in low and lower-middle income countries there has been growing interest to leverage the ubiquity of the mobile technology to develop health call centres so as to make the health care/information accessible to the much wider public (WHO 2011). GOe assesses that these approaches are gaining importance to circumvent the shortage of medical professionals, reliance on informal healthcare providers, service costs, transportation, and shortage of reliable information sources.

Commenting on the modus of operandi of the health call centres in the resource constrained regions, GOe summarises that:

- health call centres are more often a for-profit operation;
- patients are directly charged for services; and
- there exist partnerships among mHealth service providers and telecommunication providers to take advantage of brand recognition, distribution channels, and revenue collection.

2.9 Existing mHealth Services

The GOe study compiled various applications of mHealth across the globe tackling a variety of healthcare issues. A few of the important mHealth services as compiled by WHO (Ivatury et al. 2009; Vital Wave Consulting 2009; WHO 2011) will be briefly described below. The applications describe a range of opportunities being serviced through mHealth across the globe, predominantly in the developing world.

Bangladesh - Raising health awareness via SMS campaigns

The Ministry of Health and Family Welfare of Bangladesh has taken advantage of the rapidly increasing number of mobile telephone subscribers in the country to improve the health of its citizens and overcome existing communication barriers. In 2007, the Ministry started a project to increase awareness of its health campaigns by broadcasting SMS text messages to all mobile telephone numbers in the country, irrespective of their service providers, initially to mobilize citizens for National Immunization Day. Messages sent via SMS encouraged parents to bring their children to get vaccinated, along with the event's date were sent via SMS. Heartened by the positive response of the population, the Ministry now uses the SMS service for its National Immunization Day campaign, as well as other large-scale nationwide health campaigns, such as its Vitamin A Week, National Breastfeeding Week, and National Safe Motherhood Day.

Ghana – Mobile communications between doctors improve medical practice

With an estimated two thousand physicians serving a population of nearly 24 million inhabitants, doctors in Ghana need to have a reliable communication system for

conducting consultations and referring patients. With support from New York University and Switchboard5 (a US-based non-profit-making organization) the Ghana Medical Association (GMA), and in collaboration with a mobile telephony provider in Ghana, launched the Mobile Doctors Network (MDNet)/Medicareline programme (MDNet here forward) in Ghana in 2008. It provides free mobile-to-mobile voice and text services to all the physicians in Ghana currently registered with the Association. More recently, a one-way bulk SMS service was also enabled, allowing GMA to send information to doctors about national emergencies and meetings, as well as to contact doctors within a particular specialty.

Senegal – EpiSurveyor for maternal health data collection

High-quality and up-to-date health data are essential for identifying health needs, informing decision makers, and eliciting actions to improve health outcomes. This is particularly the case in developing countries, which often face the compound challenges of a heavy disease burden and weak health infrastructure. In Senegal, the Ministry of Health teamed up with WHO to improve health data collection through the use of mobile technology. Twenty community health workers in ten districts were equipped with handheld devices (PDAs) loaded with EpiSurveyor8, and trained in its use. During a six-month pilot project in 2008 the health workers made monthly field visits to 90 health posts collecting information using EpiSurveyor – basic supervisory data in real-time using an 82-question survey. The data collected were sent electronically to the district level for analysis, and subsequently transferred to the Ministry of Health for synthesis with reports from other districts. Health officials used

the processed data to reallocate their budgets in order to respond to the shortages and specific needs the data revealed.

Cambodia – Cam e-WARN monitoring disease outbreaks via SMS

The outbreak of SARS in Cambodia in 2003 made apparent the limitations of the country's existing surveillance system – an event-based telephone hotline used by the population to report specific cases of disease – to promptly respond to major outbreaks. To address this gap, the Ministry of Health of Cambodia, in collaboration with WHO, conducted a needs assessment and revised its disease surveillance programme to introduce a more advanced system for the early detection of abnormal events or outbreaks, using indicators. The system, called Cam e-WARN, intends to expedite the ongoing systematic collection, analysis, and interpretation of data on a predetermined set of diseases and syndromes affecting the population, with the purpose of ensuring prompt action in case of an outbreak.

Canada – Nursing care in aboriginal communities through PDAs

Nurses play an essential role in health service delivery both at nursing stations and through home care nursing. This is particularly true in remote and less populated regions of Canada. The essential role of nurses is first noted, where medical support is scarce and primary care nurses need to perform diagnostic and prescribing functions (outside their usual scope of practice) and secondly, in the case of home-care services where increasingly acute and complex nursing care is required in the home. Under these circumstances, registered nurses need quick access to effective tools and health information resources to support their practice. To help address these challenges, Health Canada is collaborating with on-reserve Aboriginal (First Nations) communities

in the province of Saskatchewan. The aim is to provide nurses serving these communities access to tools and detailed health information at the point of care through handheld computer technology, specifically, PDAs.

Health Hotline Services Across the World

Ivatury et al. (Ivatury et al. 2009) made an in-depth assessment of health hotline services operating around the world. The following table contrasts the four most popular services along the dimensions of an integration approach, healthcare delivery, data-sharing and a cost recovery model.

Table 2.4: mHealth Hotlines Integration with Physical Health Facilities

Source: (Ivatury et al. 2009)

	Healthline (Bangladesh)	Teledoctor (Pakistan)	HMRI (India)	MedicallHome (Mexico)
Summary of the Integration Approach	Expand rural Telemedicine facilities	Establish presence at pharmacies and Expand telemedicine	Multiple interventions in rural areas to strengthen and Supplement health system	Integrate patient records with existing facilities and build new clinics
Healthcare Delivery Activities	Deploy telemedicine kiosks in rural areas linked to health hotline	Deploy phone and video units at pharmacies linked to health hotline	Mobile vans Train rural health workers Video-con hospitals and doctors	Network of 10 clinics built
Data-sharing Activities	Single patient record	N/A	Single IT platform with data shared among blood banks, hospitals, mobile vans, health hotline etc.	Get clinics and physicians on single IT platform for single patient record, discounts
Cost Recovery Model	Charge callers	Charge callers for phone, video calls	None (government funded)	Referral fees to physicians, hospitals

2.10 mHealth: The next Generation of Telemedicine

Waegemann (2010) argues that within a short span the internet had evolved and transformed into Internet 2.0 and Internet 3.0 and became a trusted source of information. It has profoundly helped society to chart new paths. Similarly he foresees that mobile phones will eventually transform healthcare due to the connectedness it enables between the patient and care provider. He terms this evolution as a *connected health system*. He foresees an evolution of *patient-centric* healthcare from the current dominant practice of *doctor-centric* mode resulting in the care processes shifting from the physician's office (or clinic, hospital or other provider setting) toward the patient. This will connect different specialties of medicine and allows the physician to orchestrate an appropriate method of delivering care to the patient. Yet again, he terms this as *participatory medicine* or *participatory health*.

Waegemann argues that in order for this vision to become to a reality, there is a need to abandon the out-dated visions of telemedicine and health system that are *just* connected. And the prevailing views of Telemedicine 1.0 i.e., expensive and dedicated connection must be broken in order to embrace mHealth. The mHealth revolution can enable communication-based care in which the patient is at the centre of care circumscribed by wellness and health care providers. He foresees that the worldwide movement of mHealth might materialise and countries like Brazil and India may leapfrog to advanced mHealth systems. Finally Waegemann stresses that mHealth may also need to discern the concerns of security and privacy, and hopefully newer generations of smart phones may overcome those hurdles and help in realising the mHealth revolution.

In contrast to Waegemann's assertions, the mHealth literature is filled with anecdotes that eHealth is not cost effective. In a recent 'systematic review of systematic reviews,' Black et al. (2011) have studied the impact of eHealth on the quality and safety of healthcare. They conclude that that there is a large gap between postulated and empirically demonstrated benefits of eHealth technologies. They also argue that the technologies have not yet demonstrated their cost-effectiveness. They also quote paucity of evidence in relation to improvements accrued due to eHealth. The average researcher will be bewildered by these conflicting assessments. But it appears that these reviews have ignored potential mHealth applications that are practically working and enhancing the lives of people in developing countries. Black's review does not include a comprehensive assessment of working mHealth solutions like Ivatury et al. (2009), Mechael (2009), and the WHO (2011).

Turning the mobile technologies into solutions that become routine operational processes among various healthcare providers and stakeholders is not necessarily a simple process. It requires structural changes among stakeholder bodies and progressive resolution of non-technological hurdles (Essén and Conrick 2008; Venkatesh et al. 2003). Yu et al. (2006) also argue that one of the critical success factors for the mobile health application is their compliance to regulatory requirement apart from benefiting in operations and offering cost advantages. Several years ago commenting on American healthcare systems, Shortell (1988) observed that hospital systems did not achieve their stated objectives due to lack of their system-ness. Shortell ponders that in the evolving space of consumer demands and uncertainties, the biggest question is whether organisational arrangements are evolving horizontally

or vertically. Commenting on the future of healthcare, the Economist (2012) concludes that it requires an impossible number of doctors to tackle 21st century healthcare issues with 20th century approaches. Hopefully mHealth with its ingrained promise for *connected health* can fulfil those decades' long gaps in healthcare systems. However, to leverage these capabilities of mHealth a fundamental look at the origin of services and how to design and operate services are essential.

The next sections attempt to understand service quality, service life cycle and antecedents to achieving sustainable service patronage. In summary, the healthcare imperatives of the developing nations, the potential of mHealth as a powerful delivery alternative, the factors that influence and position mHealth service on par with incumbent services, prompted us to investigate on health care service design with specific reference to mHealth. The ensuing sections will detail the lessons learnt from the extant literature and chart an approach for mHealth service design.

2.11 Service Quality

Services Marketing literature is abound with discussion on *service quality,* its characteristics and measurement (Brady and Cronin 2001; Parasuraman et al. 1988). There have been efforts to characterize perceived service quality of mHealth services (Akter 2012; Akter et al. 2010a; Akter et al. 2010b). Service quality is a consequent to service delivery, design and opportunity. While the marketing literature is abound with studies on the product life cycle (Levitt 1965), there has been little focus on the *Services Life Cycle* (Lovelock and Wirtz 2010b; McGuire 1999; Motamarri 2012; Motamarri et al. 2012; Verschuren and Hartog 2005). It is possible that the services term has been used extensively by marketing, operations and computer science with

different connotations (Alter 2008). The Communications of the Association for Computing Machinery (C-ACM) had devoted a special issue on the emerging field of *Services Science* (Chesbrough and Spohrer 2006; Maglio et al. 2006; Spohrer and Riecken 2006). The author had a personal communication with Dr Jim Spohrer with regard to the *Services Life Cycle* (Spohrer 2012). Heskett et al., (2008) have discussed the *service profit chain* to depict how different parties add value at each stage of the service as it evolves. Given this opportunity to fill a research gap on both services life cycle and antecedents to healthcare service quality, the author proposes a *Services Life Cycle* model and then proceeds with a discussion on utilizing this model to understand the phases of the *Services Life Cycle* and how it can be applied in the design of healthcare services.

2.12 Services Life Cycle

An unfulfilled need is a trigger point for the emergence of a new service opportunity in the market place. The need of a buyer becomes an opportunity for a service provider. The requirements of the need may not be concrete whereby service providers perceive it depending on their core strengths and structure their strategic assets in transforming the opportunity into a service offering (OGC 2007). Service providers then align their core capabilities to meet the customer needs giving rise to the design of their service offerings. Technology plays a vital role both in design as well as delivery of the service. It can also mean that for the same opportunity, different technologies may give rise to differing service alternatives, for the same need. The next stage to service design is *service operation,* where the buyer interacts with the provider. This leads to the fulfilment of the need to the buyer and generates an experience with the

service vis-à-vis his original need. One can imagine the service quality as the perception of the buyer to the extent to which the experience matches to his original need. This is one of the reasons that service quality may be perceived differently by different people. Synthesising these aspects, the ***Services Life Cycle (SLC)*** can logically be portrayed as shown in Figure 2.6 (Motamarri 2012). Thus the important antecedents to service quality are *service operation* and *service design*.

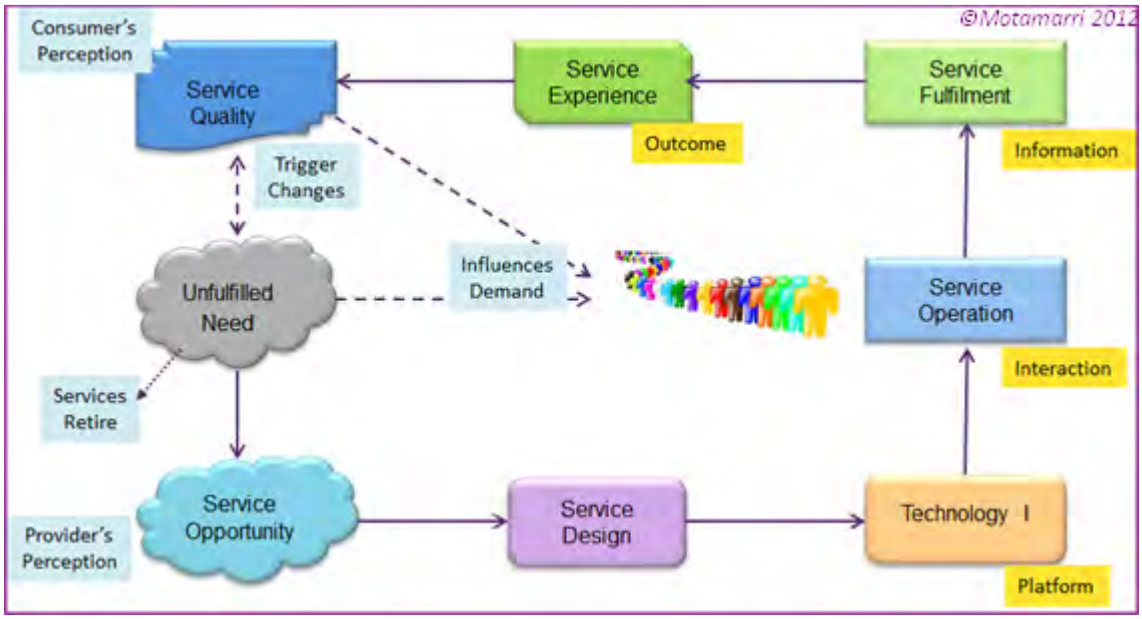

Figure 2.6: Services Life Cycle

With respect to healthcare services, a doctor uses his/her clinic as the technology platform to deliver a face-to-face consultation to a patient, which has been in existence for over a century. In the instance the doctor uses mobile wireless communications as the platform; it becomes a mHealth consultation, an alternate to the face-to-face consultation. The mechanics of the patient getting access to the service provider (doctor interaction) is service operation. The interactive consultation leads to the exchange of information between the patient and the doctor. The information/ advice received from the doctor leads to the fulfilment of the service

need of the patient. The overall process involved in fulfilling the service need, results in the service experience to the patient. The contrast of experience with the original need, in a sense measures the patients' perception of service quality (McGuire 1999).

For mHealth to succeed it has to provide a better overall value to the patients, so that they can switch to this alternative over the incumbent services in a healthcare market. Keaveney's *Customer Switching Model* (Keaveney 1995) proposes the factors that may induce consumers to switch from one service provider to another. As shown in Figure-2.6 the model underscores on factors: service quality, interaction, handling of feedback, price, inconvenience and other behavioural factors (Lovelock and Wirtz 2010a; McGuire 1999). Healthcare service providers can utilise these insights during their services strategy, design and operation phases in order to successfully deliver as well as sustain their services offering.

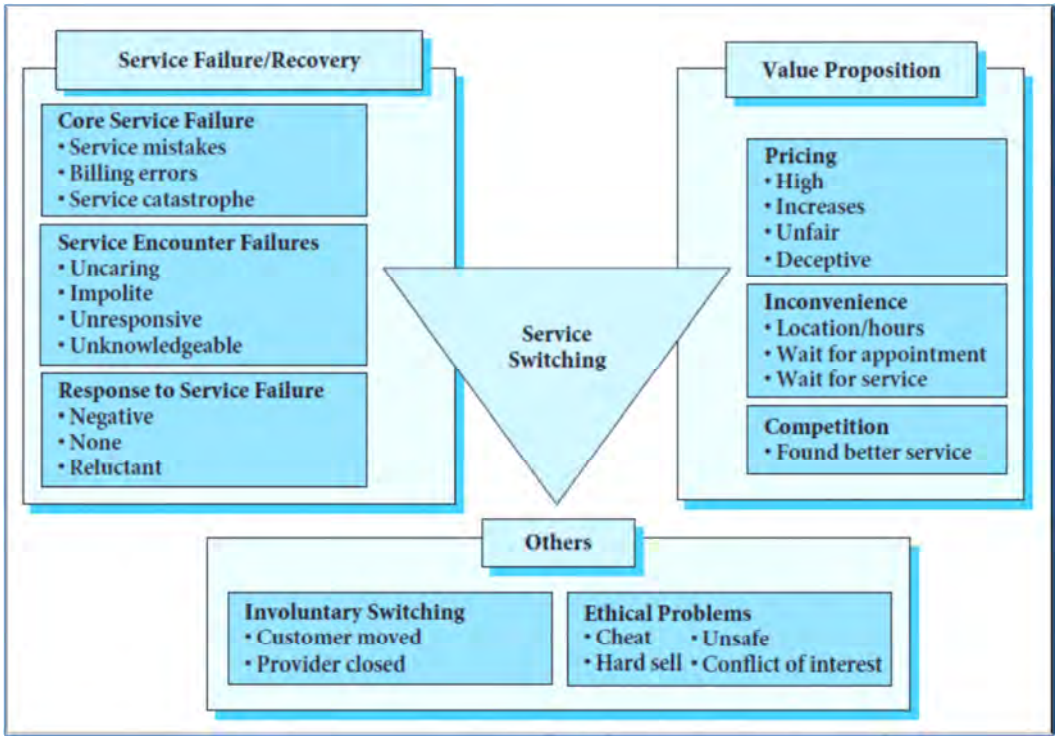

Figure 2.7: Customer Service Switching Behaviour Model

Source: (Keaveney 1995)

2.13 Study Domain

The objectives of this research are dual fold: a) understand distinguishing characteristics of the health services including mHealth; b) how these insights help in healthcare services design. The search in various sources like PubMed, Google Scholar, and SciVerse databases has not yielded any specific study that was devoted to healthcare services design itself, keeping aside mHealth. Table 2.5 presents the results of some of these search terms. A reconnaissance of the results has not pointed to any artefacts that focused on the design of healthcare services. Recently the University of Pittsburgh Medical Centre in collaboration with the School of Design Science of Carnegie Mellon University applied design principles to improve patients' experience by tracing patient needs, service flows and environmental factors and has achieved significant improvements in healthcare delivery systems (Evenson 2008). Considering the complexity surrounding health care services, and the inter-disciplinary nature of this endeavour, the research calls for assimilation of knowledge from several disciplines as shown in Figure 2.8.

Following this multi-disciplinary search in terms of healthcare services in developing countries converging to mHealth spanning the knowledge domains of ICT, Quality of Service*, IT Infrastructure Library* (ITIL) and *House of Quality* (HoQ) have provided interesting insights. As this is a significant opportunity that can benefit patients and healthcare service providers, these insights will be reviewed along the way leading to the services design framework.

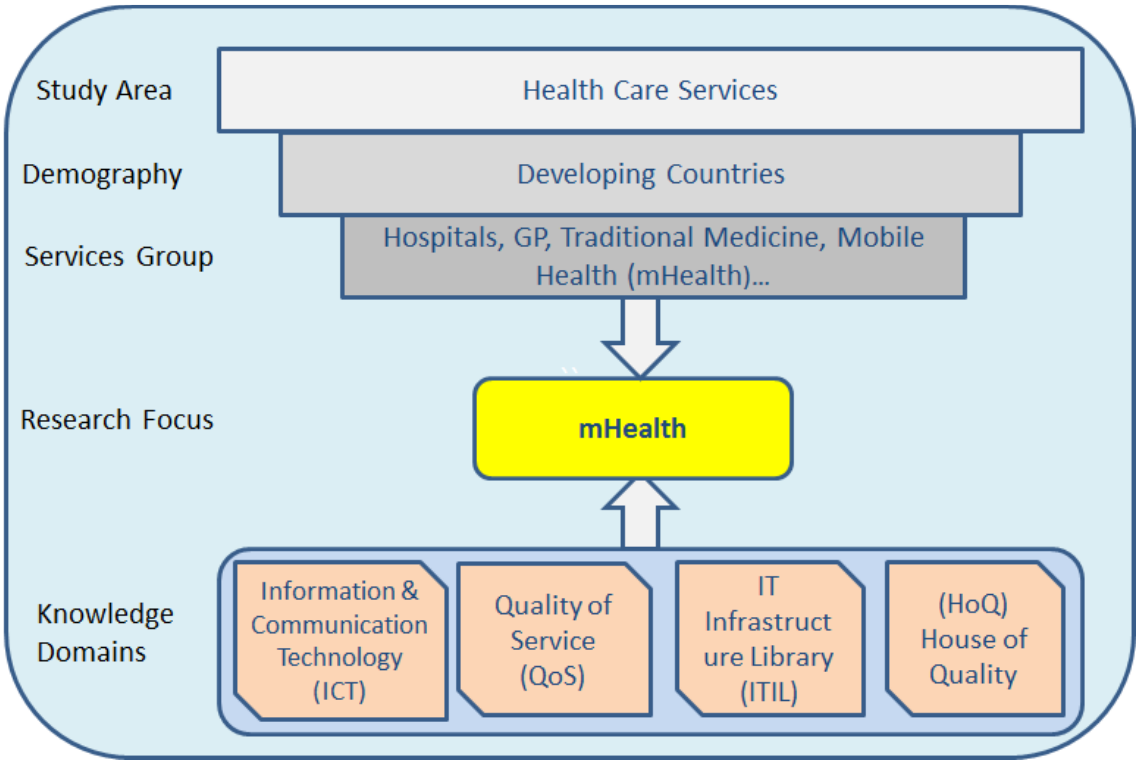

Figure 2.8: Healthcare Services Design – Knowledge Domains

Table 2.5: Literature Search for Healthcare Service Design Artefacts

No	Search Terms	PubMed	Google Scholar
1	healthcare health care service	400,170	1,550,000
2	healthcare health care service design	39,059	828,000
3	healthcare health care service design mobile mHealth	1,004	2,210
4	mobile health m-health health care healthcare service design	0	173
5	mobile mHealth m-Health health care healthcare service design	11	174
6	health care service system design	14,596	2,260,000
7	health care service system design mobile	208	341,000
8	health care service delivery system design mobile	24	92,400
9	health care service delivery system comparison	554	542,000
10	health care service delivery system comparison mobile	6	63,600
11	health care service delivery system comparison mobile mHealth	0	1,280

2.14 Healthcare Services Design

In manufacturing, finance and other services industries continual innovation has brought new forms of delivery, giving rise to new forms of services (Hwang and Christensen 2008). Competition in healthcare delivery has led to newer forms of services like: outpatient surgery centres, executive wellness programs, independent nursing group practices, hospices, nursing homes, intermediate care facilities and home health care programs (Lim and Zallocco 1988). To these range of alternatives of healthcare services, mHealth is one of the emerging alternatives.

Considering the broad agenda of better healthcare for all, the dire situation of healthcare status in the developing countries and the vast potential and promise of mHealth, there is a significant opportunity for the research community to direct attention toward service design and service operation. While ITIL (OGC 2007) comes in handy with its systematic framework to address the service operation phase, there are hardly any studies on how to bring the '*Voice of Customers (patients)*' (VoC) to the service providers and guide them in devising healthcare services. The multi-disciplinary search pointed us to review *House of Quality* (HoQ) as a potential framework to rely on for services design. HoQ is a basic design tool and part of the management approach *Quality Function Deployment* (QFD) (Mizuno and Akao 1978). Hauser and Clausing's (1988) classic paper on HoQ based on the Japanese quality movement, has brought its significance to the worldwide community. With its wide spread success in bringing together various functional divisions of manufacturing, HoQ has been applied in various forms and to various degrees of sophistication in manufacturing, engineering and subsequently in the design of services (Mazur 1993; Ray 2003). HoQ inter-links

customer requirements, their rankings, engineering characteristics, performance measures, competitive products/ services and thereby elicits in a single diagram the areas of improvements required to win in the market.

Deming's famous *PDCA Cycle* is the underlying foundation for QFD and ITIL. While ITIL focuses on the operational aspect of Services Management, HoQ essentially deals with the design of products and services. HoQ not only helps in the design of products/ services but also in drawing conclusions about their competitive position in the market. This comparative evaluation of the market helps in examining the strengths and weaknesses and thereby provides input for product positioning and also to devise an action plan to bridge the identified deficiencies. In the event a service provider ignores these competitive insights, Keaveney's model suggests that the customers may switch providers thereby either leading to the eventual decline/ disappearance of a product/ service from the market. In either case, both HoQ and Keaveney's models point to the importance of understanding the comparative analysis of healthcare services. A good service design and consistent operation of the service are essential to raise the bar of user satisfaction (OGC 2007).

2.14.1 mHealth is Unique

Researchers have investigated patient perceptions of service quality in general (Akter 2012; Andaleeb 2001; Andaleeb et al. 2007; Heje and Olesen 2002; Petek et al. 2011; Ramsay et al. 2000; Thorsen et al. 2001; Ware et al. 1975) and mHealth in particular (Akter 2012; Akter et al. 2010a). While there has been research on the aspects of service quality of mHealth from the patients' perspective (Akter 2012; Akter et al. 2010a; Akter et al. 2011; Akter et al. 2010b; Akter and Ray 2010), researchers have not

addressed how mHealth is different from other healthcare delivery systems. These insights have called for a literature search for comparative analysis of healthcare delivery systems. In the extant literature there are very few studies devoted to the comparison of healthcare delivery systems. And there has not been any study that is devoted to a comparative analysis of mHealth with respect to other healthcare alternatives. Comparison within the health care sector can be understood in two basic forms: 1) intra-system (e.g., one hospital vs. another hospital) and 2) inter-system (e.g., GP vs. mHealth). The next section will briefly review studies devoted to patients' evaluation of health systems and then look at studies that are devoted to the comparative analysis of services.

2.15 Healthcare Comparative Studies

Physicians are used to act as surrogate decision makers for the patient. However, with drastic changes in healthcare this model is replaced by consumer centric model which recognises the patient's increasing role in both influence and selection stages of the healthcare decision process (Berkowitz and Hillestad 1982; Lim and Zallocco 1988; Wright and Parsons 1982).

2.15.1 Patients' evaluations of general practice

Service delivery is challenging. Services marketing and management pose special challenges because services deal with 'processes rather than things, with performances more than physical objects' (Lovelock and Wirtz 2010b). Three management functions – marketing, operations and human resources – are intimately joined in what Lovelock has dubbed the '*service trinity*,' to create and deliver services. Ascertaining and promotion of quality in general practice and primary care is not only a

necessity but also essential in retaining the service portfolio and continual assessment helps to alter and tailor the services to suit the consumers (Ramsay et al. 2000). Similar motivations have driven Thorsen et al. (2001) to study the purpose of general practice consultation from the patients' perspective. Other researchers like van den Brink-Muinen et al. (2007) have explored the basic question whether doctors' talks with patients meet the patients' expectations. They observe that patients want an attentive, friendly, frank, and empathetic doctor who listens well to their bio-medical concerns and advises and tries to alleviate their issues. They also recommend the GPs that they can gather the patients' feedback after their consultation.

Petek et al. (Petek et al. 2011) have performed a longitudinal survey (n = 7472) in which they have collected patients' evaluations of European General Practice. As there is a dearth of internationally standardised longitudinal data on patient evaluation of healthcare, they are motivated to carry on a longitudinal assessment. The respondents are chronic care illness patients. The research objective is to compare patients' evaluation of the current study of 2009 with a previous similar study done in 1998. They have used a EUROPEP questionnaire consisting of 23-items. Petek et al. have not found any major changes between the 1998 and 2009 studies for all the countries combined. However, they noticed that English patients are fairly more positive towards general practice in 2009, whereas German patients have become slightly less positive.

An interesting point is that more than 80% of the patients rated GPs most positively (4 or 5 on the Likert scale), but they are not most happy on the factors: waiting time (72.1%), telephone accessibility (82.7%), and dealing with emotional problems (83.2%).

Petek et al. note that changes in healthcare systems, health professions and patient population might influence patient evaluations of healthcare over time. Unfortunately, no internationally standardised longitudinal data is available to test these changes. Petek et al. found accessibility over the phone to GPs and waiting time are important determinants of the healthcare system satisfaction.

