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Opportunities and Barriers for M-Health in New Zealand

BY

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.


F. B. Mirza
26/Sep/2007

Abstract

This thesis describes a study to determine the opportunities and barriers for mobile health in New Zealand.

The world total of mobile phones currently stands at 2.5 billion and is set to reach 3 billion by the end of 2007 [1]. New Zealand has approximately 3.8 million mobile subscribers [2],[3] and this country, along with many others, recognizes the opportunities for using mobile technology in healthcare. Mobile health (m-health) has moved past the hype stage overseas; there is good evidence for improved productivity, and growing evidence for improved patient engagement. Broadband wireless, improved mobile devices and integrated mobile applications will continue this growth. New Zealand health and disability providers can adapt these overseas m-health successes to develop their own mobile health strategies [4].

M-health involves the use of mobile technology to enhance health services. The mobile technology can be either a short-distance or long-distance technology, or be device driven. The health industry is an information intensive industry, and as New Zealand has a public healthcare model, the idea of information integration among and within health sectors is encouraged.

The purpose of this study is to identify the barriers and opportunities of m-health in New Zealand. Following an introduction, the literature survey defines the scope of the study. It first discusses wireless and mobile computing technologies, then looks at New Zealand healthcare information strategies and the importance of information in the health industry. Finally, these two topics are investigated by exploring the literature on the use of wireless technology in healthcare — in both clinical and non-clinical applications.

M-health is a new area of development in the health industry. Hence the practical part of the research used a qualitative research strategy, determined to be appropriate to obtaining a better understanding of any phenomena about which little is yet known [5]. The two main parts of this research include the questionnaire and the interviews. The questionnaire sample was selected from health users, health planners, health technology suppliers, and academics, and covered areas of patient care, primary care, secondary care, community care, and integrated care.

The interview sample consisted of technology strategists, primary healthcare planners, secondary healthcare planners, and community healthcare planners. The main focus of the interview was to find out about the future of m-health in New Zealand, analyze which sectors can benefit from m-health, examine the opportunity for customized software on mobile devices, gather possibilities of mobile assistance toward integrated care, and lastly, find out about the privacy and security issues of using mobile technology in healthcare.

The questionnaire results indicate that the patients would appreciate receiving health services on their mobile phones. There is strong agreement that patients will benefit from text reminders, health awareness campaigns, and patient monitoring. The findings indicate that community nurses could use m-health technology to improve integration of information. There are two differing opinions on Electronic Health Records (EHRs) and their mobility across all sectors — the technology strategists think it is very important, but the health planners are divided.

The opportunities that have been identified from the interviews include monitoring, health alarms, patient engagement in healthcare, community workers information integration, SMS reminders and alerts, ability of health workers to work offsite, prescription feedback, and

using PDAs where necessary to enable electronic data capture. The barriers include legacy systems, disparate systems, lack of standards, lack of integration tools, lack of bandwidth, DHB-led initiatives, older health planners who are resistant to technology, ill population having the least uptake of technology, inability to share information with patients, development of mobile applications, infrastructure investment, telecommunication barriers, changed management, lack of technical capabilities, and cultural barriers.

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Allahu-Akbar (God is the greatest)

Farhaanullah Baig Mirza

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Table of Abbreviations

1xRTT	1 times Radio Transmission Technology
3GPP	Third-Generation Partnership Project
A&E	Accident and Emergency
ABx guide	Antibiotic Guide
AMPS	Advanced Mobile Phone System
BAN	Body Area Network
BCU	Body Central Unit
BMIS-T	Battlefield Medical Information System-Tactical
BSU	Body Sensor Units
CAT-Scans	Computed Axial Tomography Scans
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CIO	Chief Information Officer
CMC	Centre for Mobile Computing
CPE	Customer Premise Equipment
CSD	Circuit Switched Data
D-AMPS	Digital Advanced Mobile Phone System
DHB	District Health Board
DNA	Did Not Attend
EDGE	Enhanced Data rates for GSM Evolution
EHR	Electronic Health Record
EMR	Electronic Medical Record

ePOC	Electronic Point-of-Care
FDMA	Frequency Division Multiple Access
FOMA	Freedom of Mobile Multimedia Access
GAN	Generic Access Network
GDP	Gross Domestic Product
GPRS	General Packet Radio Service
GPs	General Practitioners
GSM	Global System for Mobile Communications
HINZ	Health Informatics New Zealand
HISO	Health Information Standards Organization
HPI	Health Practitioner Index
HSCSD	High-Speed Circuit-Switched Data
HSDPA	High-Speed Downlink Packet Access
HSOPA	High Speed OFDM Packet Access
HSUPA	High-Speed Uplink Packet Access
ICT	Information and Communications Technology
iDEN	Integrated Digital Enhanced Network
IP	Internet Protocol
IrDA	Infrared Data Association
IS-95	Interim Standard 95
ISP	Internet Service Provider
IT	Information Technology
MDRTB	Multiple Drug Resistant Tuberculosis
M-Health	Mobile Health
MMS	Multimedia Messaging Service

NHI Number	National Health Index Number
NHS	National Health Service
NMT	Nordic Mobile Telephone
OEM	Original Equipment Manufacturer
PC	Personal Computer
PDA	Personal Digital Assistant
PDC	Personal Digital Cellular
PDR	Physicians' Desk Reference
PHO	Primary Health Organization
PHS	Personal Handy-phone System
qID	Latin word that means: Seen on a prescription
RFID	Radio Frequency Identification
SMS	Short Messaging Service
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division-Synchronous Code Division Multiple Access
UMA	Unlicensed Mobile Access
UMTS	Universal Mobile Telecommunications System
VPN	Virtual Private Network
WAP	Wireless Application Protocol
WiDEN	Wideband Integrated Dispatch Enhanced Network
WiFi	Wireless Fidelity
WLAN	Wireless Local Area Network
XML	Extensible Markup Language

Chapter 1

Introduction

Ownership and use of mobile technologies greatly exceeds those of personal desktop computer systems, and countries throughout the world are beginning to understand how these technologies can enhance the delivery of healthcare. The world total of mobile phones currently stands at 2.5 billion and is set to reach 3 billion by the end of 2007 [1]. New Zealand alone has 3.8 million mobile subscribers from a population of 4 million people, emphasizing that many users have multiple subscriptions [3]. These figures demonstrate the pervasiveness of mobile technologies, and indicate the potential for m-health (mobile health) applications.

This study explores mobile technology in the New Zealand healthcare domain and suggests the potential opportunities and barriers that exist.

1.1 What is M-health?

M-health was first introduced as "Unwired e-med" [6]. and is also defined as 'mobile computing', 'medical sensor', and 'communication technology for healthcare' [6]. In recent years, mobile technology has been developing rapidly in all aspects, both in its adoption and implementation. Due to the concentration of mobiles in the New Zealand population, the recent developments of mobile technology, and the demanding healthcare environments, there are massive opportunities for m-health applications in all areas of healthcare.

We can define m-health, short for mobile health, as a rapidly developing area that uses a variety of technologies to meet the information service needs of healthcare providers and consumers. The

technologies can be either short-distance or long-distance technologies.

The short-distance technologies include wireless technologies like Bluetooth, Infrared, Radio Frequency Identification (RFID) and mobile devices such as laptop computers, tablets, Personal Digital Assistants (PDAs), smart phones, and cellular phones. The long-distance technologies include wireless networks like Wireless Fidelity (WiFi), Wireless Local Area Network (WLAN), wireless broadband, 3G networks, cellular networks which facilitate mobile phone calling, Short Messaging Service (SMS), and Multimedia Messaging Service (MMS). M-health involves the use of these short- or long-distance mobile technologies to enhance health services.

1.2 Background to the Study

Developed nations are finding that the level of demand for healthcare continues to increase [7]. New Zealand faces significant pressures to provide more and better healthcare delivery, mainly because of ageing population, rising incidents of chronic diseases, re-emerging diseases, etc. [7] We can learn from m-health's adopters that mobile technology can increase productivity, improve patient health, and enable greater access to healthcare [8].

M-health has moved past the hype stage overseas – there is good evidence for improved productivity and mounting evidence for improved patient engagement such as tele-health. Broadband wireless, improved mobile devices, and integrated mobile applications will continue this growth. New Zealand health and disability providers can adapt these overseas mobile health successes to develop their own mobile health strategies [4].

M-health is a new area of development in the health industry. Hence the study described here used a qualitative research strategy, as these strategies are appropriate to obtaining better understanding of phenomena about which little is yet known [5]. The research was conducted by utilization of a questionnaire and interviews; these involved the participation of users, planners, and strategists from both the health industry and the technology suppliers.

This study is important to New Zealand, as most of the population have cellular phones and there have been significant developments overseas from which New Zealand may benefit. The sectors that this research involved are the DHBs (District Health Boards), PHOs (Primary Health Organizations), secondary hospitals, and a range of mobile technology suppliers.

1.3 Research Questions

The macro level objective of this research is to find the opportunities and barriers for m-health in New Zealand. The main research questions which evolved over the course of the study are listed below:

- Does m-health have a role to play in the New Zealand health industry?
- Which health sectors will m-health benefit the most?
- Is there opportunity for software that supports the mobile environment?
- Can m-health help enhance information integration across or within health sectors?
- What privacy and security issues effect the use of m-health?
- What are the key clinical and non-clinical m-health applications?

A qualitative research strategy was used for the research, and the specific methodology used the concepts of grounded theory. The research strategy included distribution of the questionnaire and verbal interviews with the target sample. More about the research design is presented in the third chapter of this thesis.

1.4 Structure of the Thesis

This thesis has a total of six chapters. The next chapter – 'literature review' presents the healthcare demands, the wireless and mobile technologies, and the healthcare applications that are using mobile technology. Chapter 3 discusses the research methodology and techniques that were applied to produce the results presented in Chapter 4. Chapter 5 concentrates on the discussions of the opportunities and barriers of m-health. Lastly, Chapter 6 summarizes the main conclusions with suggestions for future work.

Chapter 2

Literature Review

2.1 Introduction

Mobile devices, user-interfaces, and infrastructure are now capable of transforming productivity of health workers and enhancing patient care [4]. There is not just one ideal technology or solution for m-health. Mobile technology is fragmented and it involves cellular networks, wireless networks, a huge range of devices and many other services. The healthcare environment that m-health potentially applies to cover primary, secondary and community areas. This literature review looks at mobile technology from all these health perspectives.

The literature on healthcare needs and demands, the importance of information in healthcare, and the mobile nature and aspects of the healthcare environment are presented first. Next, the mobile devices and short- and long-distance technologies of m-health are presented. Lastly, the literature is extended to look at m-health applications – which include both clinical and non-clinical applications.

Although there are alternative ways to present this literature, this structure has been chosen to separate the literature. The healthcare and technology topics are presented prior to the m-health application to facilitate a clearer presentation.

2.2 Healthcare

The healthcare industry has many similarities to other industries; these include capture of information, implementation and operation of infrastructures, billing, scheduling, staffing, etc. There are however, some differences which make it unique. These include the sharing of

information with other organizations (health providers), the need for patient information security and privacy, and the imperative to keep the population healthy to minimize healthcare costs.

In this section, the New Zealand healthcare industry, its challenges and possible solutions are presented, followed by literature on the importance of information and the importance of integrated care. Lastly, the literature review looks at the mobile aspects of healthcare.

2.2.1 New Zealand Healthcare

The challenges facing the healthcare industry in New Zealand and in other developed nations include:

- *Ageing populations – reducing tax-raising ability and increasing pressure on the health sectors [4], [7].*
- *Longer life expectancy - changes from episodic to long-term chronic diseases such as diabetes and cardiovascular diseases [7].*
- *Changes in consumer (patient) expectations – greater demand for patient empowerment and awareness, and focus on patient rights [7].*
- *Rising technology costs – newer technologies are making more effective treatment available, often at higher prices [7].*
- *Workforce shortage – greater demand for clinicians [4].*
- *Limited health funding [4], [7].*

Fifty years ago, a man considered himself to be lucky if he celebrated his seventieth birthday; today, improved working conditions, diets, and rising standards of living have raised life expectancy of populations in developed countries [9]. A frightening statistic for New Zealand [10] is that 25 per cent (1.33 million) of the population will be aged 65 or over in the year 2051 compared with 13

per cent in 2004. This trend has given birth to newer challenges to handle long-term chronic diseases, In the UK and USA, health funds spent on chronic disease management are 65 per cent or more of the total health funds; the figures for NZ are similar [4].

The patient today (2006) is also much more aware and focused on patient rights, wanting more involvement in their own healthcare plan [7]. As a majority of healthcare takes place outside the hospital, there is an increasing need to empower patients and give them more involvement in their health plans. Patient engagement can reduce the GDP (Gross Domestic Product) spend on healthcare by 10 per cent, further to productivity gains [4].

The supply of clinicians, nurses, and the home support community workers – including those in training – is forecast to be grossly inadequate to meet the demands for the next 5–10 years in both the UK and the USA; it is a similar situation in New Zealand [4].

The high-level strategies to meet these challenges are increasing productivity, increasing patient engagement, and the use of electronic health records [4]. New Zealand healthcare services are currently (2006) spending 8–9 per cent of their GDP on health services [11]. Given that there is limited health budget spending, the Health Information Strategy Steering Committee focuses [7] on working *smarter*, and if working smarter is required, then better information is necessary to make better decisions. Information needs to be available at the right time and place in the right format [7].

2.2.2 The Importance of Information and Integrated Care

The healthcare industry in general is one of the most information-intensive of all industries [12], and information overload is a universal

problem; healthcare professionals are not excluded from this predicament [13]. It is important to have *accurate* information to avoid such overload. Other reasons why information sharing is important, as mentioned in the *Primary Health Care Strategy* [14] are to support and inform:

- *Needs assessment and effective service funding, planning, delivery and monitoring.*
- *Co-ordination of provider activities and patient care.*
- *Improving the continuity of care between episodes of illness and treatment.*
- *Clinical decisions about the care and treatment options available.*
- *Processes for monitoring and improving quality of care*

It is important to improve data quality in health care; to do so, the key is to have the health data integrated [15]. One of the strategies towards integrating health data is to capture all data electronically and store it in electronic records.

2.2.3 Electronic Health Records

EHRs (Electronic Health Records), also referred to as EMRs (Electronic Medical Records), are patient records which include summary data from their health interventions. Partial or full EHRs can be viewable by the health provider, depending on the treatment. In future, the EHR could progress to containing an individual's genome, or an entire history of interactions with the healthcare system [16]. The diagram below shows how the EHR can be utilized by the different health services.

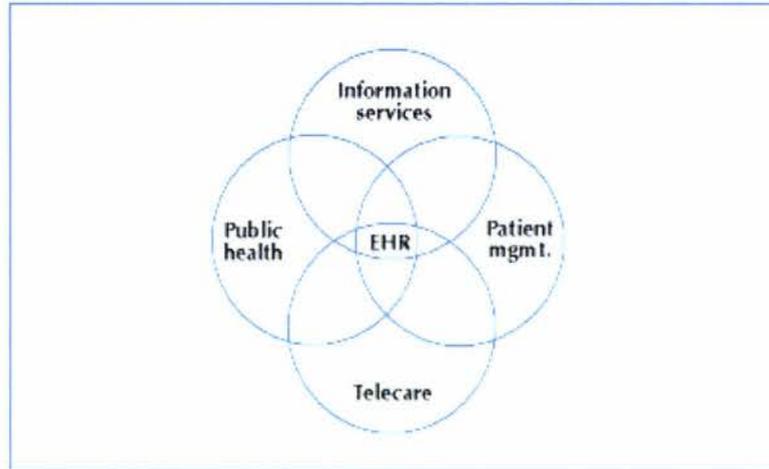


Figure 2-1 Different Health Services and EHR [16]

The data captured can make contributions to health monitoring, medical research, and measurement of system effectiveness by providing aggregate health information [16]. If EHRs are widely used and are integrated into health information systems, then the technology could empower patients – this would enable them to take control over their EHR, and take on the role of managing their own health. On the other hand, clinicians can make use of the EHR as mobile access to information can provide assistance to health professionals at the point-of-care [13]. EHRs could bring many advantages, but as medical data is of the most private nature, care should be taken to restrict access where needed [16]. Mobile devices could play a role in controlling or enabling access to these EHRs.

Despite the promising benefits EHR may bring to healthcare information systems, there have been many failed attempts to get clinicians to use EHRs in the UK — mainly due to difficulties of data entry [17]. M-health technologies can potentially overcome this barrier by enabling data collection at point-of-care, and providing a range of devices which may help clinicians with data entry. The other implications of migrating to electronic clinical note-keeping in

maintaining the EHRs will involve commitment at government levels, and support by national infrastructures [13].

The EHR is not the only way to integrate information; there need to be multiple solutions to keep information integrated. This year (2006), a computer-based system known as TESTSAFE was introduced [18] allowing patient lab results to be shared among the three Auckland City DHBs (District Health Boards). However, this system is not web-based, which means it can only be accessed from health organizations' intranets.

Most of the other information sharing is not via integration, resulting in extra effort required to find alternate ways of sending and receiving data. For example, the referrals (the process of GP referring a patient to the hospital) and the discharges (the process of hospital releasing the patient after treatment); this information sharing is usually packaged and sent between health sectors using *healthlink* (<http://www.healthlink.net/index2.htm>) which is a secure messaging framework.

2.2.4 The Mobile Nature of Healthcare

The healthcare environment is dynamic. Many health workers are working offsite, and much of the healthcare takes place outside hospitals. Mobile technology can increase productivity of clinicians by increasing automation of routine data collection and eliminating manual entry processes. An example of this [19] is at George Elliot Hospital where nurses saved 45 minutes per shift scanning pre-operative patients, and administrative staff saved 20 minutes per procedure recording surgery notes by the use of m-health technologies.

Healthcare planners are pushing key care processes closer to patients [20]. As m-health increases flexibility, it can support the

deployment of such processes. The next section presents the literature on m-health technologies which are organized into three categories – devices, short-distance technologies, and long-distance technologies.

2.3 M-health Technologies

Mobile computing is a rapidly developing area that enables wireless communication over short or long distances. Some of the benefits of mobile computing are portability, convenience, immediacy, applicability, low budget, and widespread usage by a high percentage of developed countries' populations. These benefits are being identified by healthcare providers, and are being used to support m-health applications.

M-health technology does not only include cellular voice communications and short messaging services. Recent developments include increasing bandwidth – which increases the ability to browse web applications on the handsets. The devices are able to provide increased functionality; examples include the ability to access emails and manage daily schedules. Other developments are in areas of content-rich communications of image and video transmissions. Mobile technology is also being used to provide and use wireless networks such as WiFi, Bluetooth, wireless broadband, etc. The points above emphasize that Wireless and mobile computing is not one technology, it offers a range of solutions.

2.3.1 Mobile Devices

In July 2001, the New Zealand mobile population was 2.25 million; this was 60 per cent of the total New Zealand population [21]. Today in 2006, New Zealand has 3.8 million mobile subscribers [3] from a population of 4 million people, indicating that many users have

multiple subscriptions. These statistics prove that the mobile phones are devices widely accepted by the majority of the population.

