Potential of Mobile Devices

in

New Zealand Healthcare

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. It contains results of my investigation, except where otherwise stated. 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.

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Abstract

This thesis examines the potential for the use of mobile devices in New Zealand healthcare. Adoption of mobile technology can potentially improve information access at point of care, increase efficiency and patient safety, significantly reduce costs, enhance workflow, and promote evidence-based practice to help make effective decisions.

Mobile devices of different size and form such as laptops, tablet PCs, PDAs, smart phones, mobile phones, and RFID offer portability, remote access to clinical data, traceability, convergence, and connectivity which traditional computers cannot emulate.

The pervasiveness of mobile devices is increasing both globally and within New Zealand. The potential of mobile technology in healthcare has been recognized by many developed countries; there is adequate evidence for improving productivity, efficiency, and patient engagement.

The study focuses on the three prominent healthcare sectors in New Zealand: Primary, Secondary, and Community. As mobile technology is still an underdeveloped area within New Zealand's healthcare industry, the use of a qualitative research approach involving surveys and interviews helps to determine which m-health applications are most appropriate to adopt here. The sample surveyed consists of health providers, health strategists, and technology vendors.

The potential of mobile devices that were identified from the interviews included real-time access to information such as clinical data, drug database, and medical references. the use of SMS reminders and alerts, use of RFID to reduce medical errors, manage patients and assets, and for identification of medical equipment and drug identification. Over 80 percent of the participants considered privacy, confidentiality, and security to be very important challenges in the m-health domain. Many challenges and implications were identified, including technical constraints such as form factor of mobile devices, storage space, limited battery life, durability, and reading distance of RFID devices. Privacy, security, and ethical issues were discussed including the sensitivity of personal data, sending and receiving of clinical data, RFID tracking ability, security, and encryption standards, authentication barriers, and cultural barriers.

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Asfahaanullah Baig Mirza, 2008

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Table of Abbreviations

A&E	Accident And Emergency
AIDC	Automatic Identification and Data Capture
CDMA	Code Division Multiple Access
CEO	Chief Executive Officer
CGMH	Chang-Gung Memorial Hospital
CIO	Chief Information Officer
CPT	Current Procedural Terminology
DHB	District Health Board
EHR	Electronic Health Record
ENT	Ear Nose Throat
EPOC	Electronic Piece Of Cheese
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPs	General Practitioners
GSM	Global System for Mobile Communications
HF	High Frequency
HIS	Health Information Strategy
HIS-NZ	Health Information Strategy for New Zealand
HP	Hewlett Packard Taiwan
HTML	HyperText Markup Language
ICU	Intensive Care Unit
IM	Instant Messenger
IOM	Institute Of Medicine
ISM	Industrial Scientific Medical

IT	Information Technology
LAN	Local Area Network
LF	Low Frequency
M-collaboration	Mobile Collaboration
M-commerce	Mobile Commerce
M-communication	Mobile Communication
M-computing	Mobile Computing
M-Health	Mobile Health
MICT	Mobile Information Communication Technology
MoH	Ministry of Health
MUHEC	Massey University Human Ethics Committee
OR	Operating Room
PC	Personal Computer
PDA	Personal Digital Assistant
PDC	Precision Dynamics Corporation
PHCS	Primary Healthcare Strategy
PHO	Primary Health Organization
PMS	Patient Management System
RFID	Radio Frequency Identification
RSD	Reflex Sympathetic Dystrophy
SMS	Short Messaging Service
SOP	Standard Operating Procedures
UHF	Ultra High Frequency
VPN	Virtual Private Network
WAP	Wireless Application Protocol
WCDMA	Wideband Code Division Multiple Access

WHO	World Healthcare Organization
Wi-Fi	Wireless Fidelity
WML	Wireless Markup Language
WWW	World Wide Web

Chapter 1: Introduction

1.1 The ubiquity of mobile devices

Mobile devices have been in development from the 1900s; the first mobile phone, marketed by Motorola, emerged into the commercial market in 1983 [1]. In the last decade, there has been significant development in security, battery capacity, storage, and connectivity of mobile devices that allows the potential of information systems to extend both information access and collaboration beyond the normal limitations imposed by a specific site [2]. These developments remove the constraint of fixed locations and allow information and service users to interact with convenience and flexibility.

Today, mobile devices are being utilized in many aspects of private life and communal services due to their qualities of portability, convergence, storage, connectivity, and communication that traditional personal computers (PCs) cannot emulate [3]. Examples include handheld devices such as mobile phones, personal digital assistants (PDAs), pagers, tablet PCs, laptops, and other devices such as radio frequency identifiers (RFIDs).

According to recent statistics by Informa (a statistics company), at the end of 2006, there were approximately 2.7 billion mobile phone subscriptions globally, and it was expected that the figure would exceed three billion subscribers by the end of 2007; this would be due to the rapid adoption of mobile phones around the world [4]. The pervasiveness of mobile devices is evident from the numbers of more than 3.8 million mobile phone subscriptions in New Zealand, a country with a total population of 4.1 million [5]. The figure clearly suggests there are many users with multiple subscriptions. Penetration of mobile devices is increasing globally; this is echoed by the Wireless World Forum which mentions that of New Zealand's population, 82 percent own one or more mobile phone contracts; this makes the New Zealand population one of the highest adopters of mobile devices in the world [6].

Most of the mobile devices investigated in this study are commonly referred to as handheld devices, but not all of the mobile devices fall into the same category as they vary in their specifications and functionalities (e.g. Radio Frequency Identification [RFID]). Scott Weiss [7] describes handheld devices as extremely portable, self-contained information management and communication devices (e.g. mobile phones, pagers and PDAs).

The ubiquity of mobile devices implies that they will find applications in many fields of life such as education, commerce, and health. This study endeavours to explore the potential of mobile devices and their use in New Zealand healthcare.

1.2 Mobile devices and healthcare

Healthcare has always been a mobile profession, and the rapid advance of mobile devices and adoption of mobile phones in New Zealand opens up immense potential for the application of these devices in New Zealand healthcare. By utilizing new, innovative mobile devices and high-speed wireless protocols, it is possible to achieve mobile health (m-health); i.e. to provide healthcare where it is needed.

Mobile information communication technology (MICT), which consists of using mobile devices to communicate, is said to constitute an unprecedented revolution in healthcare [8, 9]. Worldwide today, many mobile devices are being used extensively with beneficial outcomes; this has encouraged mobile devices to be applied in the healthcare sector. Devices such as mobile phones, PDAs, tablet PCs, laptops, and RFIDs, are evolving rapidly, incorporating greater functionalities, and increasing the possibilities to improve healthcare.

Mobile phones are being widely used for communicating with patients regarding their reminders, lab results, and monitoring [10]. PDAs, tablet PCs and laptops are powerful, portable, and wireless, enabling professional assistance to be brought directly to the patient's bedside [11]. Pilot studies have also identified many potential benefits with the use of these devices [8]. RFID technology is significantly being used in all health sectors for monitoring the location of patients and medical hardware [12].

One of the main issues discussed in the World Healthcare Organization (WHO), Europe, and America is patient safety [13]. Use of mobile technology can help to reduce medical errors, one of the primary drivers to enhancing patient safety. New Zealand can learn from m-health adopters that mobile technology can be used to reduce the pressure to provide additional healthcare for New Zealand citizens.

Many developed nations such as NZ, the UK, and the USA, commonly agree that demand for healthcare services continues to rise, and it is increasingly difficult for them to deliver healthcare to their citizens [14, 15]. People are becoming more health-conscious, well informed, and are living longer. There is also an increase in the aged population that historically are heavy users of healthcare services.

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Several studies reveal that New Zealand faces significant pressure to provide additional and improved healthcare to its citizens due to the increasing elderly population, rising incidences of chronic diseases, re-emergence of old diseases, new infectious diseases, diversity of communities, and the increasing cost of new medical technology-based treatments [14-16].

1.3 Scope of present research

The scope of this present research is to explore the potential of mobile devices in New Zealand healthcare. Mobile devices being analysed in this study are of different size and form: mobile phones, PDAs, tablet PCs, laptops and RFIDs. This thesis will investigate the three prominent healthcare sectors in New Zealand: Primary, Secondary, and Community. The National Ministry of Health (MOH) and the Accident Compensation Corporation (ACC) healthcare sectors will not be emphasised in this study.

1.4 Research objective and questions

The main objective of this research is to discover the potential of mobile devices in New Zealand healthcare by studying, analyzing, and evaluating different types of mobile devices, and learning how their capabilities be used to improve healthcare for New Zealand citizens. More specifically, this objective resolves into the following research questions:

- *Which health sector will mobile devices benefit the most?* Many potential sectors can benefit, but the community health sector is seen as being the most receptive to the introduction of mobile devices, as mobility is essential to providing healthcare services to a rural community.

- *What are the key clinical and non-clinical mobile device applications?* Clinical applications clearly attract major interest, but many advantages can result from reengineering non-clinical processes and making them seamless.

- *What are the critical success factors which enable us to build new applications?* New applications need to be built based on critical success factors to get the maximum benefit.

- *What are the technical constraints of using mobile devices?* Mobile technology contains both technical constraints and security risks which need to be recognized prior to deployment.

- *What are the privacy and ethical issues involved in using mobile devices?* New mobile technologies are providing effective solutions throughout healthcare, but do introduce privacy and ethical issues.

1.5 Project methodology

The research uses the principles of grounded theory, mainly because the study produces qualitative data. Verbal interviews and surveys are conducted to obtain information from the target audience. Consequently, results are analyzed to reach conclusions and make recommendations. Chapter Three describes the research design in detail.

1.6 Structure of the thesis

This thesis is organised into six chapters. Following this introduction, Chapter 2 reviews the literature, which describes the current New Zealand health sector and examines different types of mobile devices and their applications in healthcare. It also discusses the privacy and ethical issues that attend the use of mobile devices when used to enhance healthcare. Chapter 3 describes the research methodology that involved getting ethical approval and designing the survey that produced the results presented in Chapter 4. Subsequently, Chapter 5 discusses key findings and the potential of using mobile devices in New Zealand healthcare. Chapter 6 ends this thesis by summarising the major research conclusions, recommendations, and identifying potentially promising areas for future research.

Chapter 2: Literature Review

2.1 The New Zealand health sector

New Zealand healthcare consists of many different sectors that need to be identified and included to implement any opportunities for information systems to improve health outcomes. A number of healthcare strategies have been developed to deal with increasing demand, and to direct the delivery of services to needed citizens [14]. Healthcare services are normally delivered via three sector organisations: primary, secondary, and community. The community sector can include residential and long-term care. In the following sections, we will explore the three sector organizations.

2.1.1 Primary sector

Primary Healthcare was defined first at the International Conference on Primary Healthcare at Alma-Ata in September 1978. Primary healthcare is where any individual, family, or community first comes in contact with the national health system, bringing healthcare closer to them (WHO, 1978).

Based on this definition (WHO,1978), the New Zealand Ministry of Health (MoH) [17]similarly defined primary healthcare as essential healthcare based on realistic, scientifically sound, culturally appropriate, and communally acceptable methods that are easily accessible to people in their communities. It involves community participation, an essential function of New Zealand's health system, and is the first level of contact with New Zealand's health system. New Zealand's Primary Healthcare consists of individuals, whānau, families, communities, health providers, Primary Health Organisations (PHOs), District Health Boards (DHBs), non-government organisations, and government agencies [16].

Primary healthcare covers a variety of out-of-hospital services. Its main objective is to improve the health of people in communities by conducting health improvement and preventative services such as health education and counselling, disease prevention, and screening [18].

New Zealand has developed a Primary Healthcare Strategy (PHCS) that focuses on managing population, co-coordinating across providers, and having sufficient information for a complete view of high-cost diseases [14]. The vision of the PHCS is that "Primary healthcare services will focus on better health for a population, and actively work to reduce health inequalities between different groups" [16].

The PHCS achieves its objective by supporting change in the health system which is suited to prevention and supporting peoples' well-being. The PHSC seeks to increase access to primary healthcare services, encourage health education and prevention, coordinate care across service areas and teams, and enable collaborative response to community and peoples' health needs [16].

2.1.2 Secondary sector

The term *secondary healthcare* refers to all hospital-based services including tertiary and quaternary services [14]. A primary healthcare provider generally refers a patient to hospital. Hospital staff consists of specialist physicians and surgeons. Hospital services include general medicine and general surgery, paediatrics, maternity, orthopaedics, gynaecology, Ear Nose Throat (ENT) treatment, ophthalmology, urology, and community health services.

The Health Information Strategy of New Zealand seeks to improve the linkage between primary and secondary healthcare. It also improves information sharing and collaboration across the sector, that benefits both consumers and care providers [14]. Consumers will receive care that is suitable to their health needs because it is delivered in a coordinated manner by care providers who have electronic access to appropriate information. Care providers will make more informed decisions at the point-of-care as patient information will be easily accessible.

One of the strategies of integrating health data is to capture all data electronically and store it in electronic records.

2.1.3 Community sector

The community sector covers a variety of collaborative services and support conducted to improve healthcare throughout a community. Community improvement projects are valuable as they focus on a range of health problems that are often a priority to the local community. It also develops the community's network and social capital, which consequently will lead to better health outcomes [19].

Community-based projects have long timeframes; they take place in community settings, and frequently change their objectives and strategies as they evolve, making them difficult to evaluate. Nevertheless, there have been many successful outcomes from community-driven projects such as injury prevention, anti-smoking and alcohol, and drink driving [19].

The Health Information Strategy for New Zealand (HIS-NZ) [14] suggests that community providers usually have less information systems capability, and a minimal number of personnel to deliver care. They need to receive better information about consumers who are under their supervision, and be capable of sharing that information when referring consumers to other services such as hospitals [14].

2.2 Mobile devices and their applications

The emergence of mobile technology has produced considerable excitement among all industries. Mobile devices with wireless technology facilitate m-computing, m-communication, m-collaboration, m-health, and m-commerce [20]. Consequently, the technology is being applied in many areas such as education, health, travel, stock exchange, military, supply chain, disaster recovery, and medical emergency care.

The wireless technologies are rapidly developing and triggering remarkable changes throughout the world. These advancements will directly affect several aspects of our daily lives, and the nature of business. They will enable us to access data when necessary, improve communication between businesses and customers, increase mobility and traceability, and will influence our daily lives. Common mobile devices and their general applications will be scrutinized in the following sections.

2.2.1 Types of mobile devices

Mobile devices have become very common in recent years. They can be categorised into four types: unintelligent gadgets, cellular phones (mobile phones), smart phones, and devices with operating systems [21]. The categories can be disputed as smart phones and a few cellular phones have an operating system installed in them. We need to distinguish devices that are primarily of the PDA and personal computer pedigree rather than of the mobile phone.

Unintelligent gadgets have little or no processing power (e.g. sensors and RFID tags). Nevertheless, these small devices can provide immense functionality. Cellular phones (mobile phones) are highly adopted in most developed countries. These devices include voice technology, Short Messaging Service (SMS), WAP, and wireless Internet capabilities.

Smart phones provide a combination of voice and data technology. They offer an operating system such as Pocket PC or Palm OS that allows them to operate with a wide range of applications. These devices typically appear in a blend of mobile phone and PDA. Devices with operating systems refer to PDAs, tablet PCs, and laptops. Most of

these normally communicate via wireless LAN rather than through the cellular data networks. Operating systems used are from various vendors such as Palm OS, ePOC, Pocket PC, Linux, and several versions of Windows and Macintosh [21].

According to the Forrester statistic, more than 80 percent of all Europeans owned a cell phone at the end of 2004, making cell phones a very popular device [22]. At present, cell phones are commonly used for making phone calls and sending short messages. New applications are emerging as faster network solutions such as accessing websites, video calling, and streaming media are being introduced.

The following tables, 2.2-1, 2.2-2, 2.2-3, 2.2-4, 2.2-5, and 2.2-6 will describe the features and the pros and cons of common mobile devices.

Laptop computers

Today, laptop computers are considered to be the most comprehensive and functional of all portable devices available [23]. Accordingly, laptop computer sales are increasing rapidly compared to desktop sales, and it is estimated that laptop sales will surpass desktop sales by 2010 [24]. Laptop computers are also referred to as laptop, notebook computer, or simply notebooks.

Laptops have all the capabilities of a desktop computer and provide portability; however, they are more expensive than a similar specification desktop. Mobile personnel use laptops as a replacement for desktops. Workers, having an option of buying a desktop or a notebook computer, are prepared to pay the premium that a notebook computer incurs in exchange for the extra value a mobile system brings. These systems can be used at the desk, on the road, or at home.

Laptops are ideal for people who travel a lot on a daily basis, but who are stationary at regular intervals [21]. Due to the increase in their processing power, memory, and applications, laptops are now able to run most of the applications that are usually run on desktops. Adding to that, the portability of these applications makes them much more valuable in a commercial environment.

However, workers who are highly mobile may not be able to make much use of a laptop as it does not provide easy access or connectivity while on the move. For example, it is not practical for a doctor to use a laptop while on hospital rounds. As a result, some doctors tend to use a Personal Digital Assistant (PDA) that provides remote access to their desktop; others do rely on laptops as they provide higher processing power and a better keyboard and screen than a PDA does. Table 2.2-1 summarises the advantages and disadvantages of laptops.

Table 2.2-1: Advantages and disadvantages of laptops	
Advantages	**Disadvantages**
Desktop functionality	Large size
Portability	Substantial weight
Access to a full-scale computer at any given time during the day.	Battery life
Large screen	
Full-size keyboards	
Great for heavy data-input activities	
Bluetooth connectivity	
Infrared connectivity	
Wi-Fi connectivity	

Tablet PC

The tablet PC is amongst the latest generation of personal computers. Tablet PCs are very similar to laptops except the screen is on the outside of the device rather than on the inside. A tablet PC uses a pen and touch sensitive display to afford interaction in a pen-driven style. Unlike laptops and other devices, tablet PCs have extensive features such as handwriting recognition and voice to text conversion [25]. However, the tablet PCs have a touch screen keyboard which is not easy to use for editing extensive documents [26]. Table 2.2-2 indicates the advantages and disadvantages of tablet PCs.

Table 2.2-2: Advantages and disadvantages of tablet PC	
Advantages	**Disadvantages**
Touch-screen keyboard, allowing handwritten data to be imported Stylus	Cannot make phone calls, unless phone client application is installed. Size
Able to connect to wireless network	Substantial weight
Bluetooth connectivity	Battery life
Infrared connectivity	
Full-size keyboards	
Thin, light-weight, and convenient to carry	
Replacement for traditional keyboard & mouse	
Wi-Fi connectivity	

Personal Digital Assistant (PDA)

A personal digital assistant is a light-weight, compact, handheld computer [27]. It also has a pen stylus input interface like a tablet PC and provides basic computing capabilities, wireless Internet access and networking features, and includes some basic utilities such as a calendar, notepad, and address book. In addition to these, a PDA not only plays audio and video files, but also can be used to edit text documents, email, and SMS. Over time, increased processing power has improved the functionality and efficiency of these devices [25].