The other important conclusion that comes out of Petek et al. study is that there is no good correlation between patients' assessments of the quality of care and the respective biomedical outcomes. Similar observations are also made by many other researchers based on their patient satisfaction studies in relation to total hip arthroplasty (Haverkamp et al. 2008). Finally Petek et al. conclude that service providers must aim for complete patient satisfaction else there is a chance that patients will change their physician.

2.15.2 Healthcare Inter-system Comparative Studies

Lim and Zallocco (1988) for the first time studied inter-system competition by analysing the consumer attitudes toward divergent healthcare systems, namely: hospitals, home healthcare, nursing homes, and outpatient clinics. Their research objectives are:

- to determine consumer attitudes toward the four health care delivery systems;
- to determine why consumers' perceptions of these systems vary on specific attributes; and
- to identify dimensions that most clearly discriminate the four systems.

Lim and Zallocco conducted a survey in Toledo, Ohio, USA, through a self-administered, structured questionnaire and respondents were selected through a modified area sampling technique. Respondents were questioned about their attitudes

toward four healthcare delivery systems along 10 attributes: *quality of medical care, safety, speed of recovery, quality of medical personnel, risk of complications, cleanliness, convenience, comfort, privacy provided, and cost*. A 6-point Likert scale ranging from strongly agree (6) to strongly disagree (1) was used for responses. After data clean-up, they got 102 usable questionnaires.

Overall mean scores put hospitals as more safe, clean and of better quality, however, hospitals were perceived as more expensive. Nursing homes had the most negative image with respondents. In terms of lowest cost, outpatient clinics were rated more positively. On the dimensions of convenience, comfort, privacy and likelihood of speedy recovery, home healthcare were most positively rated. They performed *multiple discriminant analysis* (MDA) to classify the delivery systems. Lim and Zallocco have found that the three dimensions: *personalised care, quality of medical care and value* distinguish the four health care delivery systems. MDA has provided insights on which dimensions a particular delivery system is positively viewed there by providing useful inputs for service providers, healthcare researchers and policy makers. For example, home health care service providers can highlight their strengths as perceived by consumers in comfort, privacy, medical quality and likelihood of speedy recovery as differentiating factors to offer better services.

2.15.3 Healthcare Intra-system Comparative Studies

Andaleeb (2000) has studied quality of services provided by public and private hospitals in Bangladesh. He notes that large segments of the population in developing countries are deprived of a fundamental right: access to basic healthcare. Quoting a World Bank 1987 study he obverses that the situation is acute in Bangladesh as only

30% of the population have access to primary healthcare. Due to the Bangladesh government's regulatory reforms, during 1982-1996 there was an increase of 346 private hospitals and 5,500 beds. Though there are signs of improvement in numbers in capacity, there is a dearth of information with regard to quality of the services offered by hospitals. Public hospitals being subsidised by the government have marginal tendency to improve their services, while private hospitals which primarily run on patients' patronage are obligated to improve their services and be competitive among peers.

To gauge patients' assessments of the hospital services they have received in the past, Andaleeb has used a modified framework to that of SERVQUAL of Parasuraman et al. (1988). Through qualitative interviews Andaleeb established that a prominent cultural concept, *baksheesh* (facilitation payments) was prevalent in Bangladesh and needs to be included in the modified framework. They collected data from 216 interviews of which the final valid cases were 207. He applied 2 group *discriminant analysis* (DA) to determine whether: service quality ratings (along with education and income) predicted choice of hospitals; and which factors accounted most for the differences in the scores; and how reliably the patients could be grouped into public or private hospital users. Of the 207 cases only 191 found to have valid data, consisting of 91 respondents of public hospitals and 100 used private hospital or clinic.

The DA identified one significant discriminant function that produced a classification accuracy of 70.16%. The accuracy is 25% greater than that obtained by chance (Hair et al. 2010; Malhotra 2004) confirming a satisfactory predictive power of the model. Private hospitals were evaluated better on responsiveness, communication and

discipline thus supporting Andaleeb's premise that market incentives would explain differences in perceived quality of services provided by public and private hospitals. Furthermore he concludes that even the private hospitals level of service having not measured up to the satisfaction of some of the affordable patients. This resulted in patients switching services in foreign countries thus costing the economy on the foreign exchange front (Keaveney 1995). This is an important conclusion that there is vast opportunity to improve healthcare services in Bangladesh. It can be noted that the emergence of the mHealth service as one of the favourable alternatives is not a major surprise due to the prevailing structural failure of the healthcare delivery in Bangladesh. This conclusion is well supported by a detailed study undertaken by the World Bank on the status of services in developing countries (Ivatury et al. 2009; WHO 2011; Worldbank 2004).

Moving forward on the works of Andaleeb, Siddiqui and Khandaker (2007) compared services of public and private hospitals of Bangladesh and then compared private hospitals with foreign counterparts from the perspective of Bangladesh patients. They have quoted several prior studies that essentially concluded that public hospitals are used 30% or lower due to the facts of unavailability of doctors and nurses, their attitudes and behaviour, lack of drugs, waiting time, travel time etc. They collected questionnaires from 400 randomly selected patients. Their analysis showed that private hospitals were doing better in terms of availability of drugs, tangibility, perceived costs, empathy of nurses and responsiveness. It has also been derived that foreign hospitals are doing even better on these dimensions compared to private hospitals. Public hospitals also fared lower in the aspects of tangibility compounded by

the factors of cleanliness, water supply, and availability of equipment. The cost has been studied through the patients' perception of costs including consultation, diagnostics, accommodation etc. Based on their analysis they concluded that the overall quality of service was better in foreign hospitals than the private hospitals in Bangladesh in all the factors, including the 'perceived cost' factor.

Yesilada and Direktor (2010) have studied health care service quality differences between public and private hospitals in Northern Cyprus. In validating the SERVQUAL model, they found reliability-confidence, empathy and tangibles to be the three dimensions of service quality which were relevant, in contrast to the five factor model of Parasuraman (1988). The authors found that the perceived service falls behind expectations for both public and private hospitals. The gaps are much larger for public hospitals. One reason being that public hospitals are funded by the government and there is no competitive pressure on them to be cost effective, proactive and patient oriented in their attitude towards service. On the other hand, private hospitals are for-profit and they have to raise funds to sustain their operations. Private hospitals compete with each other and hence they must continuously improve their service quality in both curing as well as caring aspects. Similar to Keaveney's conclusions (1995), Yesilada and Direktor observed that private hospitals need to continuously improve their service quality, or else lose their business opportunity to competitors.

2.16 Research Themes

2.16.1 mHealth Comparison with Conventional Services

In the extant literature there has been very little focus on comparative analysis of healthcare services (Table 2.6). mHealth happens to be a relatively a new paradigm, so there has not been any comparative analysis of this platform vis-à-vis with conventional services. The few publications on healthcare inter-system and intra-system comparison are reviewed in Sections 2.15.2 and 2.15.3.

Thus the current research fills a significant gap in the literature and contributes to an inter-system comparative study that includes the emerging healthcare paradigm mHealth.

Table 2.6: Literature Search Summary of Healthcare Service Comparison

No	Search Terms	PubMed	Google Scholar
1	"health care" healthcare "service comparison" mHealth "mobile health"	1	0
2	"health care" healthcare "service comparison" "mHealth"	1	1
3	"health service" "house of quality" mHealth	0	3*
4	"discriminant analysis" "house of quality"	4	53
5	"discriminant analysis" mHealth	0	117

2.16.2 mHealth and Conventional Services in Perspective

The research envisages identifying service characteristics that differentiate healthcare services so that healthcare services will be designed/ improved to meet the needs of

the developing world. Thus Chapter 2 provided the contextual background to the topic and Chapter 3 will cover the specific theme of the research.

The healthcare needs of the populace drive the demand for the healthcare services. Traditionally, the healthcare services delivery is centred in facilities such as: clinics, medical centres and hospitals. These facilities converged the capabilities of a range of healthcare professionals, and offer healthcare services in response to the demands of the populace. In essence, both healthcare providers and consumers meet face to face to experience the services. ICT has actually lessened this need for face to face consultation while enabling virtual collaboration between the providers and consumers. While ICT has a significant share in the developed world, it did not generate enough traction in the developing world where actually the demand for such virtual collaboration was the highest. Figure 2.9 pictorially summarises this point as well as the forgoing observations.

The less advent nature of ICT in the developing world is referred to as the '*digital divide*.' However, the phenomenal growth of wireless communications, mobile phones and their affordability enabled mobile communications to penetrate far and wide in developing countries, including a greater portion of the uneducated population. This phenomenal growth in mobile phones over the last decade gave rise to mHealth. So much so Garawi et al., (2006 p.91) define mHealth as "a new paradigm that brings together the evolution of emerging wireless communications and network technologies with the concept of 'connected healthcare' anytime and anywhere."

The SLC discussion presented in the earlier sections of this chapter highlights that Service Design is an important element that crystallises the dynamic interplay of

organisational assets and capabilities into valuable services to the clients. While Service Quality, in general was well researched, healthcare services design has not received significant emphasis (Agarwal et al. 2010; AHRQ 2012; Motamarri 2012). The next chapter will look into the specific research questions, and how the investigations of service characteristics will be a step forward to impact better healthcare services design and how mHealth providers can leverage these outcomes so that mHealth can play a vital role. Thus briefly, the discussion presented in this chapter provides a broad perspective and a greater transformative role of mHealth in the developing world.

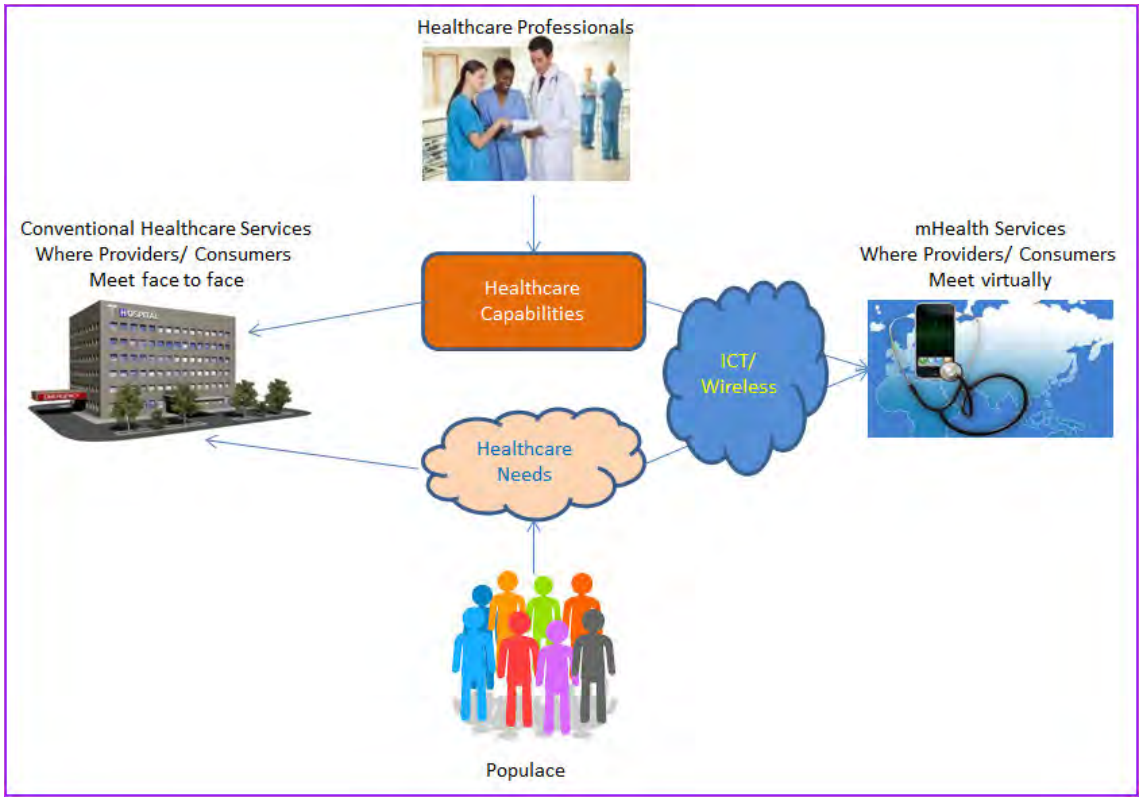

Figure 2.9 Conventional vs. mHealth Services

2.16.3 mHealth Research Agenda

In summary, the healthcare services in developing countries need a massive injection of resources to bridge the *healthcare divide*. mHealth promises to circumvent the degree of investments required in terms of both trained medical practitioners as well

as physical facilities to handle the large scale demand. In order for mHealth to be an effective and complimentary delivery system, it needs to be established that from the patients' perspective, mHealth:

- satisfies their basic need for medical advice;
- is a distinctive healthcare delivery system; and
- delivers comparable value in comparison to the incumbent alternatives.

2.17 Chapter Summary

The foregone literature review provided interesting insights into the penetration of mobile wireless communications and their emerging role in bridging the *healthcare divide* in developing countries. While healthcare shares many characteristics with the services industry in general, it has certain intricacies as they deal with human life. Service quality has been extensively studied in many disciplines including the healthcare domain. However, following the imperatives of healthcare services, the SLC model identifies the antecedents to service quality i.e., service design and operation are essential to achieve patient satisfaction. The literature review highlighted that healthcare service design has received meagre attention, and there are vast opportunities to fill this research gap by studying healthcare service design including mHealth as better architected services can outweigh the competition, and help mHealth to establish itself as a powerful alternative and thereby assist the developing world in achieving better healthcare for all. Based on these broad ideas and research themes, the next chapter will go deeper into finding a conceptual framework and research method. The discussion then moved on to the formulation of specific research hypotheses and questions to be addressed within this research context.

Chapter 3: Conceptual Framework: QFD and HoQ

3.1 Chapter Overview

The objective of this chapter is to develop the conceptual framework within which the broad research questions set forth in the previous chapter will be investigated. It argues for the need of a comparative assessment of mHealth with respect to the alternative healthcare systems. It provides a definition of mHealth within the purview of the current investigation. The chapter looks at qualitative comparison of alternative healthcare services. The discussion forms the necessary backdrop to develop the research hypotheses this investigation aims to test and the associated research questions that are to be addressed. Then it reviews *Quality Function Deployment* (QFD) and *House of Quality* (HoQ) as they form the conceptual basis for the research. The chapter also discusses QFD Matrices in the context of healthcare services, and delineates the scope of the current research task. The chapter is concluded with a summary.

3.2 The Need for mHealth Comparative Assessment

In most countries the demand for healthcare is rising faster than the supply of health care professionals. Though the developed nations are not immune to this situation, the problem is acute in the poor countries (Economist 2012; WHO 2012). The Economist (2012) observes that the labour productivity in the US has increased by 1.8% annually over the last two decades. However, the productivity in the health sector has declined by 0.6% annually. Furthermore, the Economist also notes that the shortage of health workers is a universal issue. In spite of these sectoral challenges, it is in developing

countries that innovations for newer solutions are emerging. And it is not surprising that mHealth is transforming healthcare in some of the developing countries. Though mHealth is in its infancy, it is becoming a distinct player in developing countries due to its affordability and right time and right place availability (Lewis et al. 2012).

For mHealth to be a significant player, it has to comparatively outperform or provide value to the patients over the incumbent service alternatives. A comparative assessment of user perceptions of various healthcare services also provides insights and strategic input to the governmental bodies, private entrepreneurs and health care service providers. It is imperative that both the health policy makers and health service providers recognise the user perceptions of health services for which either they provide governance or provision. User perceptions can alter patronage of services in a market place when captive restrictions are absent. Following Keaveney's model (Figure 2.7), consumers may switch service providers in a market place so as to maximise their utility. For example, if patients perceive the complimentary benefits of mHealth over other conventional services, they may switch to it in the event it provides overall better utility. This necessitates understanding a comparative assessment of available alternatives vis-à-vis mHealth. For example, several authors have presented the poor array of health services in Bangladesh (Andaleeb 2000; Andaleeb 2001; Andaleeb et al. 2007; Siddiqui and Khandaker 2007). They have also noted that when opportunities are present in neighbouring countries, the patients started visiting the neighbouring countries, negatively impacting the foreign exchange to the economy (Andaleeb et al. 2007; Siddiqui and Khandaker 2007).

Lim and Zallocco (1988) observed that patients are increasingly influencing the selection and decision making process of choosing service providers in the market place. They studied patients' attitudes towards four health care systems: hospitals, home health care, nursing homes and outpatient clinics. Lim et al. applied *Discriminant Analysis* (DA) in empirically finding the attributes that form the patients' attitude towards the four healthcare systems. Andaleeb (2000) applied DA to model users' hospital choice between public and private hospitals in Bangladesh. Siddiqui and Khandaker (2007) applied DA to distinguish public and private hospital services within Bangladesh and then between private hospitals and foreign hospitals. Both of the studies have identified sectorial weaknesses and policy changes that need to be in place to improve the health care provision.

There has been some significant research in the areas of healthcare service quality measurement both from the operator and user perspective (Akter 2012; Akter et al. 2011; Akter et al. 2010b; Akter and Ray 2010). While Lim and Zallocco (1988) focused on inter-system comparison, Andaleeb et al. focused on intra-system comparison from the patients' perspective. Comparative assessment of service alternatives is vital for effective design, operation and competitive position in the market place, which will be discussed in the next sections. Furthermore, the *Service Life Cycle* model (Figure 2.6) identifies that design and operation are key antecedents to service quality. However, there is scant research to distinguish mHealth from other existing health care services. This research attempts to fill this knowledge gap and pave a way for strengthening of the design and operation of healthcare services for which the whole world population is the customer base.

3.3 Alternative Health Care Systems

The extant literature has identified four prominent forms of health services in developing countries, namely*: public hospitals (PH)*; *general practitioner (GP)*; *traditional medicine practitioner (TM)* and *mHealth* (Akter 2012; Cokroft et al. 2003; WHO 2011). The research relies on the following definition for each of these services. A GP is a medical practitioner who treats acute and chronic illnesses and provides preventive care and health education for all ages and both sexes. The GP has similar meaning across the Commonwealth countries (Leck and Leck 1987). GPs provide services usually in the residential suburbs and usually establish bonding with the community they serve. The GPs may collect their fees either per consultation or may bill the patients periodically. Public hospitals (PH) are generally funded by the government to serve the public, and they may collect nominal fees from the patients. The range of services offered by PH may have a wide variation. While they offer at the minimum all services similar to that of a GP at the minimum, on the higher end of the scale they are the ultimate conglomeration of all aspects of care (advice, consultation, diagnosis, surgery, care, emergency etc.,).

PHs and GPs follow the established scientific form of medicine. In contrast to these forms of scientific medicine, in some Asian and African countries people do depend on *traditional medicine or complementary and alternative medicine*. The WHO defines TM as: "The health practices, approaches, knowledge and beliefs incorporating plant, animal and mineral-based medicine, spiritual therapies, manual techniques and exercises, applied singularly or in combination to treat, diagnose and prevent illnesses or maintain well-being" (WHO 2008). The PHs and GPs are in acute shortage in

developing countries. Some of the rural areas are completely short of any access to PHs and GPs (Worldbank 2004). In such situations people are left with the only option of TM (WHO 2008). This situation is changing with the affordable, accessible and reliable option of medical care through mobile phones.

3.3.1 Commonalities among the Healthcare Services

PH, GP and TM services require a face-to-face consultation between the patient and the care provider. In contrast to these services, a care provider can as well deliver the service over a mobile phone, following the definition of mHealth by the WHO (2011). The geographic separation of the patient and the care provider may limit the range of services a provider can offer over wireless communication. Excluding those possibilities, *this thesis relies on the notion that mHealth is similar to the other service alternatives: PH, GP, and TM, except that the consultation is provided over a mobile phone, whereby mHealth derives its ubiquity due to the underlying delivery channel of mobile/ wireless communications*.

3.4 Defining mHealth

mHealth has been broadly understood as health service delivery over a mobile or wireless platform (Istepanian et al. 2004). This early definition of mHealth has been expanding since its inception due to the massive uptake of mobile communications, dramatic growth in the use of mobile handsets and greater penetration of mobile services throughout the world (Akter and Ray 2010). The extant literature defines mHealth as a subset of eHealth which delivers health services over a mobile platform (Mechael 2009). Whereas eHealth is defined as the embryonic convergence of wide-reaching technologies like the Internet, computer telephony/interactive voice

response, wireless communications, direct access to health care providers, care management, education and wellness (DeLuca and Enmark 2000), mHealth is defined as using mobile communications—such as PDAs and mobile phones—for health services and information (see Figure 3.1). Broadly, mHealth is defined as the use of portable devices with the capability to create, store, retrieve and transmit data in real time between end-users for the purpose of improving patient safety and quality of care (Vital Wave Consulting 2008). These definitions of mHealth have predominantly emphasised 'wireless communication' to provide health care solutions (Vital Wave Consulting 2008).

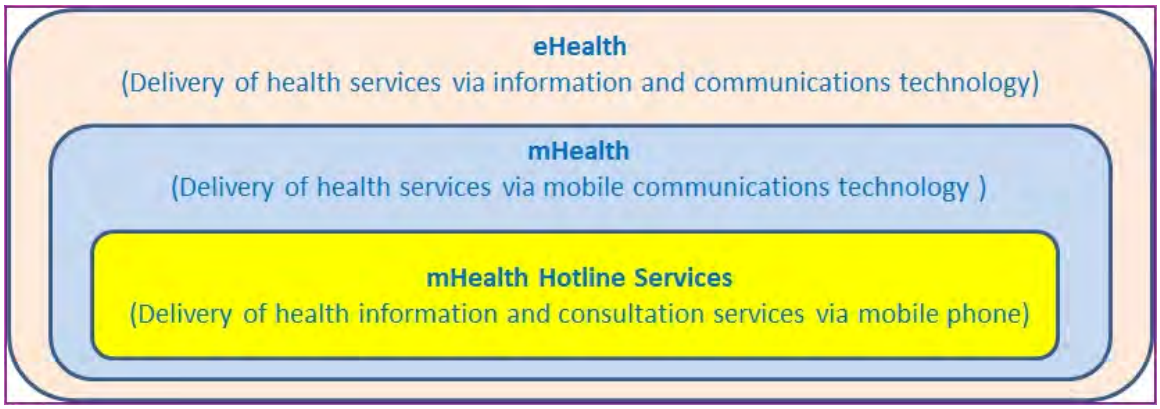

Figure 3.1: Relationship between eHealth, mHealth and mHealth Hotline Services
Source: (Ivatury et al. 2009)

Highlighting the importance of wireless communication devices to support public health and clinical practice, Kahn et al. (2010) define mHealth as the use of portable electronic devices for mobile voice and data communication over a cellular or other wireless network of base stations to provide health information. Iluyemi (cf., (Vital Wave Consulting 2009)) extends the mHealth definition by focusing on "any wireless technologies (e.g., Bluetooth, GSM, GPRS/3G, WiFi, WiMAX) to transmit various health-related data contents and services through mobile devices such as mobile

phones, smart phones, PDAs, laptops and Tablet PCs." However, this definition has targeted only health workers as the sole users of mobile health services, but there are some popular mHealth services around the world which include both patients and health workers as users, such as mHealth hotline services or mobile telemedicine services in India (HMRI), Mexico (MedicalHome), Pakistan (Teledoctor) and Bangladesh (Healthline) (Ivatury et al. 2009).

Overall, an assessment of various definitions synthesises that mHealth is all about delivering health services and information over a mobile platform (Akter 2012). The most popular mHealth platform is B2C Health which transforms healthcare services in developing countries using electronic commerce model (WHO 2011).

Thus, focusing on mobile health hotline services, **this study defines mHealth as:**

> **"**A personalised and interactive health service over mobile phone, where the main goal is to provide ubiquitous and universal access to medical advice and information to any user/ patient (Akter 2012; Akter et al. 2011; Akter et al. 2010b; Akter and Ray 2010)."

3.5 Qualitative Comparison of Health Care Delivery Systems

Based on the established definitions for PH, GP, TM and mHealth as discussed above (Leck and Leck 1987; WHO 2008; WHO 2011), and generally observable characteristics of these services, an attempt is made to arrive at a qualitative differentiation of these services. This axiomatic analysis attempts to compare these different healthcare delivery systems on a qualitative scale of Low-Med-High. Each service is qualitatively assessed to Low, Med or High depending on the service's capability along the attribute dimension.

Accessibility to the service (or service outlet) is an important attribute in determining its patronage. Next to accessibility, a service also must be available in the sense that a consumer shall be able to interact with the service provider. Apart from accessibility and availability, a service must have adequate capacity to deliver prompt service to meet the service demand. Keaveney's model (Figure 2.7) treats these characteristics as value proposition determinants. Ease of use or the ease with which consumers can interact with the service providers, the personal attention extended to individual consumer, and the empathetic behaviour of the provider in listening to the consumers' needs influence in defining a successful service encounter (Delone and McLean 2002; Keaveney 1995). When it comes to service consultations that are personal in nature like legal, medical related etc. privacy is of utmost importance to the consumer so the provider has to make conscious efforts to provide a consultation that ensures privacy of the consumer (Parasuraman et al. 2005). Table 3.1 presents a qualitative comparative summary of the identified healthcare delivery systems, and the differentiating dimensions are briefly discussed.

On the dimension of accessibility, PHs fare low as these are public facilities built to cater to a range of neighbourhoods, and in instances of developing countries these establishments could be far distant from the rural populace (WHO 2012; Worldbank 2004). As noted in Section 3.3, GPs and TMs establish their practices within the neighbourhoods, so their accessibility is relatively better than the PHs. In contrast to these alternatives, mHealth provides a virtual consultation, and the location barrier has been shattered by the wireless mobile communications (WHO 2011). Due to this ubiquitous nature, a patient can access mHealth service from where he is, rather than

to travel to the service outlets of PH, GP or TM. Thus mHealth scores higher on the dimension of accessibility than any other alternative. Similar to this line of discussion, on the dimension of availability, mHealth scores higher than the other alternatives by virtue of their 24x7x365 operation from a health call centre (Ivatury et al. 2009). While the other alternatives may not practically be available on a 24x7 basis, they may operate little over the normal business hours, thus their availability can be rated as medium.

Table 3.1: Qualitative Comparison of Health Care Services Delivery Alternatives

Sl No	Attribute	PH	GP	TM	mHealth
1	Accessibility	Low	Med	Med	High
2	Availability	Med	Med	Med	High
3	Ease of Use	Low	Med	Med	High
4	Privacy	Low	Med	Med	High
5	Empathy	Low	Med	Med	High
6	Promptness	Low	Med	Med	High
7	Capacity	Static	Static	Static	Dynamic
8	Range of Services	High	Med to Low	Low	Limited
9	End-to-End Medical Needs	High	Low	Low	Low

In developed nations health care professionals respect the privacy of the patients and are empathetic to their patients. In developing nations, due to the excessive demand for medical services, poverty and shortage of trained medical professionals they negatively influence these concerns as well as the provision of prompt service to the patients (Andaleeb 2008; Andaleeb 2000; Andaleeb et al. 2007; Worldbank 2004). Thus, on the dimensions of privacy, promptness and empathy, the PHs score low, while GP and TM services provide moderate attention to this issue. mHealth as an emergent alternative creates a level of better assurance to patients on these fronts, thus it relatively gets a high score (Akter 2012; Ivatury et al. 2009).

Any service facility has an upper bound in terms of its ability to handle demand. While there may be opportunities to alter demand in certain segments, generally PH, GP and TM operate on fixed norms, and there exists less flexibility to dynamically increase capacity to handle the service demand. mHealth is delivered through call centres concentrating on consultation and advice. The general requisite is the provision of qualified professionals to handle the impending service requests. The underlying technology of mHealth may impose certain limitations, but those can be relatively overcome with manageable tweaks, and staffing levels can be dynamically placed based on the observed demand patterns (Ivatury et al. 2009). This is evident from the fact that Grameenphone's 789 service within a short of span of three years from inception reached to the levels of 10,000 calls per day (Akter 2012; Grameenphone 2006; Grameenphone 2008; Ivatury et al. 2009). Thus, the capacities of PH, GP and TM are relatively static while mHealth capacity can be dynamically modified.

PHs may offer a range of medical services besides consultation, like diagnosis, surgeries, post operation care etc. In contrast, a GP may offer some of these services, but TM and mHealth cannot offer this full range of possibilities. Thus on the dimension of range of services PHs score high, GPs score med-to-low, and TM and mHealth score low. Thus, on the dimension of meeting the end-to-end needs of patients, PHs score high and the rest of the delivery systems score low.

In summary, the common service offered across the range of delivery systems is consultation and advice. This research attempts to find the distinguishing characteristics on the notion of this common service being offered. This qualitative

analysis lays a foundation for the quantitative study to gauge patients' perceptions of these four healthcare delivery systems.