Traditionally, the market demand was to have a device which could offer the ability to make phone calls without a fixed phone line. The market demand for communication continued to grow and mobile devices have evolved to meet it. Today, there are close to 200 million 3G (third generation technology with the ability to transfer both voice and non-voice data) users and approximately 1 billion phones are being purchased every year [4]. Most mobile devices today (2006) offer inbuilt functions to support communications of text, images, video, and access to the Internet. It is estimated that today's mobile phone is four to five years behind the laptop, emphasizing that by 2010, we may see mobile phones with the equivalent of today's laptop speed and storage [4]. There have also been developments in areas of customized mobile applications.

Some of today's common mobile devices are shown in the Table 2-1, arranged in order of highest processing power.

Table 2-1: Mobile Devices and their Functions

Device Type	Main Function
Laptop / Tablet	<p>All desktop functionality, tablets use pen or screen-touch technology.</p> <p>Cannot make phone calls, unless a phone client application is installed.</p> <p>Can connect to wireless networks like WiFi, depending on model.</p> <p>May have Bluetooth and infrared connectivity, depending on model.</p>
Handheld PC or	Some desktop functionality with smaller keyboard and smaller screen size compared to tablet or laptop.

PDA	<p>Will have a dedicated cellular phone number, will support SMS, email and mobile web browsing.</p> <p>Can connect to wireless networks like WiFi, can be used as a modem to connect desktop-computers or laptops to the Internet, depending on model.</p> <p>May have Bluetooth, infrared connectivity, built-in camera depending on model.</p>
Smart Phone	<p>Some desktop functionality with smaller keyboard and smaller screen size compared to PDA.</p> <p>Will have a dedicated cellular phone number, will support SMS, email, and mobile web browsing.</p> <p>Can connect to wireless networks like WiFi, can be used as a modem to connect desktop-computers or laptops to the Internet, depending on model.</p> <p>May have Bluetooth, infrared connectivity, built-in camera depending on model.</p>
Web Mobile Phone	<p>Also known as 3G phones or 2.5 G phones.</p> <p>Will have a dedicated cellular phone number, will support SMS, email, and mobile web browsing.</p> <p>May have Bluetooth, infrared connectivity, built-in camera depending on model.</p> <p>Will support very small mobile applications.</p> <p>Can be used as a modem to connect desktop-computers or laptops to the Internet, depending on model.</p>
Mobile Phone	<p>Will have a dedicated cellular phone number, will support SMS and mobile web browsing (slow connection speed).</p>
RFID	<p>RFID (Radio Frequency Identification) Attachable radio-frequency ID strips used to identify or locate objects, and are updateable.</p>

Table 2-2 shows mobile devices and a few healthcare applications. Many other health applications will be presented in the future sections of this thesis.

Table 2-2: Mobile devices and a few healthcare applications

Device Type	Main Function
Laptop / Tablet	<p>Useful in viewing and updating EHRs (Electronic Health Records).</p> <p>Can be used to access and operate clinical systems remotely.</p> <p>Very good for note-taking and capturing clinical notes.</p> <p>Can be used to connect to WLANs (Wireless Local Area Networks) using WiFi to access information.</p>
Handheld PC or PDA	<p>Useful in viewing and updating EHRs (Electronic Health Records) – there will be screen size issues. Might require display formatting.</p> <p>Can be used for note-taking and capturing clinical notes. There are dictation-capable devices, might not be 100 per cent accurate.</p> <p>Can be used to connect to WLANs (Wireless Local Area Networks) using WiFi to access information.</p> <p>Can be used for reading RFIDs and barcodes.</p>
Smart Phone	<p>Useful in viewing and updating EHRs (Electronic Health Records) – there will be screen size issues. Might require display formatting.</p> <p>Very useful to look up drug information or to access clinical libraries.</p> <p>Can connect to wireless networks like WiFi, can be used as a modem to connect desktop-computers or laptops to the Internet, depending on model.</p> <p>May have Bluetooth, infrared connectivity, built-in camera depending on model. This can be useful for patients to read their test results from external device and transmit using the cellular connectivity in the smart phones.</p>
Web Mobile Phone	<p>Can access web-based health information.</p> <p>Multimedia preventive care campaigns can be used to promote health and well-being.</p>

	<p>Test results can be transmitted by the patients to their health providers via SMS.</p> <p>SMS alerts and support can be provided to the patients from their health providers.</p>
Mobile Phone	<p>Test results can be transmitted by the patients to their health providers via SMS.</p> <p>SMS alerts and support can be provided to the patients from their health providers.</p>
RFID	Can be used to locate patients, assets, and specimens.

Although the applications of mobile devices may be questioned, e.g. form factor and security, there are two main reasons to employ them – their increased adoption and the need of health- workers for mobility.

The increased adoption of mobile devices is reflected clearly by the numbers, and by the phenomenal rise in mobile phone sales. Devices such as PDAs and smart mobile phones have become popular; the estimate of PDA sales in 2002 was 20 million in the USA alone [22]. In Europe, PDA sales have grown significantly between 2003 and 2004 [22]. Until recently, the healthcare industry has communicated either by physical consultation, post, or by fixed phone lines; today, the increased ownership of mobile technology has created an alternative to the conventional delivery of patient care. Privacy and confidentiality are important in healthcare and mobile devices have additional value as they are personal rather than shared devices [23].

A study [24] conducted among 244 diabetes patients investigated patient education levels, Internet accessibility, use of health-related websites, and mobile phone ownership and use. The findings show that 76.6 per cent of the patients owned mobile phones and 96 per

cent used them more than once a week — in comparison to 58.2 per cent ownership of desktop-computers with 36.5 per cent regular Internet users. The study concluded that the mobile phones are promising tools in healthcare communication technologies.

Clinicians often require mobility in their profession, so the light weight and rich functionality of mobiles makes them well-suited for clinicians [25]. Handheld computers or PDAs are being used increasingly by clinicians overseas. A study [26] investigated the use of 'handheld computerbased clinical reference software' among 1501 clinicians. The sample consisted of clinical reference software users. The results show that the clinicians have been using such devices for the past four years; the reference software on a PDA is being accessed 6.3 times a day, and 61 per cent believe that this clinical reference resource prevents medication errors. Clinicians can use mobile devices to access reference information, make medical calculations, improve coding, and track patient data at point-of-care [25].

Given that the studies above describe the success of using mobile devices in healthcare, there are also limitations; these include small screen sizes, slow data entry speeds, limited memory, and fewer security features [25]. There are also problems with the increased chance of these devices being lost, damaged, or stolen; this may cause an economic burden to the healthcare organizations [13]. Short battery life and training of staff to operate these devices properly are also problems. Most users also do not wish to carry several devices, and one device might not be able to support all functions of a health worker [27]. Lastly, expandability is an issue; the device may support today's application needs, but not future systems [27].

Some of the mobile devices like the laptop, tablet, PDA, or smart phones can run mobile applications, but often all of the mobile devices rely on connectivity. There are two types of mobile connectivity –

short-distance and long-distance. The next sections present the literature about these technologies. The short- and long-distance categorization is not a universal categorization of wireless and cellular networks; it is being used in this thesis to present the literature effectively.

2.3.2 Short-distance Technologies

Some of the popular short-range technologies include Bluetooth, Infrared, ZigBee, WiFi, BAN, and RFID. Below is an overview of each of these short-distance technologies. Several m-health applications can be created using these technologies. The literature presented below demonstrates their effective use in a health context.

2.3.2.1 Bluetooth

Bluetooth is a system for providing local wireless connectivity between devices, eliminating the need for wired connections, and is suitable for ad-hoc networking [28]. This system is supported by leading manufacturers of computing and telecommunication equipment. Zou [29] has presented a mobile diabetes management system using Bluetooth connections, in which the m-health diabetes management system captured diabetes data wirelessly, and supported the patient by updating their disease status with medical suggestions.

2.3.2.2 Infrared Data Association

Infrared Data Association (IrDA) is an industry-based group of over 150 companies that have developed communication standards to suit low-cost, cross-platform, point-to-point communications at a wide range of speeds [30]. The limitations of infrared links are that they have a very short range of one to two metres, they are sensitive to direction, and can only be used between two devices [28].

The uses for IrDA are minimal as it has a very short range which is sensitive to direction. It can still bring success to m-health solutions as most mobile phones have built-in IrDA ports, which can transmit test results or health data to an intermediate device and then on to a health provider.

2.3.2.3 Body Area Network

BAN (Body Area Network) involves the use of several miniaturized intelligent BSUs (Body Sensor Units) and communicates with a single BCU (Body Central Unit) worn on the human body; this communicates wirelessly (using some form of connectivity), and transmits health data [31]. BAN enables a range of healthcare applications and services.

Many different kinds of medical sensors are now available in the market ranging from conventional sensors based on piezoelectrical materials for pressure measurements to infrared sensors for body temperature estimation and optoelectronics sensors for monitoring heart rate and blood pressure [6]. Body area networking is an emerging concept; several studies have investigated the use of such networks and constructed m-health systems. The sensors that are used to measure health data from the human body are also referred to as *wearable devices*. Wearable computers are already being trialed for the use of patient monitoring [32]. Konstantas [33] tests the BANs and transmits the results using a 3G, and UMTS (Universal Mobile Telecommunications System) provides a long-distance network to the health providers. The study concluded that the BAN m-health system can support disease prevention, remote assistance, para-health services, physical state monitoring, clinical research, and be useful in assistance during accidents — by allowing paramedics to send reliable vital constants data, as well as audio and video, directly from accident sites.

ZigBee is a specification which provides full hand-shake protocol for transfer reliability. The main feature is that ZigBee networks will plug-and-play and will not require user configuration; ZigBee automatically adapts to the network changes [34]. The range of a ZigBee network is around 50 metres. *The ZigBee Alliance* is a consortium of leading semiconductor manufacturers, technology providers, Original Equipment Manufacturers (OEMs), and end-users that have developed a standard for wireless networking of sensors and controllers [34]. ZigBee can also be used to support BANs, as some of the wireless medical sensors have a inbuilt ZigBee compliant radio [34].

Figure 2-2 demonstrates an example of a BAN. The data is being transmitted to a personal BAN server, which can transmit these data to a PDA powered with connectivity to the Internet.

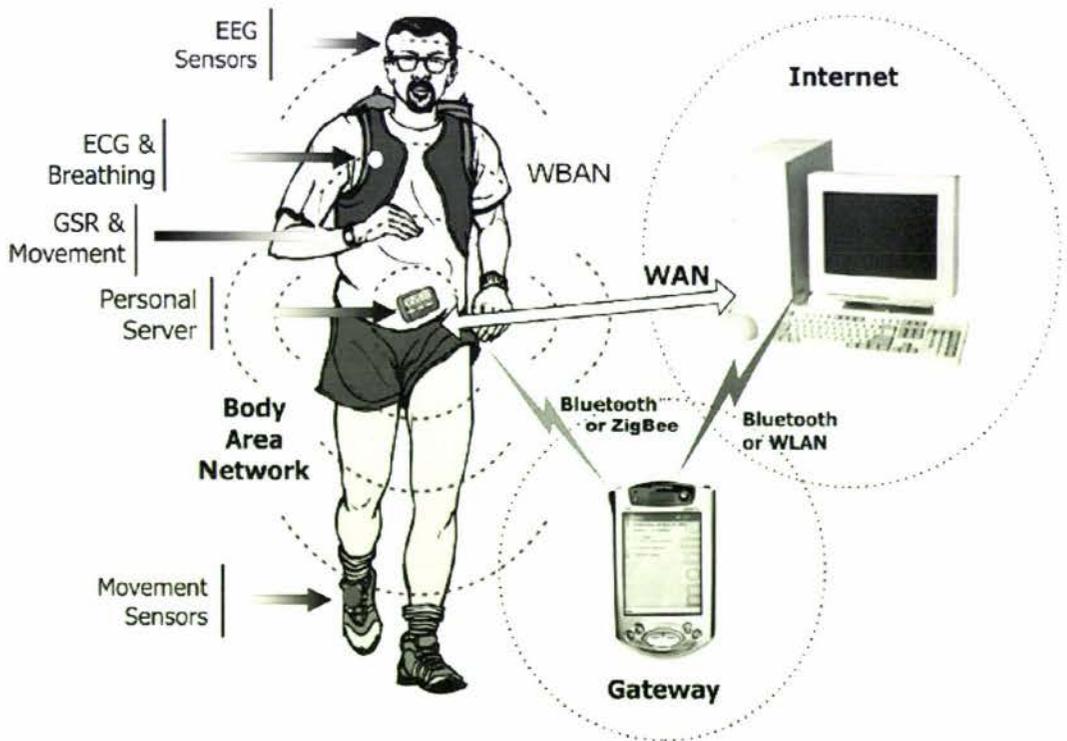


Figure 2-2 Architecture of m-health monitoring BAN systems
[6]

2.3.2.4 Wireless LAN

WiFi is a popular name given for the wireless Ethernet 802.11b standard for WLANs (Wireless Local Area Networks) [35]. WiFi LANs support up to 11Mbps data rates within 100 metres of the access points; these access points are usually connected to a wired network. This means that a WLAN capable device could work as if in a connected environment, and potentially access the intranet and the Internet applications without requiring wired connections. A number of WiFi networks can be interconnected into a mesh configuration to provide a wider area of coverage called a hot zone [36]. To extend the network to a larger coverage area or to eliminate the need for many wired access points, WiMax technology can be used to complement WiFi technology by eliminating the wires that connect the gateway mesh nodes to the core network, and replacing them with WiMax CPE (Customer Premises Equipment) that backhauls wirelessly to the core network [36].

WLANs can also support body area networks and are a cost-effective solution to cut down Internet Service Provider (ISP) data costs of wireless broadband and 3G usage. WLAN technology is being adopted rapidly. Enterprises spent over US\$1 billion on WLAN products in 2004, and it is estimated that WLAN capable products will have an annual growth of 21 per cent for the next three years [37]. Healthcare is also one of the biggest vertical markets for WLAN [37].

2.3.2.5 Radio Frequency Identification

Radio Frequency Identification (RFID) is a method that uses an RFID tag, a small microchip designed for wireless data transmission. The tag transmits data in response to interrogation by an RFID reader [38]. Some PDAs have the ability to read RFID tags. Middleware is

needed to form an interface between the reader and the enterprise systems [39]. The figure below shows a simplified view of an RFID system – on the left-hand side is the tag, reader, and the middleware, and on the right-hand side is the enterprise system.

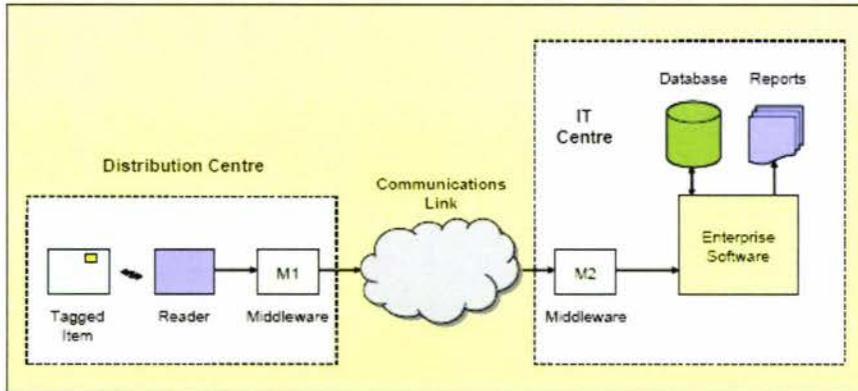


Figure 2-3 Simplified Schematic Diagram of an RFID System [39]

RFID is said to be set to revolutionize retailing by replacing the traditional bar-coding systems to introduce better billing systems and security processes; it can also form a basis for a number of healthcare services. For example, alerting the customer (who might use his mobile phone with a built-in RFID reader) if they have selected a product that is likely to cause an allergic reaction [40]. Other uses of RFID in the healthcare sector include asset and specimen management, and tracking and locating patients and objects in hospitals.

2.3.2.6 Summary

In this section, the literature has reviewed popular short-distance wireless technologies. These include Bluetooth, Infrared, ZigBee, WiFi, BAN and RFID. M-health systems are making use of these technologies to create solutions that can enhance healthcare delivery.

2.3.3 Long-distance Technologies

Some of the popular long-distance technologies include cellular voice and data networks and, WiMax.

2.3.3.1 Cellular Networks – Voice and Data

There are three basic multiple access schemes that cellular networks use:

- FDMA – Frequency Division Multiple Access
- TDMA – Time Division Multiple Access
- CDMA – Code Division Multiple Access

In theory, it does not matter if the spectrum is divided into frequencies, timeslots, or codes; the capacity provided from these three multiple access schemes is the same, but in a cellular system, one of the schemes may be better than the other [41].

Cellular networks have evolved over time, and this evolution can be studied by looking at the mobile generations, i.e. 1G, 2G, 3G and 4G.

The first Generation (1G) of mobile communication systems employed wireless access using narrowband FDMA with the channel spacing of around 25-30kHz [42]. Then, the 2G systems deployed in the 1990's, adopted TDMA with the channel spacing with a range of 25 to 200 kHz. CDMA was then introduced based on a narrow band, direct sequence, and supported channel spacing of 1250kHz; this is also a 2G system [42]. This was launched in New Zealand on July 2001 by Telecom New Zealand [21]. The 3G mobile communication system was developed to enhance the delivery of multimedia services [43] and handle voice calls; it supports channel spacing of 5MHz [44].

The evolution chart (Figure 2-4) demonstrates the voice and multimedia capabilities of each of these generations.

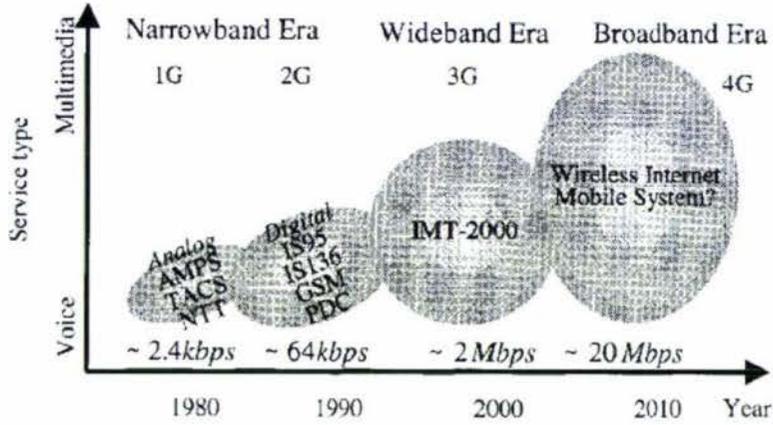


Figure 2-4 Evolution of Mobile Communication Systems [42]

The mobile generations use different data standards, dependent on the carrier and the model of the phone. Table 2-3 displays these generations and their data standards from which this data is collected [45]. The specific data standards are not described as they are out of the scope of this project.