PDAs have gained extensive attention in healthcare organisations because of their potential contribution to enhancing healthcare practice. PDAs are widely accepted by healthcare professionals due to the portability and convenience they provide for personnel who are always on the move. Recent statistics state that approximately 60 percent of physicians in the US have adopted PDAs [28].

However, the processing power and the application base of a PDA are much lower than that of a laptop or a PC, and they are suitable only for personnel who are either travelling or off premises most of the time. As a result, a PDA cannot be used to handle vast amounts of information, or as a primary storage device. Table 2.2-3 highlights the advantages and disadvantages of PDAs.

Table 2.2-3: Advantages and disadvantages of PDAs	
Advantages	**Disadvantages**
Mobility	Ineffectiveness
Real-time access	Data entry
Customisation	Maintenance
Communication with dedicated cell phone number	Security and speed of wireless transmission
Small computer with a screen	Delicate device
Expandable data storage	Usability issues
Battery powered with low level of power consumption	Limited storage (hard drive) and memory (RAM)
Infrared connectivity	Limited battery power
Supports SMS, email and WAP	Typing speed
Multimedia applications	Perceived fragility
Audio player	Screen size
Video capability	Data entry using stylus

Bluetooth connectivity	Battery life

Smart phone

A smart phone is primarily a voice communication device with an extended functionality. It contains rich telephony features along with data capability. Applications include a calendar, address book, text messaging, wireless Internet connectivity, PC synchronization, sketchpad, and a memo. They not only play audio and video files, but also send IM and text messages. A distinguishing feature of the smart phone is the capability to run applications offline. The advantage is that users do not need to be connected to the network to perform tasks such as using the calendar or other applications; this can save money and time [25].

Unlike mobile phones, smart phones contain a mobile Internet browser that supports an extensible HTML (xHTML). They may also provide a full HTML browser along with the limited wireless markup language (WML) browser [29]. This means that users can access standard HTML Web pages. In spite of these features, smart phones do have some setbacks that place them behind PDAs. Not all applications on a smart phone are compatible with standard Windows applications. Some of them may not have a QWERTY keypad, which makes data entry a tedious process. In recent years, smart phones have become widespread and are being referred to as mobile phones. Table 2.2-4 reviews the advantages and disadvantages of smart phones.

Table 2.2-4: Advantages and disadvantages of smart phones	
Advantages	**Disadvantages**
Some desktop functionality with smaller keyboard and smaller screen size compared to PDA	Data entry and editing is harder as it may not have a QWERTY keyboard.
Dedicated cellular phone number	Limited storage (hard drive) and memory (RAM)
Support SMS, email and WAP	Limited processing power
Capable of connecting to wireless networking like Wi-Fi	Can only handle small amount of information
Capable of use as a modem to connect desktop-computers or laptops to the Internet	Does not have an easy-to-use user interface
Bluetooth connectivity	Small screen size

Infrared connectivity	Not very robust
Built-in camera	Low compatibility with most standard office tools

Mobile phone

Mobile phones are mainly used for voice communication and SMS. However, depending on the applications on the mobile, not all programs can be run on the mobile phone interface. Basic features of the phone involve voice, SMS, contact management, and WAP. Some of the latest phones also allow video calling [30]. Mobile phones are widely used all over the world as one of the basic means of communication.

The latest technology in cellular services also provides advanced features such as GPS, video calling, and multimedia messaging which has proved valuable in commercial environments. However, networking features such as VPN are still not available in most mobile phones; this prevents them from being a reliable source for data access and transfer. Most of the mobile phones have customized interfaces that make it difficult to switch to different models. Table 2.2-5 illustrates the advantages and disadvantages of mobile phones.

Table 2.2-5: Advantages and disadvantages of mobile phones	
Advantages	**Disadvantages**
Dedicated cellular phone number	Small screen size
Support SMS, email and WAP	Limited memory
Capable of connecting to wireless networking like Wi-Fi	Limited ability to create content
Can be used as a modem to connect desktop-computers or laptops to the Internet	No QWERTY keypad makes data entry a tedious job
Long battery life	Very low application base
Infrared connectivity	
Built-in camera	
Support very small mobile applications	
Bluetooth connectivity	

Radio frequency identification (RFID)

Radio Frequency Identification (RFID) is generally used in the form of RFID tags that store information about an object or a person. This technology is also being used in many mainstream applications and has a significant role in asset-tracking and inventory management systems. RFID technology belongs to the "unintelligent gadgets" category of mobile devices as they have minimal or no processing power. All RFID tags enable remote and automatic reading with no "line of sight" [21, 31, 32]. RFID, speeds up the handling and traceability of goods and materials throughout the supply chain.

All RFID systems consist of three main components: an RFID tag, a transponder, and a reader. An RFID tag or transponder stores data of the object in the RFID system. An RFID reader can have the capability to both read and write data to a transponder [33].

RFID tags are available in different bands and frequencies. Garfinkel and Holtzman [34] state the common RFID bands as the Low Frequency (LF) band at 125-134.2 KHz, the High Frequency (HF) band at 13.56 MHz, the Ultra High Frequency (UHF) band at 915MHz, and the Industrial, Scientific, and Medical (ISM) band at 2.4GHz. The names of bands directly reflect the history of radio developments. Lower frequency bands are cheaper and have lower range compared with higher frequency bands that are expensive and have larger range. The applications associated with different bands will be discussed in sections 2.2.2 and 2.3.

RFID tags are available in two main classes: active and passive. Active tags are battery powered; they either have an integrated battery or are connected to an external power source. Active tags have a longer range than passive tags. Nevertheless, batteries increase the cost and size, making them impractical for the retail trade. Passive tags do not require maintenance or batteries as they acquire power from the reader. These tags come in various sizes; some are small enough to fit into a viable adhesive label [31, 32]. Hence, RFID technology is being widely adopted, and its attributes demonstrate further potential in all major sectors (e.g. commercial, industrial, and healthcare). Both generic and healthcare applications will be discussed in sections 2.2.2 and 2.3. Table 2.2-6 lists the advantages and disadvantages of RFID.

Table 2.2-6: Advantages and disadvantages of RFID	
Advantages	**Disadvantages**
Internal memory to store data	Not Plug & Play technology
No "line of sight" required	Wireless communication range
Multiple read/write capability	Cost is high if used for low profit product
Updateable	Active tags – battery-powered, size, cost and lifetime
Real time and error-free data	Passive tags – limited range
Provide information about the current physical status (quantity) of an asset	Privacy concerns: - Can be unintentionally - Invisible communication - Tracking of customers in retail industry
Traceability through supply chain	
Keep an information history of an asset	
Manage and locate assets individually	
Safe – has no health side-effects	
Internal memory to store data	
Active tags – Long range	
Passive tags – no battery required, small in size, and cheaper than active tags.	

References: [21, 31-33, 35, 36]

2.2.2 Generic applications

Laptop

Laptops are one of the most popular computing devices in the world. They are not only used in business environments, but also in educational institutions. They are commonly used in most business, and in sales and marketing environments for client presentations. Laptops are used in educational institutions for learning. Students have adopted laptops as a reliable tool to organize and carry their work home. They can download and play audio and video recordings, lectures, and presentations from anywhere, provided they have access to the Internet [25].

Laptops have Wi-Fi capability which makes Internet access easy, and after recent advances in 3G development and mobile broadband, they have become ideal for corporate or enterprise users who are accessing data remotely. Laptops have proven to be

very efficient tools in sectors like export, sales, emergency services, research, and management [37].

Tablet PC

The information worker in an organization needs tools for organizing and planning, finding reference information, gathering and analysing information, learning and self-improvement, communicating, and teaming and collaborating. The tablet PC is an innovative device to hit the technology sector and fulfils most of these needs. The handwriting conversion and digital ink capabilities allow for integration of computers into teaching and learning environments [26].

Tablet PCs have been capable of performing all the tasks that are done using a laptop, and in fact, have proven to be even better for client presentations, surveying, and interviewing. They are ideal tools for sales and marketing, education, statistical analysis, and government enterprises that involve tasks such as surveying, gathering stats, and presentation coupled with constant communication. They also provide a high level of interactivity for global collaboration, scientific experimentation, and research [25].

Personal Digital Assistant (PDA)

A PDA has less computing capability, but is more portable than a laptop. Personnel on the move generally use it where huge applications are not required to carry out a task. PDAs have a pen stylus interface that is highly preferred for gathering data, statistical analysis, and surveying. They also support Wi-Fi and networking capabilities such as VPN, which allows personnel to access their company LAN (Local Area Network) or their desktop [7].

PDAs have been ideal for project management of civil engineering projects where progress has to be reported remotely. PDAs support interactive collaborative learning. Research workers use them to conduct research, deliver results, and present projects. Students can also use them for word processing, and to take notes in lectures [25].

After recent advances in technology, PDAs now come with a built-in camera with decent resolution, which can capture images and record videos. Users can capture images and transmit them via email or MMS (Multimedia Messaging Service). This feature of a PDA is currently used to report traffic emergencies and record any essential interrogations. Some PDAs are equipped with GPS (Global positioning system) for navigation; this assists transportation services, geologists, and other professionals working in the field.

Smartphone

A smart phone is a functionally intermediate device between a PDA and a mobile phone. It is a multifunctional cell phone that provides voice communication and text-messaging capabilities, and also facilitates data processing as well as enhanced wireless connectivity. The applications and services target common consumers and enterprises using smart phones as a universal end-point for data access and networked computing [38].

A smartphone is a powerful, multi-function cell phone which includes many PDA applications such as personal scheduler, calendar, and address book, as well as the ability to access the World Wide Web (WWW) and other applications using either a keypad or a stylus. Wireless Internet is accessed using various cellular wireless networks such as GSM/GPRS, CDMA, CDMA2000, WCDMA, and 3G [39]. Additionally, users can check email, create documents, play online games, or access an enterprise network via a virtual private network (VPN) [39].

Smart phones are highly applicable to mobile banking, mobile advertising, mobile payment, business information services, and marketing — what in today's language is referred to as *Mobile Commerce*. A very good example of mobile banking payments includes payment verification and reminder notices; this has been widely adopted by many firms (e.g. parking fees to be paid at the meter) [39].

Recent developments in mobile technology and SMS allow people to get news and information about a business by sending an SMS; for example, movie timings, product availability, and airline ticket specials. Students can use smart phones to organize their schedule, download lectures, podcasts, and send content via email or IM [25]. Engineers and technicians use these devices to receive alerts in case of an outage in their service areas.

Mobile phone

Mobile phones are generally used for voice communication and SMS and are the most commonly used devices all around the world. However, with the drastic increase in features and applications, mobile phones are now used for many other purposes. A large number of commercially available mobile phones come with features such as integrated digital cameras, mobile Internet, and video calling. People take snapshots and send them via email and multimedia message [40].

SMS is a widely adopted feature today in many sectors. Codes are used to run SMS campaigns for marketing firms. SMS is also used in mobile banking. Businesses use this service to send out alerts in case of emergencies. After the recent advancements to 3G

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mobile, these devices are now capable of providing traffic and weather reports. In Japan, many companies have announced release of mobile phones that are capable of reading announcements. However, they are still not widely used by students for learning [41].

Radio frequency identification (RFID)

RFID tags trace the technology back to the radio-based identification system. They have become commonplace in access control and security applications, and in industries requiring the tracking of products. They are most commonly used in industrial warehouses and big supermarkets overseas requiring the identification of products at the point of sale or point of service.

RFID is widely used all over the world by shipping companies, logistic, and courier companies to track and trace the goods. They are also used in the food industry for food tractability. Hospitals use them to identify drugs. It has also been widely adopted for waste management [34].

2.3 Mobile device applications in healthcare

Healthcare industries globally are tackling a number of challenges including the rapid increase in costs, lack of coverage to their rural areas, and medical errors [14, 15, 42]. The healthcare industry commonly considers Information Technology (IT) as their primary enabler for providing efficient transfer of health-related information services and cost-effective decision support on demand. IT also reduces organization costs and assists in improving the quality of health services and patient care [43].

The deployment of wireless networks can improve communication significantly among patients, doctors, and other healthcare workers. Moreover, these networks facilitate the delivery of accurate medical information anytime, anywhere, thus decreasing errors and improving access [42]. Additionally, advancements in mobile devices open a wide range of efficient and powerful medical applications.

The literature for the mobile device applications in the healthcare industry is organized into clinical and non-clinical applications. Within each of these sections, it is presented by types of devices; i.e. laptops, PDAs, mobile phones, RFIDs, and others. The mobile device applications are known to be very successful in niches [28]. The sections below aim to present the usage of mobile devices in both clinical and non-clinical health environments.

2.3.1 Clinical applications

The population of the world is increasing rapidly, and the healthcare industry is more widely distributed to meet healthcare requirements of their patients. Healthcare organizations are confidently using mobile devices and protocols to access and update patient information at the point of care [44]. Clinical applications refer to delivery of healthcare services for the patients.

Laptop and tablet PC

In Intensive Care Units (ICUs), laptops are being used instead of wired desktop computers; this enables the clinicians to be available at point of care. It results in many benefits such as the improvement of patient care and increased efficiency as clinicians have instant access to diagnostic information and streamlined workflows, and the capability to perform any complex computation required at the patient's bedside. It has been widely adopted and has proved to be a successful application [45].

Both patients and clinicians would benefit from remote access to lifetime clinical records. Patients could use a handheld device to update their personal medical history into their healthcare provider's central database [42].During a check up, clinicians using laptops or tablet PCs, have the ability to access the most current patient information and decision-support tools such as drug reference. Additionally, giving clinicians the ability to update patient records at the bedside (even in rural areas), would ensure patient data is up-to-date. The wireless protocols enable the data to be submitted and validated to a central repository [44].

> *PatientKeeper® is one of many companies that offer middleware server technology that connects to any backend database. Its platform allows clinicians to manage all their patients within a single system. PatientKeeper® provides web-based software applications that can seamlessly run on any mobile device running a web browser, giving clinicians flexibility to use a device that is convenient and appropriate for their work; e.g. tablet pc, laptop, or PDA [46]. It gives clinicians the freedom of accessing patient data at the bedside, in the office, at home, or at any hospital.*

Remote access will drastically minimize medical errors, personnel time, and administration overheads, by reducing the frequency of patient, clinicians, or receptionist entering incorrect data. It will improve patient safety and care and increase revenue.

Using laptops and tablet PCs, providers can easily conduct email consultations which are cost-effective and convenient, as they require a fraction of the time and space

for physical consultations. By using an email enabled device such as computer, laptop, tablet PC, or PDA, provider and patient can send and receive at any time.

Emails can be fairly extensive and thorough, including lab results, consultations, and notes or they could simply be quick free-style writing. Authors in [47] suggest that successful communication via email depends on a clear and shared understanding by both patient and healthcare professional of its role, advantages, and limitations.

PDA and smart phone

PDAs are also very helpful in technology-oriented areas such as the Intensive Care Unit (ICU) where physicians are required to perform complex computations. ICU does consist of high-tech computerized systems, however, the clinician may still require written notes for many reasons such as patient management or medical calculations, referring to pocket textbooks, or printed management algorithms [48]. Due to the versatility and portability of PDAs, clinicians who are on the move around the hospital are able to access and compute required information, enabling them to deliver hospital-based clinical care to their patients.

Clinical decision support can be achieved by using PDAs when clinicians meet patients. The attributes of PDA enable physicians to access patient-specific information, reference tools, and knowledge bases [49] In the United States, a user study via a questionnaire was conducted in teaching hospitals in five states: Tennessee, Florida, Alabama, Kentucky, and Pennsylvania. The sample consisted of both physicians and physicians-in-training. Of the respondents, 87 percent used PDAs for patient encounters and 67 percent stated that using a PDA had a positive impact on their clinical decision making [50].

Authors in [27] have identified many decision supporting applications that include ability to access patient information [51], medical calculation [52], medical reference, [52] and clinical computational programs [52]. Additionally, using a PDA provides clinicians with the facility of real-time information access [46], laboratory result retrieval, and wireless access to Internet resources.

Physicians can also use a PDA to write prescriptions at point of care, replacing paper-based prescription pads. Electronic prescribing can assist physicians to keep track of what medications their patients are on while helping to reduce mistakes in misread prescriptions or miscalculated dosages. An Institute of Medicine (IOM) report on Preventing Medication Errors states, "Paper-based prescribing is associated with high error rates. Electronic prescribing is safer because it eliminates handwriting and ensures that the key fields (for example, drug name, dose, route, and frequency) include

meaningful data" [53]. E-prescribing systems have many benefits for patients, physicians, and pharmacists. Moreover, E-prescribing has the potential to cause a remarkable impact on quality, safety, efficiency, and eventually the value delivered by the healthcare system [54].

A PDA application was created [55] to implement a handheld *Electronic Health Record* (EHR), and to record pregnancy data at point-of-care in rural communities of India. This application really facilitated the EHR, and replaced the paper-based records.

However, a recent survey conducted in the USA reveals that the majority of clinicians are using PDAs for drug reference, personal scheduling, and medical computation, but rarely to access electronic medical records [56].

Mobile phone

Mobile phones are particularly useful in monitoring patients using Short Message Service (SMS). They are exceptionally effective as they are widely adopted globally. Patients can obtain several benefits by using mobile phone capabilities such as voice calls, SMS, and WAP. Many clinical applications are being implemented worldwide.

A systematic review was conducted by Dr Rifat Atun and Soalen Sittampalam [30] on SMS use in healthcare. Three types of benefits were identified: increased efficiency in the delivery of healthcare, direct benefits to patients in terms of improved health outcomes and quality of service, and public health benefits. Public health services are predominantly non-clinical applications.

Increasing efficiency in delivering healthcare services can overcome the problem of patients missing their scheduled appointments. Sending regular text messages can be a means to remind patients to attend their appointments. However, communicating with patients using text messaging does have a few disadvantages including the fact that not all patients have mobile phones. The ability to send multiple customized text messages, the wide availability of service, and the comparatively low cost make this a suitable means of improving patient attendance [57].

Using mobile phones would significantly develop areas where communication between clinicians and patients is vital. Applications that have direct benefits for patients include empowerment of patients, improving adherence to health advice and medication protocols, monitoring patients' conditions, distributing test results, and providing psychological support to patients[30].

As one example, the mobile phone can help reduce diabetes complications and offer diabetic patients an easier and longer life by providing regular supervision. SMS-driven support systems are being used to control diabetes. Statistics provided by

Vodafone indicate a 10 percent improvement in glucose levels for young people who use an SMS-driven support system [30]. As a result, costs are reduced through fewer admissions and long-term complications such as blindness and kidney disease.

Many m-health studies [30, 58, 59] have looked at the use of SMS to enable patient appointment and medication reminders, patient-support applications, and using SMS in preventive care to achieve healthier living populations.