3.6 Service Quality Challenges of mHealth

The extant literature on the mHealth hotline (or mobile telemedicine) service identifies that quality challenges of this platform revolve around service delivery platforms, patient-physician interaction over this platform and service benefits (Akter et al. 2010b; Ivatury et al. 2009). Kaplan and Litewka (2008) argue that mHealth is not a mere technological improvement but a reengineering of healthcare processes that brings to the forefront the non-technical, socio ethical, privacy, security, confidentiality and information accuracy issues. These concerns of mHealth get complicated due to the lack of universal acceptance for certain practices and approaches (Kaplan and Litewka 2008). The GOe assessment on mHealth (Section 2.8) identified competing priorities as the major impediments to mHealth implementation (WHO 2011). The WHO also recognises that there are legitimate concerns about the security of citizen information with regard to mHealth. However, a strategic and systematic implementation of mHealth can revolutionise health outcomes. In this context, a systematic study about the patients' perceptions of mHealth vis-à-vis other health care services provides a significant evidence base that can percolate through layers of governmental and service provider organisations and define a strategic direction for the health for all.

3.7 Qualitative Study of Service Quality

This study focuses on mHealth hotline (or mobile telemedicine) services in Bangladesh, which is one of the leading developing countries for such services. Currently, more than 24 million people in Bangladesh have access to such mHealth services provided by *Grameen phone mHealth* (Akter et al. 2010b; Ivatury et al. 2009; WHO 2011). Under this platform, patients can access this service any time by dialling some unique digits (e.g., '789' in Bangladesh) from their mobile phones and receive health services in the form of medical information, consultation, treatment, triage, diagnosis, referral and counselling from registered physicians.

The study obtained qualitative data from three *focus group discussions (FGD)* and 10 *in-depth interviews* (DI) (Dagger et al. 2007; Fassnacht and Koese 2006; Malhotra 2010; McDaniel and Gates 2010) conducted with mHealth (hotline) and other prominent healthcare systems' consumers in Bangladesh. A total of 24 participants, eight per focus group, were involved in three focus group sessions. Screening criteria were used to select respondents for FGDs and DIs. Respondents had to be at least 18 years of age and had to have Grameen phone mHealth service experience in the past 12 months. Participants ranged in age from 18 to 62 years and both genders had equal participation. Each FGD session was conducted by two moderators and lasted about 90 minutes. In addition, ten DIs were conducted to explore users' insights on the research agenda. In the context of both focus group discussions and in-depth interviews, the moderators were selected based on their proficiency in English and Bangla (Andaleeb 2008; Andaleeb 2000; Andaleeb 2001). Participants were recruited using convenient

sampling in order to ensure productive findings and the richest data for scale development (Dagger et al. 2007).

The study followed a procedure to arrange FGDs and DIs. Firstly, potential participants who met the screening criteria were provided with an invitation letter from a reputable university, which contained the phone number for respondents to check that the study was authentic. The academic purpose of the study was explained in the letter with adequate assurance of anonymity and the freedom to not answer particular questions or to withdraw opinions from the discussion at any stage. Secondly, potential respondents were contacted via mobile phone after one week to fix the schedule for FGD/DI sessions. Thirdly, each participant was provided with an SMS confirming the date, time and venue of the FGD/DI session. Finally, each participant was reminded a day before via a mobile phone call about the time and place of the FGD/DI session. In each session, respondents were asked the following questions in the local language (Bangla) to evaluate their mHealth experiences and to identify the service quality dimensions:

- In your opinion, what makes mHealth different from other health services?
- What are the primary dimensions of service quality of this health service?
- What technical level of communication is important to you?
- How do you evaluate your interpersonal interaction with physicians over this platform?
- What benefits do you primarily seek from this health service?
- Any positive or negative experience that you have had while consuming this service?

The study translated the above discussion questions into the local language (Bangla) and retranslated them into English until a panel of experts, fluent both in English and

Bangla, confirmed that the two versions were reasonably comparable. This survey's research contexts are similar to that of other investigations, like (Andaleeb 2008; Andaleeb 2000; Andaleeb 2001; Fassnacht and Koese 2006; Liu et al. 2009; Mullen 1995; Teo and Liu 2007).

The answers of both focus group discussions and in-depth interviews were recorded, synthesised and sorted into different themes using a manual content analysis system by an analyst who was proficient both in English and Bangla (Dagger et al. 2007). The objective of this analysis was to identify the dimensions of mHealth service quality (D'Ambra and Rice 2001). The analysis was conducted in several steps. Firstly, key responses were identified and highlighted in the transcript. Secondly, responses reflecting different dimensions of service quality were categorised. Thirdly, recurring themes (or sub-dimensions) were extracted under each dimension by two academic judges proficient in English and Bangla (Andaleeb 2008; Andaleeb 2000; Andaleeb 2001). These academic judges were not part of the present study in order to ensure their neutral opinion on the development process (Morre and Benbasat 1991). In this case, conflicting responses were discussed until agreement was reached and the overall inter-judge reliability was 0.86 exceeding the threshold level of 0.70 (Straub et al. 2004). Finally, each dimension was double-checked, refined and substantiated by revisiting the raw responses. The findings of the qualitative study frequently identified the following dimensions and sub-dimensions of service quality as listed in Table 3.2. Each of these dimensions are analysed from the perspective of healthcare services and mHealth in the next sub-sections.

Table 3.2: Service Quality Dimensions

Perceived Systems Quality	Perceived Interaction Quality	Perceived Information Quality	Perceived Outcome Quality
1. Reliability 2. Accessibility 3. Availability 4. Safety 5. Efficiency 6. Privacy 7. Usefulness	1. Helpful 2. Promptness 3. Courtesy 4. Empathy	1. Completeness 2. Accurate 3. Up-to-date 4. Orderliness	1. Ease 2. Convenience 3. Cost 4. Confidence 5. Enjoyable

3.7.1 Perceived systems quality

Platform systems or platform quality with respect to mHealth and other healthcare services reflects patients' perceptions about the technical level of communication (or delivery system). In qualitative analysis seven sub-dimensions are confirmed to be of importance to patients, namely, *reliability, accessibility, availability, safety, efficiency, privacy and usefulness*. The first sub-dimension *reliability* indicates the degree to which healthcare platform (PH, GP, TM or mHealth) is dependable over time (Akter et al. 2010b; Delone and McLean 2003; Nelson et al. 2005; Parasuraman et al. 2005). It measures service promise and service dependability as exemplified by the following comments: "It performs smoothly" and "It is dependable." The sub-dimensions, *systems availability and accessibility*, defines the degree to which the healthcare service platform available on an 'any-time' and 'anywhere' basis (Akter et al. 2010b; Chae et al. 2002; Parasuraman et al. 2005). Generally it was referred to as the unique and crucial differentiator for mHealth as suggested by the following comments, "I can access the mHealth platform whenever I want" and "I can receive medical service right away." The sub-dimension, *systems efficiency*, conveys the health service's adaptability to meet diversified user needs and changing user conditions (Akter et al. 2010b;

Delone and McLean 2003; Nelson et al. 2005; Parasuraman et al. 2005). This purport to the typical customer comments like: “It can flexibly adjust to meet my variety of needs.”

The sub-dimension, *privacy*, refers to the platform’s ability to secure the patients’ personal information shared via the consultation process (Akter et al. 2010b; Parasuraman et al. 2005; Varshney 2005). *Privacy* has been cited as an important differentiator for mHealth over other platforms, as reflected by the comments: “It protects my personal information” and “It does not share my personal information with others.” The sub-dimension, *safety*, measures the degree to which the health service platform is safe (Parasuraman et al. 1988; Sousa and Voss 2006). It is an essential factor for inspiring trust and confidence among patients, as reflected by the comments, “I feel safe while consulting with physicians” and “Physicians’ behaviour stimulates my confidence to deal with this healthcare platform.” Research studies in IS found that utilitarian benefit (i.e., usefulness) plays a critical role in developing a positive attitude towards information technology implementation (Bhattacherjee and Bhattacherjee 2001; Davis 1989; Limayem et al. 2007). Thus the study considers these are salient indicators of platform quality in the context of healthcare services comparison.

3.7.2 Perceived interaction quality

Services are essentially co-produced, implying the dyadic interplay of the inter-personal interaction between the service provider and consumer, and the quality of the interaction is of paramount value (Dagger et al. 2007). The qualitative findings suggest that during the consultation with a physician, based on the physician’s

attentiveness, promptness and advice, a patient perceives the quality in terms of knowledge and competence of the provider. Four sub-dimensions: *helpful, promptness, courtesy and empathy* underpin the patients' perception of interaction-quality. The first sub-dimension, *responsiveness*, conveys the willingness of the service provider to help consumers and to deliver prompt service (Parasuraman et al. 1988; Sousa and Voss 2006). Participants in the qualitative interview referred to this as willingness and promptness of the provider to deliver medical consultation, as indicated by the comment, "Physicians show a sincere interest to solve my problems."

The sub-dimensions *courtesy and empathy* reflects the caring and individualised attention of the provider to the patients. It reflects the providers' understanding of the patients' needs and accordingly tune and deliver an empathetic service (Parasuraman et al. 1988; Sousa and Voss 2006). Comments such as "Physicians understand my specific needs" or "Physicians give me individual care" are evidence of the importance of the care in the interaction quality. The sub-dimension, *helpfulness*, refers to the degree to which a healthcare service arouses positive feelings (Fassnacht and Koese 2006). Comments like "I feel helpful having service from this platform" or "I believe my future health will improve having this service" highlight the importance of the perception that a service really helps in meeting a consumer's needs. These patients' expressions and their corroborations with the service quality research, make us believe that these sub-dimensions are salient indicators of interaction-quality in the context of healthcare services in developing countries.

3.7.3 Perceived information quality

Information quality refers the degree to which it is helpful in completing a particular task (Nelson et al. 2005). The key themes of information quality are *completeness, accuracy, up-to-date and orderliness.* The first variable, *completeness*, refers to the degree to which all possible states relevant to the user population are represented in the information (Akter et al. 2010b; Nelson et al. 2005). During the exploratory study, *completeness* was frequently discussed as an important parameter of information quality, as indicated by this comment, "It gives me all the information I need." *Accuracy* refers to the correctness in providing the right information to the right person at the right time (Akter and Ray 2010). According to Wand & Wang (1996) "…the notion of accuracy to include the idea that the information not only is correct, unambiguous, and objective, but also meaningful and believable". *Up-to-date* refers to the degree to which the information is current. It is a contextual attribute of information quality which is very much dependent on task and user perceptions (Ballou et al. 1998). The final variable, *orderliness*, reflects the degree to which information is presented in a manner that is understandable and interpretable to the user and thus aids in the completion of a task. In other words, it is unambiguous, meaningful, believable, and consistent (Akter et al. 2010b; Nelson et al. 2005). Comments such as, "The information provided by mHealth platform is well organized & well presented" support evidence of its importance.

3.7.4 Perceived outcome quality

The study proposes *outcome-quality* as a critical dimension of service quality which refers to the outcome perception of a patient as a result of the consultation process

with a healthcare service provider (Aharony and Strasser 1993; Gronroos 1984). According to Dagger et al. (2007), *"Outcome does not refer to ultimate result (e.g., care) but rather to the outcomes experienced over a series of service encounters."* The extant literature highlights the importance of perceived outcome quality in healthcare in terms of several service benefits, which may have varying importance to the patient (Andaleeb 2001; Sheth et al. 1991). The direct relationship between outcome quality (or service benefits) and service quality is also cited in some healthcare studies (Andaleeb 2001).

The qualitative study identified five sub-dimensions, namely: *ease, convenience, cost, confidence and enjoyable*. The sub-dimensions *ease, convenience and enjoyable* refer to the degree to which a healthcare service results in an emotional satisfaction that produces a positive feeling in the perceptions of the patient (Akter et al. 2010b; Delone and McLean 2002; Keaveney 1995; Limayem et al. 2007). During the exploratory study it is frequently referred to as important parameters, as indicated by the comments, "it is easy to access a mHealth hotline," "it is very inconvenient to go to a public hospital," and "mHealth is enjoyable as there are no queues or waiting." Consumers in the market place always try to maximise their return by choosing an option that delivers better overall value. A product that instils confidence in the provider and costs relatively cheaper will be viewed by patients as a better outcome alternative (Keaveney 1995). It is reflected in patients' comments like, "it costs less to consult a mHealth hotline than visiting a GP" and "I am confident of a better outcome by consulting a GP than visiting a PH." Thus we consider outcome-quality is an important dimension in the comparative assessment of healthcare services.

3.8 Research Hypotheses/ Research questions

The review of healthcare services, mHealth, and healthcare delivery systems' status in developing countries, has brought to the forefront pertinent questions for healthcare services in general and mHealth in particular. Moving beyond service quality, the antecedents to service quality i.e., service design and service operation and differentiating characteristics of delivery systems are all important to bridge the *healthcare divide*. It is possible to draw a comparative analysis of existing healthcare services from a qualitative perspective. However, as the patients are the ultimate consumers of mHealth services, it is worthwhile to understand how patients perceive mHealth vis-à-vis other healthcare delivery systems. This has motivated me to pursue research to address the following research questions within the context of developing countries:

RQ1: Are the different healthcare services distinguishable from each other?
RQ2: If so, what factors contribute to the service differentiation? and
RQ3: Is mHealth distinct from other existing services?

The extant literature has presented a contrasting picture that the populations of the developing countries lack even basic healthcare advice, but they have become consumers to the mobile wireless communications. There is a tremendous gap between the demand for healthcare and supply. mHealth is emerging to play a vital role in circumventing this huge gap in health care provision through affordable services delivered via mobile phones. Due to the extent of coverage and reach of the mobile phone, these services are started serving not only under-served but unserved populations as well due to the ubiquity and affordability of the mHealth services.

Recognising this transformative impact of mobile phones in healthcare delivery, we hypothesise that in developing countries:

H_1: Patients differentiate different health care services.

H_2: Patients perceive mHealth as a distinct alternative over the other services.

The next sections will look into the conceptual frameworks and research methods that can help in guiding the research process to find answers to the research questions and thus address the hypotheses.

3.9 Quality Function Deployment and House of Quality

Globalisation, ever increasing competitive climate and continual technological sophistication have been placing tremendous pressure on organisations to deliver more with fewer employees. Support business functions like accounting, personnel, information management etc., have become integral processes and no longer ancillary functions anymore (Mazur 1993). The situation is no different with respect to services industries like healthcare. Globally all nations including the developed economies are facing escalating costs of health care at a time when it is increasingly difficult to match budgets to keep up with the service demands (PC 2011b). For example, the total expenditure on health in Australia as per the latest estimate for 2010-11 stands at A$130.3 billion while a decade ago the same figure was A$77.5 billion (AIHW 2012b). A recent study by the *Institute of Medicine* (IOM) of USA on the grave concerns of escalating healthcare costs, observed that the current expenditure on healthcare at US$2.5 trillion, which is 17% of America's Gross Domestic Product (GDP), is unsustainable (IOM 2010). These reports further extrapolate and predict that the

healthcare might consume as much as 25% of the US GDP by 2037 (Gale 2012). Ironically, IOM estimates that of the total healthcare spending, as much as US$ 750 Billion is wasteful expenditure.

The big question is on how to do more with fewer people and lesser resources without any sacrifice to the quality of healthcare (Mazur 1993). To address similar competitive challenges of the manufacturing sector, Mizuno and Akao have developed tools and techniques that later came to be known as *Quality Function Deployment* (*QFD*) (Mazur 1993; Mizuno and Akao 1978). QFD has enabled to resonate the '*voice of the customer*' (VoC) across the levels of the organisation end-to-end i.e., from planning to production. Chan and Wu (2002b) have provided a detailed account of the QFD developments in various sectors reviewing over 650 publications related to QFD. They have categorised QFD's diverse applications such as product development, quality management, customer needs analysis, product design, planning, engineering, decision-making, management, teamwork, transportation and communication, electronics and electrical utilities, software systems, manufacturing, services, education and research, and other industries.

House of Quality (HoQ) is a basic design tool. It is the first phase of the QFD approach and is fundamental and of strategic importance (Chan and Wu 2005). Hauser and Clausing's (1988) classic paper on HoQ, has brought its significance to the western community. With its wide spread success in bringing together various functional divisions of manufacturing, HoQ has been applied in various forms and to various degrees of sophistication in product development, manufacturing, engineering, and subsequently in the services industry to design and develop quality *services* (Chan and

Wu 2002b; Mazur 1993; Ramaswamy 1996; Ray 2003; Shahin 2008). HoQ inter-links customer requirements, their rankings, engineering characteristics, performance measures, competitive products/ services and thereby elicits in a single diagram the areas of improvements required to win in the market (Chan and Wu 2002a; Chan and Wu 2005; Hauser 1993; Hauser and Clausing 1988).

By propagating VoC across the organisation and across the technical specialities, QFD became the sole quality system to echo customer requirements in the process of products/services design (Mazur 1993). The core structure of QFD is HoQ, and in its most comprehensive form consists of 8 sections as shown in Figure-3.2 (Dieter and Schmidt 2008; Ramaswamy 1996; Ray 2003; Wulan 2011). Through these sections, commonly referred to as '*Rooms*', product/service planners express their understanding of the product/service. Starting at Room-1 expressing the customer needs in customer's own language, the HoQ is progressively built, refined by successively developing the rest of the rooms. The ultimate comprehensive presentation of the HoQ is a transformation of the needs into technical characteristics of the product/ service that can eventually be produced and delivered to the customer. The construction of the full house requires elaborate information, and is progressively constructed in a step-by-step process consisting of eight steps. This eight step process is detailed below taking hints from Wulan (2011).

Step 1: Identify customer requirements (CRs) in Room-1

The customer or end user needs are compiled as CRs in Room-1 in the form of customer requirements and their importance ratings. These are the initial input of a HoQ. Room-1 is also called the section "Whats". Ideally these are as stated by the customers in their own language: for example, like low price, tastes good and appetising in appearance. CRs are categorised by customers into groups. Hauser and Clausing (1988)refer to the CRs as attributes and groups as attribute bundles. Based on customer's assigned priority the "Weight/ Importance" for each CR is computed and the "Weight/ Importance" column is populated.

Step 2: Identify engineering characteristics (ECs) in Room-2

ECs describe the product's performance as a whole and its functional features to meet CRs. The ECs are also known as functional requirements. At this stage the CRs of Room-1 are expressed in parameters, design variables and constraints, for example: weight, size and thickness. These inputs of Room-2 are also referred to as "Hows".

Step 3: Build a correlation matrix of the ECs in Room-3

The triangular roof of HoQ or Room-3 is utilised to establish the correlation matrix on how the ECs support or impede one another.

Step 4: Build a relationship matrix between the CRs and the ECs in Room-4

At this step, the main body of HoQ – a two dimensional relationship matrix is constructed with individual CRs to the ECs. Each cell is marked with a symbol that indicates the strength of the combination between the CR or its row and the EC of the column. It implies how significant the EC is in satisfying the CR.

Step 5: Rank the importance of the identified ECs (CRs) in Room-5

At this step, the focus is to find which ECs are of critical importance satisfying the CRs stated in Room-1. Naturally the ECs with highest rating are given special consideration because these ECs have the greatest effect upon customer satisfaction. The ranking can be either absolute or relative importance.

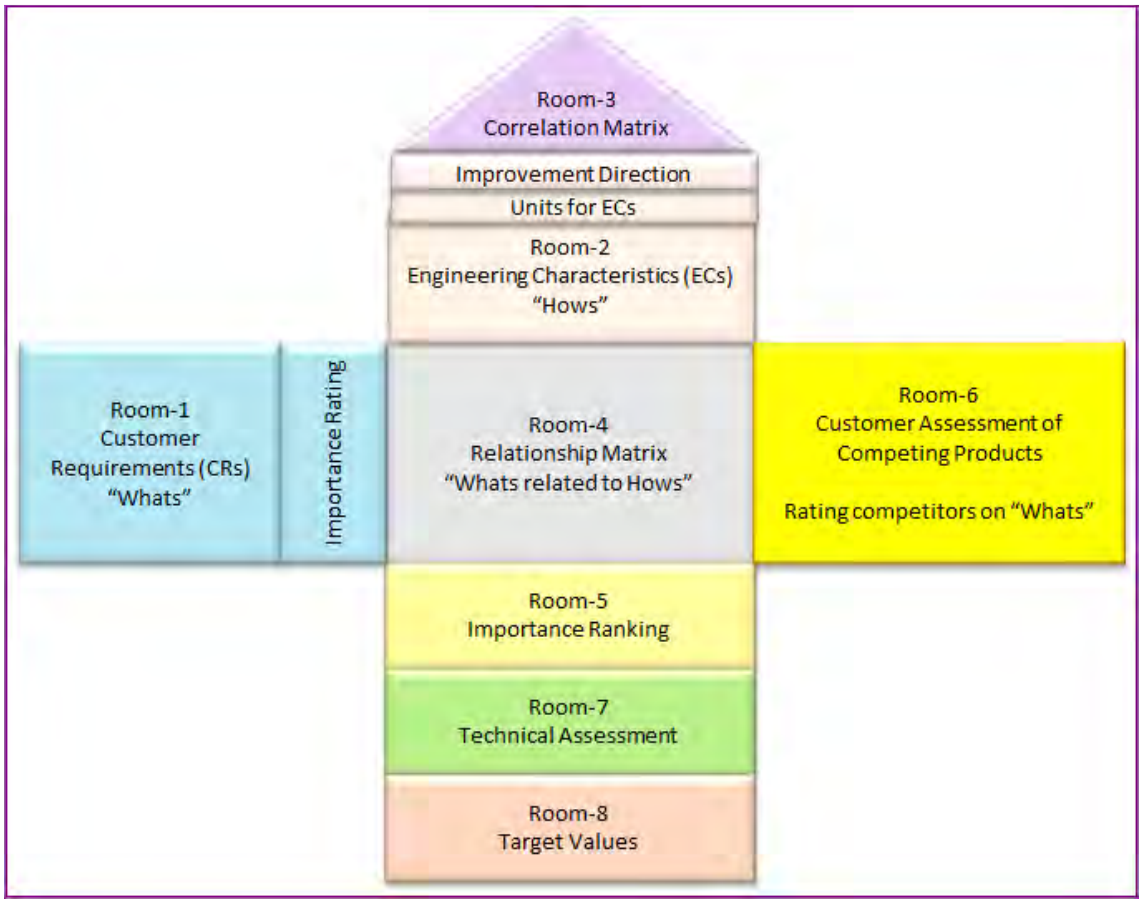

Figure 3.2: House of Quality (HoQ) Source: Engineering Design
Source: (Dieter and Schmidt 2008)

Step 6: Analyse the product with competitive products in the market in Room-6

This step involves competitive analysis or customer assessment of competing products. A table is designed to record how the top competitive products rank with respect to the CRs listed in Room-1. This information may come from customer surveys, industry consultants, and marketing departments.

Step 7: Estimate the technical advantage and difficulty of each EC in Room-7

Organisations need to ensure that their design is competitive with respect to the competing products in the market, prior to investing in the development of a new product or service (Cohen 1995). So Step-7 of Room-7 deals with the technical assessment or benchmark of important ECs with that of the competitive products/ services.

Step 8: Assign the target value to each EC in Room-8

The final step in Room-8 involves setting target values for ECs and that is the ultimate output of HoQ for the design of the product/ service.

3.10 Hierarchy of QFD Matrices

In practice, the HoQ is developed over an iterative process commonly referred to as the *hierarchy of HoQ Matrices*. Starting with customer needs and customer assessment of competitive products/ services, a series of HoQ Matrices are built where the output of the preceding matrix becomes an input to the succeeding matrix as shown in Figure 3.3. While there exists different conventions for the representation of the *Hierarchy of QFD Matrices*, this is the most common convention and referred to as the *American Supplier Institute* (ASI) model or the *Clausing Model* (Clausing 1994; Ramaswamy 1996).

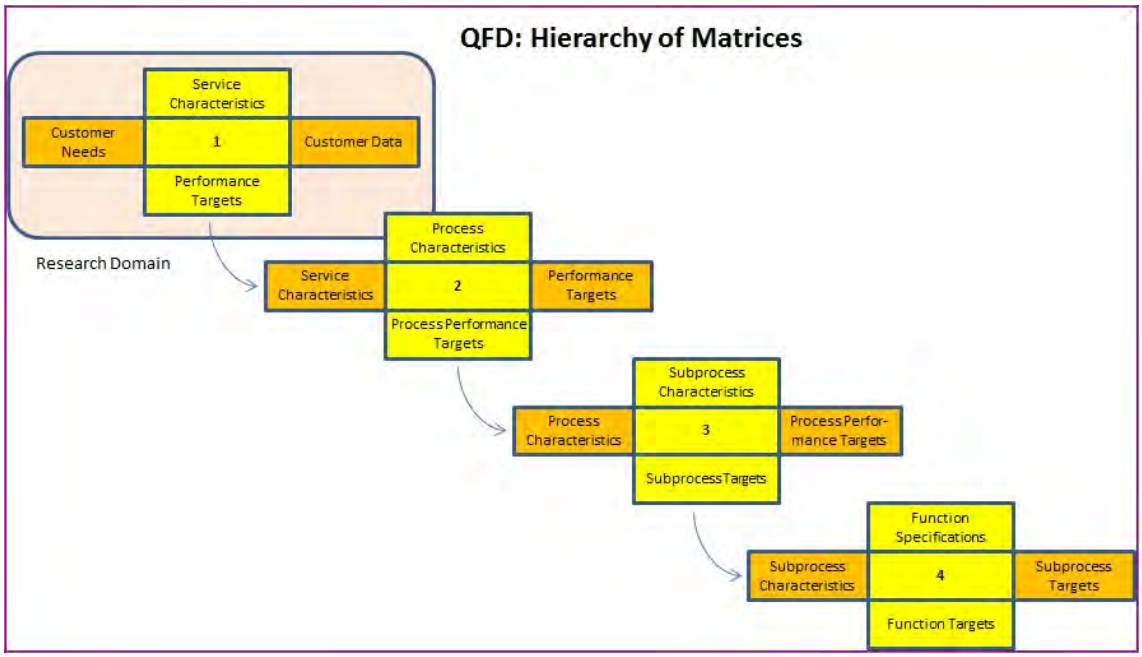

Figure 3.3: Hierarchy of QFD Matrices for Service Design
Source: (Ramaswamy 1996)

The matrix labelled 1 in this diagram is the HoQ Matrix described in the previous section. The service requirements obtained from customers are translated into design characteristics and service performance targets in this stage. The design characteristics

derived in Matrix-1 are the inputs to the Matrix-2, which is interpreted as the *service/ process matrix* (Ramaswamy 1996) as it is applied to services design. The service design attributes are partitioned into process design attributes and associated process performance targets. In Matrix-3, called the *process/ sub-process matrix* the analysis is drilled down to establish design characteristics for the sub-process that make up the process. These requirements are also the standards to which the service operations should be managed once the design is implemented (Ramaswamy 1996). Finally in Matrix-4, the *sub-process/ function matrix*, design requirements for individual sub-process/ function are computed. By linking the output of each matrix to the input of the following matrix, the hierarchy of matrices cascades VoC to drive the design of service down to the most detailed level.

3.11 The Current Research Focus

It is evident from the Hierarchy of QFD Matrices discussed above that a robust service design is an elaborate and painstaking process of translating/ transforming customer needs progressively into operational functional targets. In view of the breadth and depth involved in the application of QFD for healthcare services, the current research restricts itself to the Matrix-1 where customer evaluation of competing services is used as the basis to build the service characteristics.

The primary objective of this research is to identify the service characteristics of alternative healthcare services including mHealth and provide feedback to the service providers and planning agencies so that the quality of health services improve over time and deliver value to the society. Secondarily, in the extant literature there has not been much focus on healthcare service design. Researchers and practitioners alike

across the world invested heavily to improve quality and competitiveness of manufactured products and this has given rise to the substantial body of knowledge known as QFD and its embodiment HoQ (Chan and Wu 2002b; Cohen 1995; Shahin 2008). The general improvements that occurred in products and industrial productivity have prompted researchers to extend the HoQ model to the services industry (Chan and Wu 2002b; Mazur 1993; Radharamanan and Godoy 1996; Ramaswamy 1996).

In summary, the scope of the current research is limited to a subset of the theme of healthcare services design, i.e., evaluation of competing services. As such, this dissertation focuses on *Room-6: evaluation of competing services* of the HoQ Matrix (Figure 3.2). As a secondary goal, the research explores how the specific attributes that differentiate the alternate services can be successively cascaded up and down through the other rooms to achieve well performing healthcare services.

Having identified the conceptual framework i.e., HoQ, to achieve the comparative assessment of services, the prominent multivariate technique, *discriminant analysis*, will be employed to assist in the comparative evaluation of services to extract service characteristics. The next chapter describes this research methodology.