Table 2-3 Mobile generations and the data standards

Generation	Data Standards
1G	NMT, AMPS, Hicap, CDPD, Mobitex, DataTac
2G	GSM, iDEN, D-AMPS, IS-95, PDC, CSD, PHS, GPRS, HSCSD, WiDEN, CDMA2000 (1xRTT/IS-2000), EDGE (EGPRS)
3G	W-CDMA or UMTS (3GSM), FOMA, 1xEV-DO/IS-856, TD-SCDMA, GAN/UMA, 3.5G - HSDPA, 3.75G - HSUPA

4G	WiMax, WiBro, and the proposed 3GPP Long-Term Evolution work-in-progress technologies such as HSOPA
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(See Abbreviations Table before Chapter 1 for full terms)

The widely used data standards today (2006), in New Zealand, are UMTS and HSDPA. UMTS interoperates with GSM, uses W-CDMA radio interface, and has peak data rates of 2Mbps, but the typical throughput rates are 200 to 300 Kbps. The HSDPA is an enhancement to UMTS and has peak data rates of 10Mbps [46]. The HSDPA is backward compatible with the existing user equipment [47].

The literature above shows the evolution of cellular networks to handle higher voice and data capacities. These cellular networks are often being utilized to assist the m-health technologies. This use of these cellular networks in m-health can be categorized into four different areas; these four areas and relevant examples are listed below.

1) To facilitate the ability to make voice calls and browse WAP (Wireless Application Protocol) sites.

2) To support the short-distance technologies by connecting them to a wired network.

The study by Konstantas [33] involved making use of 2.5G and 3G technologies to support their BAN system which involves a combination of short-distance and long-distance technologies.

3) To use the messaging systems – SMS (Short Message Service) to communicate to and fro between the health provider and the mobile owner population.

The uses of SMS technologies in m-health are described in 2.3.3.2 section.

4) *To support seamless mobility in which the user can work within WLAN environments when in coverage and stay connected using a cellular network when out of WLAN coverage.*

Seamless mobility is a set of solutions in which the user gets access to a connected environment without interruptions [48]. An example could be a mobile clinician working in a hospital which has WLAN coverage, but the coverage might not be available in all areas of the hospital. This is where the cellular data network can be used to stay connected.

To prevent further costs and to achieve seamless mobility, WiMax is often utilized. WiMax is complementary to 3G; the goal of WiMax is to allow unrestricted access to mobile data at high speeds [49]. A possible solution could be to maximize the coverage of WLANs by using WiMax technology as this can interconnect access point nodes of WLANs, and use a cellular network where necessary.

The creation of decentralized and inexpensive broadband networks is known as Mesh Networking. This involves the use of nodes which transmit as far as the next node [50]. Figure 2-5 is from a Motorola whitepaper, *Mesh Networks*, which demonstrates a traditional network on the left and the mesh network on the right.

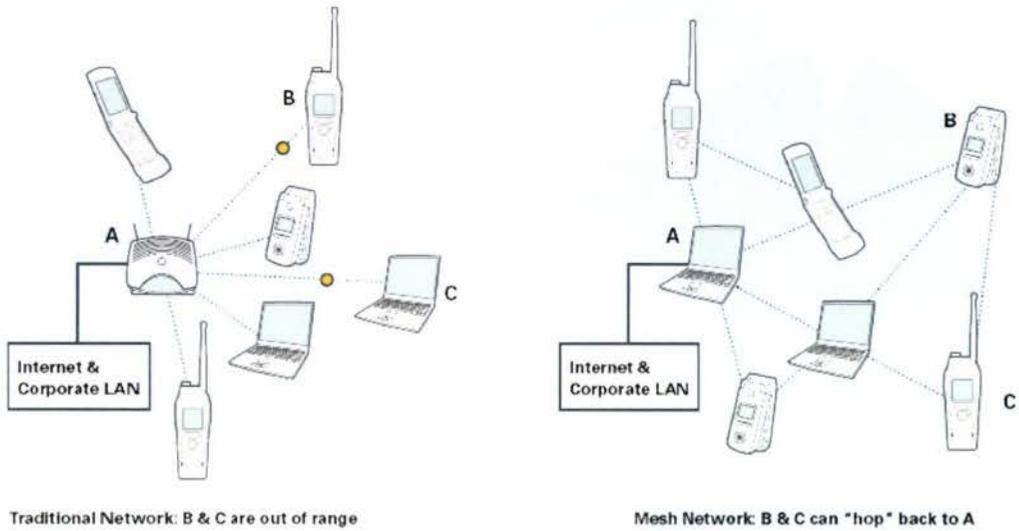


Figure 2-5 Mesh Networks

2.3.3.2 Short Message Service

Short Message Service (SMS) provides an extraordinary opportunity in the m-health domain. *Texting* has become one of the most widely used mediums for communication [51]. Eighty per cent of mobile consumers are keeping their mobile with them all day, and 94 per cent of the SMS messages are read [51], hence SMS is a very reliable medium of communication within the mobile population. The advantages of using SMS are that it provides a dynamic conduit for immediate action, and almost all mobile devices support the SMS mechanism. The limitations are its 160 character limit, and it is unable to handle content rich messages.

Many m-health studies [8], [23], [24], [52], [53], [54], [55] have used SMS and created patient-reminder, and patient-support applications as well as using SMS in preventive care to achieve healthier living populations.

The next section on 'm-health applications' describes the use of m-health technologies in clinical and non-clinical health environments.

2.4 M-health Applications

The diversity of health information systems is immense. This section presents the literature on m-health applications. To present this information clearly, the applications have been separated into clinical and non-clinical system types.

The section on clinical applications will include m-health applications in areas of point-of-care, monitoring, decision making systems, drug lookups, and prescribing. The section on non-clinical applications will review the literature on patient tracking, patient lifestyle, and reminders.

2.4.1 Clinical Applications

2.4.1.1 Point-of-care

A case study [19] at Alfred Hospital (Melbourne, Australia) presents a mobile point-of-care solution installed in an intensive care unit. The intention of the health planners at the hospital was to enable access to diagnostic data, electronic medical images (CAT scans, X-rays) at the patient's bedside. Prior to the m-health adoption, the health staff would access a wired computer away from the patient, which was time-consuming and costly. After installing an m-health point-of-care solution, the benefits included improved patient care (more time given to patient), increased efficiency (immediate access to diagnostic information, and streamlined workflows), cost savings (productivity gains showed that the solution would pay for itself within eight months).

Software developed by the US army, known as *Battlefield Medical Information System – Tactical* (BMIS-T) on the HP-iPAQ Pocket PC software was used to improve treatment of soldiers on the battlefield [56]. The outcome enabled storage and retrieval of vital medical information at point-of-care, provision of on-the-spot treatment, decision-making support, information, and availability of healthcare documentation; it allowed medical units to conduct real-time health surveillance studies in the field.

A PDA application was created [57] to implement a handheld *Electronic Health Record* (EHR), and recorded pregnancy data at point-of-care in rural communities of India. This application really supported the EHR, and replaced the paper-based records.

A work-in-progress ambulatory care system, *electronic point-of-care* (ePOC), and the considerations of developing this solution are presented in [58]. The authors conclude that electronic management systems require careful study and planning to maximize their success. Electronic data capture is essential to maintain EHRs which are very valuable in mobile ambulatory environments.

The delivery mechanism for majority of point-of-care applications is usually mobile devices, risking the development of mobile applications that may become device-specific. Mobile devices evolve and have short lifetime of usage making it frustrating to keep them up-to-date. Price [13] suggests the applications must not be device-specific and must be interoperable; this can possibly be achieved by using technologies like *extensible markup language* (XML). This is being used as a standard in UK health systems.

We can learn from the literature above that point-of-care solutions can bring benefits to health organizations, but require careful planning before deployment. It is also valuable to investigate how device-

specific these point-of-care solutions are, and whether these solutions can integrate with existing systems. EHRs must be kept in mind and considered while in the process of developing a point-of-care solution as EHRs are building blocks for integrated care.

2.4.1.2 Monitoring

M-health is being used [29], [8], [23], [59] to monitor patients, especially with chronic illnesses. Technology such as wireless-enabled scales and blood pressure monitors are being used to support patients, the data is transmitted to General Practitioners (GPs) prior to patients' visits [59].

Vodafone policy paper series [23] on "the role of mobile phones in increasing accessibility and efficiency in health care" has presented the potential of Short Message Service (SMS) for the control of tuberculosis. Their scenario modeling shows that the SMS-based interventions improved health outcomes. The Multiple Drug Resistant Tuberculosis (MDRTB) cases declined substantially, and resulted in an increased number of cures and decreased number of deaths due to the reduction of infectious phases of the disease. A separate report by Vodafone UK [8] shows cost savings of £1.9 million per 1000 patients if a SMS support system were to be introduced into treatment programs for tuberculosis patients.

Several studies on diabetes and the use of m-health indicate tight management can reduce diabetes complications and give diabetics an easier, longer life. Zou [29] presented a Bluetooth glucose meter, that transmitted test results using cellular networks like *General Packet Radio Connection* (GPRS) or *Third Mobile Generation* (3G) connection.

SMS is proving to be a vital tool to control diabetes; statistics shown by Vodafone in [8] indicate a 10 per cent improvement in glucose levels for young people who manage their condition using an

SMS-driven support system; this level of improvement can reduce diabetes-related complications such as blindness by 76 per cent and kidney disease by 50 per cent.

We can learn from the literature above how diseases can be managed better if they are monitored effectively; the use of m-health for monitoring provides a means for the health providers and patients to get necessary data to make the right decisions. There are also cost savings and improved patient health if monitoring systems are introduced — especially to manage chronic illnesses like tuberculosis and diabetes. SMS is being used frequently to create support systems. Bluetooth can potentially be built into devices that measure health data, to connect (with cellular networks), and transmit health results directly.

Monitoring m-health systems is achievable, and can potentially be adopted by the patient populations as the majority of the patients own cellular phones and use them regularly. Research [24] shows that from a sample of 302 patients with diabetes in Spain, 76 per cent of the patients owned a mobile phone , and 96 per cent of them used it more than once a week.

2.4.1.3 Decision Making Systems

The literature in the previous section dealt with the use of m-health systems in monitoring and point-of-care. The increase in monitoring by m-health technologies can lead to a gradual automation of many medical decision-making processes, empowering patients to manage their own health [60]. As m-health systems take on decision-making functions, safeguards are necessary to ensure that difficult decisions are handled by qualified medical practitioners [60].

McKesson Corporate, one of the world's leading companies in clinical decision support systems is delivering some of their solutions

on handheld computers due to market demand. McKesson [61] claims that these solutions are powerful, enhance knowledge transfer, improve efficiency, and transform the clinical review from one that is largely administrative to one that is extremely consultative. This decision support system is for the use of clinicians, not patients.

2.4.1.4 Drug Lookups and Prescribing

Electronic pharmacopoeias¹ are now widely available on mobile devices [25]. Some of these electronic pharmacopoeias that can be used on mobile devices include:

- ePocrates qRx
- Tarascon Pocket Pharmacopeia
- Lexidrugs
- PDR (Physicians' Desk Reference)
- Qid (Latin word that means: Seen on a prescription)
- ABx guide (Antibiotic Guide)
- The Sanford Guide to Antimicrobial Therapy
- There are also other general medical references that are designed specifically for mobile devices, popular examples include:
 - Merck Manual
 - Griffith's 5-Minute Clinical Consult
 - Harrison's Principles of Internal Medicine 14e handbook

¹ A book containing an official list of medicinal drugs together with articles on their preparation and use

The number of these references available on mobile devices is increasing, and carrying a virtual library of such references is appealing, although it can be cumbersome to read through large volumes of text on the handheld's small screen [25].

A case study [26] shows that clinicians have been using reference software for the past four years, and use drug lookups a mean of 6.3 times a day. The use of this reference material on mobile devices is preventing medication errors and adverse drug effects. The use of devices and reference software together is showing improvement in patient care and is a valuable tool enabling clinicians to learn about recent alerts and warnings.

Prescription errors are common, and the idea of using mobile devices to automate prescription writing is drawing significant attention [25]. Many systems which reduce errors and office inefficiencies associated with prescription writing are available on the market. Current systems include:

- iScribe
- ePhysician
- PocketScript
- Allscripts

The literature above reviewed the use of mobile devices in drug lookups and prescribing. The market for the electronic pharmacopoeias has already moved past the hype, and mobile devices are proving to be efficient tools in enabling the availability of such software anywhere anytime. There are also many limitations of the mobile devices that need to be kept in mind before adoption of m-health drug look up or prescribing solutions. The limitations include

small screens, limited memory, slow data entry, and security issues [25].

The next section presents the literature on the use of m-health in non-clinical applications.

2.4.2 Non Clinical Applications

2.4.2.1 Patient Tracking Systems

A study [19] at George Eliot Hospital in the UK presents deployment of a mobile portal to provide online access to pathology and radiology results, patient records, the Accident and Emergency (A&E) tracker, and other online resources. Laptops and tablets were provided with wireless connectivity over a WiFi wireless network. The benefits included significant time savings; this is shown in the graph in Figure 2-6.

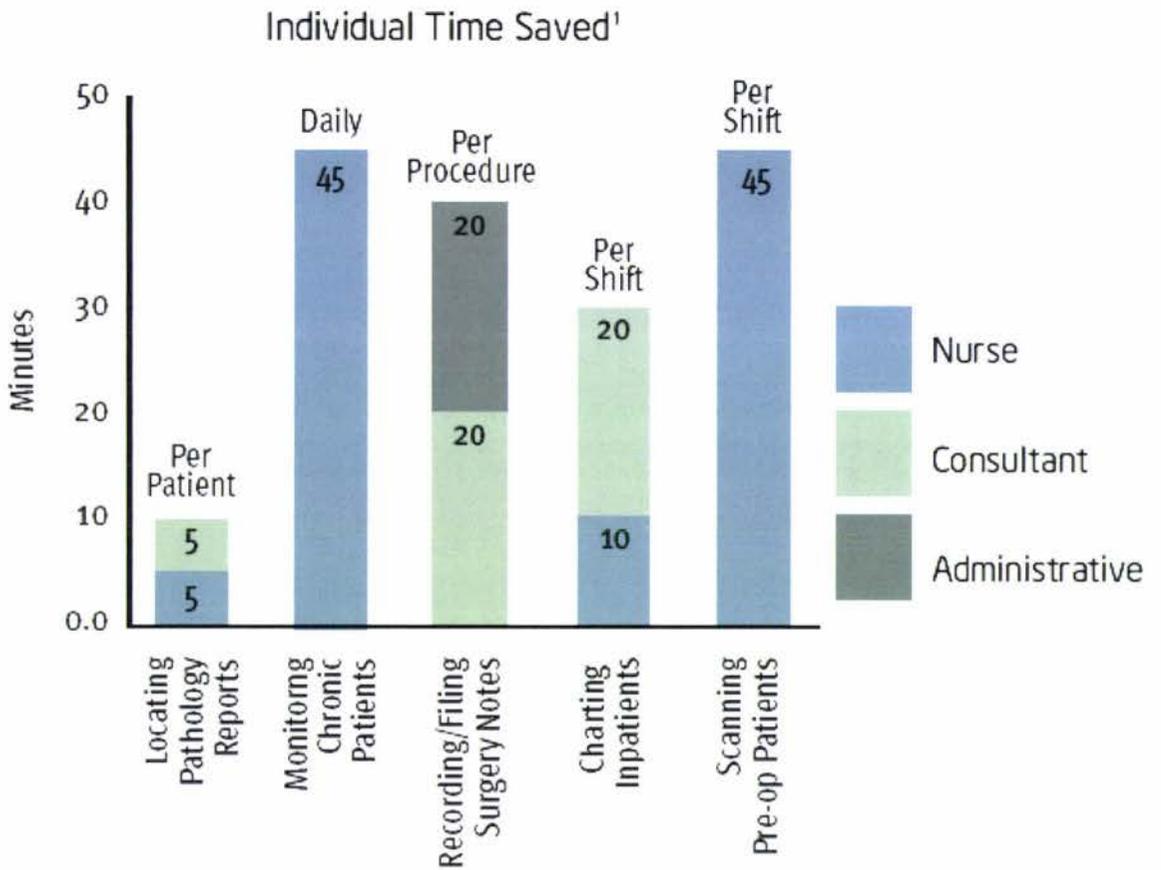


Figure 2-6 Staff time savings from pilot project [19]

In another study at Memorial Hospital in Miramar [62], RFID sensor technology was deployed to track patients. The process was such that the patients who registered at Memorial hospital were given an RFID badge attached to a lanyard that patients wear around their necks. The corresponding badge number was entered into the registration system along with patient details. RFID readers placed in strategic areas of the hospital, track the patients' movements from triage to treatment to discharge. As a result, clinicians no longer have to enter patient status information manually into separate systems; real-time patient locations are shown on a whiteboard screen. The study [62] showed RFIDs are reducing the amount of patient stay by an average

of 37 per cent for children, 18.5 per cent for adults who have been released, and 36 per cent for adults who have been admitted.

2.4.2.2 Lifestyle

One of the ways to reduce health costs nationally is to keep the population healthy, and one of the ways to achieve that is to introduce preventive care strategies; the literature below demonstrates how m-health is being used to achieve preventive care.

Some food stores have installed wireless scanners that allow shoppers to scan products as they add them to their shopping trolley. These systems provide healthcare-related information about products such as ingredients that can cause allergic reactions. This is being done by means of RFID labelling, and the use of scanning devices [59].

A successful, randomized trial of a new smoking cessation service conducted by the University of Auckland [63] involved using mobile phone text messaging. The sample size was 1705 smokers throughout New Zealand who wanted to quit. The participants received smoking cessation advice, support, and distraction via text messages. The results showed high quit rates.

A DRUG identification service was launched in Auckland City in September 2006 [53], which enabled anyone who came across a drug they could not identify to text the name to DRUG (3784), and in return receive an SMS giving the more common name of the drug, its effects, its dangers, and links to the New Zealand Drug Foundation's helpline and website. A similar service is being used in Ireland, where the majority of the users are ambulance drivers who pick up people who have been using drugs with names they cannot recognize.

The above literature presented some of the examples where m-health is beneficial and is being used to encourage preventive care to

achieve a healthier population. SMS is proving to be a useful tool when dealing with populations because all mobile devices support this technology, and it has been well adopted by most of the population.

2.4.2.3 Reminders

There is wide use of reminders in m-health applications; they have proved to be valuable in areas of patient-appointments and medication reminders. The literature presented below shows some of these application examples.

A mobile phone text messaging service consisting of daily reminders to use an inhaler, give health education tips, and safety messages was set up [54]. The service focused on 30 participants, who received text reminders to use their inhaler in contemporary jargon. This service proved to be successful, and the author states that reminders of this sort are a way to allow people with chronic health problems to make their disease comply with their lifestyle [54].