Radio frequency identification (RFID)

RFID has minimal presence in clinical applications, unlike the previous mobile devices analysed.

2.3.2 Non clinical applications

Non-clinical applications refer to administrative and management functions (i.e. charge capture, billing, and patient and asset tracking) that support clinical services. Mobile technology enables health organisations to reduce administrative overheads and provide traceability throughout the supply chain.

Laptop and tablet PC

Compared to the clinical sector, laptops and tablet PCs have fewer significant applications in the non-clinical sector. Patient tracking and monitoring are areas that can be improved through the use of laptops and tablet PCs. A study conducted at George Eliot Hospital in the UK deployed a mobile portal to a patient-tracking application to provide wireless access to track patients and prioritise their treatment in Accident and Emergency (A&E). It also provided an interface to view pathology and radiology results. Laptops and tablets were provided with wireless connectivity over a Wi-Fi wireless network. Laptop and tablet PCs with wireless connectivity were distributed to nurses and medical and surgical consultants. The health practitioners appreciated the significant time savings through mobile access to real-time information[45].

PDA

PDAs can provide assistance to both clinicians and patients in administrative support, professional activities, education and research purposes, and documentation[27]. Administrative support applications include scheduling tasks and appointments, billing patients at point-of-care, capturing data on site for tracking and evaluating services, and communications. Utilizing a PDA's intuitive user input devices (stylus, microphone, and

QWERTY keyboard), documentation such as note generation via dictation during consultation, charting, and printing patient information or results is made effortless.

PDAs assist several professional tasks by providing a portable personal information management system for clinicians' professional monitoring and reporting [60], communicating with colleagues in hospital, and patient data tracking. Moreover, this handheld device serves as an effective educational and research support to both patients and physicians by providing electronic resources to patients and using it as a teaching instrument for physicians[27].

Mobile phone

Mobile phones, using Short Message Service (SMS), can provide psychological support, advice, and communication with patients. Applications include SMS-driven drug identification services, booking services, medication remainders, health education, safety messages, and appointment reminders[28]. For example, the University of Auckland [61] conducted a study on a sample of 1705 smokers over 15 years of age from all over New Zealand who wanted to quit, and who owned a mobile phone. Using SMS on a frequent basis, the smokers received personalised text messages providing smoking cessation advice, support, and distraction; consequently, many participants quit smoking within six weeks. This study demonstrated an encouraging application of mobile phones. Moreover, using mobile phones to empower patients and improve adherence to health advice and medication is fairly affordable, personalised, suitable for different groups, and not location dependent [30, 61].

Radio frequency identification (RFID)

RFID technology has immense potential for the healthcare sector. It has many non-clinical applications that can significantly decrease overheads, improve patient safety and medical services, and speed critical treatments [62]. However, the challenge will be to integrate RFID technology into a naïve medical practice with no relevant experience. RFID applications include asset tracking, supply chain, stock control, patient identification, and drug authenticity verification.

Asset tracking is essential to providing effective healthcare services. RFID technology can provide an effective solution for tracking and monitoring a variety of assets available in a hospital such as wheel chairs, IV pumps, and stretchers. Most of these assets are not stationary, and frequently are moved to different locations (floors and wards). Locating these assets without RFID requires more staff members and reduces the

productivity of clinicians, as they are required to make requests for equipment. A unique identification number embedded in an RFID tag microchip can be attached to equipment that is to be tracked. The tracking system can be configured to display current location of the equipment on desktop, laptop, or PDA [63].

Patients and doctors can be tracked around the hospital using RFID-enabled wristbands. Staff members can use a handheld reader that provides them access to key patient information such as patient's illness detail, treatment history, and insurance policy information [63]. The staff can instantly update after any diagnosis or treatment. RFID needs no "line of light", so there is no need for physical reading of the tag, and the patient does not need to be disturbed. In addition, having RFID readers installed in key areas can capture and update patients' location on the hospital information system. Patients usually go through a series of checks or interventions, so if a patient has mistakenly travelled to a wrong section, RFID can alert the physician or staff member in charge of the patient. Having staff tracked is also helpful in case of emergency calls, ensuring the doctor can be located instantly.

As a mobile technology, RFID can enable real-time traceability in the supply chain. Inventory Control will promote reduction of inventory on hand and reduction of theft across the supply chain [64].

Authors of the book, *RFID: Applications, Security, and Privacy* [34] write that the largest use of RFID expected within the next decade is in RFID tags to track the movement of consumer product goods — from the manufacturer to the point of sale. This can be directly related to tracking and authenticating pharmaceuticals throughout the health supply chain.

RFID technology can be adopted in the pharmaceutical supply chain to address the main challenges the industry faces. Two key issues in drug distribution are medical errors in administration of drugs and the recent growth of counterfeit drugs [65]. RFID technology can deter counterfeit drugs from entering the supply chain, and trace drugs in both healthcare facilities and in the retail supply chain.

Table 2.3-1: Applications of RFID in pharmaceutical industry [66-68]	
Inventory and Warehousing Management	Ability to track entry and exit of raw materials and finished products. Enables smart shelving and smart searching [66-68].
Access Control	Restrict access to authorized resources [66-68].

Anti-Theft	Valuable assets can be tagged with RFID tags to monitor their movement [66, 67].
Asset Management	RFID can be used to track assets such as computers and other equipment. It would help automate inventory audit as well as movement of each item [66].
Dry Diversion Prevention	RFID can help identify diverted products to prevent their re-entry into supply chain [66].
Expiry Date Hiding, Fraud Detection and Prevention	Tamper-proof RFID tags can be used for preventing drug counterfeiting throughout the industry [66].
Counterfeit Drugs	

RFID will be adopted by the pharmaceutical industry to promote security, safety, and efficiency.

Case Study One:

Handheld Technology Improves Patient Safety[69]

Location: CHRISTUS Spohn Health System, South Texas, USA

http://www.patientkeeper.com/about_patientkeeper/document_center/

PatientKeeper offers innovative software applications for mobile devices (PDA, Smartphone & Tablet PC) such as Patient Care Suite, Charge Capture Suite, Documentation Suite, and Communications Suite. They also provide integration middleware PatientKeeper® Platform™ which is an open, extensible infrastructure that offers physicians integrated access to information they need throughout the day. It integrates all systems they require into one by connecting different backend databases to any mobile device (PDA, Smartphone, Tablet, and browser) via wireless, cellular, or wired connection.

Below is a summary of a case study to highlight how PatientKeeper and handheld technology can be used to improve patient safety.

"Handheld Technology Improves Patient Safety

at CHRISTUS Spohn Health System"

Problem

Managing and delivering healthcare services to a large number of patients in 1,000-bed healthcare system. Due to the large number of patients, physicians are required to go back and forth to access patient information. Consequently, physicians are losing productivity.

CHRISTUS Spohn Health System is a large, charity care provider and not-for-profit healthcare system with a network of seven hospitals across South Texas. Physicians in the 1,000-bed healthcare system began using handheld devices loaded with PatientKeeper Clinical Results™ which offered them access to essential patient information from PDAs and Smartphones. Soon after, they also used PatientKeeper Charge Capture™ to access live data stored in the Patient Information System (MEDITECH) right at the patient's bedside. The use of this technology demonstrated the benefits of mobile information for healthcare: improved use of the doctors' time, improved patient care, and safety, and more streamlined and efficient billing.

Driving clinical data down to the point of care

At seven CHRISTUS Spohn locations, 750 staff doctors were introduced to laptops and handheld PDAs. The first phase, which began as a wireless network on few cardiology floors, started in 2003. It was mostly used by nurses to enter patient vitals and I/O levels, but it quickly changed to include handheld PDAs and clinical information software from PatientKeeper.

Dr. Darrick Nelson, Assistant Professor, Family Practice at CHRISTUS, mentioned that there are two sides to the patient–safety equation.

> "Getting patient information to the docs as quickly as possible, then making sure that the instructions and diagnoses that come back from the docs are clear and have no chance of being misunderstood. The more information we can put in their hands right when they make medical decisions, the more informed those decisions can be. Therefore, instead of having a doctor searching for lab results, we put everything on a PDA. Better communications and fewer variables minimize the risk of errors and that's a very important benefit for the doctors and for the hospital."

Solution

The PatientKeeper project initially consisted of a pilot group of cardiologists, several of whom were PDA veterans. Following the six-week trial, the project team collected feedback and scheduled a series of Open Houses to display the plan to the staff and encourage them to enrol. The meetings were set up from 10.00 a.m. to 5.00 p.m. on successive days at each of the seven different locations.

More than 90 doctors joined when the system first started; another hundred doctors were expected to join as all systems started to function. The PDAs included both PatientKeeper Clinical Results and the PatientKeeper Charge Capture software. A total of 80 synchronization stations were installed across the hospitals. These synchronization units allowed the doctors to plug in their mobile devices and synch up with their patient information management system (MEDITECH), even where no wireless coverage existed. The whole process was very swift and took only about two minutes.

PatientKeeper Clinical Results on their PDAs provides CHRISTUS physicians with a variety of patient information including patient list, lab results, x-ray data, prescriptions, allergies, and much more. It also provides them with clinical notes including dictated reports, consult reports, operative progress, patient history, and physical reports. Moreover, it includes basic patient facts and demographics.

Overall, very good feedback was received from the doctors. Dr. Nelson confirms this.

> "Sometimes when I show a doctor what the program can do, his jaw drops. I call it the 'Wow' factor. They just have to have it. I know one doc in his

70s who tells me he can't leave the house without his PDA. When the applications are easy to use, it's easy to win over converts, even the technophobes. PatientKeeper is one of those killer key apps."

Results

The results of this program highlighted that physicians benefited most when the doctor was on an outside call. The physicians, using their mobile device and PatientKeeper, could synchronize data before they left hospital, enabling them to access the latest information on the patient they are visiting. If they do not have a particular patient on their visit, they have the capability to add a new patient, then synch again and get all the information before they perform the consult.

PatientKeeper Charge Capture was also deployed at CHRISTUS Spohn Health System. It allows doctors to select from a personalized list of diagnoses, and then enter standard Current Procedural Terminology (CPT) codes. The invoice is sent to the billing office the next time the doctor synchronizes the PDA.

Adding charge capture to the CHRISTUS system

Using Charge Capture on mobile devices will enable hospitals and practices to increase revenue by reducing the number of charges that are filed late or never are submitted. Dr Nelson echoes this.

> "Data shows that we should be able to increase revenues 10-20 percent by eliminating lost charges that aren't getting billed, and by submitting our claims more quickly. With PatientKeeper, the doc can send in charges even before leaving the hospital."

The key to the Charge Capture system is easy and accurate CPT codes and diagnoses. Having a handheld electronic system is much faster and easier. Traditionally, physicians would use a paper billing system, and the physician's handwriting could lead to coding problems.

This case study demonstrates that using mobile devices such as PDAs and Tablet PCs with appropriate information management systems like PatientKeeper will enhance patient care and increase revenue by 10-20 percent. It will also enable physicians to be on the move rather than being tied to a specified location.

Chang-Gung Memorial Hospital (CGMH) is part of a seven-facility, 8,800-bed health system in Taiwan. To enhance patient safety and streamline hospital procedures, they worked with Precision Dynamics Corporation (PDC) and Hewlett Packard Taiwan (HP),to develop and implement a Radio Frequency Identification (RFID) patient management system The RFID system was first implemented in its operating room (OR).

The integration of RFID using PDC Smart Band® RFID Wristbands and Hewlett-Packard RFID PDA readers, handheld readers, and printers make up the system's hardware framework.

Since the system implementation, CGMH has achieved 100 percent accuracy in patient identification in the OR — a major achievement in the advancement of patient safety.

New technology, optimized processes

CGMH implemented the RFID patient management system to improve patient safety by verifying and positively identifying patients, gathering real-time data, reducing risk of wrong-site and/or wrong-patient surgery, and ensuring compliance with hospital patient safety procedures or Standard Operating Procedures (SOP).

According to Joseph Ho, CIO at CGMH, major advantages of the system implementation were the reduction of errors related to oral confirmation and manual entries of patient, medication, and specimen ID data — demonstrating the traceability using RFIDs.

RFID system process

Smart Band is an integral part of the RFID process. The RFID wristbands store patient information which enables data to be transferred to and from RFID readers, information systems, and medical devices.

The RFID chip contains pertinent patient information including the patient's name, medical record number, sex, age, and doctor's name. The passive 13.56 MHz read/writable RFID chip offers real-time information updates. For patient and data

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security, only authorized personnel have access to the password-protected patient information stored on the wristband.

The new RFID system automates many manual functions. The diagram shown below illustrates the new OR patient ID process and highlights the areas in which RFID is used to verify data and procedures and to record time-stamps.
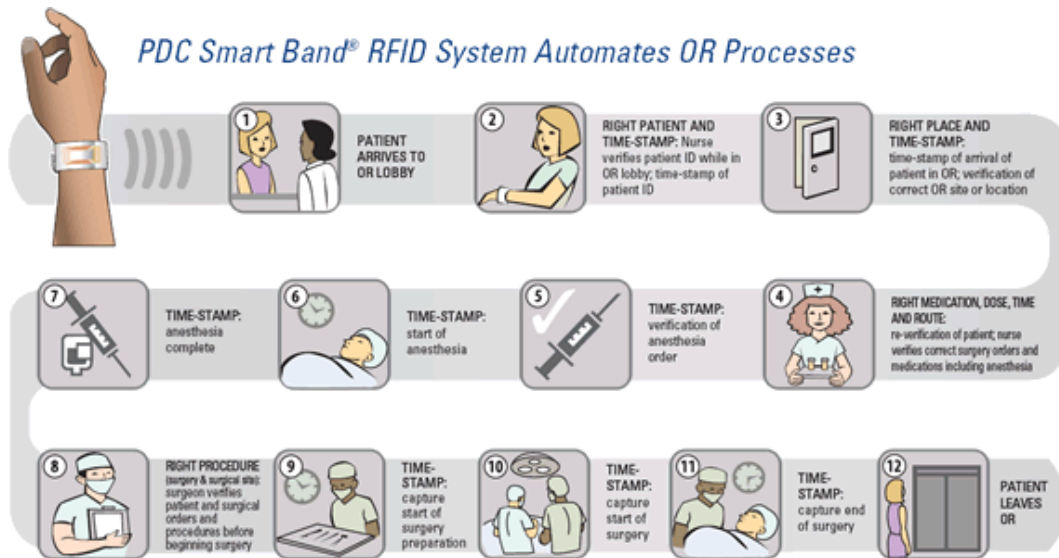
Figure 2.3-1: PDC smart band RFID system processes

The five *rights* of medication safety are easily met using Smart Band: Right patient, medication, dose, time, and route, as well as right surgery and surgical site.

RFID system Benefits: 100% patient ID accuracy

The automated patient data verification processes have saved clinicians an average of 4.3 minutes per patient, and have helped prevent common manual data entry errors, improving patient safety dramatically. "We have not had any patient identification errors since implementing the new RFID system — a significant accomplishment," says Ho.

Patient privacy is maximized by storing personal patient information on the RFID chip inside the wristband, instead of printing it on the band. Only the assigned doctor or nurse will be able to read information. The system's real-time reporting instantly alerts medical staff of the patient's status.

"With the new RFID system, the hospital has detailed, accurate information to analyze which processes encounter the most problems so they can develop solutions to manage hospital operations more efficiently," says Mingpey Chou, HP Taiwan RFID Lead.

The table below lists additional benefits from the RFID system in comparison to the previous, mostly manual, processes used in the OR.

Table 2.3-2: Additional benefits from the RFID system		
Process	RFID Function	Benefit
SOP compliance	Automated vs. Manual	100% enforcement of SOP with automated time-stamp and proof-of-action
Operation data-entry	Auto verification vs. manual entry	Automation prevents mistakes and provides real-time alerts
Wristband preparation	RFID wristband printed with human-readable information and stored information vs. human-readable patient name printed on wristband only	Prevents human errors, increases patient privacy, and integrates more information
Integration of information and processes	Automated linking of information from wristband to HIS or medical device	Simplifies and integrates procedures, as well as improves accuracy
Patient status display	Automated, instant status updates vs. manual entry	Real-time updates provide greater accuracy and patient safety

Adopting RFID technology has enabled a seamless process of capturing data from information printed on, and stored to the Smart Band Wristband. This resulted in achieving 100 percent patient ID accuracy and patient privacy, while saving staff an average of 4.3 minutes per patient.

2.4 Issues with mobile devices

2.4.1 Inherent design issues

The potential of mobile devices is always constrained by their design and use in applications [25]. Thus, the usage of these devices is dependent on the physical, environmental, and social factors which determine the capability of the device to perform as and when required.

For example, mobile devices communicate wirelessly to transfer information; this relies on the coverage for service in that geographical location. Some mobile devices lack stability due to minimal memory and sometimes may result in loss of important information. The cost-effectiveness is another vital factor in the usage of these devices. The expense of mobile Internet is not feasible for all users, and they tend to follow traditional approaches to meet their requirements.

From the perspective of New Zealand healthcare — healthcare being a very intricate industry — the telecommunication devices and standards have still not evolved

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to meet mobile health protocols. A secure connectivity is required for healthcare agents and services to transfer information as it is treated sensitively. Also, the mobile health applications are not yet considered to be cost-effective for users, and some devices are still incompatible with NZ healthcare systems [71].

2.4.2 Privacy and security considerations

Despite the benefits of mobile devices, certain social barriers such as inadequate security and privacy of user information impinge on their implementation. Most mobile devices, being location based, can be traced to determine the user's current location. Retaining users' information and previous history may result in users restricting release and access to their information. Marketing and advertising firms are very good examples as they tend to retain customers' previous records. Unforeseen messages that are passed without users' consent can also be referred to as potential threats to user privacy [72]. RFID uses tags that can reveal information without proper authentication, thereby resulting in a potential threat to user privacy should personal information or credentials be associated with the tag.

Healthcare, being an information concentrated industry, relies on preserving essential but vulnerable information. Mobile devices help access data remotely. However, it is imperative that this information is only available to authorized personnel [42]. For example, there have been situations in the past where RFID technology has exposed patient information, which has had significant effect on their medical insurance.

2.4.3 Ethical considerations

Several social and ethical concerns arise for the usage of mobile technology, with information security being the most common one. Due to the easy access of information through mobile devices, unauthorized access to information can lead to its misuse. Recent advances in location-based services have led to tracking individuals [42]. However, no legal limitations have been specified for the breach of privacy using these services [73].

Healthcare services implement location-based tracking to monitor patients. It is mandatory to obtain the patient's consent prior to this setup. Despite its potential benefits, this can lead to lack of social interaction for patients, and thereby detach them from society. Adding to this, insurance companies may be hesitant to support mobile treatment [42].