3.11.1 Recap on HoQ

As noted in Chapter 2, there are profound challenges in the provision of healthcare in an optimal fashion across the world, not just the developing world. Laudon and Laudon (2013 p.521) summarise that: “Rationalisation of procedures is often found in programs for making a series of continuous quality improvements in products, services, and operations, such as Total Quality Management (TQM) makes achieving

quality an end in itself and the responsibility of all people and functions within an organisation."

Apart from filling the gap in the extant literature on comparative analysis of healthcare services, the research also envisages a framework that will apply these comparative insights for better healthcare service design. Charteris (1993 p.1) states that: "QFD provides a systematic means of identifying customer requirements and translating them into achievable product characteristics." QFD and HoQ are the tools of TQM and have facilitated a cascade of the 'voice of the customer' down through the layers of the organisation (Ramaswamy 1996; Ray 2003). So, HoQ Matrix was adopted as the theoretical model for Service Design.

3.12 Chapter Summary

The broad research agenda identified through the literature review is refined to arrive at the hypotheses that the current research will focus on. HoQ has been identified as the conceptual framework within which the hypotheses and the associated research questions will be pursued. Within the HoQ hierarchy of matrices, as the current research directly encapsulates the VoC or voice of the patient, this conforms to Matrix-1. Furthermore the scope of the current research is confined to *Room-6 of the HoQ Matrix*. *Room-6 of HoQ* essentially deals with a comparative assessment of competing alternatives. Discriminant Analysis is identified as the quantitative technique that can extract service characteristics that differentiate competing alternatives. The next chapter will discuss this research methodology, and its suitability for the research task at hand.

Chapter 4: Research Methodology

4.1 Chapter Overview

The previous chapter discussed the HoQ framework and identified the scope of this research, i.e., *HoQ Room-6*. The objective of this chapter is to discuss the research method, discriminant analysis that enables the quantitative comparative assessment of service alternatives, the primary focus of the *HoQ Room-6*. Then it focuses on the survey instrument, survey location, and methodology.

4.2 Research Philosophy

The research hypotheses and the associated research questions require examination of group differences of healthcare service users i.e., patients. This can be achieved through a survey of patients who have used the services in question. By developing a model to relate the survey items and their specific rating of the respective service they have used, it is possible to see whether significant group differences are observable. Furthermore, to have this comparison reliable and testable, all the survey participants need to answer the same set of questions. Thus hypotheses are being examined through a quantitative survey of patients. The investigation intends to a build a quantitative model to not only help in understanding the phenomenon but also serve as a predictive aid. Thus the current research also conforms to quantitative research paradigm. Epistemologically and ontologically, *'quantitative positivist'* paradigm naturally applies to this kind of investigations (Bhattacherjee 2012; Gregor 2006; Straub et al. 2004).

4.3 Research Method: Discriminant Analysis

While reviewing various QFD tools, Charteris (1993 p.15) summarises the role of DA in QFD as: "DA is used to classify products into two or more categories using a set of predictor variables spaced at intervals. It may be used to identify which product characteristics are most important to the customer in distinguishing between products; for example, the primary determinant may be price or a perceived quality attribute of a product. The mathematical basis of DA is similar to regression analysis but differs in that DA caters for nominal data."

DA is a classification technique which helps in identifying the factors (or independent variables, IVs) that differentiate the cases into various categories of a categorical dependent variable (DV) (Hair et al. 2010; Malhotra 2004; McLachlan 1992; Schwab 2006). DA was developed by R.A. Fisher in 1936, a multivariate classification method (Fisher 1936). Subsequently it was enhanced, extended and applied to a variety of problems and contexts. It is widely used in diverse fields: physical, biological, and social sciences, engineering, medicine, image detection (pattern recognition, remote sensing) and marketing (McLachlan 1992). In DA the existence of the groups is known as *a priori*. It has been applied by IS researchers to aid in classification problems. Popular statistical packages like SPSS and SAS have inbuilt procedures to carry out DA.

DA constructs the model based on the variation of the observational units. Based on this model, new observational units or cases are classified into groups or categories (Savic et al. 2008). DA may also be used to characterise group separation based upon a reduced set of variables, analyse the original variable's contribution to separation, and the degree of separation (Savic, 2008). Savic et al. (2008, p.029) observe that:

> "DA gets its name from the way the model is constructed. Each of the groups in the dependent variable must have a set of measurements. For example, if there are five different brands of mobile phones, each brand must have its own set of ratings by a sample of respondents. Each respondent could evaluate only the brands he or she has used or separate samples of respondents could rate each brand. On the basis of collected data the discriminant model calculates the set of coefficients for each brand separately. The set of coefficients for each brand distinguishes or discriminates the brand among the others. With five brands of mobile phones, computer develops five sets of coefficients. Multiple regression method will develop single set of coefficients for the same problem."

This study intends to find the characteristics that distinguish various healthcare services based on the ratings of patients. This essentially implies that the study requires a computational scheme that classifies individual cases into various categories. Mathematically, this is a situation where the IVs are metric and the DV is categorical. Neither regression nor ANOVA/ MANOVA is suitable to find a relationship when the DV is categorical (Hair et al. 2010; Malhotra 2004). DA is naturally suited for such classification problems, for example, to differentiate the categories of healthcare services (DV) with a set of metrical rating of questions (IVs) about the healthcare services. Thus *Discriminant analysis (DA)* is the appropriate method to estimate a linear relationship between categorical healthcare services (DV) and linear combinations of one or more metrical ratings (IVs). Table 4.1 summarises similarities and differences among ANOVA, regression and DA. DA is capable of handling more than two groups for the DV. When the DV has more than two categories, the technique is commonly referred to as *multiple discriminant analysis (MDA)* (Hair et al. 2010; Malhotra 2004). Both DA and Logistic Regression (LG) are appropriate statistical techniques when the DV is categorical. LG, or logit analysis, is a specialised form of regression that is formulated to predict and explain a binary (two-group) categorical variable rather than a metric DV.

Table 4.1: Similarities and Differences among ANOVA, Regression and Discriminant Analysis

Source: (Malhotra 2004)

	ANOVA	Regression	Discriminant Analysis
Similarities			
Number of dependent variables	One	One	One
Number of independent variables	Multiple	Multiple	Multiple
Differences			
Nature of the dependent variable	Metric	Metric	Categorical
Nature of the independent variables	Categorical	Metric	Metric

DA attempts to find a linear combination of predictor variables that best separate individual cases into the prior specified groups (Mika et al. 1999). These combinations or the variates are usually referred to as *discriminant functions* (DF). A typical discriminant function (DF) looks like:

$$Z_{jk} = a + W_1 X_{1k} + W_2 X_{2k} + \ldots + W_k X_{nk} \quad \text{-> Eq-1}$$

where

- Z_{jk} = discriminant Z score of DF j for object k
- a = intercept
- W_i = discriminant weight for IV i
- X_{ik} = IV i for object k.

DA is widely used in Marketing, and it is relatively new to Information Services especially to the scale of four groups. This study is an attempt to formulate DF(s) to characterise healthcare services, especially mHealth. Hair et al. (2010) provided a detailed step-by-step 6-Stage *DA Decision Process* to conduct the analysis. A simplified version of this process is presented in Figure 4.1. Schwab (2006) provided a systematic computational procedure to analyse data through DA. The analysis of the survey data relies on these procedures as detailed. For a detailed treatment on DA, readers can refer to these excellent sources (Hair et al. 2010; Malhotra 2004; Schwab 2006).

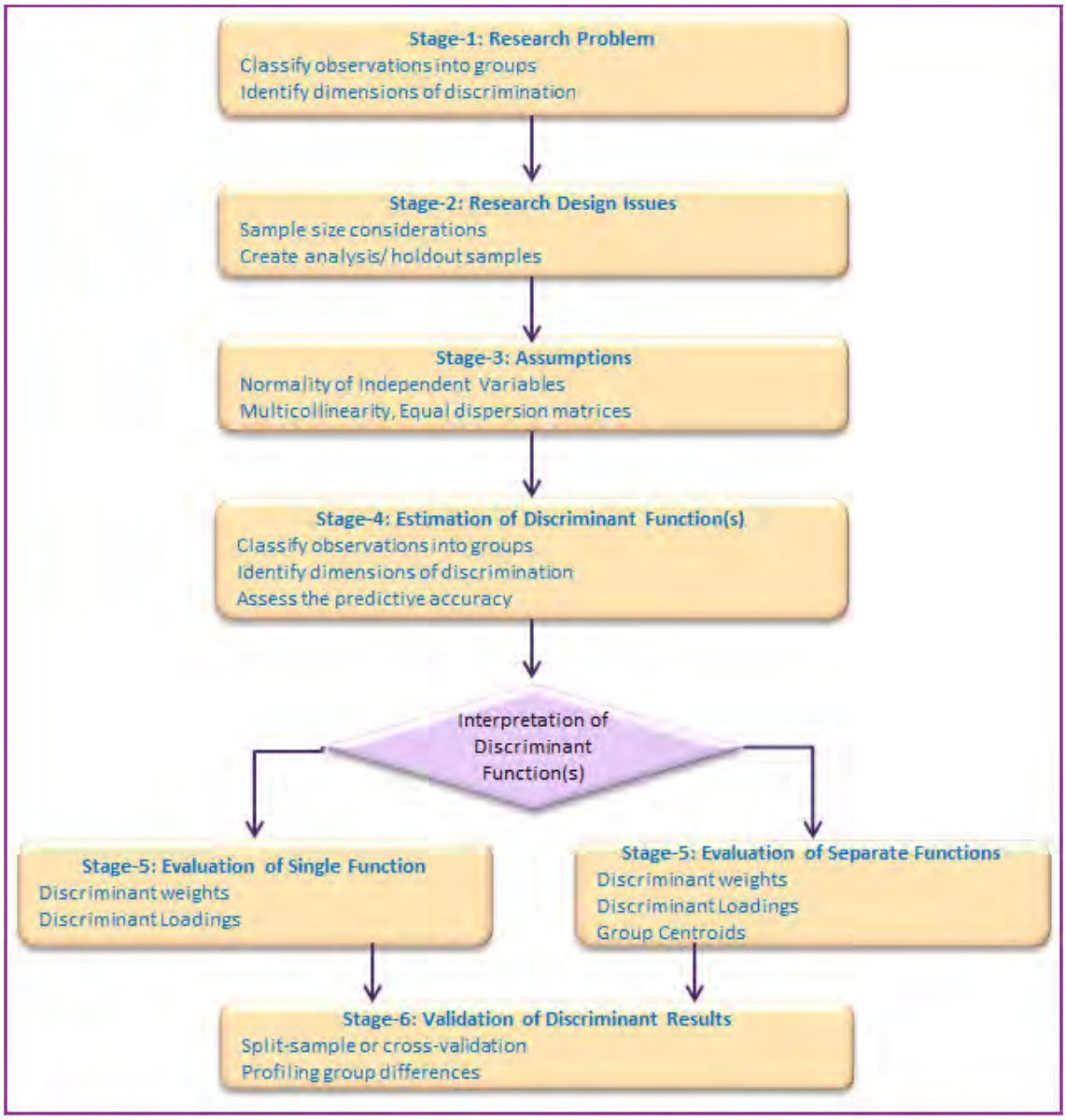

Figure 4.1: Discriminant Analysis Process Framework
Adapted from Hair et al. (2010)

4.3.1 Discriminant Functions

DA combines (weights) the variable scores into a single new composite variable; the discriminant score. Different weight combinations associated with the variables may produce different scores, meaning different functions. At the end of the DA process, each group will have a normal distribution of discriminant scores. The degree of overlap between the discriminant score distributions (Figure 4.2) can be a measure in

determining the model's success in classifying the cases into groups (Hair et al. 2010). As depicted in Figure 4.2, the top two distributions overlap too much while the bottom one has less overlap. As such the top model misclassifies too many cases while the bottom model has minimal misclassification cases (Hair et al. 2010). Consequently, the bottom model is much better than the top model. Standardising the variables eliminates scale differences between the variables. Absolute weights can be used to rank variables in terms of their discriminating power, with the larger weight the most powerful in differentiating the groups.

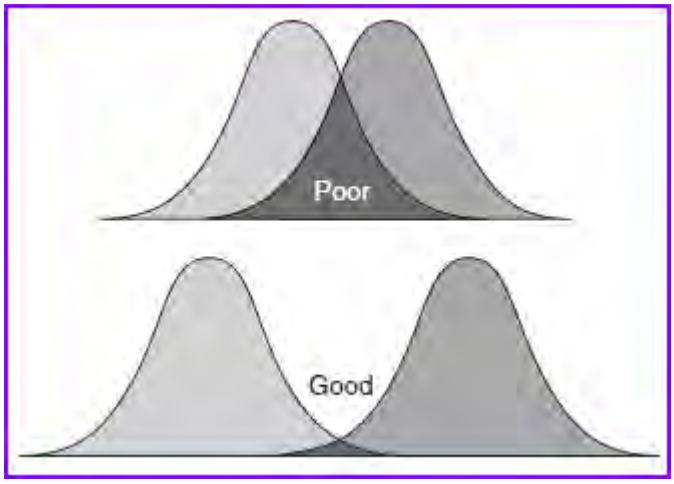

Figure 4.2: Discriminant Distributions
Adapted from Hair et al. (2010)

4.3.2 Model estimation procedures using DA

This section explains in more detail the DA method following the guidelines noted in Schwab (2006). As noted above, DA is utilised to find relationships between a categorical (non-metric) DV and metric or dichotomous IVs. DA attempts to use the IVs to distinguish among the categories or groups of the DV (Hair et al. 2010; Malhotra 2004; McLachlan 1992). The DA model's usefulness is assessed based on its predictive accuracy rate, or the ability to predict the known group memberships. DA computes a

new variable called *discriminant function score*, using eigenvalues, which is used to predict the group membership. As shown in Eq-1 *discriminant function* (DF) looks similar to a regression equation where IVs are multiplied with coefficients and summed to produce a score. Discriminant scores are standardised, as such the sign of the score determines to which group a case belongs to. A DF can be imagined as a boundary between groups. Thus, to distinguish two groups, one statistically significant function is required. Inductively it means if the DV has *n groups*, (*n -1)* significant function(s) are required to distinguish *n* categories. If a DF is able to distinguish among groups, it means that at least one IV must have strong relationship with it (Hair et al. 2010; Malhotra 2004; Schwab 2006).

Once significant DFs are identified, the next step involves the interpretation of each of these functions. The relationship between the IV and the DV is interpreted through the way a DF distinguishes the groups, and the role of an IV in each function. SPSS provides '*Functions at Group Centroids*' that indicates which groups are separated by which functions.

In order to understand the relationships, DA produces a table called '*Structure Matrix*' similar to its counterpart in factor analysis. It identifies the loading or correlation between each IV and each DF. This lets the researcher interpret which variables to interpret for each function based on the loading, and the role of each IV is interpreted on the function it loads most. DA provides two alternatives to analyse the role of IVs on DV groups. The researcher either can simultaneously load all the variables or enter the variables in a stepwise manner. The former approach is referred to as

simultaneous DA and the latter approach is referred to as *stepwise DA* (Hair et al. 2010; Schwab 2006). The next subsection briefly describes this procedure.

For the case of simultaneous DA, as all the variables entered together, only those variables, whose loadings are 0.30 or higher on one or more of the DFs, are interpreted. In the case of stepwise DA, only those variables that meet the statistical test for inclusion are interpreted. A variable can have a high loading on more than one function. In such situations, the variable is interpreted for the function on which it has the highest loading (Hair et al. 2010; Schwab 2006).

4.3.3 Stepwise Discriminant Analysis

This section follows the guidelines for Stepwise DA, as detailed in Malhotra (2010). Stepwise DA is analogous to stepwise multiple regression as the predictors entered sequentially are based on their ability to discriminate between the groups. A univariate analysis is conducted for each predictor treating the groups as a categorical variable, and an *F* ratio is calculated. The predictor with the highest *F* ratio is the first to be included in the discriminant function. A second predictor is added based on the highest adjusted or partial *F* ratio, taking into account the predictor already selected. Each predictor selected is tested for retention based on its association with other predictors selected. This process is repeated until all predictors meeting the criteria for inclusion and retention are satisfied. Standard computer packages, like SPSS provide a summary of the predictors entered or removed. The stepwise selection procedure is based on the optimising criteria called the *Mahalanobis Procedure*, named after its inventor. The Mahalanobis distance is a generalised measure of the distance between the two closest groups (Malhotra 2010).

4.3.4 DA, Analysis Sample and Hold-out Sample

The other significant difference of DA with other multivariate techniques is that the researcher can sub-divide the entire sample into two groups namely: analysis sample and hold-out sample. Thus, we can say that the DA gives rise to two possible scenarios:

a) a DA model based on an entire sample or

b) a DA model based on an analysis sample.

In the case of 'b', the DA model built with an analysis sample is reapplied to classify the hold-out sample, and thereby it is feasible to test the predictive power of the model on a dataset that is not used to build the original model. In this case, the 'Classification Matrix' contains an additional section where it shows the performance of the DA model on the hold-out sample. In this thesis, for the sake of simplicity, the author has presented the analysis based on the entire sample. However, an important point to note in either case, the DA actually evaluates the performance of the model by recursively testing the model on holding out a case, building the DA model on the remaining cases, and then tests the predictive power of the model. This output is enumerated as a 'cross-validated model' in the 'classification matrix.'

4.3.5 DA Applications

Lim and Zallocco (1988) for the first time studied an inter-system competition by analysing the consumer attitudes toward divergent healthcare systems, namely: hospitals, home healthcare, nursing homes, and outpatient clinics. They have applied MDA to identify the distinguishing factors and the most favourite healthcare delivery system i.e. home healthcare. Andaleeb (2000) applied DA to study the quality of services provided by public and private hospitals in Bangladesh. He was able to identify

the predictors for hospital choice of patients. Andaleeb, Siddiqui and Khandaker (2007) compared services of public and private hospitals of Bangladesh and then compared private hospitals with their foreign counterparts from the perspective of Bangladesh patients. Again they applied DA to identify the intra-system characteristics between government and private hospitals, and private hospitals and foreign hospitals. Based on their analysis they concluded that the overall quality of service was better in foreign hospitals than in private hospitals in Bangladesh in all the factors, including the 'perceived cost' factor.

Kwak et al. (Kwak et al. 2002) have applied DA for classifying and predicting the symptomatic status of HIV/ AIDS patients. They have identified that the AMDTOT (total patient admission) variable is the most significant factor to classify between HIV and AIDS status. They observed that classifying and predicting a patients into groups were important in the provision of healthcare. They also noted that DA may produce better results than the traditional parametric and nonparametric methods. Verdessi et al. (Verdessi et al. 2000) have studied DA in refining customer satisfaction assessment with an objective to turn routine customer information into a more accurate decision making tool. DA helped in identifying physician care as a significant variable in differentiating satisfaction of patients.

Malhotra (Malhotra 2010) illustrates DA in the context of understanding salient characteristics of families that had visited a vacation resort based on past data. The example illustrates that income, household size and importance of vacation variables are able to differentiate groups based on their recurrent visits. Similarly, Hair et al. (Hair et al. 2010) provide an illustrative application where DA identifies factors that

separate purchasers and non-purchasers for an appliance enterprise. They provide another interesting application of DA in identifying perceptual differences of customer groups based on geography (US and non-US). They further illustrate MDA through an example of identifying perceptual differences of customers grouped based on their length of relationship with an enterprise.

Watson et al. (Watson 1982) have applied MDA as a novel procedure for plotting and depicting overlaps among groups. Investigating group overlaps is one of the purposes of MDA. Wulf and Zarnekow (Wulf and Zarnekow 2010) compare value proposition of technologies for information service distribution. Their study reveals that value proposition differs with regard to type of services rather than quality of service criteria. Apart from these examples, DA is widely used for categorising customers based on their credit risk by banks and insurers. DA has been widely used in pattern recognition applications, and spatial images analysis. Thus DA is a generic and powerful technique that enables identification of group differences as well as finding the critical factors that contribute to the group separations.

4.3.6 DA Model Accuracy

DA consists of two stages: 1) in the first stage DFs are derived; 2) in the second stage, the DFs are used to classify the cases. DA does compute correlation measures however, these correlations measure the relationship between the IVs and discriminant scores. DA provides a mechanism to assess the utility of the discriminant model, *classification accuracy*. Classification accuracy is computed as a ratio of the predicted group membership to the known group membership of the respective cases (Hair et al. 2010; Schwab 2006). A typical benchmark for classification accuracy is that

it shall at least be 25% better than the rate of accuracy achievable by chance alone. Even if the IV has no relationship to the DV groups, one would still expect a certain percentage of predictive accuracy, and this is referred to as *by chance accuracy*. Thus to ascertain model usefulness, the researcher needs to assess whether the cross-validated accuracy rate is 25% more than the proportional by chance accuracy (Hair et al. 2010; Malhotra 2004; Schwab 2006).

The cross-validated accuracy rate is a one-at-a-time hold out method that classifies each case based on a discriminant solution for all the other cases in the analysis. It is a more realistic estimate of the accuracy rate because DA may inflate accuracy rates when the cases classified are the same cases used to derive the DFs (Hair et al. 2010; Schwab 2006).

In the current investigation the DV is categorical and IVs are metric, and thus DA is an appropriate technique to establish a relationship (Hair et al. 2010; Malhotra 2004). DA also has predictive abilities whereby the model constructed to explain the phenomenon can also be used to classify new cases or predict to which group they belong to. Thus DA suits the current research objectives of finding factors that differentiate a group of services and develop a predictive model so as to serve as a policy guideline and also assist in mHealth Service Design.

4.4 Research Context

In order to establish the research objective of whether patients do differentiate mHealth from other services, it is essential to search for a market where mHealth is commercially offered and competitively operated. Ivatury et al., (2009) have provided

a comprehensive overview of mHealth services in developing countries. They have identified the *789 Service of Grameen phone* in Bangladesh as one of the significant success stories of a commercial mHealth service. At present, more than 24 million people in Bangladesh have access to B2C mHealth services provided by the leading mobile operator *Grameen phone* (Akter and Ray 2010). Under this platform, a customer (or, a patient) can access health service at any time by dialling '789' from his/ her own mobile phone and receive services in the form of medical information, consultation, treatment, diagnosis, referral, treatment and counselling from registered physicians (Akter 2012; Akter et al. 2011; Ivatury et al. 2009). This service has gained popularity in a short span. Within three years from its inception, the service on the average has handled 10,000 calls per day from patients (Akter 2012; Grameenphone 2008; Ivatury et al. 2009; WHO 2011). So Bangladesh provides a proper research setting to gain insights into a comparison of various healthcare services including mHealth. The extant literature identified four prominent health care service alternatives in Bangladesh (Table 2.2) (Cokroft et al. 2003; Ivatury et al. 2009; WHO 2011).

The next sections will look into the quantitative study consisting of the survey method, instrument, sampling and finally data collection.

4.5 Quantitative Study

Data was collected from Bangladesh, one of the leading mHealth service providers in developing nations, under a global mHealth assessment project in March, 2010. A segment of a de-identified and unused dataset from that study has been made available for this research (refer to Appendix-A for Ethics Committee Approval).

4.5.1 Survey method

A sample survey serves as a quick and efficient method to understand the respondent's experience with a service and thereby facilitates drawing conclusions about the population (Zikmund et al. 2010). As the objective of this study was to measure user perceptions about service characteristics and why a particular service is chosen over other competing alternatives, a *field study* was conducted in March 2010. The survey was designed to collect data from a target population only once, thus conforming to *cross sectional design* (Malhotra 2004). In order to maximise the survey response rate, minimise missing data, avoid delays and improve accuracy especially, in a developing country context, the study adopted a combination of *location intercept* and *in-home survey* techniques (Akter 2012; Andaleeb 2001; Malhotra 2004).

4.5.2 Measurement Instrument

The questionnaire was originally developed in English, and then was translated into the local language (Bangla). The local version went through several revisions until both the English and Bangla versions were judged to be similar by a group of experts (Andaleeb 2001). Patients were asked to provide their rating to a range of questions related to health care service determinants: systems, interaction, information and outcome quality. Except the demographic information of the questionnaire, all the items were measured in a structured format on a seven-point Likert-type scale, ranging similar to "*strongly disagree*" to "*strongly agree*." A pre-test of over 10 samples was conducted in order to ascertain the content, wording, sequence, layout, format, simplicity and clarity of the survey instrument (Akter 2012; Akter et al. 2010b). The pre-test was helpful in fine tuning the instrument and facilitated a smooth data collection. The

survey instrument is presented in Appendix-C. Health service is a categorical variable consisting of four values: PH, GP, TM and mHealth. Patients are requested to rate the respective health service they have used recently based on 20 factors. The questionnaire is designed based on the outcomes of the qualitative study and consisted of 20 dimensions (Table 3.2) as listed below:

Table 3.2: Service Quality Dimensions

Perceived Systems Quality	Perceived Interaction Quality	Perceived Information Quality	Perceived Outcome Quality
1. Reliability	1. Helpful	1. Completeness	1. Ease
2. Accessibility	2. Promptness	2. Accurate	2. Convenience
3. Availability	3. Courtesy	3. Up-to-date	3. Cost
4. Safety	4. Empathy	4. Orderliness	4. Confidence
5. Efficiency			5. Enjoyable
6. Privacy			
7. Usefulness			

4.5.3 Sampling and Data Collection

The field survey took place in Bangladesh during March, 2010 under a global mHealth assessment project. In the absence of lists for drawing a random sample, 280 interviews were planned from Dhaka City using area wise cluster sampling. Areas were selected in a manner such that different socio-economic groups were represented. After a quick screening question on whether the respondent had used mHealth services in the past 12 months, the interviewers proceeded with the survey questions. Both self-completion and interviewer filled survey techniques were used in order to receive higher valid response. A total of 212 surveys were ultimately completed, of which 200 surveys were usable.

4.6 Chapter Summary

The discussion has identified that the current investigation purports to the quantitative positivist research philosophy. DA is found to be an appropriate method to test the research hypotheses and answer the associated research questions. The discussion also identifies how DA compliments in identifying the distinguishing factors of a range of competing service alternatives, the primary focus of *HoQ Room-6* as noted in the Chapter 3. The discussion then dwelt on the quantitative study, measurement instrument and how the collection of the data has been carried out. The next chapter will discuss on the computational run of the DA, its output, interpretation of results, and tests the hypotheses and extracts answers to the identified research questions in Chapter 3.

Chapter 5: Analysis and Findings[3]

5.1 Chapter Overview

This chapter focuses on the analysis of the survey data collected using the instrument described in the previous chapter. The data analysis utilises the SPSS statistical package. As a first step, demographic analysis of the data is performed to find out the characteristics of the respondents and total sample and number of valid cases. Qualitative analysis of the data is performed through histograms. Based on the recommended procedures to conduct DA, the dataset is validated for the satisfactory conformance to underlying assumptions, like sample size validation etc. Then, it moves on to the analysis of the discriminant functions and their validity. The DA model is tested for classification accuracy. As a next logical step, the hypotheses of the study are tested and attempts to find answers to the research questions. Finally the outputs of DA are utilised in building the HoQ model for the healthcare service design. The chapter is concluded with a brief summary of the analysis and findings.

5.2 Data Processing Tools

The current research has utilised the SPSS package to analyse the data. Important output from SPSS processing is quoted and presented in the ensuing sections. Detailed outputs of SPSS runs are included in the appendix D and E.

[3] The Chapters 4&5 have been the primary focus of the paper submitted for publication in Communications of the Association for Information Systems (CAIS) (2012): "Distinguishing m-Health from Other Healthcare Systems in Developing Countries: A Study on Service Characteristics."

5.3 Demographic Profile

Table 5.1 presents a summary of the descriptive statistics and demographic profile of the respondents. There are 200 cases. There is no missing information and all the cases contain valid data, thus the total sample size, N = 200 (refer to Appendix E.2.1). The total sample consists of four groups, namely public hospital (PH), general practitioner (GP), traditional medicine (TM), and Mobile Health (mHealth). As noted in Section 4.3, healthcare service is the DV, consisting of the four DV groups. All the DV groups are of equal size each consisting of 50 cases or 25% of the total sample (refer Appendix E.2.2). Of the total sample, 49% of the respondents are male and the remaining 51% are female; 40% of the patients were between 18-25 years of age and the rest of the 52% of them are in the age group of 26 to 50 years; and 48% of the patients were poor as their earnings were below 5,000 Taka. In Bangladesh, like many other Asian countries, 10 years of education is considered the minimum education. On successful completion of 10-years of education, a person is awarded a *Secondary School Certificate (SSC)*. Among the total respondents, 80% of them had minimum education or had higher degrees. Among the mobile health users, 60% of the respondents were from poor families and 64% of them had equal to or higher than minimum education.