A New Zealand-based study [52] conducted a pilot program to use SMS in the Waitemata District Health Board. The reminder service targeted 8-10 patients from the mental health clinic, and reminded them about medication to be taken in an agreed treatment regimen; the outcome was increased adherence to their prescribed medications. This study also targeted cardiology and diabetic patients; the sample included all patients in this specialty, where a clinic appointment reminder was sent which included the date and time of consultation that was scheduled. The outcome was reduced rates of non attendees. Another report [55] shows outpatient clinics that deployed SMS patient reminder systems have managed to reduce DNA (Did Not Attend) rates by up to 30 per cent. The National Health Service (NHS) in England alone is predicted to have potential cost savings between £240–370 million per year by introducing SMS reminders to patients [8].

The literature above showed some of the potential benefits in using medication and appointment reminders. The technology being used to serve these purposes is mainly SMS, as it is well-adopted by most populations and is neither device nor telecommunication carrier dependent. However, SMS has its own limitations – with a maximum capacity of only 160 characters, and the inability to handle content-rich messages [51].

2.4.3 The Future of M-health

The future of m-health looks promising. The literature review has indicated the healthcare needs as well as the demands and challenges; it has presented the m-health technologies, and lastly, the m-health applications. Many examples of the use of m-health have been presented. It is predicted [64] that wireless spends are going to increase dramatically, almost US\$2.7 billion by 2010 in the UK, for the improvement of patient management systems.

The area where m-health usage is significantly high is in chronic disease management and in applications of support, reminding and monitoring. These areas are likely to be exploited in the near future. New Zealand has minimal m-health usage. How New Zealand will adopt m-health, and when it will do so, is unpredictable. The drivers for change include many factors – political, economic, social, technical, legal, and ethical [65]. The Results chapter of this thesis has analyses of comments from the strategists of New Zealand healthcare concerning the role of m-health in New Zealand.

Chapter 3

Research Design

This chapter presents the research design. The research investigated the role of m-health in New Zealand and gathered opinions of health and technology strategists. Qualitative research, using grounded theory was used to gather data. The data was collected by means of questionnaires and interviews. Since this was an exploratory study, the concepts of grounded theory were used, but no such theory was produced.

The sections below describe why qualitative research was chosen, how the questionnaires and interviews were designed, and what sampling strategies were used.

3.1 Choosing an Appropriate Methodology

The intention of the research is to get input from health and technology strategists and enquire about m-health in New Zealand. Such a study is more suited to a qualitative rather than a quantitative research [66, 67]. Qualitative methods are particularly appropriate (as here) for pilot studies where little is known about the issues under consideration, or to gain new perspectives on well-established phenomena.

The questionnaire and the interview responses were collated and subjected to grounded theory analysis to extract and refine the main themes emerging from the data. Grounded theory does not always generate a perfected product, but leads to an ever-developing entity [5]; this returns results which are sufficiently general to be applicable to a multitude of diverse situations within the substantive area of the

study [5]. This is relevant to our investigation of m-health because primary, secondary, and community healthcare settings are diverse, and healthcare itself consists of a substantial variety of applications.

The grounded theory involves six key steps as shown in Figure 3-1.

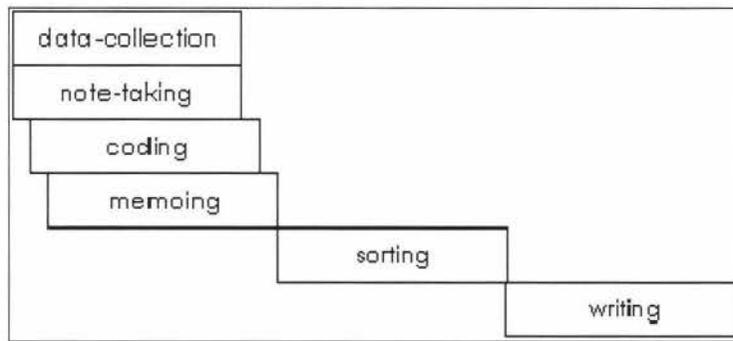


Figure 3-1 Steps in Grounded Theory [68]

The data collection, note-taking, coding, and making memos steps occur simultaneously; sorting happens when the sample is saturated; lastly, the results are generated. The methodology and concepts of grounded theory were used to carry out the research and extract the results from the questionnaires and interviews. There was no intention to produce a theory, as this study is exploratory and involves gathering ideas and opinions which cannot really be theorized.

The data for this research comes from the short questionnaires and the hour-long interviews; the data from the questionnaires is mostly in the form of an odd-numbered scale which makes it very easy for coding and presenting the results in a quantified format.

The interviews are electronically recorded; the memos are produced and sent to the interviewee for verification. They are then sorted into interview themes (see section 3.4). The verification ensures that the comments of the interviewees have not been

misinterpreted by the researcher, and gives the interviewee a second chance to change or alter anything that they may have expressed.

3.2 Ethics Approval

Since this research involves human participants as the sample, it needed an ethics approval from Massey University prior to approaching the sample. An ethics approval was obtained from the Massey University Human Ethics Committee. This involved producing the documents listed below – those specifically produced for the study are available in the appendices as shown:

- Massey University 'Notification of Low Risk / Evaluation Involving Human Participants' application form
- Massey University Screening Questionnaire – to determine the approval procedure
- Invitation letter to the participating organizations (see Appendix A)
- Invitation letter to the participating individuals (see Appendix B)
- Consent letter for participation in the interviews (see Appendix C)

Upon submission, the research was successfully approved by the Massey University Human Ethics Committee as a *low risk* research. All questionnaires were branded with the Massey University logo, and contained the low risk approval note; this was a formality advised by the Massey University Human Ethics Committee. All interviewees were given a brief explanation of the research project, and signed a consent form before taking the interview.

3.3 Sampling

The eligible sample included health and technology strategists in New Zealand, DHB planners, primary healthcare planners, and community healthcare planners. The technology strategists involved companies that cater for m-health products, or have been working with healthcare technology products extensively in non m-health areas. Given the preliminary nature of the study, the experience and positions represented by this population allowed them to articulate the views of several different groups: patients, clinicians, managers, infrastructure providers, etc. A more systematic study would include representatives from the communities directly.

The first phase of the research involved distributing questionnaires which also asked whether the individual wished to participate in further research. The second phase involved conducting interviews.

A purposeful sampling strategy was used, as it seeks information-rich cases which can be studied in depth [67]. The types of purposeful sampling [5] that are used for this research are maximum variation and convenience sampling. Maximum variation sampling is also beneficial to this study as the strategists from the three health sectors (primary, secondary, and community) are being targeted, as well as technology suppliers. Maximum variation sampling can yield detailed descriptions of each case, and can also identify shared patterns across the cases [5].

Convenience sampling involves selection of cases based on their availability for the study [69]. Convenience sampling also involves the *snowball* strategy where group members identify additional respondents to be included in the sample [69]. Given that the health and technology strategists are very busy individuals, convenience sampling can be used to effectively increase the sample for interviews.

The following sections describe the design specifics of the questionnaire and the interviews, and outline how the sample was obtained.

All sampling strategies above – purposeful, maximum variation, and convenience sampling were used to target the health and technology strategists.

3.4 Questionnaire Approach

The questionnaire was created for two main reasons. Firstly, to obtain data for three aspects of m-health: healthcare delivery, integrated care, and future of m-health in New Zealand. Secondly, the intention was to recruit interviewees by means of the convenience sampling strategy described in section 3.3.

The sample for the questionnaire was primarily obtained by circulating 300 copies of the questionnaire at the Health Informatics New Zealand (HINZ) conference in Auckland. Information about this conference can be viewed at <http://www.hinz.org.nz/content/view/127/117/> The HINZ conference attendees included: CIOs, CEOs, CFOs, Chief Medical/Scientific Officers, IT Analysts, Clinicians, Researchers, Health Informaticians, Lab Technicians, IT & Health Managers, IT & Health Strategists, Health Informatics Managers, Academics, Clinical Coders, Policy Advisors, and IT Vendors.

The conference was therefore seen as a good opportunity to reach individuals who shape the future of New Zealand healthcare. Some of the candidates who filled in the questionnaire expressed interest in participating further in this research, and were invited for the interview, depending on their background (to get maximum variation). This is how the convenience sampling and maximum variation

sampling strategies were used, as mentioned above in section 3.3. A total of 34 candidates filled in the questionnaire.

The questionnaire (see Appendix D) had five main sections as below:

1. Getting to know you
2. Delivering health service
3. Integrated care
4. New Zealand and its m-health future
5. Future contact

The first section of the questionnaire was used to identify the background of the candidates; i.e. their occupation and job title, which health sector they worked, and if not, which domain their profession was in, whether they were a technology end-user or evaluator or strategist, and lastly, their exposure to mobile devices. These questions confirmed the eligibility of the candidate, and ensured credibility of the data collected.

The second section contained questions on delivery of healthcare, where m-health has its greatest use. The questions enquired into the following:

- Patients' acceptance and m-health
- Security and privacy issues of m-health
- Using m-health for alerts and reminders to enhance health services delivery
- Patient monitoring using text messaging
- Text message reminders to reduce missed appointments

- Chronic disease management
- Dentists and optometrists and their use of m-health at point-of-care
- Rural nurses and their use of mobile devices to enhance health services
- Ambulatory care using GPS and mobile devices
- Preventive care campaigns driven by the use of mobile phones
- Asset and specimen management in hospitals using Radio Frequency Identification (RFID)
- Nursing departments and their use of m-health
- Electronic Health Records (EHRs) and their availability on mobile devices
- Security concerns of having EHRs on mobile devices
- Allowing patients to access their EHRs

The integrated care section (third section) contained questions on the use of m-health to achieve integrated care, information sharing between health sectors, and the possibilities of storing all patient information in a centralized place.

The section on New Zealand and its m-health future (fourth section) focuses on the health sectors that could most benefit from m-health, as well as the importance of government investments in analyzing m-health technologies. Lastly, the questionnaire requests further participation in the research, and gives the candidate an opportunity to add any additional comments.

3.5 Interview Approach

The sample collected for the interviews involved using purposeful sampling, convenience sampling, and maximum variation sampling as described in section 3.3. The project supervisor, Professor Tony Norris, is a member of the Health Informatics New Zealand (HINZ) committee and is a Director of the Centre for Mobile Computing (CMC) at Massey University which makes him a very well-known personality in areas of IT health consulting. He was very able to introduce potential candidates for the interviews.

The other sample came from the questionnaire candidates who were interested to participate in further research. The snowball strategy (explained in section 3.3) was used to obtain more contacts from the previous contacts; the result was a total of 18 interviews. Maximum variation was obtained by conducting interviews in different types of organizations; i.e. primary, secondary, and community healthcare sectors, technology strategists, and vendors. The number of conducted interviews was restricted by the project time limitations rather than by available candidates; this emphasizes the success from the sampling strategies.

From the literature, it is evident that m-health is not just one technology, it involves the use of many technologies and different applications are suitable in different settings. The interviews with New Zealand-based health and technology strategists provided an excellent opportunity to inquire about m-health within the New Zealand healthcare setting. The main purpose of the interviews was to conduct discussions on the five main themes below.

1. *The role of mobile technology in healthcare in New Zealand*

- This theme was a very good starting point for the interview, and usually generated several sub-questions.

2. *The health sectors that are likely to benefit most from m-health*

- This theme paid attention to the use and applicability of m-health across primary, secondary, and community health sectors.

3. *The demand and the need for customized mobile applications to suit healthcare staff needs*

- Mobile based software, implications of a small screen size and keyboard, and the necessity of mobile applications are considered in this theme.

4. *The role of m-health to achieve integrated care*

- Capturing electronic data to assist integration and eliminate paper-based data collection; current issues of integrating systems are discussed under this theme.

5. *Privacy and security implications of m-health*

- This theme concentrated on the privacy and security issues that arise when dealing with health data; additionally, the attention did turn to discussing the properties of a device as being expensive and easy to lose, and the digital ability to increase security.

The sub-questions under these themes were derived at interview time. The themes were kept consistent regardless of whether the candidate was from a health background or a technological background. The length of the interviews was kept at approximately one hour. The respondents were very helpful, confirmed the importance of m-health, and wished to be informed about the project outcome. The exact details of the interview agenda are described in full detail at the start of section 4.2.

Chapter 4

Results

To discover the barriers and the opportunities for m-health in New Zealand the research involved circulation of questionnaires and conduct of interviews. A total of 34 questionnaires and a total of 18 interviews contribute toward the results that are being presented in this chapter. The research methods used to obtain these results are presented in Chapter 3, and the analysis of these results can be found in Chapter 5.

4.1 Questionnaire Results

The questionnaire results are being presented question by question in this section. To refer to the original questionnaire, see Appendix D. The question numbers below are used so that the subsequent chapters of the thesis can refer back to these results.

SECTION ONE: GETTING TO KNOW YOU

Q#1.1 What is your occupation or job title: _____

The results include the following:

- 3X CEOs
- 3X University lecturers
- 2X Account Manager
- 2X CIOs
- 2X Managers of Information Services

- 2X Project managers
- 1X Computer analyst
- 1X Dentist
- 1X GP
- 1X Health planner
- 1X Industry development manager
- 1X Information contractor
- 1X IT consultant
- 1X Managing director
- 1X Nursing specialist
- 1X PhD student
- 1X Product manager
- 1X Registrar
- 1X Senior advisor
- 1X Technology strategist

Q#1.2 Which one of these health sectors do you work in? The available choices were: primary healthcare, secondary healthcare, community healthcare, and other.

The results include the following:

- 12X Secondary healthcare
- 5X Education
- 4X Primary healthcare

- 3X All sectors
- 2X Community healthcare
- 2X NZ health IT
- 2X Technology supplier
- 1X Contractor
- 1X DHB planner
- 1X Government department
- 1X Telecommunications

Q#1.3 Which of the following descriptions describe your involvement with mobile technology? The choices available were: technology end user, technology evaluator, technology strategist. The respondents could tick more than one and had the opportunity to leave comments

The results include the following:

- 12X Technology end-user
- 11X Technology strategist
- 3X All, i.e. Technology end-user, strategist, and evaluator
- 3X Technology end-user and evaluator
- 2X Technology evaluator and strategist
- 1X Other – Vendor
- 1X Technology end-user and strategist
- 1X Technology evaluator

Q#1.4 Are you currently using a PDA or any other mobile device at your work place?

The following table shows the answer choices and the results.

Yes	No
85.29%	14.71%

SECTION TWO: DELIVERING HEALTH SERVICES

Q#2.1 Do you think patients would appreciate receiving health services on their mobile phones?

The following table shows the answer choices and the results.

Extremely Likely	Likely	Not Sure	Unlikely	Extremely Unlikely
26.47%	64.71%	8.82%	0%	0%

Q#2.2 Do you think delivering patient information on mobile phones will cause security or privacy issues?

The following table shows the answer choices and the results.

Extremely Likely	Likely	Not Sure	Unlikely	Extremely Unlikely
11.76%	61.76%	0%	26.47%	0%

Q#2.3 Alerts can be sent to patients regarding their appointments, drug top-ups, etc. Do you think such alerts can enhance the health services provided to patients?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
55.88%	44.12%	0%	0%	0%

Q#2.4 Do you feel that patients' general health can be monitored or supported by 'texting' messages (sending and receiving SMS)?

The following table shows the answer choices and the results.

Extremely Likely	Likely	Not Sure	Unlikely	Extremely Unlikely
38.24%	44.12%	14.71%	2.94%	0%

Q#2.5 Do you agree that SMS reminders could help patients reduce missed appointments?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
67.65%	32.35%	0%	0%	0%

Q#2.6 There are many chronic diseases that need constant monitoring and support such as diabetes. Would you agree that patients with such conditions can be better monitored and supported using mobile technology?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
52.94%	47.06%	0%	0%	0%

Q#2.7 Dentists and optometrists can use PDA devices to record patient data while treating them, this can save large amounts of time and help improve health services. Do you agree?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
32.35%	35.29%	23.53%	5.88%	2.94%

Q#2.8 Rural nurses and community health workers can be equipped with PDAs to record patient data and enhance the services they provide. Do you agree?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
58.82%	41.18%	0%	0%	0%

Q#2.9 Ambulances can be installed with GPS and PDAs to locate destination sites and enter patient data and so provide better emergency care. Do you agree?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
61.76%	38.24%	0%	0%	0%

Q#2.10 Do you think that mobile phones offer an opportunity to run health-aware campaigns on issues such as quit-smoking, safe sex, UV risks, and obesity?

The following table shows the answer choices and the results.

Very Important	Important	Average	Slightly Important	Not Important
29.41%	47.06%	20.59%	0%	2.94%

Q#2.11 Do you think preventive care can be promoted using mobile technology?

The following table shows the answer choices and the results.

Extremely Likely	Likely	Not Sure	Unlikely	Extremely Unlikely
35.29%	52.94%	11.76%	0%	0%

Q#2.12 Hospitals can use Radio Frequency Identification (RFID) tags to manage assets and specimens. Do you think this feature will enhance health services?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
20.59%	55.88%	20.59%	2.94%	0%

Q#2.13 Nurses in the hospital can use mobile devices to manage beds, patients, and communicate better with their teams. Will such communication lead to better services?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
20.59%	58.82%	17.65%	2.94%	0%

Q#2.14 Do you know what "Electronic Health Records" or "EHRs" are?

The following table shows the answer choices and the results.

Yes (Complete questions 2.15, 2.16, 2.17)	No (Go to section three)
100%	0%

The candidates who ticked yes were to answer remaining questions of section two which concentrated on EHRs, and the candidates who ticked 'no' were guided to section three. However, the results above indicate the entire sample (34) had ticked 'yes' which means the sample size for the questions 2.15, 2.16, 2.17 remains at 34.

Q#2.15 Do you think EHRs should be made available on mobile devices across all health sectors?

The following table shows the answer choices and the results.

Yes	No
76.47%	23.53%

Q#2.16 Do you think having EHRs on a mobile device would cause security concerns?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
20.59%	58.82%	14.71%	5.88%	0%

Q#2.17 Do you think patients should be provided with limited access to view their own EHR?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
38.24%	50%	5.88%	2.94%	2.94%

SECTION THREE: INTEGRATED CARE

Q#3.1 Do you believe that integrated care can be better achieved using mobile technology?

The following table shows the answer choices and the results.

Extremely Likely	Likely	Not Sure	Unlikely	Extremely Unlikely
47.06%	44.12%	8.82%	0%	0%

Q#3.2 Consents and allergy information will be more useful if shared between health sectors (primary, secondary, and community). Can this goal be achieved via mobile technology?

The following table shows the answer choices and the results.

Extremely Likely	Likely	Not Sure	Unlikely	Extremely Unlikely
47.06%	26.47%	23.53%	2.94%	0%

Q#3.3 How important is it that all patient information, from birth to death, covering consultations from all health sectors, including dentist records, optometrist records, allergy information, consent information, etc. is stored in one centralized place?

The following table shows the answer choices and the results.