Chapter 3: Research Methodology

This chapter describes the research methodology used to investigate the potential of mobile devices in New Zealand healthcare by gathering opinions of health providers, health strategists, and technology vendors. Qualitative research involved the use of qualitative data such as interviews, surveys, and participant observation data to understand and articulate the results.

The chapter is organized as follows: a general overview of qualitative research, an explanation of why qualitative research methodology was selected, and sections on the ethics approval process, how the interviews and surveys were structured, and how the sample was selected.

3.1 Type of research

In order to indentify the potential of mobile devices in New Zealand, both opinion- and observation-based data need to be collected. A qualitative research approach is more suitable for this type of study than a quantitative approach. Qualitative research consists of the analysis of data such as words (e.g. from interviews), multimedia (e.g. pictures or video), or objects[74].

The motivation for conducting qualitative research rather than quantitative research is the importance of capturing speech [75] which is the distinguishing feature of humans. Qualitative research methods are very helpful in understanding peoples' opinions which are applicable for this study.

A qualitative research approach using interview and survey based methods was used as a strategy of inquiry which moves from the underlying philosophical assumptions to research design and data collection. The qualitative research interview is useful to describe and obtain meanings of central themes. The central task in interviewing is to understand the meaning of what the interviewees say [76]. The interview approach was the main means of capturing data.

The verbal data captured by interviews was transcribed into written text to make it easier to extract key information. Both the interview and survey data were collated and analysed to extract and filter key themes emerging from the data. 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 data

collection, note-taking, transcribing, coding, and memo-making steps occur simultaneously; lastly, the results are generated.

The concepts and methodology of grounded theory were used to carry out the research and extract the results from the surveys 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 surveys and the hour-long interviews and is mostly in the form of an odd-numbered scale which makes coding and presenting the results in a quantified format very easy.

The interviews are electronically recorded; the memos are produced and sent to the interviewee for verification. They are then sorted into interview themes (Table 3.5-1). The verification ensures 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

Due to the involvement of human participants as the sample, the research had to meet ethics approval from Massey University. Ethical requirements have become an essential part of research study, in line with an evolving understanding of the rights and duties of human beings. Massey University has an ethics committee in place which is required not merely to abide by ethical principles such as justice, truthfulness, confidentiality, and respect for persons, but also to attend to the developing understanding of how these principles are expressed in society at a particular time [77].

An ethics approval for this research was received from the Massey University Human Ethics Committee (MUHEC). The screening questionnaire was completed to determine the type of procedure to follow to obtain an ethics approval. The questionnaire suggested that this research project falls under the Low Risk Notification category that has a minimal nature of harm and is no more dangerous than what is normally encountered in daily life[78]. It is not necessary to receive a full approval from the Massey University Ethics Committee for a Low Risk Notification research project. The notification is used to record the research on the Low Risk Database. The ethics approval process involved producing the documents listed below according to the ethics process order (see appendices to view project-specific documents):

- Massey University Screening Questionnaire – to determine the approval procedure

- Massey University 'Notification of Low Risk / Evaluation Involving Human Participants' application form

- 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)

After submission, the documents were assessed and the research was successfully approved as Low Risk research by Massey University Human Ethics Committee (MUHEC). The paper-based survey, online survey, invitation letters, and consent letters were labelled with the Massey University logo, and contained contact details and the low risk approval note; this was advised by the Massey University Human Ethics Committee. The letter provided by MUHEC was shown to participants as a confirmation of the ethics approval. All interviewees were given a brief explanation of the research project, and signed a consent form before taking the interview.

3.3 Sampling

The sample had to be carefully selected, as the results have to be applicable to the diverse healthcare system of New Zealand. It was necessary to obtain valuable opinions from a range of sources in the health domain. In a qualitative research survey, pragmatic considerations should be included with sampling in a systematic way [79].

The appropriate sample involved three main groups: health solution providers, health strategists, and technology vendors. Health strategists included DHB planners, primary healthcare planners, community healthcare planners, and enthusiastic research in the mobile health domain. Health solution providers such as general practice clinics, hospitals, and community centres. Technology vendors included telecommunication providers and mobile device manufacturers. Also included were technology strategists who are involved with companies which innovate m-health products, or have been dealing with non m-health healthcare technology products.

The people being interviewed were experienced and represented a variety of positions which enabled them to articulate views of many different groups, including patients, infrastructure providers, clinicians, technology strategists, and managers. A larger study would have included views directly from different stakeholders.

The research involved conducting surveys and interviews simultaneously. Surveys were part of the interview process, but were also used to invite individuals to participate further by participating in interviews.

Using a correct sampling strategy is necessary when trying to target a diverse population. Purposeful sampling strategy was implemented as it selects information rich cases for in-depth study. Around 16 different types of purposeful sampling have been highlighted by Patton [74]. The three types used for this study are maximum variation, snowball sampling, and convenient sampling.

Maximum variation sampling consists of purposefully selecting a wide range of variation on dimensions of interest [74]. This method is suitable for this study as it covers three groups: technology vendors, health providers, and health strategists in all three prominent health sectors (primary, secondary, and community). It also helps to identify important common patterns that exist across variations [80].

Snowball sampling identifies cases of interest from people who know what cases is information rich, that is ones that are good examples for study, good interview subjects. This sampling method is commonly used in studies that are based on referrals.

Convenience sampling involves selection of cases based on their availability for the study [74]. Convenience sampling also involves the snowball strategy where group members identify additional respondents to be included in the sample [74].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 short survey and the interviews, and outline how the sample was obtained.

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

3.4 Short survey approach

The short survey was designed to capture valuable data that could be better captured by a survey rather than an interview. The survey was very easy to follow; the user would select their options using checkboxes. In many cases, the short survey was part of the interview and had to be concise. It was designed to take 10 to 15 minutes to complete. It was additionally used as a mechanism to recruit potential interviewees by means of convenience sampling strategy. The survey was part of the interview process as it gave the interviewees a preview of the pilot study and interview questions.

The survey targeted various health providers, health strategists, and technology vendors who were involved in the New Zealand healthcare domain. The sample for the questionnaire was obtained initially by means of convenience sampling, and followed by snowball sampling strategy. 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. Due to his widespread experience in the health informatics domain, he was able to introduce potential participants for the survey and interviews. As expected, the majority of the candidates who filled in the survey participated further in this research by taking part in the interview.

The short survey was available in two common formats for convenience: a printed version which could be posted, circulated, or handed out during a personal visit, and an online version that allowed participants to submit their survey by visiting the URL– http://mhealthsurvey.tasmanit.com. The e-survey was used mostly by participants who were not based in Auckland, New Zealand.

The convenience sampling, snowball effect, and maximum variation sampling strategies were used in order to obtain the selected sample, as mentioned in section 2.5. A total of 21 candidates filled in the questionnaire.

The short survey (Appendix D and E) consisted of six main sections as shown below.

Table 3.3-1: Main sections of survey	
Section 1	Profile
Section 2	Awareness of m-health application
Section 3	Effectiveness of mobile devices in clinical and non clinical applications
Section 4	Challenges of mobile health applications
Section 5	Critical success factors in m-health context
Section 6	Future contact

The first section was used to identify the participant's profile: their occupation, the health sector they work in, and which New Zealand mobile health group they fall under: technology vendor, health provider or health strategist. They were also asked which mobile devices they use on daily basis. The answers ensured the credibility of the data collected.

In the second section, the candidates were asked to identify which mobile applications they were aware or unaware of:

Table 3.3-2: List of M-Health Applications
Web access to evidence-based databases
Medication alerts using mobile phones (SMS)
E-prescribing for repeat prescriptions via mobile phones
Tele-monitoring to transmit patient results to clinicians
On-line electronic health records via computer or phone
Community nursing contact with clinical expert advice
Public health and lifestyle messages over mobile phones
Emergency care for accidents, natural disasters
Efficient workflow via wireless communication
Optimal asset utilisation (e.g. hospital bed rostering)
Patient or asset (e.g. clinical equipment) location using RFID
Patient application booking and alerts via wireless email
Safety of staff checks with RFID or mobile phones/networks

The next section focused on which mobile devices are more suitable for clinical or non-clinical mobile applications, and also the level of effectiveness of each device.

The challenges section (fourth section) enquires about the relative levels of importance for the challenges in m-health.

Table 3.3-3: Challenges in m-health	
Privacy and confidentiality	Negative patients' or physicians' perceptions
Security (physical and software)	Devices are used for multiple applications
Personal factors such as large fingers, poor eyesight, forgetfulness of carrying the device	RFID tags (authentication and consent)
Authenticating user without biometrics	Inability to learn or train using mobile
Affordability / Costs	

The section on CSFs (Critical Success Factors) (fifth section) examines how each of the CSFs could be achieved with the respective devices in an m-health context. Lastly

(sixth section), the candidates were requested to further participate in the pilot study, and were able to add additional comments.

3.5 Interview approach

The sample for the interviews was collected using convenience sampling, snowball strategy and maximum variation strategy as described in section 2.5. The project supervisor, Professor Tony Norris, introduced potential candidates for the interviews, as mentioned in section 3.4. The snowball strategy was then used to gather additional interviewees from the previous participants. A majority of the participants, who completed the survey, went on to take part in the interview as well.

Maximum variation was achieved by conducting interviews in different healthcare sectors of New Zealand: health strategists, and technology vendors. A total of 18 interviews were conducted. The number of interviews was reduced due to time limitations for this pilot study, rather than the number of candidates available. This shows the success of the sampling strategies used.

The literature review highlighted that m-health applications are based on various mobile technologies, and involve confronting many inherent issues. By interviewing health providers, health strategists, and technology vendors in New Zealand, we investigated the potential of mobile devices and how they could enhance healthcare services in New Zealand. Interviews provided an opportunity to collect verbal data which would have been difficult to capture by the survey. The seven different themes (Appendix F) discussed in interviews are listed in Table 3.4-1. The themes were kept consistent for all interviewees, regardless of their background.

The interview agenda is described in full detail in section 4.2. The length of the interviews was kept at approximately 45 minutes to one hour. The respondents provided valuable information, highlighting many applications for each of the devices studied. All participants showed a lot of interest and wanted to be informed about the project outcome.

Table 3.4-1: Themes discussed in interview
How mobile device technology can enhance health services
Key opportunities of mobile device usage in healthcare
Technical constraints in using mobile devices
Challenges and implications mobile devices introduce into the healthcare environment
Funding and payment of service and who will get main benefit
Privacy and Security implications of m-Health
Tradeoffs of using mobile technology

Chapter 4: Results

The research involved 21 questionnaires and 18 interviews conducted to indentify the potential of mobile devices in New Zealand healthcare. Both questionnaires and interviews contributed towards the results of this study which are articulated in this chapter. The research methods used to gather these results are described in Chapter 3. Chapter 5 presents the in-depth analysis of these results.

4.1 Short survey results

The questionnaire results are displayed question by question. The original format of the questionnaire is provided in Appendix D. The questionnaire results are presented in both statistical and text format. The questions below are numbered methodically and will be referred to in subsequent chapters of the thesis.

YOUR PROFILE

Q# A What is your occupation or job title?

The results include the following:

Table 4.1-1: Occupation or job title of survey participants	
Director - Integration & Partnerships	General Manager X 3
Health Technology Architect	Doctor / Lecturer
Marketing Manager	Business Development Manager
GP Liaison CEO	Senior Lecturer in Computer Science
Channel Manager	Consultant Physician
Director of Marketing	Interim Manager
Software Manager	Senior Consultant
CEO	Business Analyst
Developer	Managing Director

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

The results include the following:

Table 4.1-2: Health sectors of survey participants	
Primary Healthcare x 4	Secondary Healthcare x 2
Community Healthcare x 3	Information Technology x 3
Industry	DHB
Global Standards Organisation x 2	Government Regulatory Authority
Research/education	Mobility Supplier
Telecommunications	PMS Software

Q#C Which of the following categories describes your involvement with mobile health in New Zealand?
(The choices available were technology vendors, health providers, health strategist.)

The results include the following:

Table 4.1-3: Participants involvement with m-health in New Zealand	
Technology vendors x 11	Health Providers x 5
Health Strategists x 5	Cell phone only x 1
Researcher x 2	No direct involvement x 2
AIDC technology standards organisation x 2	

Q#D What mobile devices do you use (e.g. mobile phone, PDA, laptop)?

Mobile Device	Total number of users
Laptop	15
Tablet PC	-
PDA	10
Smart Phone	5
Mobile Phone	13
RFID	2
Bluetooth car kit	1
Bar-coding scanner	2

QUESTION ONE: M-HEALTH APPLICATIONS

Q#1 Please tick which of the following mobile health applications you are aware of, or you are familiar with.
(This consisted of 13 m-health applications, and participants had to tick whether they were aware or unaware of the application.)

The following tables display the choices and percentages of the m-health applications:

Q#1.1 Web access to evidence-based databases

Answer	Count	Percent
Aware	14	66.7%
Unaware	7	33.3%

Q#1.2 Medication alerts using mobile phones (SMS)

Answer	Count	Percent
Aware	15	71.4%
Unaware	6	28.6%

Q#1.3 E-prescribing for repeat prescriptions via mobile phones

Answer	Count	Percent
Aware	8	38.1%
Unaware	13	61.9%

Q#1.4 Tele-monitoring to transmit patient results to clinicians

Answer	Count	Percent
Aware	17	81.0%
Unaware	4	19.0%

Q#1.5 On-line electronic health records via computer or phone

Answer	Count	Percent
Aware	17	81.0%
Unaware	4	19.0%

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Q#1.6 Community nursing contact with clinical expert advice

Answer	Count	Percent
Aware	8	38.1%
Unaware	13	61.9%

Q#1.7 Public health and lifestyle messages over mobile phones

Answer	Count	Percent
Aware	13	61.9%
Unaware	8	38.1%

Q#1.8 Emergency care for accidents, natural disasters

Answer	Count	Percent
Aware	11	52.4%
Unaware	10	47.6%

Q#1.9 Efficient workflow via wireless communication

Answer	Count	Percent
Aware	12	57.1%
Unaware	9	42.9%

Q#1.10 Optimal asset utilisation (e.g. hospital bed rostering)

Answer	Count	Percent
Aware	11	52.4%
Unaware	10	47.6%

Q#1.11 Patient or asset (e.g. clinical equipment) location using RFID

Answer	Count	Percent
Aware	15	71.4%
Unaware	6	28.6%

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Q#1.12 Patient application, booking, and alerts via wireless email

Answer	Count	Percent
Aware	12	57.1%
Unaware	9	42.9%

Q#1.13 Safety of staff checks with RFID or mobile phones/networks

Answer	Count	Percent
Aware	12	57.1%
Unaware	9	42.9%

Q#1.14 Additional m-Health applications included:

- Monitoring patients using sensor technologies
- Smart use of GPS to locate patient's position, especially in Residential Care
- Health alarms to monitor the elderly
- RFID being used in pharmaceutical industry for pill dispensing
- Midwives downloading lab and RSD results
- Wireless point of care devices
- RFID technologies for supply chain management, patient and asset tracking and tracing

Main Features of Q#1 results:

The results demonstrate that the majority of participants were well aware of mobile health applications like web access to evidence-based databases, medication alerts using mobile phones (SMS), tele-monitoring to transmit patient results to clinicians, on-line electronic health records via computer or phone, public health, and lifestyle messages over mobile phones, and patient or asset (e.g. clinical equipment) location using RFID.

We also discovered that most participants were unaware of m-health applications such as e-prescribing for repeat prescriptions via mobile phones, and community nursing contact with clinical expert advice. It is interesting to note that most of the applications they are aware of are not being implemented in New Zealand healthcare sectors.

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QUESTION TWO: M-HEALTH APPLICATIONS

Q#2 Select which devices are more suitable for clinical or non-clinical mobile applications. Please indicate level of effectiveness of the device.
(We will first view results of which devices are more suitable for clinical or non-clinical mobile applications. Then we will look at the level of effectiveness of each device.)

The following tables display the answer selection and percentages of mobile devices:

Q#2.1A Laptop

Answer	Count	Percent
Clinical	0	0%
Non-Clinical	3	14.3%
Both	18	85.7%

Q#2.2A Tablet PC

Answer	Count	Percent
Clinical	5	27.8%
Non-Clinical	0	0.0%
Both	13	72.2%

Q#2.3A PDA

Answer	Count	Percent
Clinical	2	9.5%
Non-Clinical	5	23.8%
Both	14	66.7%

Q#2.4A Smart Phone

Answer	Count	Percent
Clinical	2	12.5%
Non-Clinical	5	31.3%
Both	9	56.2%

Q#2.5A Mobile Phone

Answer	Count	Percent
Clinical	2	10.5%
Non-Clinical	6	31.6%
Both	11	57.9%

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Q#2.6A RFID

Answer	Count	Percent
Clinical	2	11.8%
Non-Clinical	4	23.5%
Both	11	64.7%

Main Features of Q#2A results:

The results indicate that most of the mobile devices are applicable in both clinical and non-clinical mobile situations. It is important to note that 30 percent of participants considered smart phones and mobile phones to be more useful in non-clinical situations.

Below are the tables of results for the level of effectiveness of each device.

Q#2.1B Laptop

	Least		Neutral		Very
Count	0	2	4	10	5
Percent	0.0%	9.5%	19.0%	47.6%	23.8%

Q#2.2B Tablet PC

	Least		Neutral		Very
Count	0	1	3	8	6
Percent	0.0%	4.8%	14.3%	38.1%	28.6%

Q#2.3B PDA

	Least		Neutral		Very
Count	1	2	6	2	10
Percent	4.8%	9.5%	28.6%	9.5%	47.6%

Q#2.4B Smart phone

	Least		Neutral		Very
Count	2	0	7	3	4
Percent	9.5%	0.0%	33.3%	14.3%	19.0%

Q#2.5B Mobile phone

	Least		Neutral		Very
Count	3	3	4	1	9
Percent	14.3%	14.3%	19.0%	4.8%	42.9%

Q#2.6B RFID

	Least		Neutral		Very
Count	1	0	5	6	5
Percent	4.8%	0.0%	23.8%	28.6%	23.8%

Main Features of Q#2B results:

The level of effectiveness for most devices was rated between neutral and very effective: 71.4% chose effective and very effective for laptop, 77.8% chose effective and very effective for tablet PC, 76.2% chose neutral and very effective for PDA, 68.75% chose neutral and very effective for smart phone, 65% chose neutral and very effective for mobile phone. The participants chose RFID as being almost equally neutral, effective, and very effective.

We can conclude that all of the mobile devices are fairly effective in mobile health applications. None of them got a high percentage of selection as being least effective.

QUESTION THREE: CHALLENGES OF M-HEALTH APPLICATIONS

Q#3 Indicate the level of importance for the following challenges for m-health applications.
(The question consisted of eight potential challenges, and participants had to specify level of importance for each of them.)

Below are the tables of results for the level of importance of each challenge.