***Table* 5.1: Demographic profile of respondents**

Item	Categories	%	Item	Categories	%
Total Sample Size: 200					
Health service	Public hospital	25.0	Age	18-25	42.0
	General practitioner	25.0		26-50+	58.0
	Traditional practitioner	25.0	Education	>= SSC [b]	80.0
	Mobile health	25.0			
Income (Taka [a])	Below 5,000	48.0	Gender	Male	49.0
	Above 5,000	52.0		Female	51.0

a: Bangladesh Currency, Taka

b: SSC: Secondary School Certificate

5.3.1 Qualitative analysis of patients' perceptions

The survey data were analysed qualitatively using histograms to gain some insights into the response patterns among the health service groups. These histograms are presented in Appendix-D. As discussed in Section '3.7 Qualitative Study of Service Quality' and in Section '4.5.2 Measurement Instrument' patients are requested to rate the health service on a Likert scale ranging from 1-7. The instrument contained 20 variables (IV) grouped into four service quality dimensions, as listed below (refer Table 3.2).

Table 3.2: Service Quality Dimensions

Perceived Systems Quality	Perceived Interaction Quality	Perceived Information Quality	Perceived Outcome Quality
1. Reliability	1. Helpful	1. Completeness	1. Ease
2. Accessibility	2. Promptness	2. Accurate	2. Convenience
3. Availability	3. Courtesy	3. Up-to-date	3. Cost
4. Safety	4. Empathy	4. Orderliness	4. Confidence
5. Efficiency			5. Enjoyable
6. Privacy			
7. Usefulness			

5.4 DA Model

The usefulness and success of a DA Model is established based on the primary criteria (Hair et al. 2010; Schwab 2006):

1. Existence of sufficient statistically significant discriminant functions to distinguish among the groups defined by the DV; and
2. A classification accuracy rate that is substantially better than the accuracy rate obtainable by chance alone.

It can be seen that the DA Model success criteria are indeed capable to address the research questions and hence the hypotheses (refer Section 3.8), i.e., to know whether patients do distinguish different health care services. Prior to reviewing the DA Model Output for these answers, it is essential to ensure that the DA Model first satisfies a set of *level of measurement checks* as shown in Figure 5.1. The next section describes this step-by-step approach to build the model including the essential assurance checks that the data is suitable for DA.

5.5 Validating Underlying Assumptions

5.5.1 Sample size validation

The minimum sample size criterion stipulates that the smallest group size shall be more than the number of IVs and the smallest subgroup shall consist at least 20 cases (Hair et al. 2010). While there is no specific criteria for the maximum sample size, a preferred ratio of 1:20 between IV and total sample size is generally stated (Hair et al. 2010; Schwab 2006) without much reference to the number of IVs and the total resultant sample size. The current research sample has a total of 200 cases, with each group consisting of 50 cases. Thus, the sample as well as subgroups meets the minimum sample size requirement. With 20 factors and 200 cases the ratio between

IV: N is 20:200 or 1:10, and this is adequate in consideration of the absolute size of the sample and number of IVs, or else the sample size becomes too large (400) for a 20 factor situation (Hair et al. 2010). The other generally cited criterion on subgroup size is that the smallest subgroup shall have at least 20 cases (Schwab 2006). The subgroups are of same size with 50 cases, so the subgroups meet the minimum size criteria. Thus, the dataset meets the sample size requirements and hence it is suitable to conduct DA.

5.5.2 Variables selection

The DV health service is a categorical variable with four distinct categories, namely: *public hospital* (PH), *general practitioner* (GP), *traditional medicine* (TM) and *mHealth*. All IVs are ratings on a 7-point Likert scale. Thus, as summarised in Table 4-1, both DV and IVs meet the measurement requirements for DA (Hair et al. 2010; Malhotra 2004).

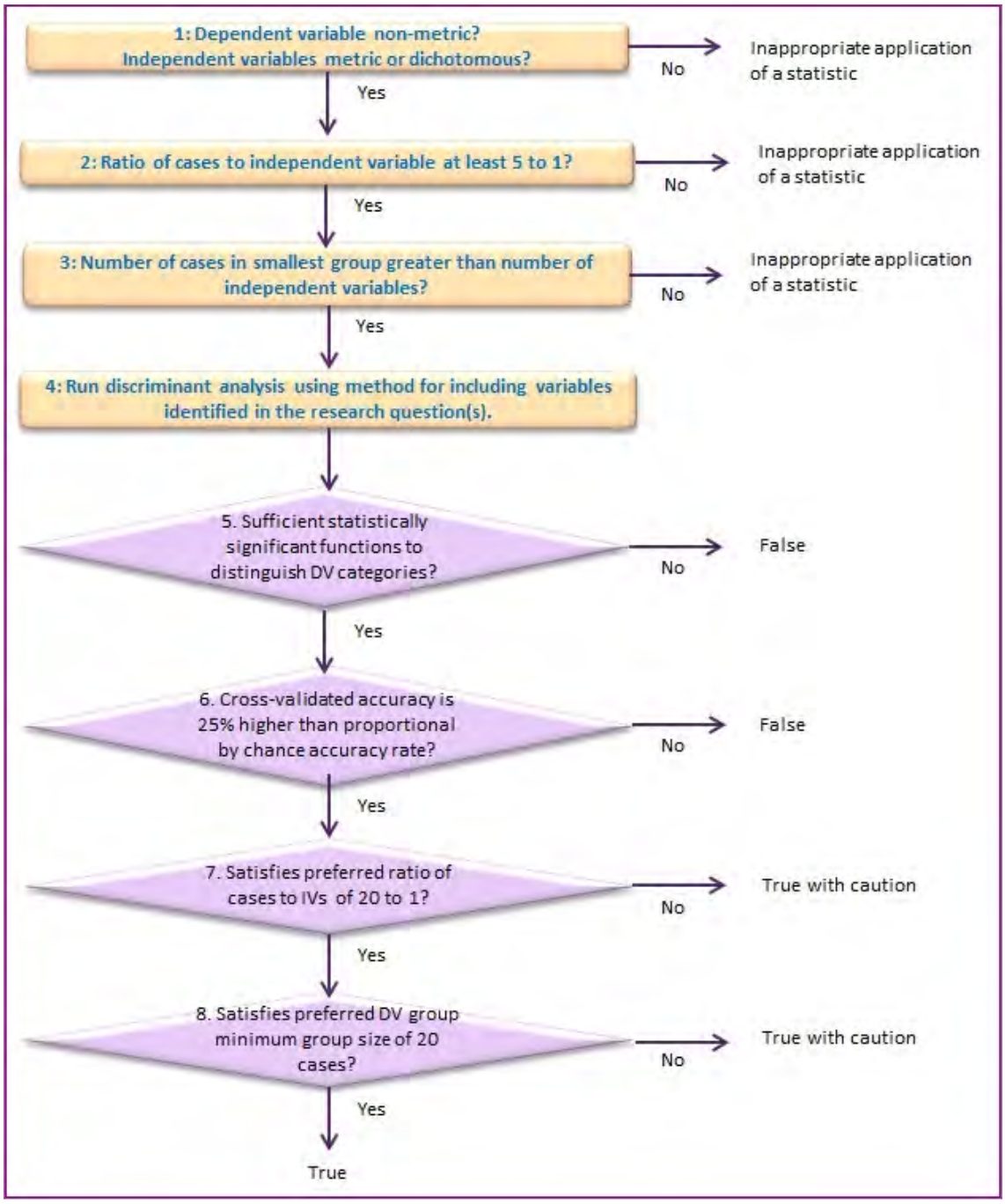

Figure 5.1: Discriminant Analysis Level of Measurement Checks

5.6 Discriminant Functions and Their Validity

The principal objective of this analysis is to identify the variables that differentiate various categories of the health service. Accordingly, a Stepwise Method for selecting variables is chosen for the computation of DFs (Hair et al. 2010; Malhotra 2004). The

statistic indicating whether there is a relationship between the IVs and DV is the significance test for Wilks' Lambda. Tables 5.2 to 5.4 present a summary of the canonical discriminant functions and Wilks' Lambda values. The Eigenvalues of Table 5.2 show how much of the variance in the DV, Health Service, is accounted for by each of the functions. Wilks' Lambda is the total variance in the discriminant scores not explained by differences among the groups. Unlike R^2, smaller values of Wilks' Lambda are desirable. The canonical correlation coefficient measures the association between the discriminant score and the set of IVs. Like Wilks's Lambda, it is an indicator of the strength of the relationship between entities in the solution, but it does not indicate the classification accuracy, which is the ultimate measure of the value of the model. The classification accuracy is obtained from the classification matrix, to be presented in a short while.

Thus, the Wilks' Lambda as shown in Table 5.4 helps in determining whether the extracted functions demonstrate any significant relationship between the IVs and DV. The Chi-square statistic corresponding to Wilks' Lambda for all the three extracted functions is highly significant ($p < 0.001$). Given that the DV has four categories, the maximum DFs possible is there (the minimum of (4 - 1 = 3) or 20 (number of IVs)). As there are three significant DFs, it implies that there is a relationship between the DV groups and IVs, and the DFs support interpretation of a solution with three DFs (Hair et al. 2010).

The DF-1 accounts for 50.4% of variance explained by the three DFs, 32.0% variance by the DF-2 and DF-3, and the remaining 17.6% of variance due to DF-3. The variance in the DV that is the Health Service Category, explained by the individual functions is

computed using the canonical correlation co-efficient of the respective functions as shown in Table 5.3 (Hair et al. 2010). The total amount of variance explained by the various DFs is worked out to be: 62.9% by DF-1; 19.2% by DF-2 and 6.7% by DF-3. Therefore, the total variance explained by all the three functions is 88.8% of the total variation in the dependent variable.

Table 5.2: Summary of Canonical Discriminant Functions – Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	1.693	50.4	50.4	.793
2	1.076	32.0	82.4	.720
3	0.592	17.6	100.0	.610

Table 5.3: Summary of Variance in IV Groups Explained by Discriminant Functions

Function	Canonical Correlation (CC)	CC^2	Remaining Variance (%)	Variance Explained (%)	Remarks
1	.793	.629	37.1	62.9	
2	.720	.518	17.9	19.2	(.371 * .518)
3	.610	.372	11.2	6.7	(.179 * .372)
Total Variance Explained by the 3 Functions				**88.8**	

For DA, multicollinearity is indicated by SPSS, by very small tolerance values for variables e.g., less than 0.10. Based on the '*Variables Not In Analysis*' output of SPSS, the smallest tolerance for any variable not included is 0.268, supporting a conclusion that multicollinearity is not a problem for this solution.

Table 5.4: Summary of Canonical Discriminant Functions – Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	Degrees of freedom	Significance
1 through 3	.112	418.690	33	.000
2 through 3	.303	228.949	20	.000
3	.628	89.081	9	.000

5.7 Classification Accuracy of DA Model

As there are four DV groups, three DFs were calculated. Wilks' Lambda helps in the determination of whether the DFs are statistically significant. However, the classification/ predictive accuracy is established through the computation of classification matrices. This is achieved through three tasks ((Hair et al. 2010):

a. Calculation of the cutting score, the criterion against which each observation's Z score is judged to determine to which group the case should be classified;
b. Repeat the classification for each case and develop classification matrices for both analysis and the holdout samples; and
c. Assess the levels of predictive accuracy and practical significance from the classification matrices.

The classification matrix for the sample is presented in Table 5.5. The model has a predictive accuracy of 77.5% in classifying the original cases. The cross-validated model has achieved 75.5% accuracy. Furthermore Hair et al. (2010) recommend that the computed accuracies or hit ratios be compared against *proportional chance criteria* and *maximum chance criteria*. As the DV consists of four groups, and all the groups are of equal size, the by chance classification accuracy is ¼ or 25%. Due to the fact that the group sizes are equal, the maximum chance criterion too is 25%. In order for the model to be meaningful and of practical significance, the threshold for these criteria are *25% more accuracy than criterion baseline* (Hair et al. 2010). This works out to be a 31.25% (1.25 * 0.25 = 0.3125 = 31.25%) accuracy threshold. The predictive accuracies for original cases and cross-validated accuracy are all much higher than the 31.25% threshold. Thus these checks on classification accuracy establish not only the model's

ability to achieve accuracy in classifying but also in the predictive power of the model in distinguishing new cases.

Table 5.5: Classification Results

	Health Service	Total Cases		PH		GP		TM		mHealth	
		Predicted Group Membership									
		Cases	%	Cases	%	Cases	%	Cases	%	Cases	%
Original	PH	50	25.0	35	70.0	8	16.0	4	8.0	3	6.0
	GP	50	25.0	11	22.0	36	72.0	1	2.0	2	4.0
	TM	50	25.0	5	10.0	3	6.0	35	70.0	7	14.0
	mHealth	50	25.0	0	0.0	0	0.0	1	2.0	49	98.0
		200	100.0								
Cross validated	PH	50	25.0	33	66.0	9	18.0	5	10.0	3	6.0
	GP	50	25.0	11	22.0	36	72.0	1	2.0	2	4.0
	TM	50	25.0	5	10.0	4	8.0	34	68.0	7	14.0
	mHealth	50	25.0	0	0.0	0	0.0	2	4.0	48	96.0
		200	100.0								

a. Cross validation is done only for those cases in the analysis. In cross validation, each is classified by the functions derived from all cases other than that case.
b. 77.5% of original grouped cases correctly classified.
c. 75.5% of cross-validated grouped cases correctly classified.

5.7.1. Press's Q Statistic: Classification accuracy relative to chance

Press's Q Statistic is a statistical test for the discriminative power of the classification matrix when compared with a chance model (Hair et al. 2010). The statistic compares the number of correct classifications with the total sample size and the number of groups. The computed value is then compared with a critical value, the chi-square value for 1 degree of freedom and the desired confidence level. If the computed value is greater than the critical value, then the classification matrix can be deemed statistically better than chance. The Q Statistic is calculated by the following formula:

$$\text{Press's } Q = [N - (nK)]^2 / N (K - 1)$$

where N = total sample size
n = number of observations correctly classified
K = number of groups.

Referring to Table 5.5,

For the sample $Q = [200 - (155*4)]^2 / 200 * (4 - 1) = 294$

The critical value for chi-square for 1 degree of freedom and p = 0.001 is 10.83. The Q value for the sample is much higher than the critical value of 10.83. Thus, it can be concluded that the predictions were significantly better than chance.

5.8 Interpretation of Discriminant Functions

The number of DFs to be interpreted is the minimum of either the number of IVs or one less than the DV categories (Hair et al. 2010). As the number of IVs is 20 and 1 less than the number of DV categories is three (4 -1), three DFs are interpreted as shown in Tables 5.2 to 5.4. Table 5.6 summarises standardised *Canonical DF Coefficients and Structure Matrix*. Both these statistics present relationships between the final set of factors entered into the DF model and the DFs. Out of the 20 IVs, MDA identified 11 factors *(ease, accessibility, promptness, confidence, orderliness, completeness, up-to-date, safety, cost, helpful, and empathy*) as significant in classifying the groups. The canonical correlation coefficients measure the association between the DFs and the significant factors. The Structure Matrix provides the important information about the factors and their loading on each DF. This valuable insight on which factor has a dominant role helps in giving meaningful names to the DFs (Hair et al. 2010; Malhotra 2004; Schwab 2006). The next section discusses the interpretation of the DFs and their relevance for service differentiation as well as service design.

Synthesising the qualitative dimensions that have led to the survey instrument (Section '3.2 The Need for mHealth Comparative Assessment') with the structure matrix (Table 5.6) helps in visualising the dimensions of the DA Model. Figure 5.2 is the outcome of that exercise which provides a snapshot view by linking quality dimensions, DFs and

their associated significant factors. The visualisation provides insights into the composition of the dimensions that separate the DV groups. Furthermore, the loadings of the structure matrix and this visualisation helps in assigning meaningful names to each of the DFs (Hair et al. 2010; Schwab 2006).

Table 5.6: Standardised Canonical Function Coefficients and Structure Matrix

	Discriminant Function Coefficients			Structure Matrix		
Function	**1**	**2**	**3**	**1**	**2**	**3**
Variables	**Ubiquity**	**Information-quality**	**Value**	**Ubiquity**	**Information-quality**	**Value**
Ease	0.394	-0.399	-0.047	.728*	-0.29	-0.16
Accessibility	0.525	0.145	0.187	.703*	0.166	0.036
Promptness	0.306	-0.084	-0.349	.584*	-143	-0.393
Confidence	0.27	0.631	-0.125	.511*	0.458	-0.371
Orderliness	-0.162	0.512	0.22	.492*	0.382	-0.278
Completeness	-0.374	-0.36	-0.296	.409*	0.289	-0.393
Up-to-Date	0.497	0.329	0.081	0.47	.529*	-0.256
Safety	-0.119	0.376	0.378	0.362	.495*	-0.148
Cost	0.246	-0.224	0.795	0.396	-0.359	.629*
Helpful	0.033	-0.424	-0.342	0.455	-0.034	-.504*
Empathy	-0.093	-0.428	-0.322	0.465	-0.027	-.469*

Pooled within-group correlations between discriminating variables and standardised canonical discriminant functions. Variables ordered by absolute size of correlation within function.

* Largest absolute correlation between each variable and any discriminant function.

Interrelating Table 5.6 and Figure 5.2, it helps to visualise that the variables *ease* of outcome-quality and *accessibility* of systems-quality are the two dominant variables forming DF-1. *Ease* and *accessibility* have a loading factor of 0.728 and 0.703 respectively on DF-1. The extant literature review identified that mobile phones are accessible even in the remotest corners of the geographies and even the lesser educated population have adopted them (Akter 2012). The World Bank (2004) study as well as the WHO (2011) have assessed that the healthcare services in developing countries are inaccessible, and people need to travel enormous distances even to avail

basic medical advice. So, the prominent feature of ubiquity of mobile phones is significantly differentiating the patients' perceptions of healthcare services, more so mHealth.

When customers seek services from a provider they want to be assured that the provider has the right knowledge, can inspire trust and deliver the service in full rather than leave the customer in a state of bewilderment. Thus, it can be seen that *confidence*, *orderliness* and *completeness* do influence the behaviour of patients in choosing services that better fulfil their needs. In analysing the attributes *ease* to *completeness* for DF-1, *ease* and *accessibility* have higher loadings (> .7). Given these insights and due to DF-1's strong association of *ease* and *accessibility*, DF-1 can be interpreted as the **u*biquity*** dimension.

The quality of advice and safety are the next best differentiating factors of healthcare services. Variables *up-to-date* of information-quality and *safety* of systems-quality form DF-2 with respective loading factors of 0.529 and 0.495. Since health services deal with human life, any incorrect, out-of-date information may compromise the safety of a patient. It signifies that the quality of the interaction and information shared during the consultation process and its relevance to the patient's needs are important determinants (Akter 2012). Much anticipated, *up-to-date* and *safety* construct is rated as the second most important by the patients. In comparison to conventional healthcare services, the patients perceived that mHealth can offer much more accurate and up-to-date information. Furthermore, mHealth setting offers privacy to the patients. In developing countries, privacy to the patient is lacking in other settings like PH, GP and TM, due to the excessive demand, and inadequate

number of qualified medical professionals (Andaleeb 2000; Ivatury et al. 2009; Worldbank 2004).

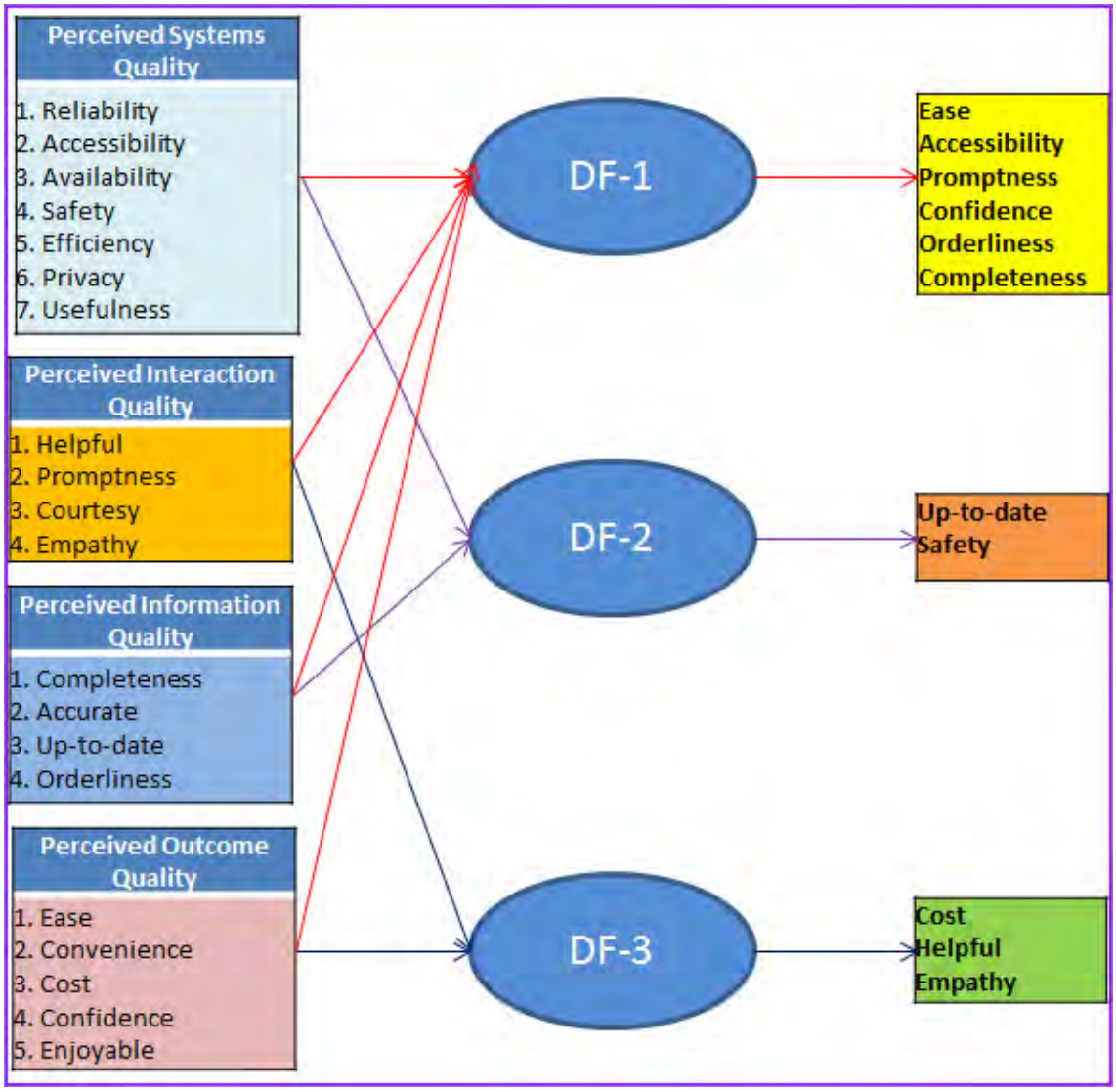

Figure 5.2 Visualising Discriminant Functions

The literature review observed that the healthcare services are of poor quality. In developing countries, service providers have not made any concrete steps to make safe and up-to-date medical consultations a priority (Worldbank 2004). So, a consultation that provides accurate information and assurance of safety will be viewed by the patients as useful. On this dimension, patients positively viewed mHealth as a better alternative due to the organised and systematic diagnostic process of

interaction with the service providers in comparison to the disorderly settings of other health care alternatives. Given these insights it is possible to interpret DF-2 comprising of *up-to-date* and *safety* can be interpreted as ***information-quality*** dimension, a determinant in comparing competing alternatives.

As noted earlier, health services deal with human life, and patients look for providers who listen to their concerns attentively and serve them with a caring attitude. Like all consumers in a market place, patients also look for services that are cost-effective and fulfil their needs (Keaveney 1995). The DF-3 consists of the variables *cost* of outcome-quality, *helpful and empathy* of interaction-quality with respective loadings of 0.629, -0.504, and -0.469. *Empathy* and *helpfulness* signify the provider's willingness to pay attention to and listen to the patients' concerns and provide them with valuable advice to alleviate their concerns. The extant literature of services observed that the value of service is realised during the interaction phase (Section '2.5 Services, Service Characteristics'). As cost is reversely coded, implying the higher the mean, the cheaper the service is. Given these insights, it is possible to interpret DF-3 as the ***value*** dimension.

5.9 Group Statistics – Mean Ratings by Service Category

Cross tabulation of the group statistics for the 11 significant factors and health service is presented in Table 5.7. Group statistics are the average means for these factors as rated by the patients. Figure 5.3 is a graphic portrayal of the group means. As noted earlier *cost* has been coded from highest to lowest, meaning the higher the score, the less costly the service is from the patients' perspective. All the means for mHealth are higher than that of other existing services, confirming the effective role of these

factors to distinguish it from other healthcare services. Patients perceived mHealth to be more ubiquitous, informative and valuable than other conventional healthcare services.

Table 5.7: Group Statistics: Mean Values of Factors vs. Health Service

Health Service / Factor	Public Hospital	GP	TM	mHealth	Total (200)
Ease	2.88	3.34	5.12	6.66	4.50
Accessibility	2.70	3.00	3.08	6.28	3.76
Promptness	3.30	4.48	5.20	6.42	4.85
Confidence	3.12	4.94	3.20	6.26	4.38
Orderliness	3.12	4.68	3.22	6.26	4.32
Completeness	3.20	5.02	3.76	6.06	4.51
Up-to-Date	3.56	5.04	3.12	6.28	4.50
Safety	4.08	5.20	3.34	6.20	4.70
Cost	5.26	2.80	5.58	6.34	5.00
Helpful	3.48	5.14	5.24	6.36	5.06
Empathy	3.26	4.90	5.02	6.28	4.86

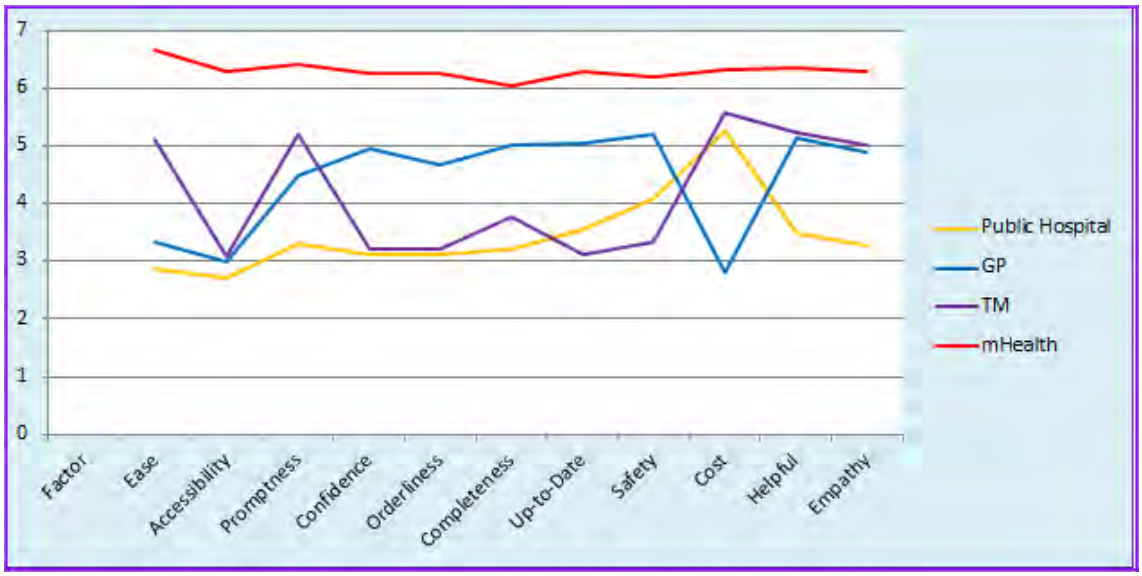

Figure 5.3 Mean Values of Significant Factors vs. Health Service

5.10 Hypotheses Testing

Based on the literature review, the current investigation identified opportunities to enhance healthcare services and formulated two hypotheses. And it is envisaged to test these hypotheses via a patients' perceptions study. Recapping Section 3.8, the investigation hypothesised that:

H_1: Patients differentiate different health care services.
H_2: Patients perceive mHealth as a distinct alternative over the other services.