Very Important	Important	Average	Slightly Important	Not Important
26.47%	20.59%	17.65%	8.82%	26.47%

SECTION FOUR: NEW ZEALAND AND ITS M-HEALTH FUTURE

Q#4.1 Which sector do you think mobile technology is going to benefit the most? The choices were: primary healthcare, secondary healthcare, community healthcare, none, and other.

The results include the following:

- 15X Community healthcare
- 6X All sectors
- 4X Secondary and Community
- 3X Other – patients
- 3X Primary health care
- 2X Primary and Community
- 1X Secondary health care

Q#4.2 How important is it for the NZ government to invest in further m-health research and investigate which m-health opportunities need to be deployed?

The following table shows the answer choices and the results.

Very Important	Important	Average	Slightly Important	Not Important
52.94%	38.24%	5.88%	0%	2.94%

Q#4.3 All hospitals have technology departments. Would you agree there is a strong demand for having an m-health analyst within these departments, so that the m-health opportunities can be identified?

The following table shows the answer choices and the results.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
17.65%	44.12%	32.35%	2.94%	2.94%

4.2 Interview Results

Interviews were an hour long and the sample of 18 health and technology strategists included:

- 4X CEOs
- 3X Project Managers
- 2X CIOs
- 2X DHB IT Managers
- 2X Health and Life Sciences Technology Strategists
- 2X Sector Leads
- 2X Technology Directors
- 1X Health Technology Account Manager

All interviews followed a strict agenda as below:

- The researcher introduction - his degree, the university, and the supervisor.
- Interviewee's profession, background, and organization.
- Project explanation including the research design.
- Brief explanation of ethical approval – how this project is a low risk, the transcript verification after the interview, and assurance that the respondents will not be identified in the thesis.
- Overview of how the interview is going to be conducted.
- Signing the consent form.
- Conducting the interview – this was organized into five themes:
 1. The role of mobile technology in New Zealand healthcare.
 2. Which health sectors are likely to benefit most from m-health.
 3. Customized mobile applications for health workers.
 4. The role of m-health to achieve integrated care.
 5. Privacy and security implications of m-health.
- Lastly an attempt to collect more interview samples using convenience sampling as described in section 3.3.

After conducting the interview, the researcher produced a transcript; during this process the electronic recorded interviews were very helpful. These transcripts were sent to the interviewees for verification. The overall process involved, of strict interview agendas, transcribing, and verifications were exhaustive, but this enabled the researcher to obtain credible data.

If all information in the transcripts were presented, it would make this section very lengthy. Additionally, the information would be repetitive as multiple interviewees might present similar opinions. Hence this section sorts non-repetitive information into themes. The following sub sections 4.2.1 to 4.2.5 present the interview results.

Note: The italic text in the sections 4.2.1 to 4.2.5 represents interviewee opinions – these are not word-for-word transcriptions, but they have been reconfirmed by the interviewees.

4.2.1 The Role of Mobile Technology in New Zealand Healthcare

The interview data establishes that m-health is a developing area in technology; all candidates interviewed were very optimistic about the m-health future in New Zealand. An assortment of m-health examples was given to back their arguments about m-health having a role to play in New Zealand. Examples given by the respondents are listed below:

- *M-health can enhance and improve healthcare delivery, mainly because of the way it can deliver information between the health parties; i.e. the primary, secondary, and community health sectors.*
- *M-health adoption can result in cost savings due to efficient information exchange and information capture.*
- *Community workers wouldn't have to visit the office as much, and the information would be made available where it's needed.*
- *Healthcare is shifting from traditional hospital-based service to a community-oriented service, as many clinicians are working offsite. Hence there is a huge need for information availability outside of the hospital.*
- *Patients can engage in their own monitoring. Health planners have admitted that without the use of mobile*

technology it would be harder to collect information from the patients.

- *M-health has the ability to draw delivery of healthcare closer to the patient, and as 90 per cent of healthcare takes place outside the hospital, m-health certainly has a role to play in the New Zealand healthcare system.*

- *Technology strategists state that the New Zealand health industry is on the verge of a huge expansion; mainly because most of the New Zealand population has mobile phones. They claim that this communication channel is not being used very much, and has a huge potential.*

When the researcher focused the discussion on New Zealand healthcare as compared with other advanced nations around the world, there was a variation of opinion among the sample. A group of the sample believed that New Zealand was the envy of the world, and others believed that New Zealand is not that advanced when compared to countries like the UK and the USA. Listed below are some key points expressed by the respondents in the interview.

- *Many New Zealand solutions are being used overseas.*

- *The National Health Index (NHI) number and the Health Practitioner Index (HPI) anchor systems of New Zealand are the envy of the world. These unique practitioner and patient references are important building blocks; New Zealand has these systems in place, making it very easy to leverage off these.*

- *New Zealand has an advantage of being small in size and having less population.*

- *There is more advancement overseas in using mobility or Internet Protocol (IP)-based technologies, as the cabling was done in the .com era and now that the infrastructure exists it makes it very easy to deploy new technology.*

- *SMS is being used in New Zealand; however, overseas (UK and USA) much more complex patient mobile applications do exist.*

- *New Zealand is not the leader in mobile health technologies and it is getting further and further behind compared to the rest of the world. Some of the reasons behind this are the broadband issues, expensive devices, and also that New Zealand is a public healthcare environment, so there are funding issues.*

- *The general level of New Zealand's web-based information systems is not that advanced.*

4.2.1.1 PDAs

Some of the sample compared PDAs with small laptops and argued about their small screens and keyboards, while others mentioned the benefits of using PDAs in a healthcare environment. Below are some of these pro and con opinions about PDAs.

- *In the hospitals the doctors are running around wards, the ability to access information then and there would be a huge advantage.*

- *The health workers need everything they need in their device or they will go back to paper-based health delivery. PDA's are not recommendable as a lot of health data involves lots of notes and text; an ideal alternate would be a small laptop. However, there might be opportunity for PDAs in areas where small tests are performed; e.g. diabetes checks.*

- *It is difficult phoning from a laptop, and health workers need a phone too.*

- *PDAs are delicate devices and some health environments require something more robust and bigger, for instance in a moving ambulance.*

- *PDAs are too small and fiddly for complex information.*

- *Laptops are much more practical, cost effective, and less problematic.*

- *Note taking can be reduced in PDAs by drop-down menus, but this will take time to familiarize, not suitable for every environment.*

- PDAs have connected and disconnected environments and are very useful for data capture. When there is no connectivity, the PDA operates in the disconnected environment and synchronizes upon entering a connected environment.

- PDAs can handle forms as the health data usually has a structure, so it actually makes data input easier.

- PDAs can minimize note-taking. Newer PDA devices are very easy to use as these often have full keyboards.

- Note taking is easier in laptops. Voice recognition data accuracy has improved over the past five years; this can assist mobile devices for note-taking functions.

- PDA screen sizes are not a barrier, but they do potentially drive and effect the software built; it is better to keep the software simple on the PDA. The point where the screen becomes too small is when it is 240 X 320 in size.

4.2.1.2 SMS

The benefits and limitations of SMS have been identified by the health and technology planners. Below are their comments.

- SMS is not being adopted by our hospitals because the existing infrastructure needs upgrades. Additionally, there is a funding issue as each message sent to mobiles would incur a cost.

- The other issues with such texting solution(s) is the maximum character limitation which means the message would need to be formatted to an extent where it fits into 160 characters.

- Not all of the population has a cellular phone, so there needs to be an alternate means of communication with the patients anyway.

- SMS is much cheaper than phone calls and mail, however it doesn't seem private enough to the health planners. The health planners also think that SMS is less secure, too basic, not content-rich, and is an entry level mechanism.

- *The hospital is now working on sending alerts to patients using SMS.*

- *A future opportunity can possibly involve diabetic patients texting in their blood sugar results; this will help hospitals to schedule an appointment with these patients when necessary.*

4.2.2 Which Health Sectors are Likely to Benefit Most from M-health?

This is the second theme. In this theme, the three health sectors and their m-health benefits are discussed. Table 4-1 shows the ranking of the sectors by m-health benefits.

Table 4-1: Health Sectors and M-Health Benefits

Health Sector	M-Health Benefits
Community	Most
Secondary	Significant
Primary	Least

The majority of the sample agreed that the community sector had the most benefits, followed by the secondary. They also said primary health care happens in a fixed environment; hence very few m-health opportunities exist. Some of the sample mentioned that m-health benefits are sector independent, as the patients across all sectors enjoy the most benefits. The following sections present the discussions of this theme by sector.

4.2.2.1 Community Healthcare

When the sample population was asked why they thought the community health sector had the most benefits, and which community healthcare situations would require m-health, they responded with the comments below.

- *Community health sector has the most mobile workers and these workers would benefit by adopting mobile technology.*

- *Community healthcare involves health services being delivered offsite, and mobility is often essential in such instances.*

- *Community workers and dental nurses could use PDAs to capture and access data.*

- *Home care visits are increasing; this is creating a need for health information to be available off-site.*

- *Mobile workers need a device to integrate with other organizations' information systems, and need the ability to access DHB systems remotely.*

- *PDAs can assist in the clinical work, and act as a means of communication, as well as recording notes, timesheets, allocation of work, etc.*

- *There are opportunities for having access to information while working off-site. We have used the 3G data-cards and found them to be absolutely hopeless. The main servers are located a distance away from the users (those willing to access information at server side) who experience delays in connecting to these servers as the Internet connections are limited.*

- *There are mass opportunities in the community sector. For example: scheduling, task management, task allocation, care planning, recording of activities performed, technology to support assessment (outcome recording), testing devices (measuring sugar levels, etc.), and a means of giving information to patients – Video demos, etc.*

- *Validated Outcome Instruments are relevant in a community setting; especially in post operative care situations*

where you can capture the outcome of interventions. Currently only surveys are being circulated which is very ad-hoc. It would be much better to have a structured outcome recording to make good management decisions.

4.2.2.2 Secondary Healthcare

The comments on m-health in secondary healthcare are listed below.

- *Our hospital has a strategy in place to enable a WiFi environment; an alternative under consideration is to have a cell phone tower at the hospital to enhance the 3G coverage.*
- *There are opportunities for RFIDs in big organizations where there are a large number of in-patients and out-patients.*
- *M-health can enable health workers to remotely order lab results and patient records at the point-of-care.*
- *Secondary health workers are often forgotten, as they do work outside their office.*
- *What is most beneficial in secondary health care is having access to EHRs on every bedside.*
- *Given example: Currently clinicians use digital certificates, how can we achieve this, by using a PDA or by using a laptop or by another device? How many devices do you need?*

4.2.2.3 Primary Healthcare

The comments on m-health in primary healthcare are listed below.

- *It is true that most primary care clinicians largely work within a fixed location; this is not an excuse to say there is no opportunity of m-health in primary care. For example: GPs who go and visit patients at home, or who do rest-home visits need to take their information with them, so there is opportunity in such cases for m-health.*
- *We have to distinguish between mobility of information and ability of a practitioner, and these are two separate ways to determine where exactly mobile technology is needed.*

4.2.2.4 Patients

Some of the interviewees said benefits of m-health are sector-independent. The respondents debated whether there would be more benefits to the patient related to any of the three providers, if the technology were to be deployed within community, secondary, or primary providers. Some of the examples included how secondary healthcare can use appointment reminders, how a device can monitor patients, and how patients can send their test results to primary care GPs. All of these examples bring benefits to the patients at the different provider levels.

4.2.3 Customized Mobile Applications for Health Workers

The third theme of the interview was to enquire about the opportunities and barriers of mobile based software. The implications of a small screen size and keyboard, and the necessity of a mobile application for health workers were also aspects of this enquiry. The comments of the interviewees show that these health planners were well aware of these customized mobile applications – hence they presented the positives, the negatives, and also expressed that the problem isn't always related to technology, but that usually it is the medical process that causes the barrier.

Below are some positive comments about mobile applications.

- The cell phone is the device which has the highest penetration; this device can be used to run customized mobile applications which can benefit patients or even the health workers.

- Patients will share their medical record with people who are involved in their care; patients may also want to reveal only a part of their medical record — in such conditions, mobile technology can be useful.

- *The number of devices that health staff use is increasing. To deliver effective clinical care we need to enable easier access to these devices.*

- *Customized software is useful, and can be very powerful if worked across the organization instead of being individual specific.*

- *A PDA is a multifunctional device. It might be used for a basic email, a text alert or a quick phone call, besides this, if there is a health application that might be useful to the health worker, then there is no reason why not to bundle this up in this device.*

- *Real time information entry is important as data on paper is only valuable for the eye!*

- *The clinical record is evolving, this means everything is moving to an electronic environment. Mobile device is good but an offline mobile device is a problem. However, these days most devices come with some form of connectivity. The health workers are aware of current technology and have demanding needs.*

- *Our DHB has a long history of customized applications; so far, there have been no failures. DHBs have lengthy business processes. These processes have clinical involvement, which may delay production, but produce good solutions.*

- *These applications would be ideal. XML web services will drive development of such customized applications.*

Below are some negative comments about mobile applications.

- *At the moment there is no vision for mobile applications; the health workers are using Virtual Private Networks (VPNs) for information access.*

- *A PDA cannot be used to fully assist a health worker throughout the day, as there are many limitations; one of which is the amount of text and notes that a health worker would enter and the PDAs generally tend to have small keyboards. A good alternative would be to use a small laptop.*

- *These applications are very costly to create.*

Below are some comments that reflect the participants' views on medical process barriers.

- There are opportunities in care protocol or care plan assistance or even management. The devices are not the problem, it is the process that is very hard to finalize.

- Rather than thinking there is a need for a mobile application, it is important to identify existing systems and processes. The next step would be to convert these to be enabled in the mobile world, using the best possible device; this could be a mobile phone, PDA, tablet, or thin client. The best strategy would be to primarily deal with processes, as there are many processes that are being transformed that shouldn't be.

- People are bored with the latest and greatest device, it is important to have the adequate clinical process to make it a value. Health industry is not like other businesses which have work flow issues that can be easily solved by a business analyst. This makes it slower to pick out the clinical processes which can potentially be mobilized.

- Not all hospital staff carry or own a mobile device; if their organization provides them with a mobile device, then it is likely that there will be a demand for mobile applications.

- Technology is the enabler - some of the questions that need to be answered before deploying applications on devices are:

- Can I read the screen?
- Is the keyboard big enough and usable?
- Can I use this device in sterile environments?
- What is the impact this is going to have on the existing processes?

4.2.4 The Role of M-health to Achieve Integrated Care

This is the fourth theme and the sample was questioned about 'the role of m-health to achieve integrated care'. In this section the results are being presented in the following three parts

4.2.4.1 Health Information Integration

4.2.4.2 Role of M-health in Integrated Care

4.2.4.3 Security Issues in Integrated Care

This theme was of particular interest to most of the sample, and some of the discussions went beyond the scope of this project, hence some of the comments are being omitted in this thesis.

4.2.4.1 Health Information Integration

In general, health information integration is a challenge. Centralized storage and federated storage were heavily debated.

- There are two models being explored by the health planners; these are the centralized model and the federated model. Centralized model is where everyone feeds information into this database with respect to an NHI number. Federated model is where every GP and every hospital has their own database, but they are all connected and they all allow each other certain permission levels. The trade-off in the federated model is that there needs to be a high level of ICT maintenance.

- NZ is very unique as everyone in the health industry wishes to share information, but there is unwillingness to actually do it.

- If there were only a few patient management systems in the DHBs then it would be easy to create a central repository of health event summaries. But there are lots of patient management systems. This is mainly because of the departmental and specialty specific requirements. So we have to assume that there will be multiple systems between specialties; for example, Orthopedic will have a different system compared to mental health. What needs to happen is to have one system or service in one area. That would considerably reduce the number of systems, and it would also give the smaller DHBs good systems. We are never going to get a small number of systems because of the complexity of the health environment. Assuming that this will carry on, we need to come up with a way of dealing with multiple systems.

- *It is better to go down the path of standardising things nationally, then you can introduce standards for integration to a virtual electronic record. This requires a lot of initiative from the centre which historically has not been the case. This encourages people to lead region-wide projects or introduce region-wide systems. Unfortunately the regions have to lead the way.*

4.2.4.2 Role of M-health and Integrated Care

In direct relation to m-health and integrated care, the respondents made the following comments.

- *Integrated care can be improved using mobile technology. There are many ways in which mobile technology can assist. For example: activity recording, structured, and outcome recording.*

- *The health industry, unlike other industries, relies heavily on information sharing; thus achieving integrated care is very important. There are two perspectives in information integration: access and exchange. In terms of information access, mobile technology can play a role. On the other hand, mobile technology has no role in driving integrated care, as integrated care involves server-based information exchanges.*

- *Mobile technology wouldn't be the enabler of integrated care. However the role of mobile in an integrated environment would be for example: a nurse having wider access to results across the region.*

- *The health data needs to be synchronized. This can be better achieved by keeping the data in an electronic format and avoiding data collection on paper. Dental nurses, mental workers, and district nurses, often collect the data on paper. These health workers can be equipped with a PDA to capture such data.*

- *All patient lab results can be forwarded to the secondary hospitals; this would contribute to achieving integrated care. Mobile technology can also help to enable delivery of patient health records.*

- *Integrated care can be better achieved by the use of m-health as more information can be recorded easily, and*

electronic data capture can increase the validity and usefulness of data.

4.2.4.3 Security Issues in Integrated Care

Integration of information often brings up the issues around security, ownership, and accuracy of data being shared. The comments below are in relation to the security issues and to barriers of integrated health information.

- *People have perceptions of privacy of their health information and who has access to it.*

- *Several categories of information exist when speaking of health data; i.e. there is information you can share, information you cannot share.*

- *Patient's consent needs to be received before sharing information; sometimes this is a barrier because it may involve several additional steps.*

- *Cost is a barrier; for example, why would a GP pay to obtain more information about the patient?*

4.2.5 Privacy and Security Implications of M-health

This was the last theme. Security of health information is extremely important; this is an area that could generate concerns before mobile technology is deployed. This theme concentrated on the privacy and security issues when dealing with health data, the properties of a device — being expensive and easy to lose — and the digital ability to increase security. The comments in relation to this theme are below.

- *There are certain security standards we have to adhere to regarding patients' information. However, the privacy of patients' information can be protected by establishing a central privacy code.*

- *Storing information on server side while using a Virtual Private Network (VPN) is much more secure than storing*

information on the client device, which could potentially be a mobile device.

- Security is a big issue, but also an issue that has been identified early in the sector. Health Information Standards Organization (HISO) is addressing privacy, security, and authentication frameworks. The security in a manual system doesn't perform very well anyway; at the same time, it is very easy to be criticizing electronic systems.

- The issue is mainly privacy rather than security. Security is needed to achieve privacy. You have to understand the true risk and the impact of that risk. Big risk is an unintentional breach of patient's privacy, that's why we need to make sure that the patient is feeling safe, and we should ensure that the patient will be prepared to share information.

- The tendency is to exaggerate the amount of security needed. It is one of the cornerstones of the relationship between the patient and his GP.