Q#3.1 Privacy and confidentiality

	Least Important		Neutral		Very Important
Count	0	0	2	2	17
Percent	0.0%	0.0%	9.5%	9.5%	81.0%

Q#3.2 Security (physical and software)

	Least Important		Neutral		Very Important
Count	0	0	1	2	18
Percent	0.0%	0.0%	4.8%	9.5%	85.7%

Q#3.3 Authenticating user without biometrics

	Least Important		Neutral		Very Important
Count	0	0	8	5	8
Percent	0.0%	0.0%	38.1%	23.8%	38.1%

Q#3.4 RFID tags (authentication and consent)

	Least Important		Neutral		Very Important
Count	1	0	8	3	9
Percent	4.8%	0.0%	38.1%	14.3%	42.9%

Q#3.5 Negative perception of patients or physicians

	Least Important		Neutral		Very Important
Count	1	0	8	4	8
Percent	4.8%	0.0%	38.1%	19.0%	38.1%

Q#3.6 Personal factors such as large fingers, poor eyesight, forgetfulness of carrying the device

	Least Important		Neutral		Very Important
Count	1	0	8	4	8
Percent	4.8%	9.5%	23.8%	14.3%	52.4%

Q#3.7 Inability to learn or train using mobile devices

	Least Important		Neutral		Very Important
Count	0	1	6	6	8
Percent	0.0%	4.8%	28.6%	28.6%	38.1%

Q#3.8 Affordability / Costs

	Least Important		Neutral		Very Important
Count	0	2	6	5	8
Percent	0.0%	9.5%	28.6%	23.8%	38.1%

Main features of Q#3 results:

The findings demonstrated the level of importance for the challenges in m-health applications. Most significant was that over 80 percent of the participants considered privacy, confidentiality, and security (physical and software) to be very important

challenges. Also considered to be very important challenges were personal factors such as large fingers, poor eyesight, forgetfulness of carrying the device, 52.4 %; RFID tags (for authentication and consent) 42.9 %; and authenticating the user without biometrics, negative perception of patients or physicians, inability to learn or train using mobile devices, and Affordability / Costs 38.1 %. The other challenges were considered to be neutral. None of the challenges were considered to be unimportant in the mobile health domain, which points out the sensitivity of the healthcare sector.

QUESTION FOUR: CRITICAL SUCCESS FACTOR

Q#4 Please match which critical success factors can be achieved with the respective devices in m-Health context.
(This consisted of 10 critical success factors, and participants had to select which mobile device(s) are suitable to achieve the critical success factor in m-Health context.)

The following table displays the answer selection and percentages of each of the critical success factors.

Q#4.1 Reduce Cost

Answer	Count	Percent
Laptop	8	38.1%
Tablet PC	8	38.1%
PDA	13	61.9%
Mobile Phone	12	57.1%
RFID	6	28.6%
None	5	23.8%

Q#4.2 User acceptance

Answer	Count	Percent
Laptop	13	61.9%
Tablet PC	11	52.4%
PDA	13	61.9%
Mobile Phone	14	66.7%
RFID	8	38.1%
None	1	4.8%

Q#4.3 Increased efficiency

Answer	Count	Percent
Laptop	12	57.1%
Tablet PC	14	66.7%

PDA	16	76.2%
Mobile Phone	12	57.1%
RFID	11	52.4%
None	0	0.0%

Q#4.4 Improve patient safety

Answer	Count	Percent
Laptop	10	47.6%
Tablet PC	10	47.6%
PDA	9	42.9%
Mobile Phone	10	47.6%
RFID	14	66.7%
None	0	0.0%

Q#4.5 Improve patient care

Answer	Count	Percent
Laptop	13	61.9%
Tablet PC	13	61.9%
PDA	13	61.9%
Mobile Phone	13	61.9%
RFID	11	52.4%
None	0	0.0%

Q#4.6 Quality of Service

Answer	Count	Percent
Laptop	13	61.9%
Tablet PC	13	61.9%
PDA	13	61.9%
Mobile Phone	11	52.4%
RFID	14	66.7%
None	1	4.8%

Q#4. 7 Secure Connectivity

Answer	Count	Percent
Laptop	15	71.4%
Tablet PC	10	47.6%
PDA	14	66.7%

Mobile Phone	11	52.4%
RFID	9	42.9%
None	2	9.5%

Q#4.8 Remote access for clinicians

Answer	Count	Percent
Laptop	16	76.2%
Tablet PC	11	52.4%
PDA	16	76.2%
Mobile Phone	12	57.1%
RFID	6	28.6%
None	0	0.0%

Q#4.9 Sustainability of mobile application and or device

Answer	Count	Percent
Laptop	13	61.9%
Tablet PC	11	52.4%
PDA	13	61.9%
Mobile Phone	11	52.4%
RFID	8	38.1%
None	1	4.8%

Q#4.10 Location independence for patients

Answer	Count	Percent
Laptop	7	33.3%
Tablet PC	7	33.3%
PDA	14	66.7%
Mobile Phone	16	76.2%
RFID	5	23.8%
None	1	4.8%

Main Features of Q#4 results:

The results show that the majority of critical success factors (CSFs) could be achieved by several of the mobile devices. An alternative approach, therefore, is to consider which device facilitates a particular CSF.

Table below displays which are the most important devices to facilitate a particular critical success factor.

Table 4.1-4: Most important devices to facilitate CSFs						
Q#4	**Critical Success Factor**	**Most Important Devices**				
		Laptop	**Tablet PC**	**PDA**	**Mobile Phone**	**RFID**
1	Reduced cost			*	*	
2	User acceptance	*		*	*	
3	Increased efficiency		*	*		
4	Improve patient safety					*
5	Improve patient care	*	*	*	*	
6	Quality of service	*	*	*		*
7	Secure connectivity	*		*		
8	Remote access for clinicians	*		*		
9	Sustainability of mobile application and or device	*		*		
10	Location independence for patients			*	*	

The most important devices were PDA and laptop as they were considered to be capable of facilitating most of the critical success factors. RFID is the least significant device as its applications are more specialised compared to other devices. We can conclude that by utilizing PDA, we can achieve all of the CSFs with the exception of improved patient safety, which can be argued.

4.2 Interview results

The interviews were designed to obtain relevant information for the research which could not be captured in the short survey. On average, interviews were approximately 45 minutes. The interview questions are provided in Appendix F.

Table 4.2-1: Job roles of interview participants	
Marketing Manager x 3	General Manager X 2
Health Technology Architect	Doctor / Lecturer x 1
Director - Integration & Partnerships	Systems Engineer
Managing director	GP Liaison
Channel Manager	Director of Marketing
Developer	Business Development Manager
Senior Lecturer in Computer Science	Senior Consultant

The interviews had a semi-structured approached which also involved referring back and forth to the short survey completed by the interviewee. This enabled us to fully understand the reasons behind their selections, and allowed them to elaborate on their choices. The structure is similar to F. Mirza's [81] approach. Below is a rundown on how the interviews were conducted:

1.   Introduce the researcher: degree, university, and supervisor involved.

2.   Determine interviewee's profession, interest, and organization.

3.   Describe project background, motivation, research design, and its importance.

4.   Briefly explain ethical approval – how the research is assessed as a low risk project, transcription and short survey approval, and confidentiality of their input.

5.   Present interviewee with a short survey (if they are interested and willing to participate). *Note: They also had the option of filling out the short survey prior to the interview or after the interview at their own convenience, via mail or online URL – http://mhealthsurvey.tasmanit.com.*

6.   Outline how the interview is going to be conducted.

7.   Sign the consent form

8.   Interview focused on seven different themes:

   a.   How mobile device technology can enhance health services.

   b.   Key opportunities of mobile device usage in healthcare.

   c.   Technical constraints in using mobile devices.

   d.   Challenges and implications mobile devices introduce into the healthcare environment.

   e.   Funding and payment for service and who will get main benefits.

   f.   Privacy and security implications of m-Health.

   g.   Tradeoffs of using mobile technology.

9.   Lastly, an attempt to collect more interview samples using convenience sampling as described in section 2.5.

The procedure was altered depending on the situation. With the consent of the interviewee, interviews were electronically captured on a voice recorder. Each interview

was professionally transcribed to enable maximum extraction of information. To ensure credible data were collected, these transcripts were verified by interviewees.

The transcripts contained a large amount of valuable information. Not all information will be displayed in the following sections, as it would be very lengthy and hard to assimilate. Moreover, it would contain repetitive information as multiple interviewees had similar views. Therefore, the non-repetitive results will be distributed among similar themes in sections 4.2.1 to 4.2.7. The full text of transcripts are provided in the attached CD-ROM.

Note: The italic text in the sections 4.2.1 to 4.2.7 represents interviewee opinions – they have been reworded slightly to align them with their relevant theme.

4.2.1 Enhancement of health services

Interviewees were questioned and asked to comment on *"How do you think mobile device technology can enhance health services?"* — by different sectors and by patient/provider. The interview data reveals all interviewees were very positive regarding the potential of mobile devices to enhance healthcare services. The section below is divided into four subsections highlighting comments made by respondents regarding: mobile devices, primary healthcare, secondary healthcare, and community healthcare.

Mobile Devices – Mobility
(Below are generic comments made by respondents on how mobile devices can enhance health services.)

- *The primary focus for most healthcare practitioners will be on patient safety, it's the first bit.*

- *90 to 95% of the staff are highly mobile, and when they're mobile they're interacting with customers, patients, suppliers, everyone, and while they're on the move. So being able to take their desk, or being able to have access in real time to information that's applicable, especially around patient care.*

- *Blood meters can be put on the bottom of a mobile phone now. In theory, I would expect the phone companies to have partnered with a diagnostic company. So patient's results would go off to a centralised location (e.g. Server).*

- *Brings medicine closer to the individual and it gives the physician the ability to deliver healthcare anywhere.*

- *Mobile devices allow users to have convenience and they offer portability.*

-   A mobile device is all about having information when you need it. If it's a mobile device, it means you've got it with you. So it's all about instant gratification of having that information that you need there and then.

-   Portability and mobility are the two main benefits. Because most other things you can do via desktops providing you want to sit in front of it.

-   It provides a communication between provider and patient; there are several studies that show, email is becoming an increasingly accepted mode of communication, although there are problems with it.

-   Recent changes with the Telco number portability, it means practices can still get hold of their patients due to the fact that I can change my plans with Telco, yet retain the same cellphone number. So that's been quite powerful.

-   It actually strips efficiencies and costs out of the healthcare supply chain. And secondly, shoring up the supply chain for things like theft and counterfeit of drugs and pharmaceuticals, and medical devices.

-   Helps ensuring and delivering the five rights of a patient. Right Patient, Right Drug, Right Dose, Right Route, Right Time, — an important thing to have in a hospital type environment.

-   Clearly, our research shows that between 150 and 1500 people a year die in New Zealand hospitals as a result of wrong drug, wrong patient, wrong time, wrong route, and wrong dose. So if we can use mobile technologies to definitely and uniquely identify the five rights, well surely that achieves one of our objectives in improving patient safety and saving people's lives.

-   Mobile technology allows constant monitoring of the patient, because it's with patient all the time. So I think the mobility factor is the key to the whole mobile device.

Primary healthcare sector
(Comments made on how mobile devices can improve healthcare in the primary healthcare sector.)

-   Can use a mobile phone as a time tool. Also, if we're out and about, our practices can contact us in between home visits and things like that when we're out of the office.

-   When we're looking after a patient intensively, it's possible to give them your mobile phone number and then they know they can get hold of you when required.

-   Mobile phone historically, looking at international case studies, has been proven to not only improve patients' care, but also to reduce administration costs for the practice. And this applies to both primary healthcare and secondary healthcare.

-   Fujitsu implemented it in the UK, there was one done on Waterside Healthcare. They basically put electronic systems and a WIFI network into general practice. And they issued the GPs the ultimate tablet PC. They didn't

change any of the software at all. The aim was to make data accessible from wherever the GP actually was.

\- *GPs and so on, communication outside the office perhaps, over the Telco network, be it Vodafone or Telecom.*

\- *RFID readers and bar code readers can be utilized for better accuracy of data, and minimising mistakes through poor handwriting from scripting, e.g. when a GP writes a prescription. That's some of the things that we've seen overseas that have helped the health industry, the primary sector.*

\- *Standard form and procedure of storing that information on mobile devices, then when a person has an accident, you can pick up the person's mobile phone and actually find their health records on it.*

\- *Practices have been able to reduce patient DNAs (Do Not Attend), which in turn translates into thousands of dollars. Software being able to automate the process of appointment reminders.*

\- *Mobile communication has been able to really reduce the administration quite significantly for high needs patients. Now for high needs patient, it adds to the service; e.g. if you're a patient who lives in a low socio-economic area, you can carry a handheld cell phone and not necessarily have any credit, yet still receive messages on it.*

Secondary healthcare sector
(Comments on the use of mobile devices in secondary healthcare are listed below.)

\- *Certainly, within the hospital system I've noticed that they're developing the use of PDAs and laptops on ward rounds. And I think there's going to be a much larger use of mobile technology.*

\- *Clinicians need to be more mobile and, also most hospitals are moving away from paper notes to electronic type system.*

\- *A great deal of use is with the larger devices, such as tablets and laptops. It's the use of them for accessing the general health record and also for information sources such as drug lookups.*

\- *Mobile devices for patient tracking, identification of objects, and drug identification.*

\- *Remote monitoring helps free up facilities, particularly things like beds, spaces like that, by allowing people to go home earlier so that they can be monitored.*

\- *It will cut down the amount of in-house care, postoperative care, for example: in fact pre-op care that needs to be done, thereby freeing up facilities. I mean the ideal out of that would be to cut down waiting lists for a start of course, that would be a dramatic improvement.*

-   Mobile devices are being used to monitor patients, manage assets, and look after wards.

-   Once again, with waiting times, etc., it's ridiculous to have someone waiting in an Emergency Department (ED) for six hours. If you could actually do a point of care test, and a mobile device test while they're actually sitting waiting in the waiting room.

-   A US-based hospital, of how they're using a wireless infrastructure and the mobile devices together to improve communications around the hospital.

-   Using RFID to reduce errors, as well as asset tracking, that's a big thing in hospitals, to minimise expenditure in buying new multiple amounts of equipment.

-   Accuracy of data, and communication through voice over IP or patient notes. Also for Drug administration.

-   Greater impact on those services which require greater mobility, which are not necessarily always located in the community, they may be located in secondary care. Will be located under the umbrella of secondary care, but are run out in the community.

-   PDAs will help within the hospital if the hospitals move away from paper notes. And, therefore, it will increase the mobility to move around and still have access to the data.

-   Using RFID technologies and bar coding type technologies to identify the movement of assets through a hospital type environment, beds, etc.

-   All patients going into hospital will be fitted with an armband, a wristband, which will contain a unique identification number identifying that patient. So that patient's wristband will be scanned on entry into the hospital, and it will form the basis of an electronic patient record.

-   Huge potential in hospitals because you've got nurses moving around, you've got pharmacists moving around, doctors moving around. So, they may or may not have an office, but they spend a lot of time visiting their patients. So even if it's just a reference check, or an ability to calculate drug dosages, or used as a glorified calendar.

Community healthcare sector
(Comments on mobile devices in community healthcare are listed below.)

-   One of the big sort of changes that's happened in health and IT is the availability of mobile phones in particular, also internal Internet access for people who are mobile. So that includes community nurses, obviously patients, in terms of that sector, it often entails driving around to people's homes, etc.

-   The community can benefit because of the large number of community care workers that are out there in the workforce that need to visit patients in their

home. This is where we see healthcare progressively moving towards. So as the healthcare model changes and it's more and more distributed out towards the home and away from hospitals, then obviously mobile devices would seem to be a good way to go.

- *They want access to information in real time, especially in areas like Auckland where it's hard to go back to offices. It's ideal to be able to be out on the road for a number of days and to have access to that information and share it in real time. It adds to the patient care as well, especially around diabetes and home care.*

- *If GPs or practices start using, start going out a lot more to remote locations, then mobile technology would be useful. But the problem with a lot of remote locations is that you don't always have network reception.*

- *Clinicians in emergency situations, sending texts to a base for advice.*

- *There are systems that you can use, to take a digital photograph, and then download it, and then send it to a person. But that's quite cumbersome and slow, whereas PXT seems to be a whole lot better; it's kind of leap-frogged over that technology really.*

- *Community nursing can be undertaken a lot easier by fewer people, because they don't need to visit people every day to monitor Instead use an electronic monitor.*

- *The way that New Zealand is set up we have a lot of rural population that can't have access to some of the secondary care and something like a cardiac marker; you know a mobile technology that could go into a rural practice, is obviously beneficial.*

- *People like nurses who do house visits, so I'd say it's relevant to those people who are mobile.*

- *The key concepts now are patient-centred healthcare, patient ownership of their own healthcare, and care out in the home, and care out in the community.*

Adoption in New Zealand healthcare system
(Comments made in regards to the adoption of mobile devices in New Zealand healthcare system.)

- *The announcement by the government in recent times has showed definite leadership in addressing the problem of patient safety. And when the project of using RFID gets out of the blocks, New Zealand actually comes from a situation of being, if you like, a slow follower to actually being a fast implementer. And so we actually could head the pack if the momentum for the project starts reasonably soon.*

- *As a countrywide initiative, I think it's actually quite exciting and puts New Zealand right at the front. In a sense, small countries are more controllable. So it's more of an experiment or a lab type of environment.*

- *So even if you went from a pharmaceutical point of view, if they went for a full rollout in the whole of New Zealand, that could still be considered for them as being some stage of a pilot project. Whereas if you're going to start in the USA, things move about from all over the country. So in a sense, I could see New Zealand being more attractive just from that more controllable point of view.*

- *Most of the big secondary care services are looking at implementing some kind of electronic health record. But at the moment, it's all paper-based.*

- *An initiative by the New Zealand Health IT Cluster, who want to monitor in one hospital in a pilot environment, the movement of patient beds through a hospital to identify when a bed is empty, so consequently can be filled. If they can gain some efficiencies in there it means better utilisation of hospital equipment, and patients get their care quicker, so certainly in that area.*

Disadvantages for end users
(A few of the respondents highlighted the disadvantages end users would face by adopting mobile devices in healthcare.)

- *Patients might view this as a less human touch, which possibly could be an issue.*

- *What we've found so far is it gets redirected towards the end for what they perceive is more important. Saving lives by buying a new heart machine as opposed to getting some mobile computers.*

- *The benefits aren't seen . . . the overall efforts aren't seen for implementing these sorts of handheld devices to help with drug administration, as opposed to a crash cart. That's got a much more immediate ROI, or it's able to save lives a lot quicker, or more of a direct relationship with it.*

- *There are increased risks of security with portable devices. They don't come so much with the desktops.*

- *One of the problems with increasing the mobility of the technology is, at the moment if you're away from your desk, you can actually have a break rather than being contactable.*

- *One of the problems with mobile phones, and mobile email and what have you, you can be potentially contactable 24/7, which is good in business, people get no downtime.*

- *It's been frustrating for practices. Because first of all, their administration costs have been increasing due to the fact that they cannot get hold of the patients.*

- *There are studies which demonstrate that the quality of service of homecare is less than that of hospital care. So for example, the chance of being administered the wrong pharmaceutical is higher if you have home care than if you're in a hospital, and if you don't have access to IT systems as they would*

have in hospitals, there's a whole range of additional possibilities for things to go wrong.