Moving forward with the HoQ conceptual framework the study identified MDA as a suitable method, to test the hypotheses. Primarily the hypotheses are looking at the successful classification of cases into a known set of groups (Chapter 4). The collected survey dataset is processed and tested for its suitability to run MDA on this dataset (refer to Section 5.5 and 5.6). The dataset satisfied the theoretical criteria for MDA and thus the outputs of MDA run were suitable to test the hypotheses. As noted in Table 5.4, the MDA extracted three DFs. For a four group MDA with 20 IVs, there shall be three significant DFs for the MDA Model to be interpreted (Hair et al. 2010; Schwab 2006). The three DFs of Table 5.4 have satisfied the statistical significance test, thus supporting the argument that healthcare services are distinguishable from each other, from the patients' perspective. Beyond statistical significance, these DFs have been tested for their classification accuracy (Table 5.5) and found to be performing much better than the baseline accuracies. This indicates that patients do differentiate the four different forms of healthcare services (PH, GP, TM and mHealth) as distinct. Empirically it thus implies that hypothesis H_1 cannot be rejected.

There are 11 factors constituting the three DF dimensions as identified by the Structure Matrix listed in Table 5.6. Having the DFs significant in distinguishing the healthcare service categories satisfactorily, group mean ratings for these variables vs. healthcare service are tabulated in Table 5.7 and represented through a bar graph in Figure 5.3. It is evident that mHealth was consistently rated over 6 (on a Likert scale of 1 to 7) for all the 11 factors, whereas no other service consistently performed well in all the dimensions. The distinct deviation of the mHealth rating curve implies that mHealth is distinctly viewed by the patients over other services. The model has attained original and cross validated classification accuracies of 98% and 96% respectively for mHealth (refer to Classification Results, Table 5.5). For the rest of the groups, the accuracies achieved were only about 70%. These revelations support H_2 that patients do perceive mHealth as a distinct healthcare service alternative.

Thus MDA has helped in testing the hypotheses and concludes that there is enough support to accept both the hypotheses that patients do distinguish different healthcare services as different and that patients do perceive mHealth as a distinct alternative over the other delivery systems.

5.11 Review of Research Questions

This research was set out to test the hypotheses that patients differentiate different healthcare services and that mHealth is distinct over other healthcare services. Section 5.10 reviewed these premises with the help of MDA output based on a survey dataset pertaining to a developing country, Bangladesh, and found empirical support from the findings. The literature review also motivated to address a set of research questions.

Having successfully tested the hypotheses, the next stage of the work is to address the following three research questions (refer Section 3.8):

RQ1: Are the different healthcare services distinguishable from each other?
RQ2: If so, what factors contribute to the service differentiation? and
RQ3: Is mHealth distinct from other existing services?

As noted in Section 5.10, the hypotheses testing supported H_1 that patients differentiate different healthcare services. RQ1 is a corollary of H_1, the significant extraction of DFs and their satisfactory performance in categorising the cases, implied that from the patients' perspective, the different healthcare services (PH, GP, TM and mHealth) are distinguishable from each other. Thus, the significance of the DFs positively supports RQ1.

In the case that the different health care services are distinguishable from each other, the second research question, RQ2, sets out to know what factors contribute to the differentiation. From the structure matrix (Table 5.6), MDA has extracted 11 factors (*ease, accessibility, promptness, confidence, orderliness, completeness, up-to-date, safety, cost, helpful and empathy*) out of 20 factors. These 11 factors constitute the DF constructs as shown in Table 5.6 and Figure 5.2. Thus, Table 5.6 implies that along the dimensions of the DFs (*ubiquity, information-quality and value)* consisting of the 11 variables, the service differentiation occurs. Thus, Table 5.6 positively supports RQ2.

The other premise (H_2) of the investigation that mHealth is distinct from other healthcare services is supported by the group mean statistics of Table 5.7. The high mean values (>) 6 of the 11 significant factors for mHealth, confirm the effective role of these discriminant functions to distinguish the various health services and how

mHealth is distinctly viewed from the rest of the service alternatives. Figures 5.4 and 5.5 provide more insights on how patients perceived the healthcare services (PH, GP, TM and mHealth). All these positively reinforce RQ3, implying mHealth is perceived as distinct from the other existing services. Thus, MDA has helped in answering the research questions and empirically supported the hypotheses.

5.12 HoQ Model for Healthcare Service Design

HoQ as popularised by Hauser and Clausing (1988) consists of comprehensive representation of customer needs, customer assessments, engineering characteristics, ranking of requirements and a correlation matrix. As discussed in Section 3.9 the HoQ is constructed in a sequence of steps schematically represented in Figure 3.2. This study has taken interesting approach whereby *customer requirements (HoQ Room-1)* are derived through MDA. The factors or characteristics that essentially differentiate competing services (*HoQ Room-6*) based customers' evaluation are regarded as the critical customer requirements that a service needs to address in order to achieve well performing alternative.

With these insights, the HoQ Matrix is constructed based on the output of the MDA, and is presented in Figure 5.4. The MDA Model's DFs (Table 5.6) rightfully serve the purpose of the *attribute bundles* of HoQ Matrix. The DF dimensions of *ubiquity*, *information-quality* and *value* serve as the *attribute bundles,* and the respective *variables of these dimensions* are treated as *attributes*. So, variables *ease, accessibility, promptness, confidence, orderliness, completeness, up-to-date, safety, cost, helpful, and empathy* are interpreted as customer attributes of the HoQ Matrix. Thus, these attributes also serve as *service characteristics* along which healthcare services are

contrasted. The next step in HoQ Matrix construction is to assign importance for these attributes. For this purpose, again reference is sought to Table 5.6. Leveraging on the variables' absolute loadings on to DFs, the variables are ordered in descending fashion. The highest association variable, i.e., *ease* has been assigned importance 1, and repeating this step all the 11 variables have been assigned rank ranging from 1 to 11. Customer perceptions for each of the health services are derived from the group means based on the patients' rating of these services. Typically Figure 5.4 includes a graphical portrayal of these ratings. For reasons of space and clarity this diagram is shown separately in Figure 5.5.

Design Characteristics

Attribute Bundles	Customer Attributes	Importance	Service Measures	Customer Perceptions			
				PH	GP	TM	mHealth
Ubiquity	Ease	1	Out of scope of current research.	2.88	3.34	5.12	6.66
	Accessibility	2		2.70	3.00	3.08	6.28
	Promptness	4		3.30	4.48	5.20	6.42
	Confidence	6		3.12	4.94	3.20	6.26
	Orderliness	9		3.12	4.68	3.22	6.26
	Completeness	11		3.20	5.02	3.76	6.06
Information Quality	Up-to-Date	5		3.56	5.04	3.12	6.28
	Safety	8		4.08	5.20	3.34	6.20
Value	Cost	3		5.26	2.80	5.58	6.34
	Helpful	7		3.48	5.14	5.24	6.36
	Empathy	10		3.26	4.90	5.02	6.28

Figure 5.4: HoQ Model for mHealth Service Design

Figure 5.5 portrays graphically a cross-tabulation of the patients' rating of each of the health services along significant attribute dimensions. It provides a visual clue on how a service is performing, relative to the competing services along each *attribute dimension or service characteristics*. It is evident that along every single dimension, mHealth is faring exceptionally well, compared to the other alternatives. It provides an

interesting view about the next best performing service i.e., GP. Along the dimension of *cost,* GP has the lowest score, indicating that it is relatively the most expensive alternative for the patients. GP services have also got some low scores along the *accessibility* and *ease* dimensions.

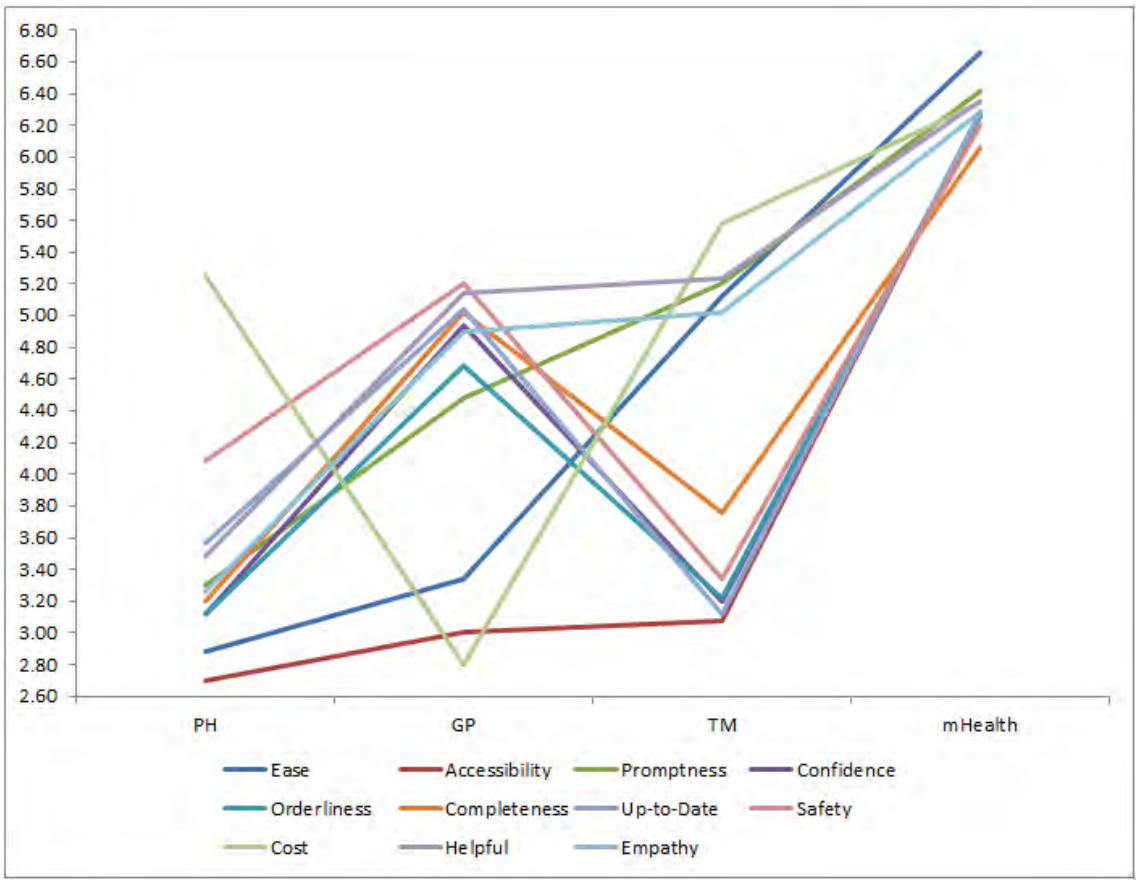

Figure 5.5: HoQ Model for mHealth Service Design- Service Characteristics

On the other hand, PH service fared better relative to GP and TM along the *cost* dimension alone. It is understandable, as PHs are government funded and are supposed to be cheaper. In that respect, they should have been much more favourably rated than even mHealth. But the fact is that despite being government funded, these institutions are still more costly to the patients, due to the ill-social practice of *baksheesh* (Andaleeb 2000), prevalent in Bangladesh.

The TM service has fared relatively well along the dimensions of *cost*, *confidence*, *promptness*, *ease* and *empathy,* relative to PH and GP. Of all the services, mHealth has been the most positively viewed and the service distinctly separates from other services along all the attribute dimensions identified by MDA. These insights are very valuable for all the service providers in affecting changes to their services design and services operation.

In summary, Figure 5.4 broadly covers the derivation of the following sections as depicted in Figure 3.2: *Room-1 Customer Requirements, Importance Rating, and Room-6 Customer Assessment of Competing Services*. Future research endeavours will look into the derivation of the rest of the HoQ.

5.13 Chapter Summary

This chapter is the epitome of the research endeavour, motivated by the study of the extant literature, we identified research opportunities that have significant impact both for research and practice, and alleviate the healthcare status across globe. The outcomes of the study are visualised through the application of the research method, i.e., DA in processing the survey data. Having checked the demographic and summary of the dataset for the basic suitability of the dataset for DA, the discussion moved on to understand and interpret the outcomes from the perspective of the research questions and hypotheses. The hypotheses are tested and research questions are analysed using the outputs of DA, and found empirical support to the basic premises that:

- healthcare services are distinguishable from each other from the perspective of the patients.
- The study further empirically established that mHealth is perceived much more positively by patients; and
- that the different healthcare services are differentiated by 11 variables constituting the dimensions of *ubiquity, information-quality and value*.

These outcomes have formed as input into the construction of *HoQ Rooms*, primarily *Room-6: customer evaluation of competing services and derived additional clues to populate other HoQ Rooms,* such as: *attribute bundles, attributes, priorities etc.* The next chapter will discuss these outcomes and their contributions to theory, practice, healthcare services provision and opportunities to address global issue of *healthcare divide*.

Chapter 6: Discussion and Conclusions

6.1 Chapter Overview

This chapter recaps the research objectives and reviews them from the perspective of the empirical findings derived from the MDA, based on the patients' perception study in a developing country: Bangladesh. The discussion relates these research outcomes to the research gaps identified in the literature review, presented in Chapters 2 and 3. This chapter discusses on how the outcomes address the three research questions and two hypotheses. The theoretical, practical, and methodological contributions of the research are highlighted. Limitations of the current study and opportunities for future research are outlined. Finally, the chapter concludes with a brief summary of the work, its relevance in alleviating the *healthcare divide* and the significant tasks ahead for the worldwide community to enhance healthcare services across the world.

6.2 Research Objective

Service quality, including that of healthcare services, has been extensively addressed in the extant literature. Recently, mHealth service quality dynamics too received significant focus [Akter 2012]. However, the antecedents to service quality i.e., *service design* and *service operation,* have not been adequately addressed in the extant literature. Added to this, the emerging mHealth, as an alternative healthcare delivery platform in bridging the *healthcare divide,* has motivated us to address the following three research questions within the context of developing countries:

RQ1: Are the different healthcare services distinguishable from each other?
RQ2: If so, what factors contribute to the service differentiation? and
RQ3: Is mHealth distinct from other existing services?

There is a tremendous gap between the demand and supply for healthcare (Table 2.1). mHealth is emerging to play a vital role in circumventing this huge gap in healthcare provision through affordable services delivered via mobile phones. Recognising this transformative impact of mobile phones in healthcare delivery, we hypothesise that in developing countries:

H_1: Patients differentiate different health care services.
H_2: Patients perceive mHealth as a distinct alternative over the other services.

A patient survey was conducted to gather their perceptions in order to address these research hypotheses and questions. The instrument is designed based on the outcomes of the qualitative study and consisted of 20 dimensions (Table 3.2) as listed below:

Table 3.2: Service Quality Dimensions

Perceived Systems Quality	Perceived Interaction Quality	Perceived Information Quality	Perceived Outcome Quality
1. Reliability	1. Helpful	1. Completeness	1. Ease
2. Accessibility	2. Promptness	2. Accurate	2. Convenience
3. Availability	3. Courtesy	3. Up-to-date	3. Cost
4. Safety	4. Empathy	4. Orderliness	4. Confidence
5. Efficiency			5. Enjoyable
6. Privacy			
7. Usefulness			

The dataset has been processed using MDA and the output is analysed in the previous chapter. A summary of the outcomes is presented in the next sections.

6.3 Summary of Findings

The MDA extracted three significant DFs as required for a DV, health service, consisting of four groups (PH, GP, TM and mHealth) and 20 IVs, as listed in Table 5.4 (Hair et al. 2010; Schwab 2006). Beyond statistical significance, these DFs performed well in

classifying the original cases with accuracies better than the baseline (Table 5.5). Thus, these outcomes support the hypothesis H_1: that patients do differentiate the four different forms of health care services (PH, GP, TM and mHealth) as distinct. MDA has extracted 11 factors (*ease, accessibility, promptness, confidence, orderliness, completeness, up-to-date, safety, cost, helpful and empathy*) out of 20 factors that significantly differentiate the four services. mHealth was consistently rated over 6 (on a Likert scale of 1 to 7) for all these 11 factors, whereas no other service consistently performed well in all the dimensions (Table 5.7 and Figure 5.3). The model has achieved higher classification accuracies in classifying mHealth cases over other groups. These revelations supported H_2: that patients do perceive mHealth as a distinct healthcare service alternative.

Research question RQ1 is a corollary of hypothesis H_1, the significant extraction of DFs and their satisfactory performance in categorising the cases, implied that from the patients' perspective, the different healthcare services (PH, GP, TM and mHealth) are distinguishable from each other. Thus, the significance of the DFs positively supported the RQ1. Along the dimensions of the DFs (*ubiquity, information-quality and value),* consisting of the 11 variables, the service differentiation occurs (Table 5.6), positively supporting RQ2.

The premise (H_2) of the investigation, that mHealth is distinct from other healthcare services, is reinforced from the group mean statistics of Table 5.7. These revelations supported RQ3, implying mHealth is perceived distinctly different from other existing services. Thus, MDA has helped in successfully testing the hypotheses and answering the research questions.

6.4 Contributions of the Study

> *"Contribution is a relative term in that it also implies that the work is adding to a body of literature or methodological development."*
>
> - (Grover et al. 2009)

This section reflects on the contributions of the current research from the perspectives of theory, methodology, practice, and policy makers. Interrelating the findings and outcomes of this research with the extant literature this section also serves as a useful aid to stakeholders of healthcare sector like, the governmental agencies, service providers, managers and international agencies.

The qualitative study enabled to identify the quality needs for healthcare services. The DA enabled to identify the distinguishing characteristics of various healthcare services. The DA Model facilitated to visualise the dimensions along which service differentiation occurs and opportunities for improvements to be augmented by competing service alternatives. Thus the DA Model helped in analysing the critical Room-6, i.e., competitive benchmarking of service alternatives.

While arguing the case for QFD as a quality engineering technology for food industry, Charteris (1993 p.20) concludes that: "Successful companies must be able to provide products that are differentiated from their competitors in terms of quality, cost and timing, and these differences must be discernible to the customer."

Thus the discussion of HoQ Framework and DA Model complimentary and HoQ enumerated the service characteristics that are of important to patients, and provided broad basis for actions to be contemplated to cascade this VoC down the provider organisations to improve Healthcare Services Design.

6.4.1 Contribution to Theory

> "He who loves practice without theory is like the sailor who boards ship without a rudder and compass and never knows where he may cast."
>
> - Leonardo da Vinci

The findings empirically support the hypotheses that patients do distinguish different forms of healthcare services. The study also found empirical support that mHealth is a distinct form of healthcare service from the patients' perspective. The study further identified that the service differentiation occurs along three dimensions: *ubiquity, information-quality and value*. As shown in Table 5.6, variables *ease, accessibility, promptness, confidence, orderliness and completeness* are associated with DF-1 or *ubiquity*. Variables *up-to-date and safety* constitute DF-2 or *information-quality*. And variables *cost, helpful and empathy* define DF-3 or *value*. Thus 11 variables out of 20 variables (Table 3.2) are found to be effective in service differentiation.

From the service quality perspective, the SERVQUAL model suggests that consumer satisfaction can be gauged by *tangibles, reliability, responsiveness, assurance and empathy* constructs (Parasuraman et al. 1988). In contrast, the DA Model identified that the service differentiation occurs along the dimensions of *ubiquity, information-quality and value*. Thus it can be noticed that 11 variables of service differentiation are much in common to the dimensions of the SERVQUAL model.

The study is a significant step towards inter system comparison study within healthcare services from the perspective of patients (Andaleeb 2000; Andaleeb 2001; Andaleeb et al. 2007; Lim and Zallocco 1988; Siddiqui and Khandaker 2007). It provides

a comparative assessment of mHealth, with respect to other conventional healthcare delivery systems.

mHealth, in comparison to other existing healthcare services such as: PH, GP and TM, is much easier to use. The patient or his/ her care provider has to simply dial a prescribed number from his/ her mobile phone or from a designated community phone. From the IS perspective, the UAT models empirically ascertain that usefulness and accessibility will influence the acceptance of IT (Davis 1989; Venkatesh et al. 2003). In terms of *ubiquity*, to avail the service of PH, GP or TM a patient has to make a physical trip to these places. Furthermore, the trip is only meaningful during the operating hours of the provider while the mHealth help line can be reached from a location convenient to the patient, and that too at the very moment he/ she requires the service, i.e., it could be mid-night, a weekend or on a holiday (Akter and Ray 2010).

In developing countries, the health services, are in general, overcrowded and it is imperative that the patients are required to queue up to be serviced as the capacities of these institutions are much lower than the demands (Economist 2012; Ivatury et al. 2009). Thus, similar to the SERVQUAL model, *responsiveness* and *promptness* are important aspects from the patients' perspective in differentiating services.

The *Services Life Cycle* model (Figure 2.6) helps visualising the different phases of services that emanate from an unfulfilled need in the market place. It further helps in visualising the antecedents to service quality i.e*., services design* and *services operations, which have* been scarcely researched. Thus, the SLC model proposes that services design and services operations are crucial elements, there is an enormous

scope to improve quality, optimise tackle cost pressures and thereby improve the performance of healthcare services.

QFD and *HoQ* (Figures 3.2 and 3.3) have been employed in manufacturing, not only to echo the *voice of customer* across the organisation, but also to address the mounting cost pressures. The current investigation made a preliminary attempt to compute *Comparative Analysis of Healthcare Services* or *Room-6 of HoQ* (Figure 3.2) and extracted *service characteristics* a key element to move forward with healthcare services design.

6.4.2 Contribution to Methodology

The study applied *multiple discriminant analysis* or MDA and explained the methodological gestalt. The study, in a way, was a step forward applying MDA in the context of QFD/ HoQ design philosophy, especially in arriving at *customer evaluation of competing service alternatives* (*HoQ Room-6*, Figure 3.2). The study proves its usefulness in comparative analysis of service alternatives. This investigation is also a significant move in applying an established and popular classification technique from the realms of Marketing Research and Pattern Recognition (Hair et al. 2010; Malhotra 2004; McLachlan 1992) into *IS & OM Research and Practice*. Thus, MDA model not only helped in generating the patients' perceptions of healthcare services, but their significant statistical role in extracting the factors that differentiate the services, or service characteristics.

6.4.3 Contribution to Practice

In essence, our MDA model presents three important constructs: *ubiquity, information-quality and value* as the determinants in differentiating various healthcare

service delivery alternatives: PH, GP, TM and mHealth. The 11 variables constituting these three constructs have a considerably higher means for mHealth (Table 5.7 and Figure 5.3). Though Telehealth (including mHealth) has been researched extensively, it has not made substantive inroads into becoming a routine practice. One of the reasons cited by the researchers is that it is not cost-effective (Motamarri et al. 2011). Some authors noted that there has not been a concrete demonstration of cost-effectiveness of mHealth initiatives (Hsu et al. 2010). Contrary to these notions, this research has empirically established that patients perceive mHealth as cost effective and delivers better value over the other conventional systems (Figure 5.5). Figure 6.1 presents a graphical portrayal of group means rolled up to DF level: Ubiquity, Information-quality and Value.

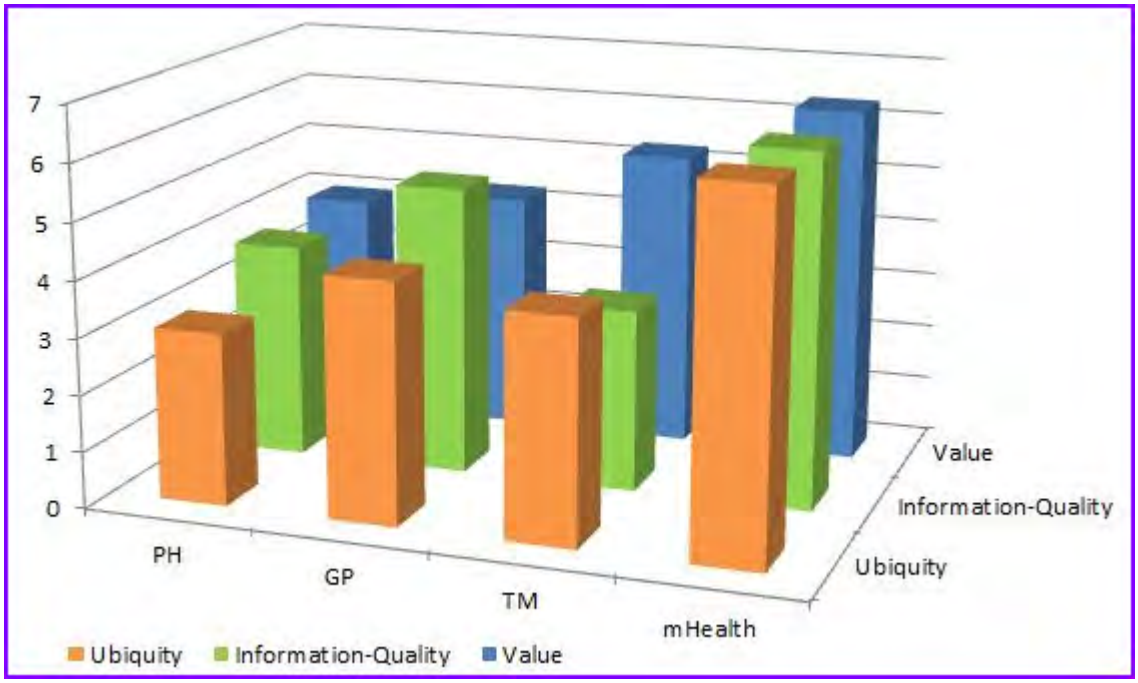

Figure 6.1: Aggregate Group Means vs. Healthcare Service

Important lessons can be derived from Figures 5.3, 5.5 and 6.1 that have practical implications and valuable insights for both theory and practice. Public hospitals have

been perceived as the most difficult to use, provide lowest value and in terms of *information-quality*, and rank slightly higher than TM. These results confirm similar outcomes about the public hospitals and their apathy to serve the people in need (Andaleeb 2000; Andaleeb et al. 2007). TM is viewed to provide the next best overall value after mHealth while their *ubiquity* or *information-quality* is lower than GP. Along the dimensions of *ubiquity* and *information-quality*, GP is viewed as the second most preferred alternative to mHealth.

The competing alternatives to mHealth can utilise these insights to adequately respond, to improve their service portfolio in order to meet or exceed in overall experience of their patients. It is imperative for these services to improve their stature in the midst of an emerging service contender, mHealth (Keaveney 1995). This critical patients' feedback on healthcare service portfolio, shall be a motivational element both for incumbent service providers as well as would be entrants.

6.4.4 Contribution to Policy Makers

The exploding global population and the *healthcare divide* will pose far more challenges in ensuing years, unless a careful multi-disciplinary study is undertaken. Given its ubiquity, affordability and high penetration even among the poor population, mHealth can be a potential healthcare service delivery alternative, to complement other forms of healthcare delivery. mHealth has the potential to overcome the complex socio-economic fabric of the developing countries, and can deliver the healthcare where it is required, and thus can reach out to the underserved and unserved population groups.

Taking the patients' feedback on the healthcare delivery systems, governmental, not-for-profit and commercial healthcare institutions can embark on transformation programs to fix the shortcomings of their services by revitalising their services through better service design. Recognising the popularity of mHealth among the community, planning agencies can initiate concrete planning initiatives to move this delivery system into a fully supported alternative. This step will hopefully bridge the *healthcare divide* and assist the developing countries in achieving better healthcare for all, and eventually lead them in achieving the WHO's MDGs.

National and international planning and policy formulation bodies like the: AIHW, PC, IOM, WHO etc., are all concerned about the rising costs of healthcare provision in developed nations. Healthcare improved the quality of life indicators and increased life expectancy (AIHW 2011; IOM 2010; PC 2011a; WHO 2010). However, as a corollary population ageing is becoming a challenge, and hence the disease burden on the economy is escalating too (Motamarri, 2011). Healthcare is continually taking up an increasing chunk of GDP, and thus the planning agencies are concerned about the sustainability of current care models (IOM 2010; PC 2011b). mHealth and expansion of its role will certainly benefit the society. This research found that patients consider mHealth to be of superior value than other alternatives. We thus hope policy makers will start recognising and leveraging on mHealth. Furthermore, this study provides a positive experience and large pool of patients' acceptance of mHealth (Grameenphone 2008; Ivatury et al. 2009) to the organisations like WHO and Centre for Health Markets Innovation (CHMI 2012) in their ongoing efforts of promoting mHealth.

6.5 Limitations

This study has some limitations. The DA Model depicts the patients' perspective at a point in time as the data is collected through a cross-sectional survey. The data collection might not have covered all geographies within Bangladesh. It is possible that the user perceptions may change over time (temporal validity), due to continual changes that happen in the market place (Motamarri 1992). It is worthwhile to examine the temporal validity of the model through on-going surveys. The model reflects that of a developing world, particularly with reference to Bangladesh. It is worthwhile to examine the model for other geographical settings to ensure locational transferability (Marwah and Motamarri 1987).

6.6 Future Directions

Future research will focus on enhancing the current HoQ model with the computation of performance targets (Figure 3.2), and then cascade these outcomes towards development of process characteristics, sub-process characteristics and function specifications and function targets (Figure 3.3). The lowest level of the QFD Matrix in essence is the operational characteristics and operational targets.