- Mobiles can secure information by data encryption; there are products that implement encryption to meet security needs and demands of healthcare. Mobiles are risky, as they are easy to lose. Some software expires unsynchronized data after a set time to secure information.

- Some of the mobile technology can enhance the security; on the other hand, mobile technology can bring new security challenges.

- There are a lot of mandatory requirements such as passwords, expiry dates, etc., in order to secure health systems. There is a regional privacy framework, which addresses security needs. This framework suggests the minimum security requirements that every system deployed must meet.

- It is all about protecting information of the patient. There are many strategies that could be introduced to deal with the security issues and prevent any danger to information. For example: password protection, data encryption, SD cards, or user card authentication.

4.2.6 Opportunities and Barriers

After discussing the five themes (4.2.1 to 4.2.5) with the interviewees, a last-minute opportunity was given to the respondents to mention any barriers and/or opportunities of m-health that exist from their perspective. Below is a list of these barriers and/or opportunities. Again, only the unique data is presented to avoid repetitiveness of information.

4.2.6.1 Barriers

The barriers can be divided into three areas: technology, patients, and planning.

Technology Barriers

- *Legacy systems*
- *Disparate systems*
- *Lack of standards*
- *Lack of integration tools*
- *Lack of bandwidth*
- *Infrastructure investments*
- *Competing products*
- *Expensive software development*
- *Software limitations*
- *Many DHBs are using old infrastructure (becomes a barrier when introducing new technologies)*
- *Telecommunication infrastructure unavailability*
- *Lack of technical capabilities*
- *PDA screen and keyboard size*
- *SMS can only contain a maximum of 160 characters*

Patient Barriers

- *Ill or chronically ill populations have lowest technology uptake*
- *Creating consciousness among patients*
- *Inability to share patient information*
- *Cultural barriers*
- *Patient inability to use mobile technology*
- *Patients might choose not to use mobile technology*

Planning Barriers

- *Competing priorities*
- *DHBs have no compelling force making them work together*
- *Patient models of m-health might not have that much money compared to DHB models*
- *Funding*
- *Lack of direction from the national level*
- *Caliber of resources*
- *Hard to determine where m-health is most useful*

4.2.6.2 Opportunities

The opportunities mentioned by the sample are:

- *Mobile can be used as an alternate means of communication*
- *Near patient technology (enables patients to conduct tests such as blood sugar level) and send the results to the health provider – an effective way to control diseases such as diabetes and tuberculosis)*
- *PDA's are getting better (thus overcoming the barriers of screen size and keyboards)*
- *Electronic data collection at point-of-care (PDA's can be used for this)*
- *Integrating community health worker information with the hospital systems*
- *Increase health worker mobility (allowing them to work from anywhere)*
- *Prescription feedback from patients*
- *Patient engagement in their healthcare plans*
- *Health alarms*
- *Home motion sensors*
- *Monitoring*
 - *Chronically-ill patient monitoring*
 - *Remote patient monitoring*
 - *Smart inhalers for asthma*
- *Reminders*
 - *Reducing DNA (Did Not Attend) rates*
 - *Medication reminders*
 - *Lifestyle reminders*
 - *Health campaigns*

Chapter 5

Findings and Discussion

The project involved exploring the opportunities and barriers for m-health in New Zealand. From the literature review (Chapter 2), we can learn that m-health involves using mobile technology in a health context. The research involved circulating questionnaires and conducting interviews with health and technology strategists. This chapter presents an analysis of these results by discussing the opportunities and barriers of m-health at patient, provider, and national levels. Additionally, this chapter looks at the issues in relation to m-health adoption.

Note: This chapter often refers to the results in Chapter 4. For example "see Chapter 4.1 q# 1.4" points to section 4.1 of the thesis and to the questionnaire result of question number 1.4.

5.1 Sample

The sampling strategy used convenience sampling which proved to be successful by attracting 18 interviewees and a total of 34 questionnaire responses. The accomplished target was to get input from health and technology strategists, and to maintain a variety of health sectors and technology suppliers.

The questionnaire sample included CEOs, CIOs, managing directors, academics, account managers, clinicians, health planners, project managers, IS managers, computer analysts, general practitioners, information contractors, IT consultants, development managers, nursing specialists, product managers, registrars, senior advisors, and strategists. The background of these people was from

the telecommunication industry, secondary, primary and community health sectors, education, NZ health IT strategists, contractors, DHB planners, and government departments. This satisfied the intention of gathering the thoughts of a wide range of health and technology strategists, and additionally, maintained a variety of planners from backgrounds of health, technology, academic and national planners. A majority of this sample were using mobile devices at their workplace (see Chapter 4.1 q# 1.4).

Some of these questionnaire samples helped recruit interviewees. The interview sample included CEOs, CIOs, project managers, DHB IT managers, health and life science technology strategists, sector leads, technology directors, and health technology account managers. 6 out of 18 interviewees were from technology backgrounds, and 9 out of 18 were from the health sectors; the remaining 3 were from the NZ health IT backgrounds which bridged the gap between technology and health sectors. The sample had a sound understanding of the New Zealand health industry and was previously involved in large scale health projects. This is shown by a questionnaire result (see Chapter 4.1 q# 2.14) in which 100 per cent of the sample knew about EHRs.

Once the premise of m-health as a beneficial direction was established, the interviewees were eager to discuss the difficulties and the benefits that they foresaw. The following sections present an in-depth analysis of the results, and outline the opportunities and barriers of m-health in New Zealand.

5.2 Opportunities of M-health

There was a wide range of perceived uses of mobile technologies by those interviewed, with many covering a range of m-health ideas that are presented in the literature review. The most obvious benefit of mobility is convenience, and mobile technologies offer the possibility of

'convenience medicine' more so than any other previous innovation. Instead of the patient receiving care where the medicine originates, much of the medicine will come to the patient wherever he or she is. This demand will be flamed by the fires of patient consumerism and expectation so that m-health truly forecasts a revolution in healthcare delivery. The following subsections present the opportunities of m-health at patient, provider, and national levels.

5.2.1 Patients

A frequently expressed view from the study was the perceived impact that mobile technologies would have on patient empowerment. The convenience aspect, patients' greater access to information, and easier communication with clinicians were all seen as triggers for patients to become more involved with and responsible for their own care.

M-health can significantly improve patient health services as patients are likely to accept and appreciate receiving health services on their mobile phones (see Chapter 4.1 q# 2.1). From a patient's perspective the opportunities of m-health which the research results point to are in the areas of text reminders and chronic disease management.

The results discover many successful uses of text reminders, especially for patients. One of these opportunities is to use text messaging to remind patients of their appointment times and drug top-ups (see Chapter 4.1 q# 2.3). The results indicate that 100 per cent of the sample agrees that these text reminders are bound to help patients reduce missed appointments. One of the interviewees admitted that their hospital and many others are looking into patient appointment reminders.

Discovering these opportunities for patient reminders is no big surprise; the literature section (2.4.2.2) of this thesis also looked at many successful m-health reminder applications worldwide. Text reminders prove to be very successful wherever deployed because they enhance health services in the patient populations, as they did in the study at Waitemata District Health Board [52], and generate cost-savings for the health-providers. The NHS (National Health Service) in England alone is predicted to save £240-370 million a year by introducing text-messaging reminders to patients [8].

Text messaging services could also boost the impact of public health and lifestyle messages within the context of preventative care if a suitable format or incentives could be found. A majority of the sample identified an opportunity to drive health awareness among the population by the use of mobile phones, informing the population about health issues like smoking, safe-sex, UV risks, obesity, etc. (see Chapter 4.1 q# 2.10, 2.11). This is already happening within New Zealand, as pointed out in the literature review in the number of studies including the successful randomized trial of a new smoking cessation service conducted by the University of Auckland [63] which involved using mobile phone text messaging. A DRUG identification service was launched in Auckland City [53], which enabled anyone to find information about suspicious or obvious drugs. A daily text service [54] was used to remind and educate asthmatic patients about using their inhaler.

Vital signs monitoring and the transmission of test results for patients with chronic conditions were recognized as increasingly important roles for mobile technologies; this is reflected in the questionnaire results (see Chapter 4.1 q# 2.4). Monitoring is identified to be most useful in chronic illness disease areas, to which 100 per cent of the questionnaire sample agrees that 'constant monitoring and support for diabetics' can be facilitated effectively by

means of mobile technology. Some of the interviewees also echoed this:

A future opportunity can possibly involve diabetic patients texting in their blood sugar results, this will help hospital schedule an appointment with these patients if necessary

The studies [29], [8], [23], [59] are using m-health to monitor patients, mainly the chronically ill. M-health technologies make patient monitoring easier as there is a buffet of choices; one could use Bluetooth glucose meters [29] to measure and transmit results or on the other hand, simply use the SMS technology to drive a monitoring m-health application. The Vodafone policy paper series [23] outlines the use of SMS for the control of tuberculosis. The diabetes control systems are shown in [8] used SMS which resulted in significant improvements of up to 10 per cent in glucose levels for younger people. This level of improvement is reducing complications such as blindness and kidney diseases.

At the patient level, we can say there are opportunities for m-health in the area of reminders such as for appointments, alerts for medication, or drug top-ups, etc. There are also opportunities to conduct health awareness campaigns and encourage preventive care. As the wide-spread adoption of cellular phones is significant, most of the population can be reached using this medium. Lastly, the patients can and are being monitored by the use of m-health technologies, particularly chronically-ill populations. The literature of this thesis supports these results.

5.2.2 Providers

The providers can benefit from m-health, and many opportunities exist for all health sectors. The key opportunity for providers is electronic data capturing at point-of-care which can be facilitated by mobile devices. The greater m-health opportunities are in the community

sector followed by secondary and primary sectors. M-health can enhance and improve healthcare delivery and has opportunities for providers mainly because it can bring treatment closer to the patient, and because of the way information can travel by the use of m-health between the three health sectors.

5.2.2.1 Community Healthcare

Information management in the community sector is a challenging task as there seem to be network coverage issues, paper-based recording processes, needs of allied health services, increasing home care, and many clinicians who are working offsite. Providers saw the use of mobile technologies to collect data in an electronic format as a major advance in increasing the utility of data and its value in both operational and strategic decision making. The questionnaire results favor the use of devices for rural nurses and community health workers; this is based on the 100 per cent agreement of the sample (see Chapter 4.1 q# 2.8). The interviewees have indicated the same, and no interviewees have posed a negative opinion about the need of devices for community workers.

Community workers wouldn't have to visit the office as much and the information would be made available where it's needed.

The community health sector has the most mobile workers, and these workers can benefit by adopting mobile technology.

Such comments from both the health and technology strategists supported the necessity of using mobile technology in community healthcare. The supply of home support workers is also forecast to be inadequate to meet demands [4], hence requiring the need for existing staff to be very efficient. Devices tend to decrease the amount of time taken for an intervention by having smarter layouts for capturing data, and by streamlining the process of paper-based data collection followed by an electronic data-entry procedure. Although devices have

been presented as an opportunity, many interviewees discussed the benefits and barriers of using devices. These barriers are discussed in section 5.3.

The benefits of using PDAs include assistance in clinical work, means of communication, electronic note-taking capabilities, timesheet recording, task allocation, etc. This is supported by the questionnaire result where 67 per cent of the sample agreed that dentists and optometrists can use PDA devices to record patient data at point-of-care to save time and improve service (see Chapter 4.1 q# 2.7). In ambulatory care, 100 per cent of the sample supported the idea of using GPS and PDAs to locate and care for patients in emergency care (see Chapter 4.1 q# 2.9). These data show that whenever there is need for health services out of office or at time of intervention, mobile devices are seen to be effective solutions. The notion of using mobile devices as Validated Outcome Instruments (VOI) was mentioned by one of the interviewees.

Validated Outcome Instruments are relevant in a community setting, especially in post operative care where you can capture the outcome of interventions. Currently only surveys are being circulated which is very ad-hoc. It would be much better to have a structured outcome recording to make good management decisions.

The comment above emphasizes the value of having data in an electronic format; this can be used in the decision making processes and to keep a better audit trail when compared to paper-based systems.

5.2.2.2 Secondary Healthcare

Secondary care providers were especially vocal about the value to them of mobile technologies used as vehicles for communicating with colleagues, particularly members of the care team, and obtaining access to clinical information. On a more mundane level, a hospital

had managed to reduce its missed appointments percentage from 18 to 9 per cent over the last two years, and was determined to exploit SMS to reduce this number even further. This corresponds with Hodgson's [52] study that found that messaging significantly reduced the number of missed hospital appointments although a further effect on patient behaviour — in respect to increasing self management — was not recognized by those interviewed.

The use of devices is not supported in the secondary healthcare sector as much as it is in community sector, but a significant percentage of the sample support the use of mobile devices in secondary healthcare. Of the sample population, 78 per cent agreed that hospital nurses could use mobile devices to manage beds, patients, and communicate better within their teams, and that this would lead to better health services (see Chapter 4.1 q# 2.13). The other areas where hospitals can adopt m-health are in areas of asset and specimen management, to which 75 per cent of the sample agreed in the questionnaire (see Chapter 4.1 q# 2.12). A successful use of RFIDs in a secondary healthcare setting to manage in-patients was shown in the study at Memorial hospital in Miramar [62].

These results indicate that in a secondary healthcare setting there are many ways for m-health technologies to be useful. One of these is in the construction of connected environments through the use of WiFi, 3G, or WiMax. The other uses include RFIDs to manage inpatients and outpatients. There is also need for mobile devices to enable point-of-care activity recording, ward management, bed management, and remote access to hospital systems.

Secondary health workers are often forgotten, as they do work outside their office.

The sample mentions that the amount of mobility required by the secondary healthcare workforce is increasing. Hence the health

planners have to utilize m-health to facilitate their staff's needs. The interviewees did not suggest any immediate plans to use RFIDs, but the hospitals are planning to create WLANs by the use of WiFi and 3G to enable intranet and Internet access for its staff. The study [19] presents the use of WiFi at a hospital and shows that this results in staff time savings. Additionally, the health planners are also looking at sending appointment reminders to patients by using SMS.

5.2.2.3 Primary Healthcare

There are many uses of m-health in primary care from a patient's perspective; these are discussed in the section 5.2.1. However, from a primary healthcare provider perspective, there seem to be very few opportunities.

It is true that most primary care clinicians largely work within a fixed location; this is not an excuse to say that there is no opportunity of m-health in primary care. For example, GPs who go and visit patients at home or who do rest-home visits need to take their information with them, so there is opportunity in such cases for m-health.

The GPs who would do homecare visits could benefit with similar m-health applications as the community healthcare workers. The next section discusses the opportunities of m-health in New Zealand, at a national level.

5.2.3 National

The opportunities of m-health are being recognized at a national level, 90 per cent of the questionnaire sample (see Chapter 4.1 q# 4.2) expressed the importance of investment by the New Zealand government in further m-health research in order to exploit m-health opportunities; additionally, 61 per cent of the questionnaire sample (see Chapter 4.1 q# 4.3) agreed it is important for hospitals to employ m-health analysts to explore the m-health opportunities.

One reason why the health and technology strategists think m-health is important is because they realize that without the use of mobile technology, it would get harder and harder to collect information from the patients. This opportunity is achievable as cellular phones have the highest penetration levels in New Zealand population. Additionally, there is an increasing demand for information to be available outside of hospitals. The comments from an interviewee below, echo this.

Healthcare is shifting from traditional, hospital-based service to a community-oriented service as many clinicians are working offsite. Hence, there is a huge need for information availability outside of the hospital.

There are also intentions of health planners to work towards an EHR. This electronic record is evolving, for this to work all means of health interventions need to be captured in an electronic format - this is another area in which mobile technology can be useful. The next section looks at integration of health information and the role of m-health to support integrated care.

5.2.3.1 Role of M-health in Integrated Care

We learn from the literature that EHRs make many contributions to improve health services [16]. EHRs can bring benefit to patients by empowering them, and on the other hand, clinicians can use these EHRs to study the patient effectively. When we speak of EHRs, the health information first needs to be integrated, and when talking about integrated care in New Zealand, two models are said to be heavily debated.

There are two models being explored by the health planners - these are the "centralized model" and the "federated model". Centralized model is where everyone feeds information in this database with respect to NHI number. Federated model is where every GP and every hospital has their own database but they are all connected and they all allow each other certain

permission levels. The trade-off in the federated model is that there needs to be a high level of ICT maintained.

The centralized model proposes that all patient information should be stored in one central place referenced to the patient NHI number. The alternative is the federated model which integrates parts of information to compile an electronic record per patient. There are many pros and cons of both models, and this investigation was beyond the scope of this project, hence was left unexplored.

The role of m-health toward integrated care is vital. To achieve integration, the key is to deal with electronic data; m-health can support clinicians to capture data electronically and provide access to data where necessary.

Integrated care can be better achieved by the use of m-health as more information can be recorded easily and electronic data capture increase the validity and usefulness of data.

The business processes of having server-server based interactions between health-organizations for data sharing are issues m-health cannot address. These issues need resolutions at a national level and m-health only needs to be used where necessary to assist with electronic data capturing and data accessing.

5.3 Barriers to M-Health

The potential benefits to m-health should not blind implementers to the inherent barriers and challenges. From a healthcare standpoint, first and foremost amongst these problems are concerns over the privacy and security of personal healthcare information [70]. Whilst these apprehensions are sometimes more perceived than real, the ethical issues surrounding the electronic storage and transmission of sensitive data and their misuse cannot be ignored. Wireless security protocols are improving rapidly, but often it seems only fast enough to

keep pace with the ingenuity of hackers and other intruders who wish to gain illegal access to information.

A further clinical, and perhaps more limiting, challenge to m-health is the acceptability of the technologies to both patients and healthcare practitioners. Consumer empowerment and convenience are likely to overcome patient concerns without too much resistance, but clinicians are rather more traditional when it comes to alternatives to face-to-face delivery of medicine [60].

Several concerns present themselves to clinicians; the potential for automating diagnosis and clinically-related decisions concerning treatment, the multidisciplinary nature of care which means that all members of the care team must accept the technologies if treatment is to be seamless and integrated, and the impact that the wireless and mobile devices and services may have on the doctor-patient relationship [60]. The involvement of commercial enterprises offering value-added services as mentioned above is an example of the last concern.

From a technology perspective, one aspect of m-health offers an interesting paradox. The acceptability of the mobile phone is based on the simplicity (although some phones are no simpler to use than video recorders!) and the convenience with which they perform their main function: voice communication by telephone. However, as the technology and power of the devices progresses, their expanded functionality exposes them as examples of a disruptive technology [71, 72].

A disruptive technology is one that, when introduced, does not meet the needs of users. Thus, a desktop personal computer or a laptop meets the computing needs of users in terms of modeling for example MS Office® applications, or Web searches, but mobile phones,

some of which are as powerful as a 1960s mainframe, cannot satisfy these requirements. The main limitation here is of course the form factor. The demands of portability have so far not been matched by a release from the tyranny of small screens and cramped keyboards. Similarly, the reliability of mobile devices and their fault-tolerance attributes do not meet the exacting requirements of the mission-critical applications found in healthcare. Even the item that makes the mobile phone portable – the battery – is a limitation. Computing technology doubles in power every 18 months or so; battery power has taken 30 years to achieve the same level of improvement.