Examples illustrating how mobile devices can enhance healthcare services

- *Ministry will buy and strategically locate repackaging machines in New Zealand to singulate dosages into uni-level dose. It means that at bedside point of care, for argument's sake, the patient's wristband will be scanned. The administrator of, let's call it a pharmaceutical, their unique identification will be scanned, a bar code somewhere on their person. The drug will be scanned. Then what you will have is match, match, match.*

- *In home care, so if any aspect that I could see mobile devices will be helpful, even more so than in a hospital environment, could be around home care. It could be people visiting patients and caring for them. It could also be people who care for themselves, like sugar diabetes particularly; they care for themselves. So if you can give them mobile devices to allow them to report on whatever they are doing. Again, it decreases the risk of any errors occurring by home care.*

- *Hospitals are big places as well, and I know that physicians, those who have migrated to using PDAs and the like, basically they swear by them due to their benefits.*

4.2.2 Key opportunities of mobile device usage in healthcare

The second theme involved discussing valuable opportunities of mobile usage in the healthcare industry. Many opportunities were highlighted by utilizing devices such as laptop, tablet PC, PDA, mobile phone, and RFID. If the interviewees highlighted more than five possible applications, they were asked to rate their choices according to the application's importance. This section discloses comments made by interviewees in the order of general opportunities, laptop/tablet PC, PDA/smart phone, mobile phone, RFID, examples, and barriers of using mobile devices.

Mobile health opportunities discussed

- *They are small and portable which is ideal for the healthcare industry professionals.*

- *The opportunities are definitely there to speed up waiting. In healthcare, it seems there's always waiting lists. There are always multiple visits back to go to several different divisions within the healthcare industry, whether it's the cardiology, ultrasound, etc. Could minimise the whole process of patient care and it can speed up through use of this technology.*

- *90 percent of the New Zealand market of people with diabetes will have a meter, a blood glucose meter that's capable of being downloaded by infrared lens, which means it's really fast and easy to download results, that's the reality.*

- *Web access to evidence-based systems are being introduced.*

- *Minimise the errors and hopefully deaths from overdose, or wrong dose of medication.*

- *Doctor's prescriptions are sometimes misread and cause the wrong drugs to be administered from the prescription. Instead, they could have a number of drugs that they can have from a drop down list to administer from, which ensure no errors are made.*

- *E-prescriptions have a lot of prospect but would be a long way off. I think there would be ethical issues around that.*

- *Patient appointments through email and text would be a fantastic idea.*

- *Also in the secondary health setting there are many opportunities for mobile devices to manage assets, manage staff, and manage patient beds.*

- *Opportunity in the community health sector for capturing data when you're away from the computer. So the data is electronic, synchronised, and the data has more value as compared to paper written data which needs to be taken back to base and recorded onto a clinical system.*

- *Remote monitoring can help to handle everything from post op care, through palliative care, through mental health, aged care, etc.*

- *We've got more of a distributed population, though our population density is less, which would improve the tele-medicine preference.*

- *A provider can utilize video and tele-health as it has a lot of efficiency gains.*

Opportunities for laptop / tablet PC

- *Emergency care people will use mobile devices such as laptop and tablet PCs in their ambulances.*

- *Increasingly in the secondary healthcare environment, especially within large hospitals, it's the personal mobile devices that allow clinicians to access all the facilities remotely. So you'll have access to patient management systems, and lab results. All these sort of scheduled tasks.*

- *Community nurses can actually prescribe medications on tablet PC; e.g. nurse/doctor or nurse practitioners.*

- *Opportunity for training and development. So it could be that the healthcare providers provide training to other healthcare providers remotely.*

Opportunities for PDA / smart phone

-        *Data capture by using the right device, using a PDA to record key results. Midwives can carry these PDAs and record results. Dentists can use them in the community rural healthcare setting. Obviously this allows the data to have higher value, because it's captured electronically. It can be searched, it can be reported on, compared to free text or paper-based data.*

-        *There's increasing moves towards the use of video phones, and sending picture images via smart phones and what have you, rather than having to set up complex video conferencing things.*

-        *Mobile phone with video capability can record and send videos in real time. Video consultations between healthcare providers and patients are certainly something that we would see happening.*

-        *The PDA version of MIMS Online, which is the drug prescribing, which is easier than having to always log onto a computer.*

-        *To perform Tele-dermatology consults, out to the rural areas, you need a certain level of resolution and reliance on the service.*

-        *Mobile phone to send images of an accident site through to the base hospital.*

-        *PDAs are being utilized for reminders and alerts for healthcare providers.*

-        *In a hospital environment, shifting from the simple mobile phone that works off the standard Telecom network, to something that works with a Wi-Fi network, using VoIP. And can set up rules on your phone to divert to mail, and convert it to text. So it's actually integrating the phone with the workflow, and using PDA, can use as phone and to check emails*

-        *Mobile devices can enhance evidence-based medicine. So you could send in a few variables using your PDA application, or a text message, or ring a phone number and push some buttons. And based on that, the evidence base and algorithms can be run. And the patient gets the feedback on what they should do and which medication they should take.*

-        *The courier drivers love the PDAs these days and it pretty much simulates their whole business workflow and helps them carry out all their activities during the day. So if you're a midwife and you just want to record how your patients are doing using a few dropdowns and check boxes, PDAs might be ideal.*

Opportunities for mobile phone

-        *Medication alerts, definitely things like sexual health. Mobile phones and text messaging is a good way to get to the youth market if you're doing things around sexual health, or any of those sorts of campaigns.*

- *For example in New Zealand, we've got a problem with absenteeism for hospital appointments. And mobile device text messages offer the ability for systems to communicate with patients reminding them of their appointments. This will reduce absenteeism and could save money to the health practices.*

- *Location, medication, making sure that they take their medications. Texting them to tell them to take their meds, and this goes for all patients. Alerting when certain physiological signs start triggering certain alerts.*

- *Vocera is a product that allows mobile staff to communicate as they move around the hospitals, which is similar to wireless phones. It's well-known to communicate from a voice point of view and not have to use State owned networks within the health industry, etc.*

- *Mobile messaging can also be employed in primary healthcare, with people who have bad debts, debtors that have accounts overdue. Moreover patients that are enrolled with the practice, but they're enrolment status is about to drop off. So they can confirm with patients that they wish to remain enrolled with the practice via mobile message, rather than having to pick up the phone or send a letter with a form for them to respond...*

Opportunities for RFID

- *Opportunity in enhancing work, non clinical workflows in a secondary hospital, asset management, bed management, patient management, and patient location management. These can be achieved by using smarts like the RFID and wireless networks.*

- *Things around mobility, it's real time location of equipment using active RFID,*

- *Supply chain efficiency, product and inventory controls, and stock management. But certainly, the hot button is always improving patient safety, saving people's lives.*

- *The use of mobile technologies can enable the supply chain by making it more efficient. The way it does that is identifying inventory, and stock levels, using machinery information in a simple cost effective robust manner. A decrease in wastage, which I think is significant in healthcare throughout the world. So it's waste, it's visibility of the total supply chain.*

Examples demonstrating the opportunity of mobile devices:

- *Ten percent of drugs in the world, as you probably know, are counterfeit. And so if mobile technologies can assist in the fight, I suppose, against counterfeit drugs especially, that must be a good thing.*

- *If it were on a house call, or a visit to a rest home, for example, then those sorts of mobile devices don't have to be on the laptop. They can be on smaller devices, they're more mobile and easier to use and quicker to use as well (e.g. PDA, mobile phone, tablet pc). So the same sorts of benefits in the software*

could then be given to a person to make them more mobile and therefore you get the efficiencies in mobility.

- Post operative care can, to a certain extent, benefit by getting the patients out of the bedroom and back to home. In other words carrying out as much of the post operative care as can be done remotely. So I mean cardio for example, rather than staying in hospital and being closely monitored attached to the machines that go ping. The monitoring machines can do that for them in the home. And that means they're saving money, time, and resources.

- You can rest assured that pharmaceutical companies do put economic measures against patient safety. Other arguments may actually take precedence over patient safety, although nobody will admit that publicly, but it will happen. But obviously, everybody would like to say that patient safety is more important than anything else.

- If you're a diabetic patient, you could text in your test results, which could be read by a system.

- Basically, in primary healthcare, all the practice communication can essentially be mapped onto mobile text messaging. A message that is short and sweet, straight to the point. You're due for something, pick up the phone, make an appointment, real easy.

- Remote monitoring — A number of devices, sensors, so there's cardio, scales, that sort of stuff, so blood pressure, the whole, that sort of shooting match, which then goes back. All Blue Tooth inside somebody's house. And there's a device which is also a mobile/landline device, which collects all the data and forwards it to a database. So the local clinician can actually monitor what's going on and see what they've done. So a lot of the care, post op care for example, or pre op care can be done using that system.

Barriers to taking up mobile devices in healthcare

- It's still quite a pain to lug a laptop around. So although laptops improve mobility they don't take it the full way.

- One of the things that seems to have come out from small devices is that the screen size is too small to have with the large records and all the things that you put in there yourself. They're trying to look at extremely little screens.

- It's still easier to look up the book rather than a device, I'm afraid. The book's a lot smaller than the computer. It doesn't take as long to boot up.

- Appointment reminders via email and text would be dependent on the area. Can't imagine all GP's patients having access to email- or even texting.

- You can't carry a laptop in some areas where there is a problem with theft or there is a problem of spillage. For example, you may go into environments where there is no room for you to, dock your laptop, so what are you going to do then? And also, laptops are quite hard to look after.

4.2.3 Technical constraints in using mobile devices

This is the third theme and the sample was questioned about 'the technical constraints in utilizing mobile devices in the healthcare environment'. As the sample contained many technical experts, they were very competent in addressing many of the technical constraints involved. They commented on aesthetics, costs, infrastructure, connectivity, and constraints for each of the devices which are being covered in this study. This section's results are being presented in the following five parts: generic technical constraints, laptop/tablet PC, PDA/smart phone, mobile phone, RFID, and infrastructure/connectivity constraints.

Generic technical constraints
(Below are the generic technical constraints highlighted by the interviewees.)

-        *There are obviously issues with the devices being not that user-friendly for patients.*

-        *Need to make mobile applications as simple to interface with as possible so that people are not having to key vast information in. They can quickly tick boxes and move onto the next field, or scan if need be and tick a box to verify, so it's from that side of things.*

-        *You have to move to a mobile computer on wheels type product in hospital as its fine in most circumstances doing rounds.*

-        *As a physician, one doesn't want to use an application on the PDA and then switch over to a laptop and use another system. And then switch over to a tablet PC to do, to take some freehand notes which are converted into text. One physician would only be prepared to use one device. And if you're a patient, you'd want the same as well.*

-        *It's definitely an issue with the elderly population. They don't feel confident, they might be shaky, and their eyesight might not be good.*

-        *Sort of robustness both in terms of the actual hard drive of the device, battery life of the device, because that's a big issue if you've got people working 12-hour shifts and they expect the battery to survive in terms of that.*

-        *You have to make it look like a medical device. And so yeah, there are issues with aesthetics and ways of making them possibly less intrusive.*

-        *Cost! A lot of the mobile devices aren't that cheap, particularly when you're looking at ones that would be particularly useful within health.*

-        *Size is an issue and there's always a trade-off with the size of a mobile device. The mobile device as it gets smaller becomes more mobile. However, the*

screen real estate is a problem for applications. But fitting that right device to the application is key.

- The issues are less about the technology and more about how that is applied, educated, and rolled out effectively.

- Battery life is a constraint. By providing them with two batteries so they can change out. And make sure that the software is persistent through battery changes.

- The size of not only the screen real estate, but also the comfort and form factor, as in does it fit in a shirt pocket, is it that mobile, or is it a case of it's something that I have to bring out from my laptop bag.

- Input size and medium need to be enhanced to larger screens, and potential voice input.

- Smaller and handier the size is, the easier they are to be dropped and damaged as well.

- It's easy, it's quite fiddly, and you may just drop the stylus and you're stuck with a device which you will find hard to work with throughout the day.

Laptop / tablet PC
(Below are technical constraints related to laptop / tablet PC devices.)

- Mobile tablets, etc., really it has to be durable, IP 69 rated so they're going to survive that, and high drop tested to survive that environment of water and being very mobile.

- To turn my laptop on it takes three minutes, and to set it all up, or to get it out of the bag and pack up time, it takes some time. I rather would use a PDA.

- When you come to tablet PC's again, the Internet connectivity increases, but the cellular connectivity decreases because tablet PC's don't have a phone number. So you would need a tablet PC and a mobile phone if that's your requirement.

- You're not going to get a cheap tablet that's in any way effective, so cost is quite a barrier. They also look quite fragile. Tablets — you can damage their screens quite easily.

PDA / smart phone
(Below are the technical constraints for PDAs / smart phones.)

- The uptake globally, that it's starting to filter through that tablets and ruggedized PDAs, or industrial type PDAs are starting to come down and be competitive in price to allow that to be implemented as well.

-        *The keyboard would be real small, so I couldn't type as fast as I could on a laptop. The screen size would be really small. Then the legibility for application and installation on PDAs would reduce.*

-        *Types of applications you can have on a PDA would be very rare. And the functional aspects of the applications that are on the PDA would be limited also.*

-        *For PDAs again, screen size of the keyboard can be a problem. But it may not be the problem. Sometimes the need or the application is so small that PDA might be very comfortable for a person to work with. PDAs do have slightly more generous screen sizes which allow for a number of things to happen.*

-        *The size of the screen is very relevant. I can't wait for the day where they have the flexible screen and I can just roll it out and actually have a decent sized screen that I can read. So I definitely see that as a huge constraint at the moment.*

-        *Data entry, again with my old device I used a foldout keyboard, so with a small device like that it just becomes very slow with an infrared.*

Mobile phone
(Following are some of the mobile phone constraints revealed by individuals.)

-        *For mobile phones, they've got a very small interface and there's limited amounts of things that you can do with mobile phones.*

-        *Mobile text messages are limited by 160 characters and to some clinics that might be a bit of a constraint technically.*

-        *I don't think that having elderly people necessarily, well for a while anyway, until the generation Y people come through, or X or whatever, using mobile phones for complicated exercises is not going to work.*

-        *But I think that if they have the right device with a big enough screen so that they could see it, and it's legible, that will be perfectly acceptable.*

-        *They need to be drop proof, flood proof, standing on proof, idiot proof. They need to bounce basically, there's a trade-off between how small you get versus the screen size.*

-        *Security is a big one. Mobile devices are easily lost, or nicked. So there's a whole issue there if you're storing particularly clinical data on mobile devices, to make sure that you don't breach, security issues there. E.g. security in the wider sense, using text messaging to patients, but how do you know that the person currently with the cell phone is the person to whom you're sending the message.*

RFID

(Below are the RFID technical constraints highlighted in the interviews.)

-        *So if you operate RFID as UHF, that is electromagnetic field, that is highly absorbed by water based liquid. So obviously, that field energy is absorbed in the liquid. In a sense, the liquid heats up and by heating up that will actually, it potentially could affect the clinical nature of the active ingredients. And that is actually a reason why some pharmaceutical companies are quite reluctant right now to use UHF technology. At lower frequencies, it has been proven to be negligible. So that's not necessarily wireless as such, but certainly UHF RFID, that has some concerns. Potential impact, the doubt of the use of RFID technologies on blood products.*

-        *Typically reading distance can be a plus, but it can also be a minus if you start reading objects that are all over the place, that may be more of a nuisance. If you're identifying a patient that's carrying this and your reader captures stuff up to five metres away, you'll be scanning a whole ward of patients, instead of the one that you're looking for.*

-        *There's two ways you can solve the reading distance problem, if that could potentially be an issue. How you could solve that is by turning down the power level on your reader. So the less power it uses, the shorter the read fields drop back. So if you have multiple applications you might need to go with fairly big tags, because you want to support one step. And then, for another step where you need less distance, you would tune down the power of your device.*

Infrastructure / connectivity

(Infrastructure and connectivity constraints are described below.)

-        *Reasonable level of reliability and connectivity. Currently things like Wi-Fi networks are good, but they're not as good as what you get from a mobile phone.*

-        *Make sure that you have multiple H ports around the site, or access points. and those have to be located precisely and monitored to make sure that your coverage is sufficient to carry things like voice network, you know wireless voice, voice over IP it's called. The investment goes up in terms of putting wireless into these concrete buildings, as opposed to an office space, they might have GIB walls and the signal goes through that.*

-        *The coverage matters when you're trying to retrieve data on a PDA from the server. E.g. Let's say you're a nurse and you decided to go to Warkworth to treat a patient. And your clinical database is in Manukau. When you're in Warkworth, there is no coverage, so you won't be able to get that patient record in Warkworth. So it may be a complete waste of time; even though you're equipped with a mobile device, you can't really operate it.*

-        *The whole issue of broadband. Probably if you wanted to say what can New Zealand do best to improve end health, it's to sort out its broadband.*

-   Unless there's a wireless infrastructure, then mobility is not going to be rolled out in that area.

-   Some rural areas around New Zealand don't have either Telecom or Vodafone coverage and therefore what do you do in those situations? So timing of data synchronisation captured data is important as well.

-   Emergency care. So if you've got an emergency you're mobile is pretty much going to be useless. You're not going to be able to get crucial information when you need it most. It's not because the network is necessarily broken, it's just that it will be jammed with the people trying to contact everybody. So I don't think they've got the capacity in New Zealand to be able to deal with that, a disaster situation.

-   The connectivity is going to be the issue. I mean laptops seem to be getting smaller and smaller and easier to use, and more kind of ubiquitous really. If there's no connection, then you can't use it. So that's the thing that I think will be the key factor really.

-   Obviously, concerns about wireless, wireless connectivity interfering with the devices and people still ask you for a good reason to switch off your mobile phone, or not operate your Blue Tooth connection if you're sitting in an airplane.

4.2.4 Challenges and implications of mobile devices

The fourth theme involved discussing what sort of challenges and implications mobile devices introduce into the healthcare environment. Many challenges and issues were highlighted by introducing mobile devices such as laptop, tablet PC, PDA, mobile phone, and RFID into the healthcare environment, especially regarding the privacy, security, and ethical issues. This section discloses comments made by interviewees in the order of generic challenges and implications, privacy issues, security issues, security of infrastructure issues, ethical issues, and privacy issues solution.

Generic challenges and implications:
(Below are the generic challenges and implications highlighted by the interviewees.)

-   In terms of acceptance, I think that the largest portion of the population, say the 40 year olds and below, they will accept it.