The outcome of the DA model for healthcare services can also be viewed as the patients' perception of service operation. The three dimensions and the associated 11 factors are to be ingrained in *services design* in order to improve *services operation*. ITIL is developed by the United Kingdom's Office of Government Commerce (OGC) as a response to systematically execute services management in a five phase model. ITIL is the de-facto industry standard for IT Services Management (OGC 2007). It is possible

to integrate higher phases of QFD Matrices to the ITIL Operational Framework, in order to aid in the *health care services design* as well as *operation*.

6.7 Conclusions

The multi-disciplinary search on healthcare services has uncovered several interesting facts about healthcare services, provided a framework to understand the antecedents for a quality healthcare service and proposed that HoQ can be utilized in the process of healthcare services design. The discussion highlighted the lack of comparative evaluation of healthcare service alternatives and how such an evaluation can contribute to the design of efficient healthcare service alternatives to address the healthcare challenges of the developing nations.

Our research identified three dimensions along which healthcare services are distinctly viewed. It also helped in establishing mHealth as the preferred alternative over other existing healthcare services. The research confirms that patients perceive mHealth as an effective alternative. Its large scale deployment and adoption can substantially bridge the *healthcare divide*. mHealth service providers can take a hint from these conclusions and work towards continual differentiation. The other existing service providers can utilise these inputs in developing long term plans to improve their relevance and performance. Ultimately, the future of any discipline very much depends on the codification and dissemination of critical knowledge and evidence base that can influence the policy makers and health administrators (Mechael 2009). Our comparative analysis of patients' perceptions of healthcare services and their positive attitude towards mHealth over the other services, will also serve the goal of

establishing mHealth as an effective alternative to the delivery of healthcare services in developing countries.

The research has addressed the question on whether patients distinguish competing health care service alternatives. The DA Model also helped in identifying the specific dimension and factors along which the service differentiation is perceived. mHealth has been viewed by patients much more positively over the conventional services. Patients are looking for *ubiquity, information-quality and value* when they consult a healthcare service provider. In comparison to other services, mHealth is viewed as less costlier, helps in alleviating their health concerns in an empathetic manner. Patients, as consumers of healthcare services, look in the market place to maximise their return for their investment, whether it is money or time. Naturally, the patients look for a service that is cheaper and at the same time helpful, and the service provider that empathises with their needs.

This is an important outcome, as service providers can utilise these patients' expectations in their *continual service improvement* phase of services management. In the absence of captive restrictions consumers typically opt for services that fulfil their needs, at minimal cost and convenience. Unless conventional service providers start reforming their services delivery and improve the service operation, patients will tend to choose the most optimal service that maximises their utility.

The perceptions of patients in the sub-groups formed by age, gender, income or education are found to be relatively uniform. This ascertains the fact that the conventional healthcare services are generally viewed as less valuable in comparison to mHealth. The group means and the three discriminant dimensions also positively

support the question that the health care services are distinguishable from each other from the patients' perspective. Furthermore mHealth is significantly distinguishable from the rest of the services on the identified dimensions of *ubiquity, information-quality and value*.

The exploding global population alongside with the continuing *healthcare divide* will pose far more challenges in ensuing years, unless a careful study is undertaken on multi-level (country, region, and world). Given its *ubiquity, information-quality and value* offerings, and the patients positive attitude towards its service offering, mHealth can help bridge the *healthcare divide* and assist the developing countries in achieving better health care to the under-served and unserved population groups.

6.7.1 mHealth can Alter the *Healthcare Divide*

The attitude shift of patients towards the emerging mHealth over other services seems to be quite natural, as the conventional services are dysfunctional, inaccessible, unresponsive, of poor quality and costly in many parts of the developing world including Bangladesh (Andaleeb 2008; Worldbank 2004). Thus, our research conclusions of poor performance of conventional services as perceived by the patients, purports to the assessments of the World Bank and other researchers. While the generic notion is that mobile health is costlier, the user perception is that it is far cheaper and more valuable than the other alternatives. With the burgeoning penetration of mobile phones, the offering of cost-effective medical services through mobile phones has naturally been viewed positively by patients as the conventional services lack capacity and attitude to improvise the services environment (Andaleeb 2001; Ivatury et al. 2009; Mechael 2009). A well designed and delivered service will

naturally generate a better satisfaction for a consumer. As noted earlier that consumers generally opt for the services that are easy to use, accessible, promptly served, organised and fulfil satisfactorily their original need.

We thus believe that service design is an important antecedent to achieve well performing healthcare services. We hope that service providers and planning agencies will progressively work towards addressing the existing shortcomings with their services portfolio, and also recognise the complementary nature of mHealth in achieving better healthcare for all.

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A. Ethics Committee Approval

From: Gary Monroe
Sent: Tuesday, September 20, 2011 11:27 AM
To: Pradeep Ray
Subject: RE: HREA Reference: 09703

Hi Pradeep

Your understanding is correct.

Gary

Professor Gary S Monroe
School of Accounting
Australian School of Business
University of New South Wales
Sydney, NSW 2052 Australia
Telephone +61 (2) 9385 6443
Fax +61 (2) 9385 5925
Mobile 041 9418 244

-----Original Message-----
From: Pradeep Ray
Sent: Tuesday, 20 September 2011 11:25 AM
To: Gary Monroe
Cc: Shahriar Akter; Saradhi Motamarri
Subject: RE: HREA Reference: 09703

Dear Gary,

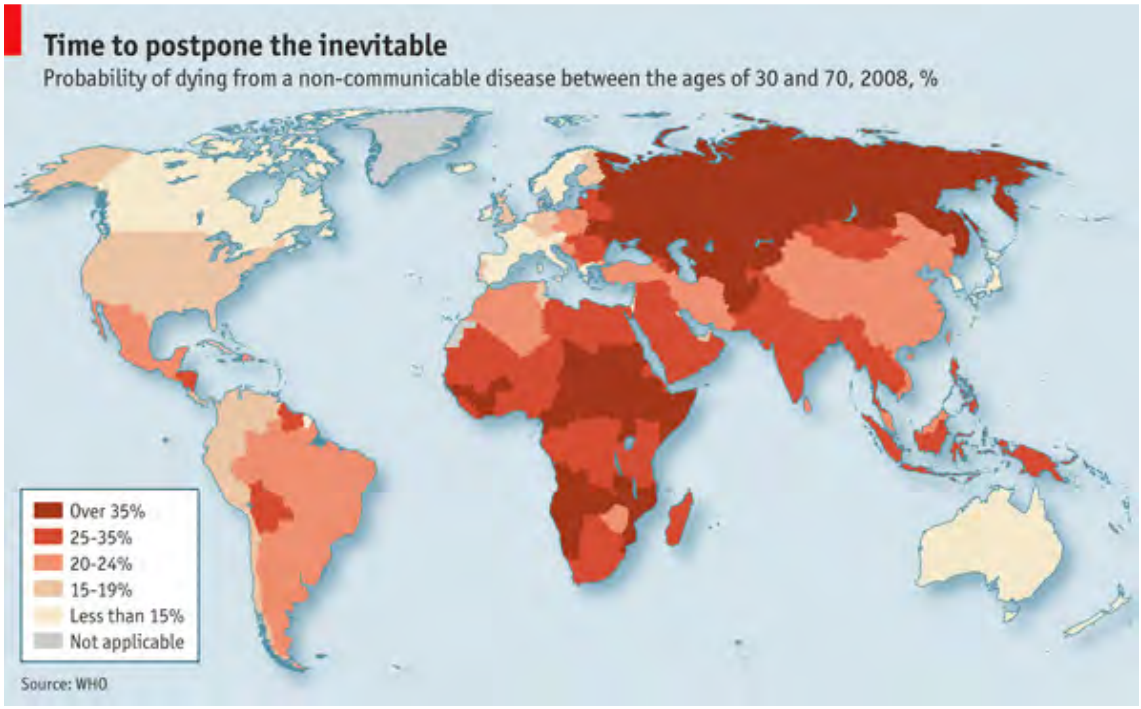
As discussed today, Saradhi (our M.Phil student) need not apply for ethics clearance because he is using de-identified data already collected by Shahriar as approved by UNSW Ethics Committee in 2009 and Shahriar is co-researcher in this project.

Pl respond to this email within two days in case my understanding is not correct.

Thanks,

Pradeep

B. Time to Postpone the Inevitable



Source: [Economist, 2012]

C. Survey Instrument

Questionnaire on Health System in Bangladesh for primary health information Services

For **primary health information services**, which health system did you use in the past one year?

1. Public hospital 2. General Practitioner 3. Other medicine practitioners *(Pharmacists, Homoeopaths, Kabiraj etc.)*
4. Mobile Health (789 of Grameenphone)

Code	To aid me in receiving primary health information services, overall, I feel this **healthcare system** is:						
SYS1	**Unreliable** 1	2	3	4	5	6	**Reliable** 7
SYS2	**Not always accessible** 1	2	3	4	5	6	**Always accessible** 7
SYS3	**Not always available** 1	2	3	4	5	6	**Always available** 7
SYS4	**Unsafe** 1	2	3	4	5	6	**Safe** 7
SYS5	**Inefficient** 1	2	3	4	5	6	**Efficient** 7
SYS6	**Having Less privacy** 1	2	3	4	5	6	**High privacy** 7
SYS7	**Quite useless** 1	2	3	4	5	6	**Quite useful** 7
	To aid me in receiving primary health service, overall, I feel **physicians of this healthcare system** are:						
INT1	**Unhelpful** 1	2	3	4	5	6	**Helpful** 7
INT2	**Providing Delayed service** 1	2	3	4	5	6	**Prompt service** 7
INT3	**Not courteous at all** 1	2	3	4	5	6	**Very Courteous** 7
INT4	**Providing less individual attention** 1	2	3	4	5	6	**High individual attention** 7
	To aid me in receiving primary health service, overall, I feel **information** from this healthcare system are:						
INF1	**Incomplete** 1	2	3	4	5	6	**Complete** 7
INF2	**Inaccurate** 1	2	3	4	5	6	**Accurate** 7
INF3	**Not up-to-date** 1	2	3	4	5	6	**Very up-to-date** 7
INF4	**Disorganized** 1	2	3	4	5	6	**Organized** 7
	To aid me **in receiving primary health information**, overall, I feel this healthcare system is:						
OUT1	**Difficult to receive service** 1	2	3	4	5	6	**Easy** 7
OUT2	**Inconvenient** 1	2	3	4	5	6	**Convenient** 7
OUT3	**High cost** 1	2	3	4	5	6	**Low cost** 7
OUT4	**Confidence degrading** 1	2	3	4	5	6	**Confidence enhancing** 7
OUT5	**Not Enjoyable** 1	2	3	4	5	6	**Enjoyable** 7

Gender: 1. Male 2. Female
Age: **1.** 18-25 **2.** 26-33 **3.** 34-41 **4.** 42-49 **5.** 50+
Income: **1.** below 5000 **2.** 5001-10000 **3.** 10001-150000 **4.** 150001-20000 **5.** 20001-25000 **6.** 250001-30000 7. 30000+
Education: **1.** primary **2.** SSC **3.** HSC **4.** Honours **5.** Masters **6.** Others
Occupation: 1. Student 2. Housewife 3. Business 4. Public service 5. Private service 6. Others
Location: 1. Urban 2. Suburban 3. Local

D. Survey Data Analysis

The following Charts D.1 to D.9 portrays graphically the responses and categorical distribution of patients' perceptions of health service. The charts also enable to view the patients ratings of different health services along the major dimensions of platform, interaction, information and outcome quality.

The legend for the accompanying charts is presented below.

Legend:

Health Service 1: Public Hospital (PH)
2: General Practitioner (GP)
3: Traditional Medicine (TM)
4: Mobile Health (mHealth)

SYS_1: Reliability
SYS_2: Accessibility
SYS_3: Availability
SYS_4: Safety
SYS_5: Efficiency
SYS_6: Privacy
SYS_7: Usefulness

INT_1: Helpful
INT_2: Promptness
INT_3: Courtesy
INT_4: Empathy

INF_1: Completeness
INF_2: Accurate
INF_3: Up-to-date
INF_4: Orderliness

OUT_1: Ease
OUT_2: Convenience
OUT_3: Cost
OUT_4: Confidence
OUT_5: Enjoyable

D.1: Service Platform Perceptions vs. Health Service

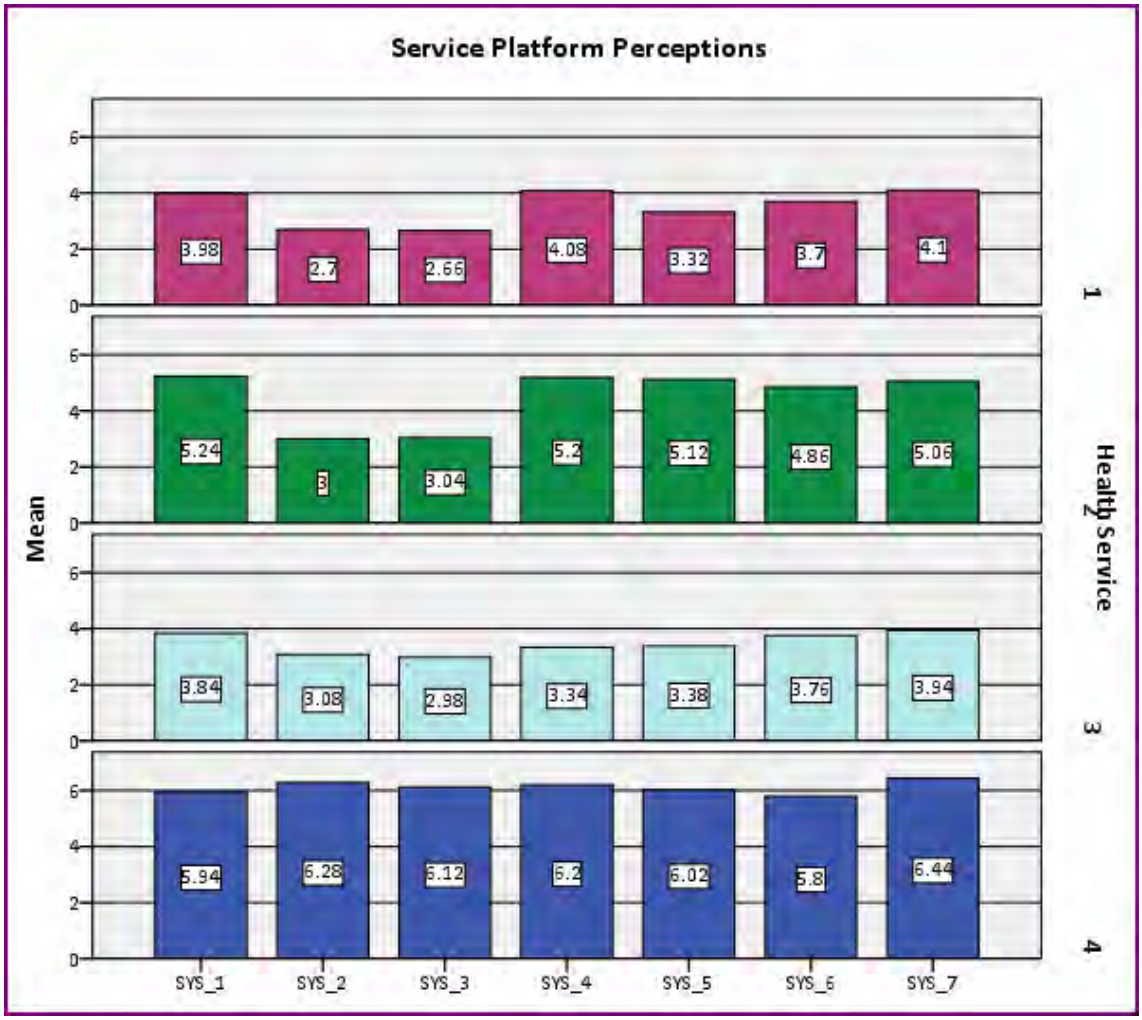


Chart D.1 presents the patient ratings on service platform consisting of seven variables *reliability, accessibility, availability, safety, efficiency, privacy and usefuless*. For all variables mHealth has the highest means, a mean rating of about six or higher for all the variables. No other service has received mean ratings above 6 for any item. Visually, it is clear that GP is the next best performing service. TM has lower platform perceptions over PH. The *Usefulness* attribute of mHealth got the highest mean rating of 6.44, and *availability* of PH has the lowest mean rating of 2.66.

D.2: Service Interaction Perceptions vs. Health Service

Chart D.2 presents the patients' ratings on service interaction consisting of four variables *helpful, promptness, courtesy and empathy*. Again for all the variables mHealth has the highest means, a mean rating above six. On this dimension, the next best performing service is TM, followed by GP and lastly PH. The *promptness* of mHealth got the highest mean rating of 6.42 while *empathy* of PH received the lowest rating of 3.26.

D.3: Service Information Perceptions vs. Health Service

Chart D.3 presents the patients' ratings on service information consisting of four variables *completeness, accurate, up-to-date and orderliness*. Again for all variables mHealth has the highest means, a mean rating above six. On this dimension, the next best performing service is GP, followed by PH and lastly TM. The *up-to-date* of mHealth got the highest mean rating of 6.28 while *up-to-date* of TM and *orderliness* of PH got the lowest ratings of 3.12.

D.4: Service Outcome Perceptions vs. Health Service

Chart D.4 presents the patients' ratings on service outcome consisting of five variables *ease, convenience, cost, confidence and enjoyable*. Here again mHealth dominated in attaining highest ratings above 6 for all the dimensions. The next best rated service is TM followed by GP and lastly PH. The *ease* of mHealth got the highest mean rating of 6.66 while *cost* of GP received the lowest rating of 2.8. The *cost* variable is reversely coded, meaning the higher the score the cheaper the service is. Thus mHealth followed by TM and PH fared well on this dimension while GP service rated as one of the costliest.

D.5: Gender Composition vs. Health Service

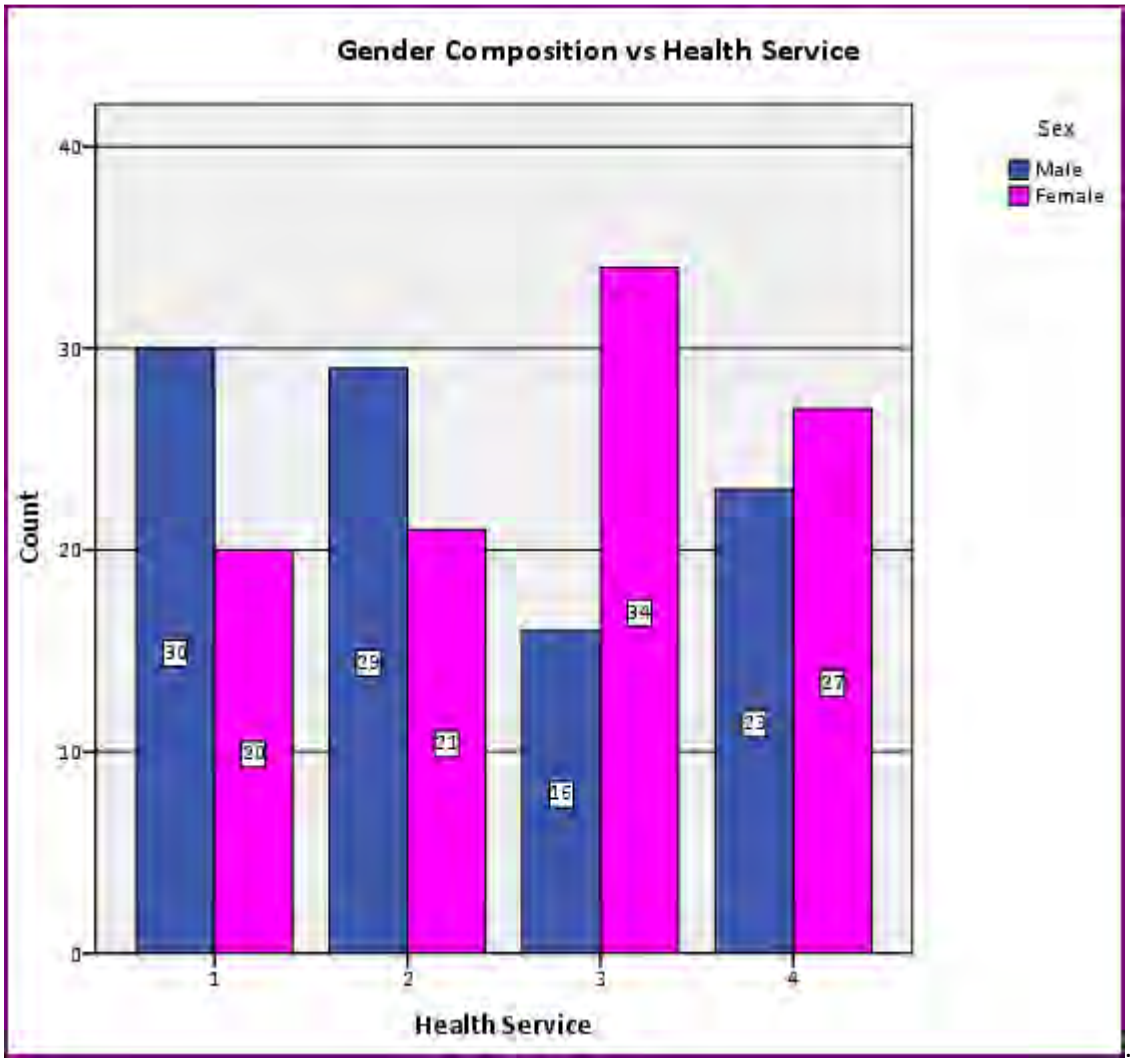


Chart D.5 depicts the gender composition of respondents by service category. While the total sample had fairly equal number of male and female respondents, TM group has the highest number of female respondents of 34 and lowest male respondents of 16. mHealth group has fairly equal gender composition.

D.6: Respondents' Age Group vs. Health Service

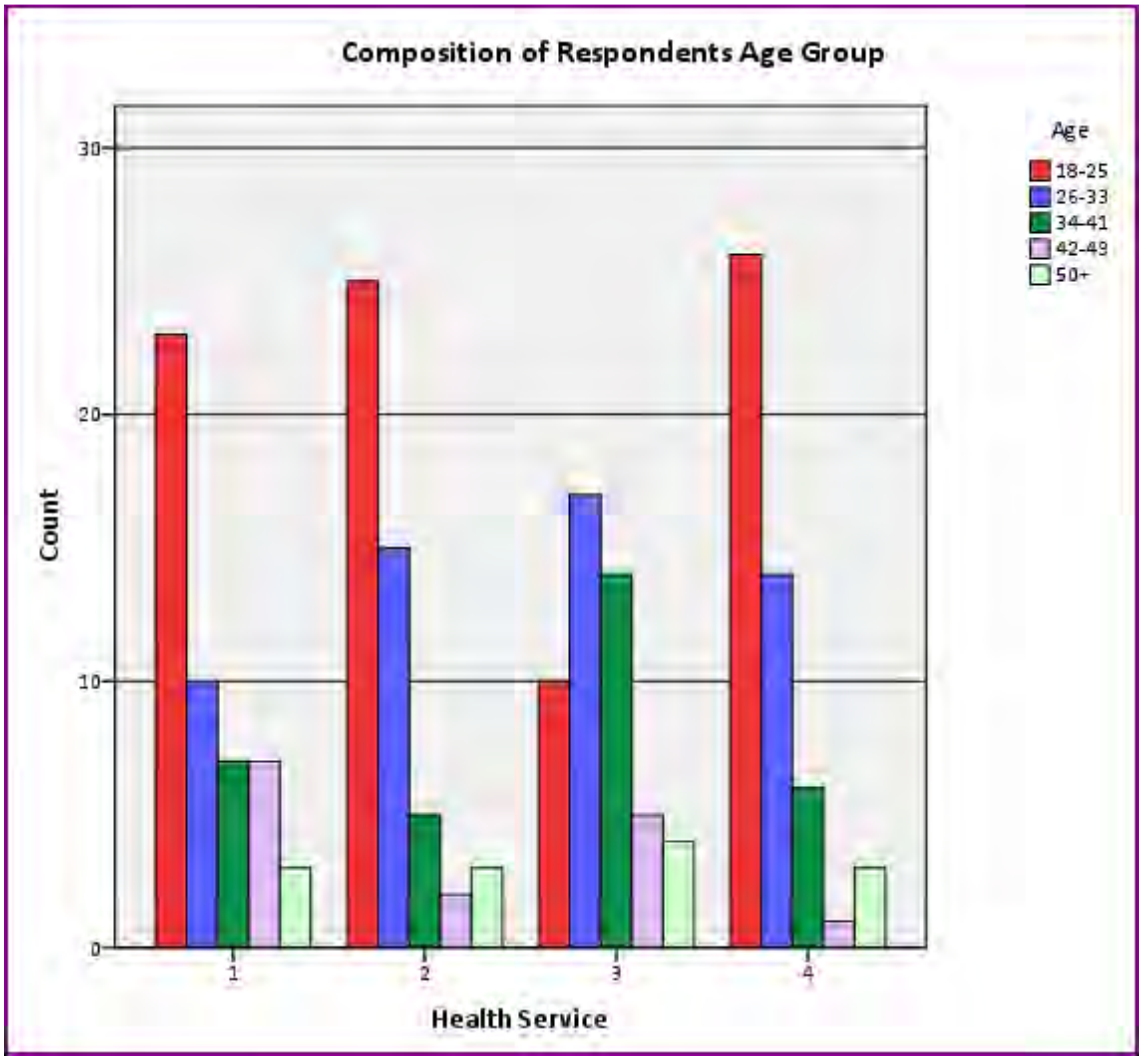


Chart D.6 depicts the age composition of respondents by service category. Across all groups over 40% of the respondents are in the 18-25 years age group.

D.7: Platform Perceptions vs. Health Service vs. Gender

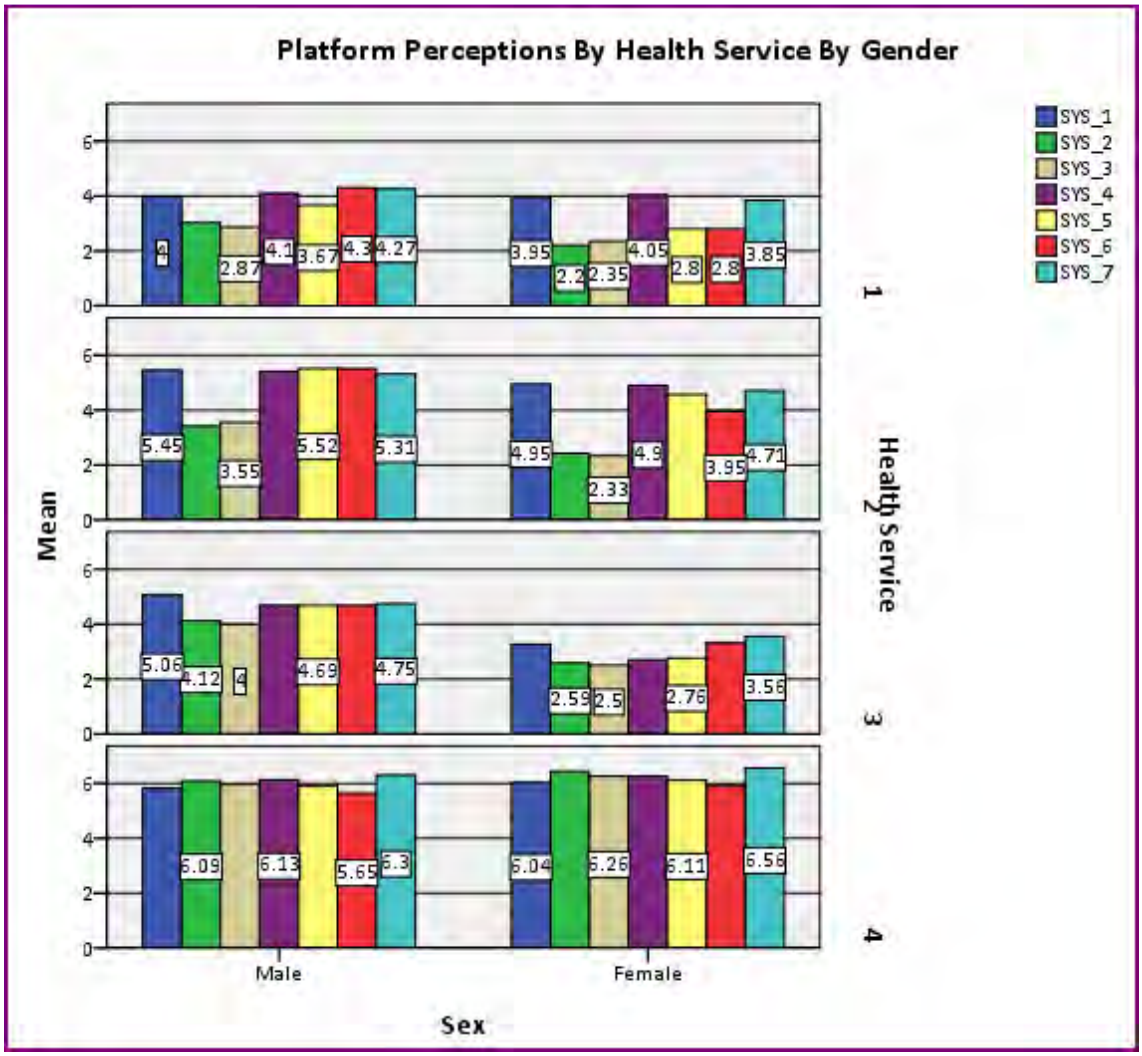


Chart D.7 depicts the service platform perceptions by health service by gender. It indicates that the response pattern among both the genders is fairly uniform. mHealth is relatively uniformly perceived by both the genders, while males rated TM service has slightly better than females.