The following sections discuss the barriers at patient, provider, and national level.

5.3.1 Patients

Though using mobile communication to interact with patients is a valuable opportunity, 72 per cent of the questionnaire sample agrees that delivering patient information on mobile phones will cause security and privacy issues (see Chapter 4.1 q# 2.2). Thus when creating m-health applications that involve delivery of patient information on cell phones, privacy needs must be identified, and necessary security measures should be addressed.

5.3.2 Providers

From a health provider perspective, the only m-health barriers are in the area of mobile devices, especially PDAs. The results show that mobile devices have many opportunities for usage in community and secondary health sectors (see sections 5.2.2.1 and 5.2.2.2), and these opportunities were identified by the health and technology strategists. On the other hand, the barriers for these devices are discussed extensively, mainly by the health planners, and to a lesser degree, by the technology strategists.

One of the main concerns of a health planner is that they want an all-in-one device. For example, even if they decide to use PDAs for community nurse operations, there would still be many daily activities which would require paper-work as the health industry is information-intensive, requiring substantial notes and text. Devices do not yet seem to be promising this all-in-one requirement to health planners, although the devices are improving in their note-taking and voice-recognition abilities.

PDAs are too small and fiddly for complex information.

The other health planner concern is the idea of such a device at all; this is backed by many reasons. The delicate build of these devices is not suitable in some health environments; for example, imagine using a PDA with a stylus in a moving ambulance. PDAs also have small screen sizes and keyboards which are not likely to suit all workers. The cost of the better PDAs is almost the same as a laptop. The health planners are also well-aware of the lack of standards in PDAs, its many operating systems, compatibility issues with mobile software, etc. - are some of the barriers they refer to.

Laptops are much more practical, cost effective and less problematic.

The idea of capturing information at point-of-care, and accessing information anywhere at any time is mouth-watering, and PDAs can support such m-health applications. However, the given reasons above keep health planners away from investing in PDAs.

5.3.3 National

The national level barriers for m-health are to be presented in this section. The three main barriers involve areas of text messaging, complex processes of health organizations, and security.

5.3.3.1 SMS

The literature presented many m-health applications which are using text messaging to enhance health services. However, there are a few barriers to text messaging which the interviewees raised. The health planners say that they are unable to use text messaging because of current state of their infrastructure, and funding issues.

SMS is not being adopted by our hospitals because the existing infrastructure needs upgrades. Additionally, there is a funding issue as each message sent to mobiles would incur a cost.

The other issues which complicate the usage of text messaging are its 160 character limitation per message, and despite the huge cell phone penetration, there is still a minority of the population without mobile phones thus an alternative needs to exist. SMS also lacks security control, and it is not a powerful tool. Having mentioned these limitations of SMS, they can also be looked at as huge advantages, as SMS is also a very simple, device, independent, and with no compatibility issues.

5.3.3.2 Processes

A key point in the discussions was the use of m-health applications in an appropriate manner. The strategists saw that necessary technology was available or could be made available by using m-health, but expressed frustration over the difficulty they face in dealing with the health processes. The majority of the sample felt that the main barrier, when dealing with introduction of new technologies, has nothing to do with the technology itself; instead, it is the actual process that it is going to have an impact on. The finalization of processes is usually a very difficult task, especially in the health environment, as it is information-intensive and involves many complex

processes. This is one of barriers that challenges diffusion of new technologies into the health eco system.

People are bored with the latest and greatest device; it is important to have the adequate clinical process to make it a value. The health industry is not like other businesses which have work flow issues that can be easily solved by a business analyst. This makes it slower to pick out the clinical processes which can potentially be mobilized.

5.3.3.3 Security Issues

Those who took part in the interviews were keen to separate the issues of privacy and security. Participants felt that security was not the main issue since its governing parameters were mainly operational and technical. Privacy of information and consent to its use or to treatment [70], however, were more conceptual and philosophical matters with strong ethical overtones.

The health industry has high information security needs, due to patient data; on the other hand, there is also demand for information sharing with different sectors. Though health and technology strategists exaggerate the amount of security required, the results do not indicate any huge barriers that would prevent deployment of mobile technology in the health industry as they equally agree that the necessary security standards can be easily met, and sometimes these security standards are actually enhanced by technology.

One of the ways that is repeatedly reported by the interviewees is to have health data reside on servers rather than on clients (these clients could well be mobile devices). The health planners do not necessarily think mobile technology is insecure, but they do mention it will bring new security challenges. On the other hand, the technology strategists state that mobile devices can encrypt data to increase security and store all information on the server; that is unless the mobile is operating in disconnected environments (when

communication to the external system is impossible). There is a nationwide security framework, and in most cases, these security standards need to be implemented; this is helpful when introducing new technologies in health space.

Interestingly, the privacy issue divided clinicians almost equally on the possibility of supporting Electronic Health Records (EHR) on mobile devices. Everyone saw the merit of maintaining the health records via mobile devices, but whilst some providers would alter the privacy requirements to make EHRs available, others said they were unlikely to become available until security improvements could guarantee privacy.

Objections to the transmission of information using m-health would probably diminish over time as the technologies matured and the benefits and convenience were seen to outweigh the risks, but privacy concerns were paramount, and m-health protagonists must incorporate them in the new ways of working.

5.4 Adoption

As frequently happens with the introduction and diffusion of new technologies, the benefits are driven partly by the needs of the domain and partly by the capabilities and opportunities offered by the technologies themselves [70]. Within the mobile environment there is also strong evidence that the external and internal organizational contexts impact on a user's satisfaction with mobile devices [73]. This section discusses the adoption of m-health from several perspectives, addressing the expected benefits, cost of adoption, reward elements, and contributing elements of *relative advantage* as a predictor of rates of innovation [74]. Adoption is discussed from both the social and technical perspectives, together with the issues arising from economic and organizational contexts.

5.4.1 Social Issues

The adoption of mobile technology has several implications beyond those identified in more familiar IT environments, although the need to balance the introduction of technology with the social needs of stakeholders remains. Reducing face-to-face interaction through the use of IT can impact on the social needs of people and lead to resistance to new technologies, even at a subconscious level. This is of concern where there is an adverse impact on those needs arising from rejection of the technology [75]. However, mobile phones are now an integral part of the social mainstream and are perceived as symbols of affluence and integration in many segments of society. This may reflect the status-conferring quality of innovation adoption described by Rogers [74], and prove to be a positive driver for m-health within certain socio-economic groups. This can have an advantageous impact on patient use for healthcare management as it removes the stigma that may arise from more obvious medical monitoring devices [76] and encourages regular and sustained use. Mobile devices have the advantage of being location independent, giving flexibility and mobility to the range of healthcare stakeholders [77, 78]. This also improves the ability of both patients and clinicians to access information with consequent advantages for constant monitoring of patients' conditions, interactive consultancy, remote/rural care, and fast emergency responses [77-79]. Mobile technologies also offer the possibility of managing non-critical care within the community thus reducing hospitalization, improving patients' quality of life, and controlling costs [80].

In contrast, mobiles are often seen as an interruptive technology that can increase workloads by the immediacy that they offer, creating the need for response in a synchronous timeframe [81]. In addition,

the intrusiveness of mobile phones in public spaces and private lives is influencing attitude changes towards user behavior.

A significant driver in healthcare is the ageing of populations in developed countries [82]. New Zealand, for example, is predicted to double its proportion of those over the age of 65 to 25 per cent of the total population by 2051. The longevity that results from the success of modern medicine increases individuals' demand for better standards of health over a longer period of time. Despite this, public health interventions and campaigns frequently report limited success and fail to raise personal awareness of preventative health management strategies through appropriate lifestyle and care. However, the pervasive nature of the mobile phone offers opportunities for targeted marketing of the health message and its reinforcement by repetition and with incentives [54]. The possibility of reducing the incidence of chronic disease through preventative education is a positive driver towards m-health initiatives.

These examples of the potential health benefits of applications represent two of the generic improvements, namely efficiency and effectiveness, that are sought from the introduction of new technologies. The third general benefit is increased access to services and resources; the pervasiveness of mobile technologies, particularly mobile phones, is set to have a major impact on how we think about the delivery of healthcare, and the relationship between provider and consumer [83]. Although it seems highly probable that the increased ease of communication between clinicians and patients will be beneficial to patient empowerment, it will also lead to higher workloads with more informational demands on healthcare providers [81, 84-86]. This will involve the development of new services, potentially managed by the involvement of intermediaries who can add value for all participants.

5.4.2 Technical Issues

Rapid communication contributes to efficiency of the service operation and to the ease of data collection and exchange. This ease, in turn, increases the value of data leading to improvements in their quality and longevity [15]. These advantages have particular importance in a country such as New Zealand that derives added-value from its national data collections. If data can be collected directly and effortlessly from people via their mobile phones, then with appropriate management and analysis, the derived information could have an enormous impact on the quality and efficiency of service planning and operation.

Although not solely a technical issue, from a healthcare standpoint, concerns over the privacy and security of personal healthcare information are often concentrated in technical discussions [70]. Whilst apprehensions over ethical issues surrounding the electronic storage and transmission of sensitive data, and their misuse, cannot be ignored, they are sometimes more perceived than real. Wireless security protocols are improving rapidly and compliance standards for both security and privacy are being developed in several countries along with effective biometric and cryptographic systems [87].

The matching of mobile devices to clinicians' needs is important if acceptance of the technology is to be widespread [87]. Similarly, the reliability of mobile devices and their fault-tolerance attributes do not meet the exacting requirements of the mission-critical applications found in healthcare.

Further technical issues that remain to be addressed before mobiles can become a ubiquitous part of healthcare include familiarity with the equipment and the applications. This will take education and training if it is to encompass all stakeholders regardless of demographic influences [87].

5.4.3 Economic Issues

A core value proposition of mobile technologies for healthcare is their apparent low cost. Certainly, unlike many medical innovations, the cost of mobile technologies to the consumer is very small, and their cost-effectiveness very high. There are the capital and operational costs of the supporting infrastructure, but such costs are shared over many markets, and the expansion of generic mobile services has produced dramatic falls in service costs; this is a trend that shows no signs of abating. Indeed, as the technologies become more powerful, the introduction of more innovative and seamless applications is anticipated to drive costs down even further. These effects will encourage enterprises with no previous presence in the health sector to offer value-added products and services.

There remain some concerns about the high cost of mobile connections in some countries that may effect the ability of some patients, particularly those suffering the economic hardships often associated with chronic diseases, to participate in m-health benefits [79]. This is particularly true in New Zealand with its small population and lack of competition in the telecommunications marketplace that gives rise to high call costs. Currently, this has led to a preference for the cheaper method of *texting* over voice calls, but has not greatly inhibited the sale of mobile phones.

5.4.4 Clinical and Organizational Issues

The health industry is complex, and sometimes to achieve organizational change there needs to be a shift in stakeholder power. Training of staff is going to incur costs, but might be worth it in the long run. Integration of information sources and records can be improved by data collection and data access over mobile devices. These need to demonstrate real savings [77].

A further clinical, and perhaps more limiting, challenge to m-health is the acceptability of the technologies to both patients and healthcare practitioners. Consumer empowerment and convenience may overcome patient concerns without too much resistance, but clinicians are rather more traditional when it comes to alternatives to face-to-face delivery of medicine [60]. Organizational change is required to accompany the development of mobile health technologies and the associated shift in stakeholder power that they will support. Acceptance and adoption by clinicians is seen as a primary success factor in the development of m-health [87], and will influence other practitioners to embrace initiatives in the delivery of healthcare services. This will require that all stakeholders identify the reward elements of the relative advantages of adoption [74].

An earlier study into m-health in Australia found that management problems were not addressed during implementation and the lack of an enterprise perspective gave rise to adhoc solutions [88]. As with many information system implementations, the lack of basic systems development planning led to security implications, no appreciation of cost benefit, and lack of appropriate information available from the systems. Although Gurujan et al [88] considered only the technical aspects and not the management or organizational aspects in their study of the implementation of m-health initiatives, they concluded that lack of management involvement led to short-term fixes that were not sustainable.

The challenge of management involvement and the requirement for organizational change is not a new one, with many businesses failing to appreciate the redesign that is needed to realize benefits from the Internet or other technology tools. Healthcare providers need to rethink their roles and make fundamental changes to behaviour, business models, and inefficiencies that tend to be traditional in the health sector [89].

5.5 Summary

This chapter discussed the opportunities and barriers of m-health at patient, provider, and national levels. Additionally, the issues regarding social, technical, economic, and organizational adoption are presented.

M-health has a role to play in New Zealand, mainly because of a wide range of possible uses in all sectors of healthcare, but these opportunities should not blind implementers to the inherent barriers and challenges. When thinking about using m-health at patient, provider, or national level, the adoption issues must not be overlooked.

Chapter 6

Conclusions

M-health involves the use of mobile technology to enhance health services, and *mobile technology* has a huge application domain; the mobile devices and the short- and long-distance networks consist of many features that can be applied to all health sectors and patients to achieve better healthcare.

The New Zealand health industry faces its own challenges and problems; some of these are: ageing populations, workforce shortages, increasing chronic illnesses, etc. The health planners feel the solution to these issues is firstly, to work smarter as opposed to working harder — to work smarter there is a need to have the right information, at the right time, at the right place — and secondly, to move healthcare out of the hospitals and clinics, and bring it closer to the patients. This is where mobile technology is most useful.

Although it is easy to say m-health is useful to drive the healthcare closer to patients and that it can carry the health information where necessary; it is also important to recognize that m-health is not just one solution, or that it has a best-fit framework defined. M-health contains a range of solutions driven by devices, or by short- and long-distance networks, to address specific healthcare applications. Thus it is essential to understand that each opportunity is independent of the other opportunity and that an opportunity might benefit one population more or less than another population.

6.1 Opportunities

The study participants painted an optimistic picture for the future and promise of m-health, and whilst this research was conducted in New Zealand, the implications and the results and conclusions can reasonably be extrapolated to most developed nations. Benefits and uses for mobile technologies were well-recognized, with all participants confident that m-health initiatives that contribute to improving the health sector will continue to be developed. Overall, acceptability and recognition of the advantages of m-health were strong.

One of the main areas heavily appreciated is the use of mobile technology in community care; the obvious reason is that community healthcare workers work offsite, and paper-based records are common to these workers. Mobile technology can facilitate data collection at point-of-care, which is very useful in community environments; this can also reduce the later effort undertaken by the health worker in converting the data on paper to an electronic format. There are two reasons why this opportunity is very important: firstly, m-health applications are becoming abundant for community healthcare type operations; and secondly, the health planners strongly believe that data in electronic format has very high value compared to data on paper. Electronic data allows health planners to make better decisions, and also gives them the flexibility to retrieve and analyze health information.

Other areas which are not specific to a healthcare sector, but a very big opportunity to the population, are the opportunities for reminders, alerts, and monitoring. These three can provide the ability for providers — secondary, community, or primary — to stay in touch with their patients. Reminders are useful as they can reduce the DNA rates, alerts can be used to inform patients with the most valuable information to them, and finally, monitoring will help connect the

patients and providers at times when the patient is not in the care environment. All three opportunities can be exploited by SMS, although SMS is not the only way to implement these opportunities.

The idea of creating health awareness in the New Zealand population is expressed both by the technology strategists and the health planners. As identified in the literature, the New Zealand population has a high concentration of mobiles; this invites the opportunity to use this medium as a tool to educate the population about health risks and well-being. Preventive care methods promote healthier living which in turn reduces health budgets and increases the quality of life for the population.

The health planners often mention that efficient healthcare delivery can be achieved by having the patient information integrated, either by holding patient information in a central database, or by having distributed data that is accessible where required. In relation to the role of mobile technology in integrated care, there is opportunity only with data capture and data access; the management aspect of data integration does not have any opportunity for m-health. The data access and capture are cornerstones for keeping information in electronic format, and mobile devices will have a huge role to play in these areas. Although the benefit of mobile devices in capturing or accessing health information is widely accepted, it is expressed by the health planners that implementing m-health solutions is not as difficult as it is to figure out the health business process requirements that need to be mobilized. The reason for this is that the health industry is not only data intensive, it also requires thorough process design as health processes generally involve a large number of stakeholders across the health ecology.

The study can conclude that there are many opportunities for m-health within the areas indicated above. The specific details of the

opportunities can be extracted depending on the sector and the population that is being targeted. For example, if you were to think about deploying an alerts application, an analysis would need to be conducted to determine which population is being targeted and what benefits the alert can bring to that particular population — and to the provider. Many m-health applications, both clinical and non-clinical, are presented in this thesis: prescription feedbacks, smoker support, ambulatory care, etc.

One of the key benefits of m-health is that it can empower patients, giving them more control over their healthcare plans. This can revolutionize the traditional healthcare models allowing patients to become more up-to-date with their health plans, and be better able to manage their diseases. This effect will move the healthcare closer to the patient. Another key benefit of m-health is that it can enable providers to connect with their patients; this will enable smarter decision making as the provider is informed about patients' health; for example, it will give clinicians the ability to determine when the patient should be called in for a checkup. Lastly, the other key benefit of m-health is that it can be used nationally as a new medium of healthcare delivery — whether this is to educate patients, or to connect patients to the health ecology.

6.2 Main Barriers

There are many ways to look at m-health barriers; for example, screen size issues in a PDA can be regarded as a barrier although it is just a device limitation. It is important however, to understand that these types of limitations have effects on specific problems, and just because one health planner finds a PDA screen to be too small, it does not mean that all health planners will have similar issues. It could well be true that small screen sizes would actually be preferred by other health

applications. In this section, the barriers (not limitations of mobile technology) to m-health on a generic basis are being described.

The main barriers of m-health identified by this study can be grouped into four different areas: technological, political, financial, and cultural.

From the technological perspective, the barriers include providers who do not have the latest infrastructures; this presents a struggle when installing the latest software releases, and therefore keeps providers away from exploring new technologies like m-health. Many health information systems currently being used in New Zealand are often disparate, and it is usually difficult to work with fundamentally different systems. Additionally, the health information servers are very busy, and lack of bandwidth is occasionally a barrier when planning to install bandwidth-intensive applications. The development of m-health applications is often very costly compared to the traditional desktop applications; this can be argued by saying the cost would depend on the application being developed, but generally speaking, m-health applications (such as mobile software) involve a lot of effort to cater for multiple devices, and often, using long distance technologies like SMS, include telecommunication carrier costs.

There are many political barriers which effect the development of m-health applications. Some of these are the result of a lack of standards being dictated in the health ecology. It is not unusual for a health planner to be in a position of leading his own initiatives and implementing them without the clear guidance of national standards (the mandatory requirements, security standards, etc.). The other political barrier involves complications related to privacy of patient information. Mobiles are often seen as less secure devices, and there could also be barriers to convincing the planners of the security of mobile devices and services. Although privacy poses a huge obstacle

in development of m-health applications, there are security features which are becoming available and being implemented on mobile devices which may satisfy the privacy requirements. For example, keeping devices synchronized with servers; this is so that no data resides on the device, and when there is no connectivity, that all data residing on the device is encrypted.