-   The productivity, etc., is far greater than any risks that are potentially there, although in saying that, they are not to be discarded.

-   it helps if a company that supplies mobile devices, parts and support; is based in New Zealand rather than an overseas company.

- *The uptake of these, your grey-haired brigade will be far less keen to adopt new technology. It's a lot more confusing for them, so it's age demographics being brought into.*

- *It depends on the language barrier. Because there's two sides to it. Most devices are based around the English language. Cangai character set, or different keyboards for different countries, different operating systems with different languages on them as well.*

- *Barriers whereby adoption to using the device, the change control you'd have to go through to get people to want to use the device. People within the health industry that are a little bit negative towards changes, you quite often find that.*

- *In terms of access and connectivity, often there's a barrier for diabetes. It has had much greater improvements in Maori and Pacific Island people for example. And there's a bit of a barrier in terms of the fact that they would be a bit reluctant to have new technology, they're struggling with some of the basics.*

- *The billing system has been designed for the dark ages really. It's on the community care organisation may not necessarily want a different efficiency gain because they may be paid based on a visit, a physical visit. So if we were to substitute a physical visit with a virtual visit, then they don't get paid.*

- *What I think the biggest risk is, rather than those security risks, from a priority perspective, it's them dropping them in the bath, down the toilet and places like that.*

Privacy issues:
(Below are the privacy issues in healthcare, highlighted by the interviewees.)

- *The privacy is definitely an issue with results, especially when sending results.*

- *Do not put anything in the text message that could potentially expose a privacy issue with that patient if someone should acquire the mobile handset and read the message itself.*

- *Need to be as abstract as you can so that if it does get in the wrong hands, actually it's not giving out any information.*

- *It's a matter of putting higher boundaries for people to do it. And at the same time informing people about, you know what is reasonable and what is not reasonable. And again, giving them choice when it comes to RFID products.*

- *People should be made aware of the RFID tag items that they have in their life. It could be loyalty cards, if there was an issue around that, I would turn that, for example into the wrist band. People need to be told that this is not any type of wrist band, but this is actually an RFID wrist band. Because if they find out themselves, they're going to be upset.*

- *They should even be explained how to disable RFID wrist bands. If you really want to make sure, just cut it through the antenna.*

- *Privacy is hugely important. It's worse than your bank and your pin number. You can stop the credit cards and you can stop all. But if someone steals a piece of private information, it's very irreversible. E.g. 16 year old daughter, you've put her on the pill.*

- *Privacy is a huge issue for mobiles, simply because it can be much easier lost than if it's locked up in an office in that sense.*

- *Most people in the general public don't understand issues of privacy until you start to talk about it. It comes down to the general public's awareness of privacy.*

- *Privacy of data, either by somebody getting on your network, or hijacking a mobile device is paramount.*

- *If I have a PDA and I use it for my personal phone calls, and work and so on, then does work see what I'm doing with my personal phone calls, or personal emails? So there's personal privacy and also the hospital, or patient privacy as well.*

- *Laws around that, patient privacy with wireless networks, HIPAA. So it's about privacy of patient records. There are already guidelines globally for this to state that if you have a wireless network, it has to comply with these encryption standards, and these authentication standards to make sure that patient confidentiality is kept confidential.*

- *In terms of general privacy, that's again one of the reasons why you need to have a good set of business rules as to the person.*

- *Appointment reminders are the one that springs to mind. Because if a patient is not at home and we leave a message on the answering machine, then how much information do you leave?*

- *It is much easier to lose a device or misplace them.*

Generic security issues
(Security is one of the prominent issues discussed by the interviewees; below are some of the comments.)

- *Simply password protecting your phone is enough. And most of that won't be kept on the phone anyway, it doesn't have to be kept on the phone. It can always be deleted.*

- *Well devices will get nicked, like things get nicked from hospitals today anyway. So that's going to happen. It's how the data is treated that might be on the device that's the issue. And there are more than plenty of methods for securing the device, even if somebody steals it.*

-       *you can remotely turn it off, and you can suck the data out of it remotely. It's no worse than somebody taking the note pad out of your hand is it?*

-       *I think I always use 'that what's in it for me' scenario. If it's going to improve the care I get, and if I'm going to be able to get quicker action, and it's going to aid my exit from hospital, or aid my recovery, then that will outweigh the security side of things.*

-       *I think there's a heightened awareness that protection of data is paramount — and protection of people's information.*

-       *It's related to the fact that the devices can easily be lost, or stolen. They can easily be transferred. How do you know, how do you authenticate the end user? How do you secure the data in the system, or do you perhaps use the system to interface with databases.*

-       *The difficulty there is that, it goes down to the fact that, yes, the technology works, right, but the technology has to be used appropriately. So for example, when we get people registering online, they register with their name, their date of birth, what their challenge phase is, and we send them out a digital certificate. Before they can use it, they have to phone us up and re-identify themselves.*

-       *We have a system called MSP that if the device goes missing and it doesn't report into the server for so many check-in periods, it becomes automatically locked down. But the point is that, yeah, if your device is stolen, it gets locked down.*

-       *Wipe a device with our new MSP product as well. So if you wanted to, and you had communication to the device and used it for a phone call or whatever, you can enable the GPS data and get down and wipe it.*

-       *It's quite safe using mobile devices, you know like a nurse going into a rural area, So potential for losing data, or for having people maliciously use data that's on the device has already been thought of. And we have lock downs in place to be able to do that.*

-       *Phones are extremely personal devices, even if they're owned by a hospital or healthcare. But at the same time, there's a lack of awareness of security issues essentially. I think that's something that's an educational process for the health professionals and also the systems guys. And there's got to be collaboration between the two2 in order to prevent there being sort of onerous situations.*

-       *So they take responsibility for the paper notes, but they don't take responsibility for the data. Now I think that's change and they do take responsibility. And I think it's only a, it's a continuing educational process to address.*

-       *The more authentication barriers you have, then the less usable the system is. So it's a balancing act.*

-        *If you use RFID's you can save a lot of equipment that's stolen from our hospitals, and that's a big problem as well. So RFID's are known to solve that problem.*

Infrastructure security issues
(Below are concerns highlighting the security issues related to infrastructure.)

-        *From a wireless infrastructure point of view, and the RF network side of it, communicating through, most of those security risks can be mitigated nowadays. Those security risks though are minimal compared to the productivity and the patient safety that mobility can offer as well.*

-        *You've got issues to do with the network, the security of the network*

-        *Over which you're receiving and sending information. And currently all health, personal health information is meant to go through a parental authenticated network, which has a cost incurred.*

-        *You've got the need to again monitor and make sure how you're going to determine who the end user is, how do they identify themselves, who maintains that database of users.*

-        *The implications are that when you add wireless, it takes the — a reasonably good analogy — basically takes your network cable and hangs it out the window. Anyone can plug-into that, or connect to your wireless network. Be sure that it's secure enough to prevent them from getting on your network firstly by encryption and authentication. And it stops them associating to your network.*

-        *Make sure that your network and the data on it is non-penetrable. And you also make sure that your mobile devices are not able to be hijacked by your neighbour's access point, or someone sitting in the car park. Multiple sorts of hijackers, or attacks to wireless networks, deniable service attacks, preventing your handhelds from communicating with your system, jamming really is what it's called.*

Ethical issues
(Following are the discussion extracts regarding ethical issues which arise by introducing mobile devices to healthcare environments.)

-        *There hasn't really been much around, on the use of ethnic differences between adopting mobile devices or not. And I'm just trying to think if there's an age thing but no, no, it's probably money. It comes down to whether you can afford it.*

-        *The whole thing about who adopts the technology? Well you've already got a digital divide between those who can afford it and those who can't. But then, the cheaper you make it, the less that becomes a divide.*

-        *Ethnic demographics, that's about education. you definitely will come across groups in society who will not want it.*

- *In terms of ethical issues, there's obviously the issue of whether people are happy to have their data recorded on the systems which are accessed by lots of people.*

- *You may be operating in a hospital and you've got 30 nurses, 25 may be very comfortable to use a PDA and walk around and take readings. But five of them won't be able to work it, so what are you going to do, give them the paper and record their results at the end of shift? Or invest intensively in their training and what's the guarantee that after they are trained they're going to be capable of applying those training skills into reality. And what happens if they make a mistake?*

- *I'm Chinese and I can't read English or understand properly. So you send me a text message which actually confuses me. Because I settled an appointment yesterday at a clinic, now this text message has really, really confused me on where I need to go and what do I need to do.*

- *Some people like a printout, or some manual form of reply. But when things get too electronic then they feel like it's not very much appreciated.*

Privacy issue solution
(Comments below describe how privacy issues can be mitigated by educating end users about mobile technology.)

- *I think one of the biggest challenges, if you like, is misinformation about what technology can and can't do. But certainly, the misinformation about what, the pervasiveness, or as one recent report referred to it as, the promiscuousness of RFID, doesn't help.*

- *If you're going to give a patient a wristband it only takes you 10 seconds to come up with a couple of big brother scenarios. Will they be tracking me throughout the hospital? Will people have access to all of my medical records if they have access to my wrist? Because they don't see the information that's on there, and they also don't know what it can be linked to. Now what they don't know is that with the current system, people may already have access to all of that data by just walking into your room and having your room number and your bed number.*

- *It all has to come down to a voluntary code of conduct, or a regulatory code conduct, and information to the patients.*

- *So it's kind of also informing people of what is the current situation, and telling them we're basically trying to achieve the same thing, just in a more efficient way. Or if we are trying to achieve more this is precisely what we will do. And clearly state that there is an amount of information that could be used, there's no point denying it.*

- *If they understand potential benefits they are typically willing and that study showed it in the US. They are willing to give up some of their privacy rights if they understand, for example, this will decrease the risk of being administered*

the wrong type of medicine. And then they understand it and they can make a trade-off for themselves.

-   When they register in the hospital, I think they should be given the choice of whether they want to wear one of these wristbands or not. You can't ever think that having mandatory wristbands is a feasible solution. And they need to be given clear and comprehensive information about what it will be used for, and what it won't be used for. But the information part is to me the one and only solution to any privacy concern.

4.2.5 Funding, payment and main benefits

This is the fifth theme; the sample was questioned about 'the funding and payment options of m-health services and who will get the main benefits'. The sample came from a variety of backgrounds in the New Zealand healthcare system which helped to collate different views. This section's results are being presented in the following order: free healthcare, patient pays, government funded, provider initiated and funded, shared cost approach, patient benefits, provider benefits, government benefits, and all stakeholders' benefits.

Free healthcare

-   In New Zealand we basically have free healthcare, so it's pretty hard to actually bill some of your patients when you've got an environment that is free healthcare like we have.

-   We have huge efficiency gains within the system, but if it means that you've got to charge a patient, then of course the patient won't pay anything because they're used to everything being free. But they're ultimately paying for it by their tax

-   If patient's got to pay money for it, naturally it's going to be hard to justify.

Patient pays

-   It seems reasonable to expect that if patients are getting convenience, they should be contributing something towards it.

-   Who pays depends on who's getting the greatest benefit from it, I'd have to say. The simple reality of a lot of innovation and technology is increasingly going to have to be paid for by a patient. I actually believe that the patients do have to pay something for it. Otherwise there tends to be a culture of not understanding the value of innovation.

-   Public healthcare - who pays for the technology then? Is the cost passed on to the person that benefits by the extra benefits they get out of using mobile

equipment? Probably yes in either a direct or an indirect way. I mean we do pay for healthcare through taxes in the long run.

- *The patient normally has to pay if it's something like a diabetes monitor, or Coagucheck the patient pays.*

Government funded

- *The government pays for it.*

- *I think that the government would have to put up the most in terms of trying to get technology within different DHB's and so on.*

- *Rolling bar coding out into the hospitals which will obviously require, you know hardware, software, integration, and all those sorts of things. The government have provided, through Treasury, the funding for that project to happen.*

Provider initiated and funded

- *Initially, they're driven mostly by the healthcare providers. They tend to be people with the money.*

- *It should be the practice that pays for the messaging, purely because it's their business. To every business you're going to have costs, and the nature of the business is that they need to communicate with their patients.*

- *I think it's quite clear from most of the studies globally, and information provided, that mobility applications, mobility devices, give a high return on investment when used appropriately within that business environment, or health environment.*

- *The providers have to, as they benefit the most. What we're talking about here is reduction of costs in hospitals, and in the health system in general. People are taxed quite plenty enough at the moment, so I mean if we can save the taxpayers about 10 thousand dollars a bed in a hospital, we can save 10 thousand dollars a day.*

- *Well at the end of the day, you, the patient, you pay for it by going to the dentist, right? What the dentist wants to do is avoid missed appointments, because they cost the dentist right? So if somebody doesn't turn up, there's a slot that they could have used, right? So what is it? A 17 cent SMS to remind somebody about appointments is a pretty good deal, yeah I would have thought.*

- *I think that you will probably see a lot of private adoption of technology first, due to the extra value that they have to offer the public in order for them to pay for private healthcare.*

Shared cost approach

- *The shared cost approach is the best. It's a bit like insurance; you don't actually mind paying your excess. If you have to pay the whole lot of it, you'd*

think twice about whether you're getting value for money out of what you're doing.

- Commercial entities, we're really good at developing, researching and developing products and bringing them to market. And we recognise that the innovation costs money, and we have to recoup that through sales effectively. So if the patient is going to benefit direct from it, then I suspect that it would probably be a mixture of both centralised funding and patient funding.

- There's a combination of people who need to pay for it. Everybody benefits, and therefore everybody should contribute. It shouldn't be everything with big business, or everything with the poor recipient. Everybody should have a share of the cost in proportion to the benefit to them.

- Basically all groups that will potentially benefit from the adoption of the technology should have the costs shared out across them.

Patients' benefits

- Patients would get the main benefits, as they require healthcare services.

Provider benefits

- Well, I think quite often the health professionals, the physicians, and the nurses will be sort of the first to get the main benefits. But the patient should be fairly quickly getting the benefit.

- Mobile GPs would get the most benefit by using Mobile technology

- It really is mutual, because practices are reducing their costs, and patients are getting a better service that enables the practice to reach them wherever they may be.

- Providers benefit, as they don't have to worry about shortages of staff and things like that.

Government benefits

- Short-term, they definitely gain the most out of it. And the big gains to be made, it's probably the government that's going to gain the most.

- The government was probably going to be one of the biggest benefactors from introducing technology that helps patient administration, reduces errors, reduces also the exposure to a poor healthcare system for the government.

All stakeholders' benefits

- So, in terms of the benefits, I see it's a win/win for everybody in these types of situations. Obviously our mandate is to improve patient safety, save people's lives, and if possible strip inefficiencies out of the supply chain. Process efficiency and/or reduction of waste in all those sorts of things. Everyone who's involved in it, it just makes their life a lot easier, more efficient and cost effective.

> *- Patients benefit obviously with having results there and then. And providers benefit by reducing waiting times, etc.*

> *- At the end of the day, mobile technology benefits right across the organisations. It means that the information is available at the point of care. It's electronic information that is available to patients potentially, to the doctors, to the nurses, and to the Ministry of Health as well. E.g. really the payback is availability of information, improved patient care, improved patient safety by just having real time information available.*

> *- I think in order of preference, it's patients, nursing, and doctors in the primary, and in the community as well. And then from there, the hospital, because of more effective labour usage*

4.2.6 Resistance of uptake to mobile devices

The sixth theme involved conversing about the resistance of uptake of mobile devices in the healthcare sector. The interviewees highlighted most of the stakeholders as resistant, as well as technology and cost. Some argued that there is no resistance to the adoption of mobile devices. This section discloses comments made by interviewees in the order of generic resistance, patient, provider, government, technology/cost, no resistance, and how to reduce resistance and provide opportunities.

Generic resistance

> *- The consumer advocacy type organisations will have an interest in this. Obviously the privacy commissioner.*

> *- It tends to be the elder generation, from my experience in the industry.*

> *- A bit of a language barrier. If language is a problem then they have a problem understanding training and what they're supposed to do with this new device.*

> *- Public system, yes, I agree. There will be resistance to change and paying for healthcare because of the new technology,*

> *- Communication for older patients is difficult, as they need specific instructions.*

> *- You need to take about devices effectiveness and efficiency. Technology is just the vehicle. So the analogy would be, if someone had never seen a car before, you wouldn't start talking about how fabulous the engine is and it's got a six-speed gear box. You'd talk about how this would allow you to drive to the shops and back, and make it easier to get to the shops and back.*

> *- If PDA applications are kept nice and simple. They recognise that they could (a) visit more of their patients and then not have to go back to the office*

and spend hours doing the work that they were supposed to, that they couldn't do on the road, they'd leap into it.

-   What will be the most important part is making sure that if somebody's dropped their device and it's damaged, that the replacement is quickly turned around and got to them.

Patients

-   It will be people who are concerned about privacy. The retrieval, retention and security of patient information, so I suppose that is a privacy concern. And that extends to the patients themselves, doctors themselves, who will be interrogated.

-   Patients, because they don't have the money. The service is going to be costly. There's no motivation. Why do the mobile thing? Why can't I just be called into the doctor's office and be treated? I don't want to learn a new technology again from a patient's perspective. These are all the excuses which will limit the uptake.

-   Patients are not likely to want to pay very much more, so there might be some resistance if you had to charge them.

-   Mid 50s. Anyone younger than that tends to be reasonably open to new technology to varying degrees. Once you get over that age they're very resistant to change.

-   There's a big different between a patient choosing to use a mobile phone to text something, and being told the only way you have of communicating with the health service is texting.

Providers

-   There will be resistance from anyone who likes doing things one way, especially in healthcare. An attitude from the healthcare providers that's been mostly patient care comes first and if technology is going to hinder my day–to-day patient care, then I don't want to have anything to do with it.

-   It's definitely a combination of patients and providers. We need to spend more time with them and really show them the cost benefit to deploy a service. That's purely because of the way they think, and moreover, the types of patients that they see, especially in areas where you have, a lot of elderly patients who aren't particularly comfortable with technology.

-   Initially, there's a fair chance of doctors feeling that they are somehow bypassed by a machine that's now going to decide on some things that ideally the doctor should decide upon.

-   The greatest resistance would come from the practitioners.

- One of the most significant barriers; I mean if you talk to busy health professionals, especially doctors. They're very resistant to it, because they see it as taking a lot of time.

- We realise having access all the time is a double-edged sword, being accessible. Like you're in the Coromandel getting text messages about next year's budget, and it's really not great for relaxing.

- The resistance is from is the total lack of co-ordination and a lack of understanding. And maybe overload in terms of projects and things that are going on in the healthcare sector itself, probably due to the lack of direction from the Ministry of Health. So, in short, people that I see responsible for it not having a big uptake are the health providers themselves.

Government

- The government resistance is in the sense that ultimately they have to pay some funding for mobile.