D.8: Platform Perceptions vs. Health Service vs. Age Group

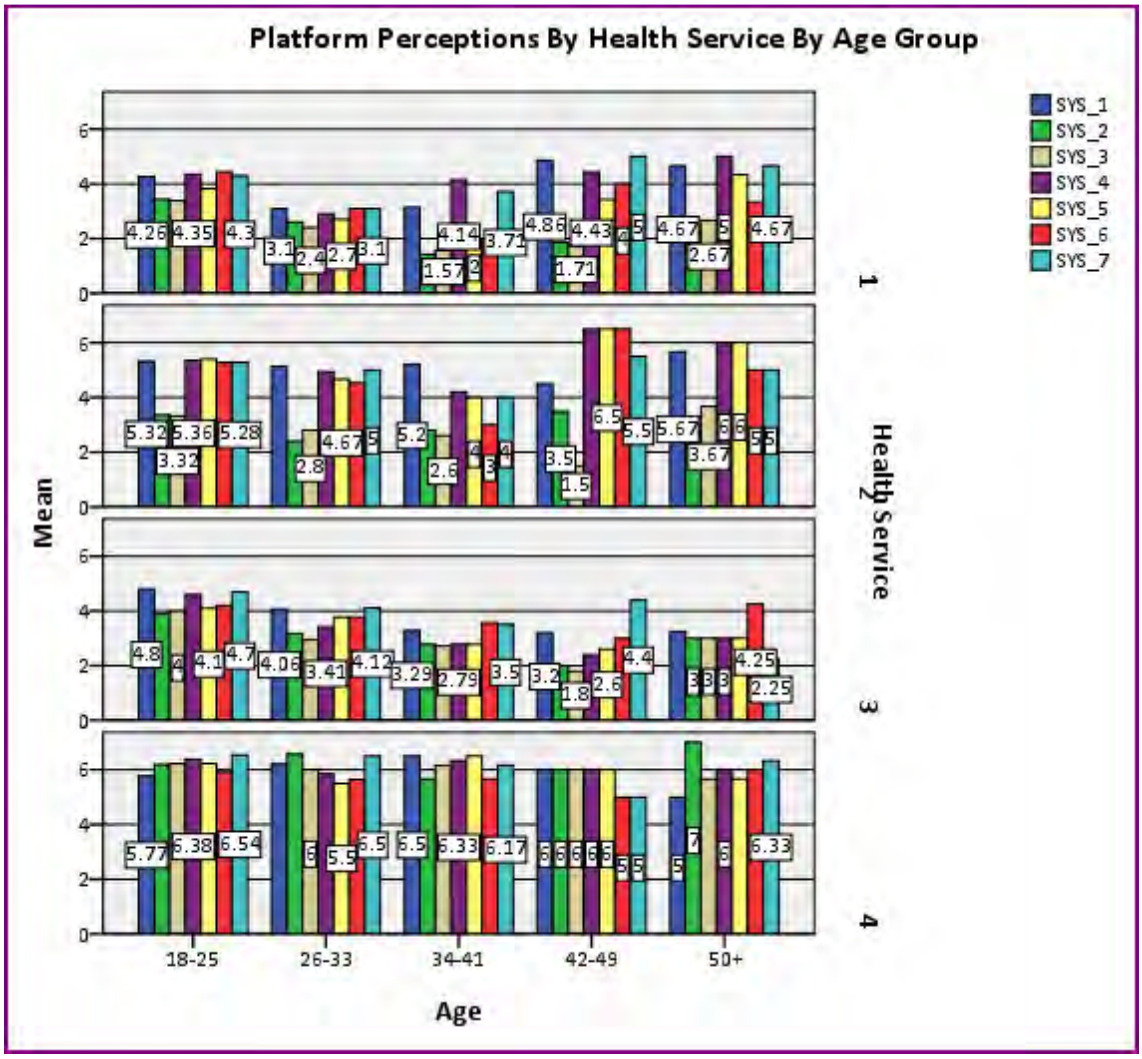
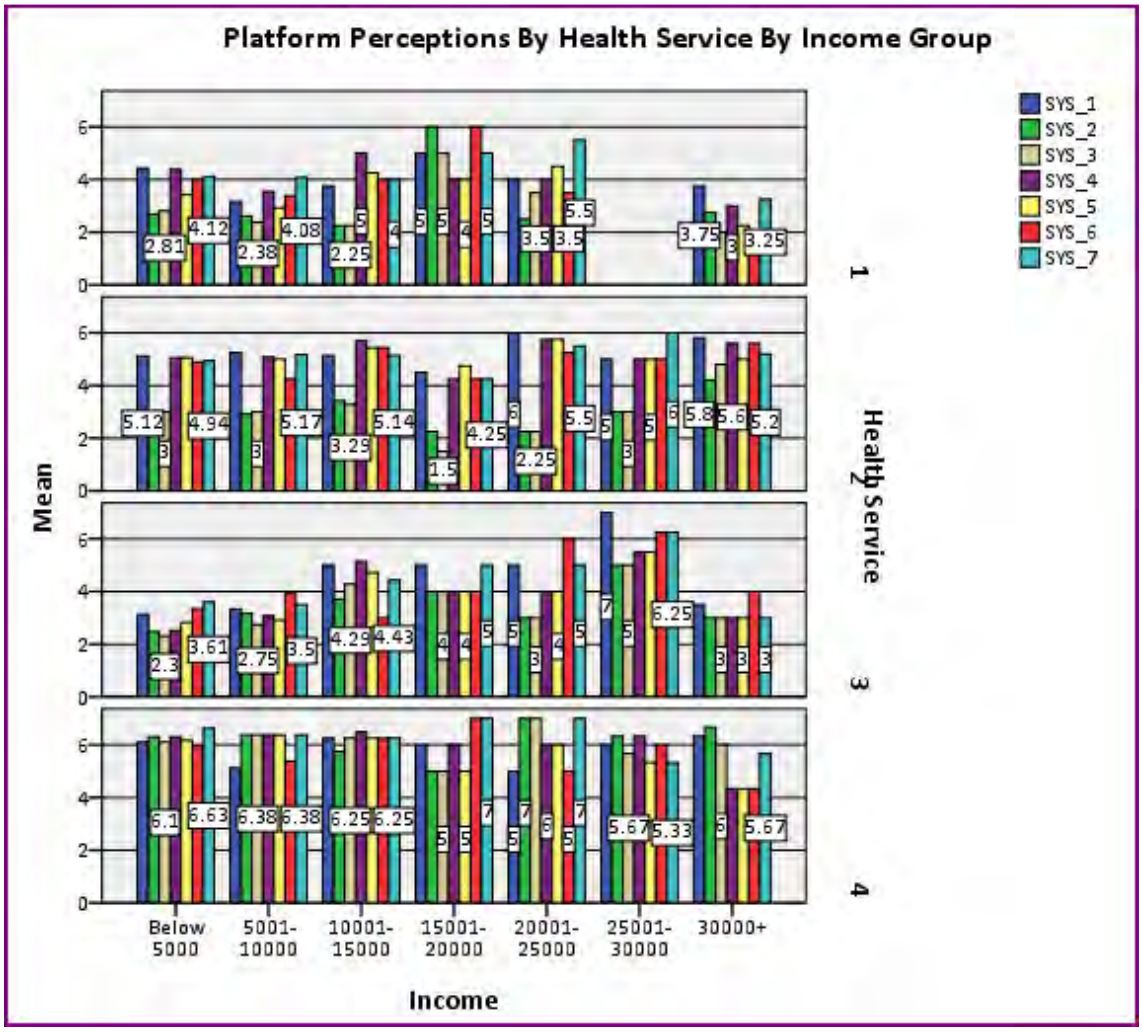


Chart D.8 depicts the service platform perceptions by health service by age group. Here again across the age groups the perception of mHealth is fairly uniform. Chart D.9 depicts platform perceptions by health service by income group. mHealth is fairly received by all the income groups. These charts help in visualising that that mHealth is fairly uniform among the demographic dimensions of age, gender and income.

D.9: Platform Perceptions vs. Health Service vs. Income Group



E. SPSS Output – Multiple Discriminant Analysis

E.1 Process Command and Options

```
DISCRIMINANT
 /GROUPS=HService(1 4)
 /VARIABLES=SYS_1 SYS_2 SYS_3 SYS_4 SYS_5 SYS_6 SYS_7 INT_1 INT_2 INT_3 INT_4 INF_1 INF
_2 INF_3 INF_4 OUT_1 OUT_2 OUT_3 OUT_4 OUT_5
 /ANALYSIS ALL
 /METHOD=MAHAL
 /PIN=.05
 /POUT=.10
 /PRIORS EQUAL
 /HISTORY
 /STATISTICS=MEAN STDDEV UNIVF BOXM CORR FPAIR TABLE CROSSVALID
 /PLOT=COMBINED SEPARATE  MAP
 /PLOT=CASES
 /CLASSIFY=NONMISSING POOLED.
```

[DataSet1] G:\UNSW\Discriminant Analysis_mHealth\Data\SM_Survey Data w Selection 10-May-2012.sav

E.2 Output Tables

E.2.1: Analysis case processing summary

Unweighted Cases		N	Percent
Valid		200	100.0
Excluded	Missing or out-of-range group codes	0	.0
	At least one missing discriminating variable	0	.0
	Both missing or out-of-range group codes and at least one missing discriminating variable	0	.0
	Total	0	.0
Total		200	100.0

E.2.2: Group statistics

Health Service		Mean	Std. Deviation	Valid N (listwise)	
				Unweighted	Weighted
PH	Reliability	3.98	1.767	50	50.000
	Accessibility	2.70	1.776	50	50.000
	Availability	2.66	1.847	50	50.000
	Safety	4.08	1.614	50	50.000
	Efficiency	3.32	1.974	50	50.000

	Privacy	3.70	1.972	50	50.000
	Usefulness	4.10	1.632	50	50.000
	Helpful	3.48	1.930	50	50.000
	Promptness	3.30	2.003	50	50.000
	Courtesy	3.62	2.079	50	50.000
	Empathy	3.26	1.904	50	50.000
	Completeness	3.20	1.738	50	50.000
	Accuracy	4.02	1.584	50	50.000
	Up-to-Date	3.56	1.668	50	50.000
	Orderliness	3.12	1.881	50	50.000
	Ease	2.88	1.859	50	50.000
	Convenience	2.86	1.841	50	50.000
	Cost	5.26	1.967	50	50.000
	Confidence	3.12	1.792	50	50.000
	Enjoyable	3.14	1.927	50	50.000
GP	Reliability	5.24	1.519	50	50.000
	Accessibility	3.00	1.616	50	50.000
	Availability	3.04	1.737	50	50.000
	Safety	5.20	1.400	50	50.000
	Efficiency	5.12	1.573	50	50.000
	Privacy	4.86	1.895	50	50.000
	Usefulness	5.06	1.300	50	50.000
	Helpful	5.14	1.690	50	50.000
	Promptness	4.48	1.474	50	50.000
	Courtesy	5.12	1.734	50	50.000
	Empathy	4.90	1.753	50	50.000
	Completeness	5.02	1.584	50	50.000
	Accuracy	4.96	1.442	50	50.000
	Up-to-Date	5.04	1.428	50	50.000
	Orderliness	4.68	1.743	50	50.000
	Ease	3.34	1.661	50	50.000
	Convenience	3.28	1.539	50	50.000
	Cost	2.80	2.040	50	50.000
	Confidence	4.94	1.476	50	50.000
	Enjoyable	4.48	1.693	50	50.000
TM	Reliability	3.84	2.198	50	50.000
	Accessibility	3.08	1.828	50	50.000
	Availability	2.98	1.744	50	50.000
	Safety	3.34	2.076	50	50.000

	Efficiency	3.38	1.839	50	50.000
	Privacy	3.76	1.869	50	50.000
	Usefulness	3.94	1.800	50	50.000
	Helpful	5.24	1.238	50	50.000
	Promptness	5.20	1.030	50	50.000
	Courtesy	5.54	1.164	50	50.000
	Empathy	5.02	1.450	50	50.000
	Completeness	3.76	2.095	50	50.000
	Accuracy	3.44	2.091	50	50.000
	Up-to-Date	3.12	1.814	50	50.000
	Orderliness	3.22	1.765	50	50.000
	Ease	5.12	1.573	50	50.000
	Convenience	4.82	1.508	50	50.000
	Cost	5.58	1.592	50	50.000
	Confidence	3.20	1.784	50	50.000
	Enjoyable	3.56	1.459	50	50.000
mHealth	Reliability	5.94	.956	50	50.000
	Accessibility	6.28	.948	50	50.000
	Availability	6.12	.872	50	50.000
	Safety	6.20	.904	50	50.000
	Efficiency	6.02	.958	50	50.000
	Privacy	5.80	1.030	50	50.000
	Usefulness	6.44	.675	50	50.000
	Helpful	6.36	.693	50	50.000
	Promptness	6.42	.575	50	50.000
	Courtesy	6.30	.909	50	50.000
	Empathy	6.28	.809	50	50.000
	Completeness	6.06	.956	50	50.000
	Accuracy	6.26	1.006	50	50.000
	Up-to-Date	6.28	.904	50	50.000
	Orderliness	6.26	1.103	50	50.000
	Ease	6.66	.688	50	50.000
	Convenience	6.34	.961	50	50.000
	Cost	6.34	.823	50	50.000
	Confidence	6.26	.853	50	50.000
	Enjoyable	6.06	.740	50	50.000
Total	Reliability	4.75	1.878	200	200.000
	Accessbility	3.77	2.145	200	200.000
	Availability	3.70	2.122	200	200.000
	Safety	4.71	1.891	200	200.000

	Efficiency	4.46	1.992	200	200.000
	Privacy	4.53	1.928	200	200.000
	Usefulness	4.89	1.725	200	200.000
	Helpful	5.06	1.783	200	200.000
	Promptness	4.85	1.776	200	200.000
	Courtesy	5.15	1.817	200	200.000
	Empathy	4.87	1.867	200	200.000
	Completeness	4.51	1.977	200	200.000
	Accuracy	4.67	1.897	200	200.000
	Up-to-Date	4.50	1.941	200	200.000
	Orderliness	4.32	2.081	200	200.000
	Ease	4.50	2.127	200	200.000
	Convenience	4.33	2.025	200	200.000
	Cost	5.00	2.130	200	200.000
	Confidence	4.38	2.001	200	200.000
	Enjoyable	4.31	1.882	200	200.000

E.2.3: Tests of equality of group means

	Wilks' Lambda	F	df1	df2	Sig.
Reliability	.781	18.355	3	196	.000
Accessibility	.535	56.729	3	196	.000
Availability	.560	51.417	3	196	.000
Safety	.667	32.563	3	196	.000
Efficiency	.662	33.329	3	196	.000
Privacy	.797	16.640	3	196	.000
Usefulness	.666	32.777	3	196	.000
Helpful	.666	32.773	3	196	.000
Promptness	.591	45.122	3	196	.000
Courtesy	.709	26.753	3	196	.000
Empathy	.668	32.467	3	196	.000
Completeness	.682	30.402	3	196	.000
Accuracy	.683	30.389	3	196	.000
Up-to-Date	.583	46.641	3	196	.000
Orderliness	.620	40.000	3	196	.000
Ease	.499	65.624	3	196	.000
Convenience	.538	56.171	3	196	.000
Cost	.610	41.733	3	196	.000
Confidence	.572	48.944	3	196	.000
Enjoyable	.644	36.169	3	196	.000

E.2.4: Box's test of equality of covariance matrices

Log Determinants

Health Service	Rank	Log Determinant
PH	11	5.889
GP	11	1.130
TM	11	.988
mHealth	11	-6.071
Pooled within-groups	11	3.713

The ranks and natural logarithms of determinants printed are those of the group covariance matrices

Test Results

Box's M		632.908
F	Approx.	2.879
	df1	198
	df2	82665.121
	Sig.	.000

Tests null hypothesis of equal population covariance matrices.

E.2.5: Stepwise statistics

Variables Entered/Removed[a,b,c,d]

Step	Entered	Min. D Squared					
				Exact F			
		Statistic	Between Groups	Statistic	df1	df2	Sig.
1	Promptness	.274	GP and TM	6.844	1	196.000	.010
2	Confidence	1.597	PH and GP	19.865	2	195.000	1.406E-8
3	Cost	2.233	PH and TM	18.415	3	194.000	1.486E-10
4	Ease	3.502	PH and TM	21.552	4	193.000	1.030E-14
5	Safety	4.446	PH and TM	21.777	5	192.000	3.009E-17
6	Helpful	4.725	PH and GP	19.187	6	191.000	1.878E-17
7	Empathy	4.795	PH and GP	16.601	7	190.000	5.245E-17
8	Accessibility	4.821	PH and GP	14.527	8	189.000	1.860E-16
9	Up-to-Date	4.842	PH and GP	12.901	9	188.000	6.382E-16
10	Completeness	4.865	PH and GP	11.604	10	187.000	2.031E-15
11	Orderliness	4.873	PH and GP	10.511	11	186.000	6.781E-15

At each step, the variable that maximizes the Mahalanobis distance between the two closest groups is entered.
a. Maximum number of steps is 40.
b. Maximum significance of F to enter is .05.
c. Minimum significance of F to remove is .10.
d. F level, tolerance, or VIN insufficient for further computation.

E.2.6: Variables in the Analysis

Step		Tolerance	Sig. of F to Remove	Min. D Squared	Between Groups
1	Promptness	1.000	.000		
2	Promptness	.841	.000	.003	PH and TM
	Confidence	.841	.000	.274	GP and TM
3	Promptness	.792	.000	.038	PH and TM
	Confidence	.840	.000	.843	TM and mHealth
	Cost	.937	.000	1.597	PH and GP
4	Promptness	.713	.000	2.397	PH and TM
	Confidence	.812	.000	1.311	TM and mHealth
	Cost	.924	.000	1.654	PH and GP
	Ease	.780	.000	2.233	PH and TM
5	Promptness	.712	.000	3.253	PH and TM
	Confidence	.570	.000	3.759	TM and mHealth
	Cost	.910	.000	1.654	PH and GP
	Ease	.760	.000	2.837	PH and TM
	Safety	.598	.000	3.502	PH and TM
6	Promptness	.664	.005	4.280	PH and GP
	Confidence	.508	.000	4.091	TM and mHealth
	Cost	.907	.000	1.886	PH and GP
	Ease	.730	.000	4.563	PH and TM
	Safety	.558	.000	4.130	PH and TM
	Helpful	.490	.000	4.446	PH and TM
7	Promptness	.653	.010	4.400	PH and GP
	Confidence	.466	.000	4.143	TM and mHealth
	Cost	.906	.000	1.932	PH and GP
	Ease	.710	.000	4.781	PH and GP
	Safety	.551	.000	4.383	PH and TM
	Helpful	.429	.011	4.724	PH and GP
	Empathy	.428	.041	4.725	PH and GP
8	Promptness	.647	.006	4.450	PH and GP
	Confidence	.461	.000	4.473	PH and GP
	Cost	.904	.000	1.939	PH and GP

	Ease	.603	.000	4.819	PH and GP
	Safety	.543	.000	4.487	PH and TM
	Helpful	.429	.018	4.752	PH and GP
	Empathy	.428	.049	4.751	PH and GP
	Accessibility	.745	.000	4.795	PH and GP
9	Promptness	.645	.008	4.482	PH and GP
	Confidence	.436	.001	4.551	PH and GP
	Cost	.891	.000	2.060	PH and GP
	Ease	.603	.000	4.840	PH and GP
	Safety	.441	.004	4.718	PH and GP
	Helpful	.426	.037	4.768	PH and GP
	Empathy	.415	.016	4.787	PH and GP
	Accessibility	.744	.000	4.818	PH and GP
	Up-to-Date	.478	.003	4.821	PH and GP
10	Promptness	.640	.007	4.524	PH and GP
	Confidence	.389	.000	4.654	PH and GP
	Cost	.887	.000	2.131	PH and GP
	Ease	.586	.000	4.860	PH and GP
	Safety	.419	.002	4.722	PH and GP
	Helpful	.426	.040	4.791	PH and GP
	Empathy	.413	.033	4.815	PH and GP
	Accessibility	.740	.000	4.838	PH and GP
	Up-to-Date	.413	.000	4.859	PH and GP
	Completeness	.309	.019	4.842	PH and GP
11	Promptness	.631	.004	4.524	PH and GP
	Confidence	.389	.000	4.660	PH and GP
	Cost	.886	.000	2.133	PH and GP
	Ease	.576	.000	4.870	PH and GP
	Safety	.414	.013	4.740	PH and GP
	Helpful	.413	.012	4.792	PH and GP
	Empathy	.404	.013	4.818	PH and GP
	Accessibility	.726	.000	4.850	PH and GP
	Up-to-Date	.385	.001	4.864	PH and GP
	Completeness	.302	.012	4.846	PH and GP
	Orderliness	.335	.012	4.865	PH and GP

E.2.7: Summary of canonical discriminant functions

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	1.693	50.4	50.4	.793
2	1.076	32.0	82.4	.720
3	0.592	17.6	100.0	.610

E.2.8: Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 3	.112	418.690	33	.000
2 through 3	.303	228.949	20	.000
3	.628	89.081	9	.000

E.2.9: Standardized canonical discriminant function co-efficients

	Function		
	1	2	3
Accessibility	.525	.145	.187
Safety	-.119	.376	.378
Helpful	.033	-.424	-.342
Promptness	.306	-.084	-.349
Empathy	-.093	-.428	-.322
Completeness	-.374	-.360	-.296
Up-to-Date	.497	.329	.081
Orderliness	-.162	.512	.220
Ease	.394	-.399	-.047
Cost	.246	-.224	.795
Confidence	.270	.631	-.125

E.2.10: Structure Matrix

	Function		
	1	2	3
Ease	.728*	-.290	-.160
Accessibility	.703*	.166	.036
Convenience[a]	.656*	-.242	-.103
Promptness	.584*	-.143	-.393
Availability[a]	.570*	.154	.049
Confidence	.511*	.458	-.371
Orderliness	.492*	.382	-.278

Usefulness[a]	.488*	.275	-.187
Efficiency[a]	.440*	.366	-.267
Enjoyable[a]	.430*	.211	-.374
Completeness	.409*	.289	-.393
Privacy[a]	.363*	.156	-.215
Up-to-Date	.470	.529*	-.256
Safety	.362	.495*	-.148
Accuracy[a]	.413	.414*	-.253
Reliability[a]	.319	.376*	-.199
Cost	.396	-.359	.629*
Helpful	.455	-.034	-.504*
Empathy	.465	-.027	-.469*
Courtesy[a]	.411	.032	-.441*

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions
Variables ordered by absolute size of correlation within function.
*. Largest absolute correlation between each variable and any discriminant function
a. This variable not used in the analysis.

E.2.11: Functions at Group Centroids

	Function		
Health Service	1	2	3
PH	-1.093	.324	1.125
GP	-.871	.988	-.969
TM	-.192	-1.723	-.308
mHealth	2.156	.410	.151

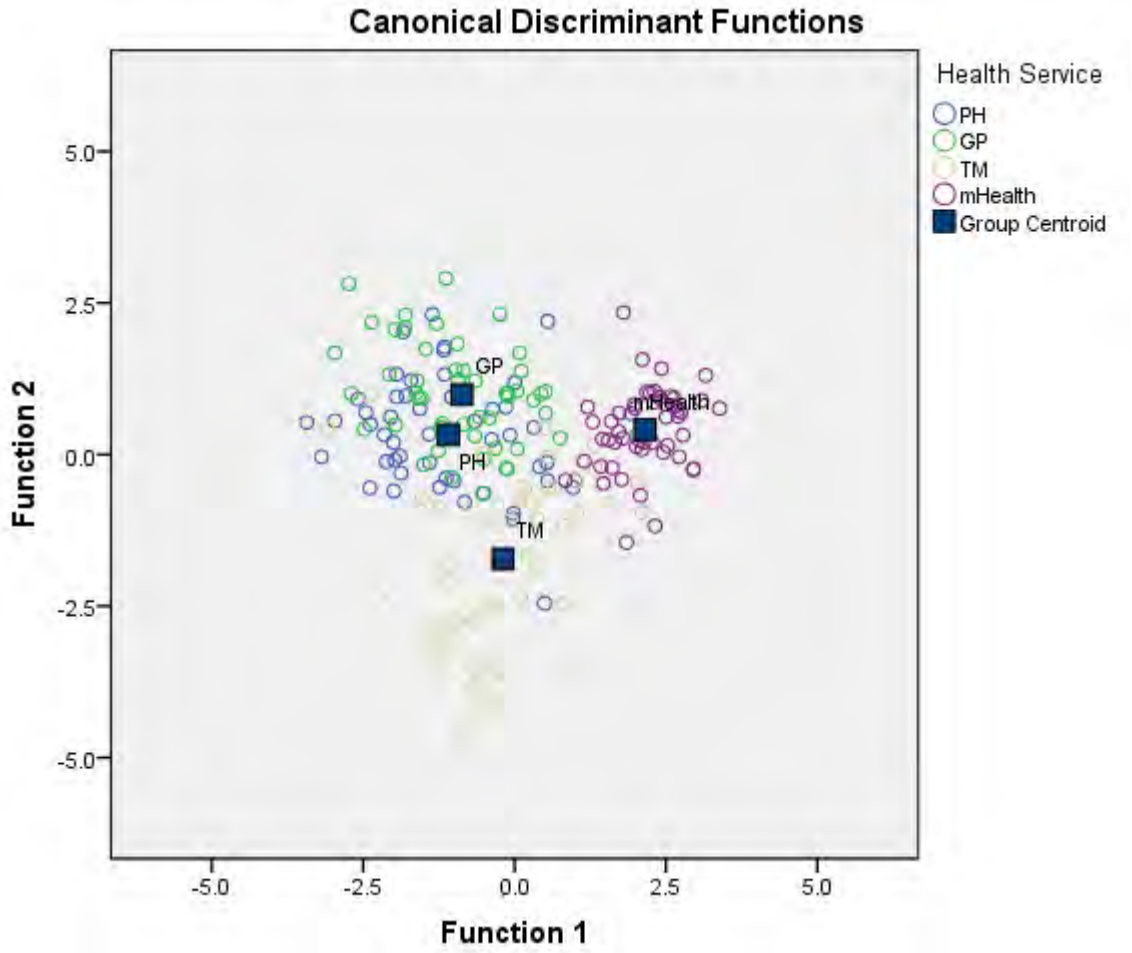
Unstandardized canonical discriminant functions evaluated at group means

E.3: Classification Statistics

Classification Processing Summary

Processed		200
Excluded	Missing or out-of-range group codes	0
	At least one missing discriminating variable	0
Used in Output		200

E.3.1: Discriminant function graphs



E.3.2: Classification results

			Predicted Group Membership				
		Health Service	PH	GP	TM	mHealth	Total
Original	Count	PH	35	8	4	3	50
		GP	11	36	1	2	50
		TM	5	3	35	7	50
		mHealth	0	0	1	49	50
	%	PH	70.0	16.0	8.0	6.0	100.0
		GP	22.0	72.0	2.0	4.0	100.0
		TM	10.0	6.0	70.0	14.0	100.0
		mHealth	.0	.0	2.0	98.0	100.0
Cross-validated[a]	Count	PH	33	9	5	3	50
		GP	11	36	1	2	50
		TM	5	4	34	7	50
		mHealth	0	0	2	48	50
	%	PH	66.0	18.0	10.0	6.0	100.0
		GP	22.0	72.0	2.0	4.0	100.0
		TM	10.0	8.0	68.0	14.0	100.0
		mHealth	.0	.0	4.0	96.0	100.0

a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

b. 77.5% of original grouped cases correctly classified.

c. 75.5% of cross-validated grouped cases correctly classified.