There is also a change management barrier, some of the factors such as changing planners, exhaustive projects, introduction of new technology, divided thoughts of planners about an idea, etc, cause frustration. One of these examples is of the different opinions on EHRs and their mobility across all sectors; The technology strategists think it is very important, but the health planners are divided.

Almost all health planners express their funding issues, wishing they had a budget to spend on new technology, but there are those who feel funding would not be a problem if there were cost-effective solutions. Lastly, there are cultural barriers involved; for instance, using a tablet in a high crime community or translation of languages over SMS.

6.3 Exploiting the Opportunities

The proliferation of m-health devices and technologies will continue (and is inevitable); as applications mature, we will learn more about what works well and what does not. The convenience factors and the ease of communication with m-health will empower patients, and when used appropriately, will improve both their capacity to remain well, and if they do become ill, their ability to recover quickly and to enjoy a greater quality of life.

A firm recommendation from this study is to not get carried away by the enchantment with technology or with the latest killer

applications, but to carry out considered and systematic research along with product and service development that extracts the principles of good practice and disseminates them to all who can deploy them.

6.4 Overcoming the Barriers

The barriers fortunately are not internal to the m-health space, but each m-health application will have limitations; for example, the 160 character maximum size message limitations in a text message — this should not be confused with or regarded as a *barrier*. The findings of this study recommend conducting systematic research prior to applying any m-health technology, during which time the technology limitations (like 160 character limit in SMS) can be identified and dealt with – possibly via a work-around solution, or by choosing some other mobile mechanism.

Apart from understanding the technology limitations, a detailed analysis of workflows and processes, plus considerable effort towards recognizing and alleviating social and organizational effects of change as they arise, is important prior to implementing any m-health application.

6.5 Future Research

Further research can be recommended in a few areas. Firstly, it would be worthwhile to launch an enquiry into chronic care disease management. It would be valuable to understand the common chronic illnesses in New Zealand, and to try to propose m-health applications that can empower patients and more tightly manage their diseases; all of which will lead to better care and cost savings.

The other area which can be explored is in the community sector; it is established from this research that there are significant opportunities in the area of community care. As an extension, one may wish to explore what these specific opportunities are, and how

efficiently m-health can be applied to them. Community care opportunities have a lot to do with electronic data capturing; it would be worth measuring the performance of PDA type devices; i.e. determining how good the stylus is and how accurate the current dictation tools are. Also, it would be wise to look at the mobile device based software and suggest implementation guidelines so that these applications can be multi-device and multi-mobile operating system compatible.

Mobile security seems to worry many health planners and is one of the mobile barriers everyone is aware of; having mentioned that, not everyone thinks of it as a barrier, but considers it to be something that can be easily resolved. This research shows that if the mobile device is working in a connected environment, the data can be stored on the server as opposed to the mobile device. So if the device is lost, there is only financial loss, but the data remains protected. However, when the device is in a disconnected environment, the data is kept in an encrypted format on the device; this ensures the data-privacy is maintained. It would be very valuable to investigate the efficiencies and limitations of such processes. Another aspect of mobile security is authentication; it is a challenge to validate the owner of the mobile phone, usually with *banking*, a security code suffices, but with healthcare, biometric security might be worth investigating.

Lastly, this research project recommends measuring the successes of health awareness campaigns, as this area has the fewest political barriers and security issues. It would be valuable to know if these campaigns are successful, and if so, by how much.

Appendix A

Invitation Letter for Participating Organizations

Below is the invitation letter in its original format.



Institute of Information and
Mathematical Sciences
Massey University
Auckland, Albany
Private Bag 102 904

PARTICIPANT INFORMATION SHEET

<name>
Chief Executive
<organisation name>
<address>

Dear <name>

Re: Research Project: Barriers and Opportunities of Mobile Health.

My name is Farhaan Mirza. I am a student at Massey University, Auckland studying Master of Software Engineering degree. I am conducting research for the above-named thesis.

Mobile Technology in health organisations is increasingly being adopted world wide. Many countries, for example, the UK and the USA are looking at the opportunities for using mobile technology in healthcare. There are approximately 3.5million mobile subscribers in New Zealand and there is evidently considerable potential for the use of mobile technology in the health sectors. The present research is directed to indentifying the opportunitis and barriers for mobile healthcare in New Zealand.

I am aiming to conduct interviews with health industry professionals in Primary, Secondary and Community health sectors and with solution providers. I would like to invite staff from <organisation name> to participate in my research and I would appreciate any assistance you can offer me. The research will be divided into two parts:

- a) Case studies in organisations;
- b) Questionnaire.

Should you agree to participation in this research by members of your staff, the next step would be to distribute, via your internal email system, a request to participate for your staff members. A sample of this request is attached. Participants can be involved by being interviewed for a case study, or answer a questionnaire, or any combination of the two. Interviews will be limited to one hour each and will be arranged at a time and place convenient to the individual being interviewed. The questionnaire would take thirty minutes to answer.

There is no obligation for your organisation to participate at all. If you do agree to organisational participation, there will be no obligation for any individual staff member in your organisation to participate. All identifiable information regarding your organisation and participating staff members will be held in strictest confidence, and no identifiable information will be published. You may withdraw your consent to participate at any time without giving a reason up until 31 December 2006. All identifiable data will be destroyed on completion of the thesis, and will be stored securely until it is destroyed.

I would be pleased to provide <organisation name> with a copy of the final results of the research at no cost if you so desire.

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more please phone me on [REDACTED] or write to me at :

Farhaan Mirza

c/o Professor Tony Norris
 Institute of Information and Mathematical Sciences
 Massey University Auckland, Albany
 Private Bag 102 904
 North Shore Mail Centre, Auckland
 [REDACTED]

My supervisor is :

Professor Tony Norris
 Institute of Information and Mathematical Sciences
 Massey University Auckland, Albany
 Private Bag 102 904
 North Shore Mail Centre, Auckland
 Tel. 09 4140800 extn. 9319

The Head of Department is:

Professor Robert McKibbin
 Institute of Information and Mathematical Sciences
 Massey University Albany, Auckland
 Private Bag 102 904
 North Shore Mail Centre, Auckland.
 Tel. 09 4140800 extn 41040

Note: This project has been evaluated by peer review and judged to be a low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher named above is responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher, please contact Professor Sylvia Rumball, Assistant to the Vice-Chancellor (Ethics & Equity), telephone 06 350 5249, email: humanethicspn@massey.ac.nz

Appendix B

Invitation Letter for Participating Individuals

Below is the invitation letter in its original format.



Massey University

**Institute of Information and
Mathematical Sciences
Massey University
Auckland, Albany
Private Bag 102 904**

PARTICIPANT INFORMATION SHEET

Re: Research Project: Barriers and Opportunities of Mobile Health.

My name is Farhaan Mirza. I am a student at Massey University, Auckland studying for a Master of Software Engineering degree. I am conducting research for the above-named thesis.

Mobile Technology in health organisations is increasingly being adopted world wide. Many countries, for example, the UK and the USA are looking at the opportunities for using mobile technology in healthcare. There are approximately 3.5million mobile subscribers in New Zealand and there is evidently considerable potential for the use of mobile technology in the health sectors. The present research is directed to indentifying the opportunitites and barriers for mobile healthcare in New Zealand.

You are invited to participate in my research and I would appreciate any assistance you can offer me. There is absolutely no obligation to participate and all information will be held in the strictest confidence. The Chief Executive, <name of CEO> has given approval for staff of <organisation name> to participate. If you do consent to participate, you may withdraw from the research project at any time without giving a reason up until 31 Dec 2006. All identifiable data will be destroyed on completion of the thesis, and will be stored securely until it is destroyed.

The research will be divided into two parts:

a) Case studies

Your participation would involve a one-on-one interview. Interviews would take about an hour, and be conducted during your own convenience. I would prefer to audio tape the interview but this would only be done with your consent and could be turned off at any time or you can withdraw information any time up to 31 December 2006.

b) Questionnaire.

Depending on the interview, I may like to send you out a short questionnaire with some supplementary questions. It is expected that this questionnaire would take around 30 minutes to complete.

If you are interested in participating in any or all of the above, please let me know by filling in the attached Consent Form and sending it to me at the address given. If you prefer, this can be done by email. All information you provide is confidential and your name will not be used. All participants will be sent an email copy of the results of the research if they so desire.

I would be pleased to provide you with a copy of the final results of the research at no cost if you so desire.

I would be grateful if you could indicate approval for your participation by filling in the attached consent form and sending it to me at the above address.

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more please phone me on [REDACTED] or write to me at :

Farhaan Mirza

c/o Professor Tony Norris
Institute of Information and Mathematical Sciences
Massey University Auckland, Albany
Private Bag 102 904
North Shore Mail Centre, Auckland
[REDACTED]

My supervisor is :

Professor Tony Norris

Institute of Information and Mathematical Sciences
Massey University Auckland, Albany
Private Bag 102 904
North Shore Mail Centre, Auckland
Tel. 09 4140800 extn. 9319

The Head of Department is:

Professor Robert McKibbin

Institute of Information and Mathematical Sciences
Massey University Albany, Auckland
Private Bag 102 904
North Shore Mail Centre, Auckland.
Tel. 09 4140800 extn 41040

Note: This project has been evaluated by peer review and judged to be a low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher named above is responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher, please contact Professor Sylvia Rumball, Assistant to the Vice-Chancellor (Ethics & Equity), telephone 06 350 5249, email: humanethicspn@massey.ac.nz

Appendix C

Consent Letter for Participant

Below is the consent letter in its original format.



**Institute of Information and
Mathematical Sciences
Massey University
Auckland, Albany
Private Bag 102 904**

INDIVIDUAL CONSENT FORM

THIS CONSENT FORM WILL BE HELD FOR A PERIOD OF SIX YEARS

Title: Research Project: Barriers and Opportunities of Mobile Health

Researcher: Farhaan Mirza

To: Participant

I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered.

I understand that I may withdraw myself or any information traceable to me at any time up to 31 December 2006 without giving a reason, that identifiable data will be destroyed on completion of the thesis, and will be stored securely until it is destroyed.

I agree to take part in this research programme.

I agree to (tick all that apply)

- Interview for case studies. I agree that the interview may be audio taped¹ (YES/NO)
- Complete a questionnaire after the interview.
- I would like to receive a copy of the results of the research. (tick if applicable)

Signed:**Name:**

(please print clearly)

Title:**Email address:**

(confirmation of participation will be emailed)

Date: ____/____/____

¹ Transcripts will be made from the taped information by the researcher. Draft transcripts will be circulated to participants. Participants will be given the opportunity to withdraw any comments from the transcripts. Tapes will be erased once final transcripts are agreed.

Note: This project has been evaluated by peer review and judged to be a low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher named above is responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher, please contact Professor Sylvia Rumball, Assistant to the Vice-Chancellor (Ethics & Equity), telephone 06 350 5249, email: humanethicspn@massey.ac.nz

Appendix D

Questionnaire

Below is the Questionnaire in its original format.



Massey University

SHORT SURVEY ON MOBILE HEALTH

Project: Barriers and Opportunities for Mobile Health

By: **Farhaan Mirza**
 Massey University 2006
 Supervisor: Professor Tony Norris

Overview: The world total of mobile phones currently stands at 2 billion and is set to increase by a further 600 million by 2010. New Zealand has approximately 3.5 million mobile subscribers and this country, along with many others, recognises the opportunities for using mobile technology in healthcare. The present research is directed to identifying the opportunities and barriers for mobile health in New Zealand. This survey is expected to take less than ten minutes of your time and the results will contribute valuable data to the project. Please leave your contact details if you would like to receive an executive summary of the project findings. For more information about this project, please visit the project website at: <http://www.farhaan.co.nz/mastersproject>.

Many thanks for your interest and help.

SECTION ONE: GETTING TO KNOW YOU

What is your occupation or job title _____

Which one of these health sectors do you work in?

<input type="checkbox"/> Primary Health Care	<input type="checkbox"/> Secondary Health Care	<input type="checkbox"/> Community Health Care	<input type="checkbox"/> Other, Please specify below _____
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Which of the following descriptions describes your involvement with mobile technology? You may tick more than one.

<input type="checkbox"/> Technology end user	<input type="checkbox"/> Technology evaluator	<input type="checkbox"/> Technology strategist
--	---	--

Comments: _____

Are you currently using a PDA or any other mobile device at your work place?

<input type="checkbox"/> Yes	<input type="checkbox"/> No
------------------------------	-----------------------------

SECTION TWO: DELIVERING HEALTH SERVICES

Do you think that patients would appreciate receiving health services on their mobile phones?

<input type="checkbox"/> Extremely Likely	<input type="checkbox"/> Likely	<input type="checkbox"/> Not Sure	<input type="checkbox"/> Unlikely	<input type="checkbox"/> Extremely Unlikely
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Do you think delivering patient information on mobile phones will cause security or privacy issues?

<input type="checkbox"/> Extremely Likely	<input type="checkbox"/> Likely	<input type="checkbox"/> Not Sure	<input type="checkbox"/> Unlikely	<input type="checkbox"/> Extremely Unlikely
---	---------------------------------	-----------------------------------	-----------------------------------	---

Alerts can be sent to patients regarding their appointments, drug top-ups etc. Do you think such alerts can enhance the health services provided to patients?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
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Do you feel that patients' general health can be monitored or supported by 'texting' messages (sending and receiving SMS)?

<input type="checkbox"/> Extremely Likely	<input type="checkbox"/> Likely	<input type="checkbox"/> Not Sure	<input type="checkbox"/> Unlikely	<input type="checkbox"/> Extremely Unlikely
---	---------------------------------	-----------------------------------	-----------------------------------	---

Do you agree that SMS reminders could help patients reduce missed appointments?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

There are many chronic diseases that need constant monitoring and support such as diabetes. Would you agree that patients with such conditions can be better monitored and supported using mobile technology?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

Dentists and optometrists can use PDA devices to record patient data while treating them, this can save large amounts of time and help improve health services. Do you agree?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

Rural nurses and community health workers can be equipped with PDAs to record patient data and enhance the services they provide. Do you agree?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

Ambulances can be installed with GPS and PDAs to locate destination sites and enter patient data and so provide better emergency care. Do you agree?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

Do you think that mobile phones offer an opportunity to run health-aware campaigns on issues such as quit-smoking, safe sex, UV risks and obesity?

<input type="checkbox"/> Very Important	<input type="checkbox"/> Important	<input type="checkbox"/> Average	<input type="checkbox"/> Slightly Important	<input type="checkbox"/> Not Important
---	------------------------------------	----------------------------------	---	--

Do you think preventive care can be promoted using mobile technology?

<input type="checkbox"/> Extremely Likely	<input type="checkbox"/> Likely	<input type="checkbox"/> Not Sure	<input type="checkbox"/> Unlikely	<input type="checkbox"/> Extremely Unlikely
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Hospitals can use radio frequency identification (RFID) tags to manage assets and specimens. Do you think this feature will enhance health services?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

Nurses in the hospital can use mobile devices to manage beds, patients, and communicate better with their teams. Will such communication lead to better services?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

Do you know what "Electronic Health Records" or "EHRs" are?

<input type="checkbox"/> Yes (Please complete the remainder of section two)	<input type="checkbox"/> No (Skip the questions below and answer questions from Section three)
---	--

Do you think EHRs should be made available on mobile devices across all health sectors?

<input type="checkbox"/> Yes	<input type="checkbox"/> No
------------------------------	-----------------------------

Do you think having EHRs on a mobile device would cause security concerns?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

Do you think patients should be provided with limited access to view their own EHR?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

SECTION THREE: INTEGRATED CARE

Do you believe that integrated care can be better achieved using mobile technology?

<input type="checkbox"/> Extremely Likely	<input type="checkbox"/> Likely	<input type="checkbox"/> Not Sure	<input type="checkbox"/> Unlikely	<input type="checkbox"/> Extremely Unlikely
---	---------------------------------	-----------------------------------	-----------------------------------	---

Consents and allergy information will be more useful if shared between health sectors (primary, secondary and community). Can this goal be achieved via mobile technology?

<input type="checkbox"/> Extremely Likely	<input type="checkbox"/> Likely	<input type="checkbox"/> Not Sure	<input type="checkbox"/> Unlikely	<input type="checkbox"/> Extremely Unlikely
---	---------------------------------	-----------------------------------	-----------------------------------	---

How important is it that all patient information, from birth to death, covering consultations from all health sectors, including dentist records, optometrist records, allergy information, consent information etc. is stored in one centralised place?

<input type="checkbox"/> Very Important	<input type="checkbox"/> Important	<input type="checkbox"/> Average	<input type="checkbox"/> Slightly Important	<input type="checkbox"/> Not Important
---	------------------------------------	----------------------------------	---	--

SECTION FOUR: NEW ZEALAND AND ITS M-HEALTH FUTURE

Which sector do you think that mobile technology is going to benefit the most?

<input type="checkbox"/> Primary Health Care	<input type="checkbox"/> Secondary Health Care	<input type="checkbox"/> Community Health Care	<input type="checkbox"/> None	<input type="checkbox"/> Other Sectors, Please Specify: _____
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How important is it for the NZ government to invest in further m-health research and investigate which m-health opportunities need to be deployed?

<input type="checkbox"/> Very Important	<input type="checkbox"/> Important	<input type="checkbox"/> Average	<input type="checkbox"/> Slightly Important	<input type="checkbox"/> Not Important
---	------------------------------------	----------------------------------	---	--

All hospitals have technology departments. Would you agree that there is a strong demand for having an m-health analyst within these departments, so that the m-health opportunities can be identified?

<input type="checkbox"/> Strongly Agree	<input type="checkbox"/> Agree	<input type="checkbox"/> Neutral	<input type="checkbox"/> Disagree	<input type="checkbox"/> Strongly Disagree
---	--------------------------------	----------------------------------	-----------------------------------	--

SECTION FIVE: FUTURE CONTACT

- I would like to receive an executive summary of the project results.

Please provide your email or postal address below to receive the executive summary

Name:	
Email:	
Postal Address:	<hr/> <hr/>

- I would like to participate further in this project and I am contactable if the student wishes to consult for research purposes.

Additional Comments:

Thanks so much for your time, your survey scores will be held in strictest confidence, and no identifiable information will be published. If you have any queries or wish to know more please phone me on [REDACTED] or email me on [REDACTED] or write to me at:

Farhaan Mirza
 c/o Professor Tony Norris
 Institute of Information and Mathematical Sciences
 Massey University Auckland, Albany
 Private Bag 102 904
 North Shore Mail Centre, Auckland

Note: This project has been evaluated by the University's Human Ethics Committee and judged to be of low risk. The researcher named above is responsible for the ethical conduct of this research.

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