Technology / Cost

- It's a cost. There's a capital outlay for those mobile devices and it always seems to come up against whether we buy a medical piece of equipment, or a clinical device, or do we buy something that is not so much in the clinical field, but can it aid that.

- The healthcare is basically very slow to take on new technology.

- Cost is a resistance. People also, organisations also like to believe that they should have the only answer. They seem to want a solution for everything.

- The context of what we've been talking about, to enable the DHB's to function using barcode and scanning type technologies, none of them have any of it. So there's no infrastructure at all really for scanning within a DHB as a systemised approach.

- They have an un-inter-operable infrastructure. So that's a big word which means that the DHB's in New Zealand can't inter-operate with each other. They don't share standardised data structures. They don't share standardised numbering structures, and so in essence, they're islands.

No resistance

- The patients wouldn't be resisting at all, if they can go home one day early, they would, they'd be happy to. Everybody who has stayed in hospital can't get out quick enough. It's not exactly the most conducive environment for them getting better.

- It is the less you talk about technology, the better, because in my experience you talk about new programmes to GPs, computer programmes, I mean, or new technology, they will run a mile. But I find that they're really

resistant to that, until you actually talk about the benefits to them and their patients.

How to reduce resistance and provide opportunities

- *When things break, there's got to be a sufficient service plan. And an efficient, quick turnaround of repairs or replacement units to speed up the process. It's got to be minimal in terms of their disruption to the patient and the healthcare provider.*

- *Making sure that there are good service plans for when things go wrong Things do break, when you drop the phone it usually doesn't survive.*

- *Patient messenger and it's going to have voice, text to speech facilities. So the practice can essentially type their message and that message will in turn translate into a dialled voice message.*

- *Privacy and security and cost issues, and the training required to be able to use the systems appropriately would need to be addressed. And then as long as there is proven value to the sector, and to the people using it, a lot of the resistance will go away.*

4.2.7 Tradeoffs using mobile technology

The final theme discussed the trade offs of using mobile technology in the healthcare environment. Also, how services will change as a result of mobile technology.

- *The whole thrust of this is to improve patient safety. And so any compromise on quality is abhorrent.*

- *Now if you compare, if you look at the argument of these mobile devices as a vehicle for providing service versus some other devices, there may be some trade-off between screen real estate, versus the fact that it's a mobile device.*

- *When it comes to the quality of the medical service, there shouldn't be any compromise.*

- *Certainly, it comes down to individual preferences. Have agreed that they're happy with lower quality of service going mobile.*

- *People would be prepared to compromise, but only to a certain point. trying to read my email on my web mail on my cell phone is painful in the extreme. And if I had to do that all the time I'd just not bother anymore. Whereas if I could do it on my PDA that would be considerably better, because at least I could read it all in one line. But there's the cost incurred with getting a PDA that can have broadband access.*

Chapter 5: Findings and Discussion

The pilot study involved questionnaires and interviews with health solution providers, health strategists, and technology vendors that led to the results presented in Chapter 4. This chapter discusses those results in an effort to address the potential of mobile devices in New Zealand healthcare. The literature review explored various devices and m-health applications in all aspects of health environments. The following sections aim to analyse the results and discuss the potential of mobile devices across different health sectors, their technical constraints, challenges and implications, and effectiveness.

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 Generic potential of mobile devices in NZ healthcare

The business processes in healthcare systems demand integrated information, sustainability, efficiency, and effectiveness to battle nationwide healthcare challenges such as ageing populations, rising incidences of chronic diseases, re-emergence of old diseases, new infectious diseases, diversity of communities, and the increasing cost of new medical technology-based treatments [14-16]. These pressures could be addressed by increasing the health spend, but this is not always a feasible option. Hence, the requirement to work smarter and more efficiently needs to be satisfied. Given the obvious high adoption rates of mobile phones, rising laptop sales, and availability of telecommunication networks for a relatively affordable price gives birth to increased awareness of mobile devices and their usage, and its dependence factors in both personal and business situations. The awareness factor was identified in the results where 81 percent of the interviewees felt online electronic health records should be made available either on computer or by phone (see chapter 4.1 q#1.5).

Mobile devices such as laptops, tablet PCs, and PDAs allow personnel to have real-time access to information such as clinical data and drug databases, that would otherwise have been located at their desk. Using the example of a physician, mobile technology could assist by providing information when required and make him capable of providing mobile care. This could well bring healthcare closer to the patient. One question that needs to be asked, however, is whether the patients prefer healthcare coming

to them or if they prefer visiting their preferred healthcare provider. The interviews disclosed that the recent trend is healthcare moving towards patients.

Patient safety, as the primary focus in the healthcare environment, was expressed by the interviewees and by the World Healthcare Organization (WHO) [13]. The use of mobile technology in healthcare has the potential to transform the delivery of care, provide more accurate and efficient healthcare, and moreover, increase patient safety by reducing the risk of human error [82].

A recent study [83] highlighted that at least 44,000–98,000 people die in hospitals each year due to medical errors. These staggering statistics were readdressed by a health strategist interviewee: between 150 and 1500 people die every year in New Zealand hospitals as a result of wrong drug, wrong patient, wrong time, wrong route, and wrong dose. RFID can be used as a prevention mechanism to reduce these medical errors and create a safer healthcare system. RFID was selected as the most suitable device to achieve the critical success factor of "improving patient safety" in an m-health context by questionnaire sample (see chapter 4.1, q#4.4). It helps to uniquely identify and deliver five "rights" to a patient, and avoid the five "wrongs" to the patient. Right Patient, Right Drug, Right Dose, Right Route, and Right Time are important criteria to have in the healthcare environment.

Strong confirmation of cost reduction was found as many interviewees commented on how mobile devices can cut costs out of the healthcare supply chain. Moreover, this technology can help to secure the supply chain from theft and counterfeit of pharmaceuticals and medical equipment. As analysed in the literature review (page 31-33), mobile technology can deter counterfeit drugs and provide a cost-effective solution for tracking assets. Numerous studies have explained how RFID can be utilized to enable real-time traceability in the supply chain, and promote security, safety, and efficiency [12, 33, 36, 64, 66-68, 84]. One criticism to be considered before wide adoption of RFID is that the associated security threats must be recognized, and suitable countermeasures should be analysed and engaged by RFID developers and vendors, as well as by government regulatory agencies [85].

The interviewees mentioned the potential uses of video and tele-health techniques to overcome physical barriers between patient and treating physician. Telemedicine is known to improve efficiency by sending and receiving results and allowing communication between providers and patients. From an awareness point of view, 81 percent of participants were aware of telemedicine technology, emphasising an interest in its usage. Günter Burg [86] also mentions various uses of telemedicine: communication

of electronic medical records (EMR) and images, remote monitoring, teleconferencing, and interactive teleteaching.

The most significant and obvious benefits of mobile devices are that they provide convenience, functionality, and portability. Overall, the results of this study indicate that mobile devices, using voice calls, email and SMS, can enhance communication between all parties involved in healthcare including whether they are providers or patients. A review of potential benefits is presented in the following sections.

5.2 Potential in primary healthcare

Mobile devices are widely used in the primary healthcare sector by General Practitioners (GPs), patients, healthcare providers, and administration staff. Because the New Zealand population is adopting mobile technology rapidly by purchasing mobile phones, the potential for exploiting such a large mobile phone user base is significant. This finding of the current study is consistent with Statistics New Zealand in 2007 [5], stating that there are more than 3.8 million mobile phone subscriptions in New Zealand.

Another important finding was that mobile devices such as mobile phones, smart phones, and PDAs are very helpful to communicate among GPs, practices, patients, and administration staff. For example, a practice can contact a GP when they are out of the office on home visits. Also, patients who require intensive care can contact their GP in case of emergency.

It is important to note that international case studies have shown that the use of mobile phones by practices in primary healthcare improves patient care, and also reduces administration costs. Research conducted by Car and Sheikh [47] highlights the email consultation method as a huge opportunity to enhance the delivery of preventive healthcare and to assist the patient with self-management. Perhaps the disadvantages of this method are that the email medium is not suitable for all demographics; it is unable to examine the patient, and responses could be delayed in case of emergency needs. A serious weakness with the use of email consultation is, however, that it reduces patient safety due to the risk involved in diagnostic or communication errors [47].

There are rising absenteeism problems in the primary health sector. As most patients now carry mobile phones, a cure for this can be found by utilizing automated software that sends appointment reminders via simple and cost-effective SMS technology; as a result, practices would reduce patient DNAs (Do Not Attend),

decreasing administrative costs significantly. An added advantage with texting is that it is compatible with all phones and telco carriers.

Over 70 percent of the questionnaire sample (see chapter 4.1, q#4.4) were aware of the use of SMS for medication alerts. This is another area where SMS can be used in the primary health sector to improve efficiency and patient safety. A strong relationship between SMS usage and increased efficiency in delivering healthcare services has been noted in the systematic review on SMS use in healthcare [30]. One of the problems with the use of SMS is that it fails to take demographics into account. For instance, use of mobile phones would not be applicable if the healthcare provider is located in a community where mobile usage is minimal; a practice cannot assume all of their enrolled patients would be technology literate.

5.3 Potential in secondary healthcare

Mobile device technology is significantly prevalent in the secondary healthcare sector overseas, especially in the UK and the USA, where they have been funding projects. A recent release of The Health Information Strategy of New Zealand describes initiatives which are going to proceed in the New Zealand healthcare environment [14].Secondary care initiatives include a health network and secure email, eLabs, hospital discharge summaries, ePharmacy, electronic referrals, national outpatient collection, and chronic care and disease management. This confirms that there is a potential need for mobile technology.

In response to the interview Question 1 (*How do you think mobile device technology can enhance health services?*), a majority of the sample indicated that in hospital systems, PDAs and laptops are becoming prevalent. Hospitals are implementing electronic systems instead of paper-based notes, enabling clinicians to be mobile, and to access data remotely. The opportunity for instant access to clinical data was also expressed in the literature review. It results in many benefits such as improvement of patient care, streamlined workflows, enabling clinical decision support by access to medical references and knowledge bases [27, 45, 52]. One major drawback of this approach is that clinicians need to be well-trained; otherwise, it would result in inefficiency rather than efficiency in delivering healthcare service.

The results further exposed the usage of RFID technology to reduce errors, track patients, manage assets, and identify medical equipment and drugs in the secondary healthcare environment. As discussed in Chapter 2, asset and patient tracking is essential

to delivering a high quality healthcare service. Without using RFID, locating assets would require additional staff, and consequently would increase management costsRFID tracking can also help to minimise expenditures for multiple amounts of new equipment, as there can be improved utilization of existing equipment [63]. A majority of survey participants (71.4%) indicated they are aware of RFID usage in tracking patients and assets; however, there is currently no significant adoption in the New Zealand secondary sector.

Interviewees added that patients can be better tracked around the hospital using RFID enabled wristbands which contain a unique identification number and that has the capability of storing key information. The wristbands can be scanned using a RFID scanner without disturbing the patient, thereby increasing efficiency and streamlining workflows [63]. As discussed in case study two (page 30); the five rights of medication safety are easily met using RFID tags: right patient, right medication, right dose, time, and right route, as well as right surgery and surgical site [70].

The results also emphasised that remote monitoring can help to assist everything from post-operative care, through palliative care, mental health, and aged care. Moreover, it allows patients to return home earlier, freeing up hospital facilities such as beds, rooms, equipment, and staff. It will also decrease costs related to in-house care and post-operative care. Although remote monitoring has benefits, we should ensure monitoring is not considered as a treatment but as an additional means of methodically organising effective care.

From the survey results, we can also extract that mobile technology can help reduce waiting times — especially in an Emergency Department (ED) — by using mobile devices for point-of-care tests while the patient is still in the waiting room. A previous study [87] also concluded that point-of-care testing can significantly reduce the length of stay of paediatric patients in ED, and can also be very useful when there is an overflow of patients.

In the secondary care environment (i.e. hospitals), clinicians require mobility to interact with customers, patients, and suppliers. The use of laptops and tablet PCs that can provide all desktop features — with mobility — is considered as ideal for replacement of desktop devices. Mobile devices allow clinicians on the move to access the most current patient information and decision-supporting tools, something that was previously only available in their desktop environment [44]. As mentioned earlier, remote access to full patient records will minimize medical errors and time and administration costs.

5.4 Potential in community healthcare

The community sector is arguably one that heavily requires the use of mobile technology as it involves serving communities and remote locations. A research study reveals that community care professionals cannot perform their job without mobile technology assistance [88]. The results confirm that community carers require real-time access to information, especially in areas where it is hard to return to their office. Surprisingly, only a small number (20%) of survey respondents (see chapter 4.1, q#1.6) indicate an awareness of community nurses communicating with clinical expert advice. This could be due to the lack of m-health applications in New Zealand's community sector.

One of the comments made by interviewees was that mobile phones can be modified to attach to blood meters, which can then be used to test and transfer their results to a centralised location; the results could potentially be monitored by a clinician or an organisation. A study by Bu and Lin [89] further reveals that this is an inexpensive, convenient, and quick method to obtain blood sugar level data The results also disclose that electronic monitors can be used instead of requiring community nurses to physically visit patients daily to monitor their health. New Zealand has a large rural population, some of whom do not have access to secondary care; incorporating mobile systems such as cardiac markers into rural practice could be very beneficial.

Devices such as laptops, tablet PCs, and PDAs with wireless Internet connectivity allow health practitioners to be out of their offices for many days and still access and share information remotely as mentioned in [27, 45, 52], and at the same time help to improve patient care. However, when the network is unavailable the user only has access to the unsyncronised stored data on the device.

In emergency situations, clinicians can communicate with their base station via SMS or voice to obtain advice. This finding supports previous research that also mentions Personal Networks (PNs), including mobile devices, provide a means to seek remote assistance [90]. Furthermore, instead of the cumbersome and slow process of taking a digital photograph, downloading it, and then sending it to a person, PXT is being used. This technology is easy and instantly sent and received, however, this also requires telecommunication networks.

The implementers should not be blinded to the barriers and challenges which accompany the potential benefits of m-health. From a healthcare perspective, first and foremost amongst these problems are concerns over the privacy and security of personal

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healthcare information [91]. Mobile technology also has technical constraints that affect its adoption. This could well be one of the critical elements of successful implementation of m-health applications. In the following sections, we discuss technical, privacy, and security issues in the context of m-health.

5.5 Technical constraints

This section first discusses generic technical constraints related to all devices examined, followed by specific devices' constraints. Over 75 percent of the questionnaire responders and interviewees referring to technical contraints were knowledgeable technology vendors and researchers; this significantly influenced the results (see section 4.2.4) of this section.

The acceptability of mobile devices in an m-health context is based on the simplicity and the convenience with which they perform their main function. The major concern is with the form factor which needs to ensure portability, and accommodate the constraints imposed by the small screen and keyboard size. The smaller the devices, the more portable they are. However, screen real estate is considered a constraint for developing rich applications. Other potentials for problems are device instruments such as the stylus which, if lost, would make operating the device impossible. Over half of those surveyed reported that personal factors such as large fingers and poor sight are a major technical challenge in m-health adoption. Technology vendors need to build mobile devices with a balance of both screen size and large keypad. Introducing a multi touch screen without a stylus, like Apple iPhone, can provide both screen real state and on-screen keypad.

The health professionals interviewed highlighted that devices need to be able to carry out all tasks. Currently, many mobile devices being used in the health industry are designed for a specific task. Physicians are required to switch between devices while delivering healthcare, causing inefficiencies. For example, switching between PDA and tablet PC to record freehand notes.

Additionally, limited hard drive capacity and the battery life of a device are issues, especially if clinicians are working on 12-hour shifts. The limited battery life restricts the length of usage of the device and the mobility of the users [92]. Technology vendors suggest that by using two batteries, they can be swapped during the shifts without causing any downtime.

Due to New Zealand's free trade agreements, a majority of mobile devices are imported from overseas. However, this has an impact on the service a health organisation receives from the manufacturer. It would be a lot more convenient if a New Zealand-based company were able to supply mobile devices, parts, and service; this would considerably reduce replacement costs and service time.

Laptop / tablet PC

Tablet PCs are considered to be expensive devices, making cost a barrier. They can also be easily damaged; interviewees suggest they also need to be more durable and should be able to withstand accidental spills and drops. Many users are inclined to use protective cases, but these are not sufficient to protect them from accidental drops.

Laptop and tablet PCs have desktop functionality with the benefits of portability [23-25]; consequently, like a desktop, they can take a long time to start up and be ready to use, which in emergency cases can cause problems for clinicians. For this reason, some potential users may be more inclined to use a PDA.

Tablet PCs and laptops help increase Internet connectivity, but on the other hand, decrease cellular connectivity, as they do not have a phone number associated with them. Hence, a user needs to be equipped with both tablet PC and a cellular phone. There are applications available, however, such as Skype, VoIP, and Providers, which allow users to place and receive calls on a mobile laptop.

PDA / smart phone

Health planners reported that recording information into a portable device such as PDA or smart phone can be difficult due to their size. Data entry can be improved by using a foldout keyboard or touch screen keyboard with large letters to enter data. Additionally, mobile software applications which use simple checkboxes and drop down lists rather than typed in information can be created. Both health strategists and technologists believe that once the clinicians recognize the benefits, they would have little resistance to adopting the new technology.

Mobile phone

Mobile phones have very limited interface and limited functionality compared to other mobile devices. Interviewees highlighted some of the constraints of SMS, including a limit of 160 characters per message, which might restrict clinics that would want to send larger messages. The other issue of SMS is that it lacks security control, and it is not a powerful tool [81].

RFID

Technology vendors interviewed who specialize in RFID technology highlighted some of the technical constraints which encompass RFID technology. RFID is not suitable if operated as UHF, as its electromagnetic field is highly absorbed by water-based liquids such as blood. Due to RFID, UHF chips' liquid heats up which could potentially affect the clinical nature of the active ingredients. At lower frequencies, it has been proven to be negligible. However, appropriate countermeasures need to be analysed prior to implementation of RFID in a clinical environment.

Additionally, the reading distance of RFID tags is considered to be an advantage; but it can also be a disadvantage if the reader picks up irrelevant objects. Instead of scanning one patient, it could capture many patients and objects within its range. The reading distance issue can be resolved by reducing the power level of the reader. The less power it uses, the shorter the read fields. Hence, to have multiple long- and short-range applications, it is best to use large RFID tags, because the power can be modified based on the application.

5.6 Challenges and Implications

5.6.1 Privacy issues

Concern for privacy was identified as one of the significant barriers to the uptake of m-health. Privacy of personal data is a very sensitive issue, especially in health industry; 81 percent of the questionnaire sample agreed that privacy and confidentiality is a very important challenge in m-health (see Chapter 4.1 q# 3.1). Health planners consider it to be worse than loss of one's credit card; transactions can be stopped, but when private, sensitive information is breached, it is literally irreversible. Many people do not understand the issues of privacy until they are informed about them.

One of the most important privacy issues arises when sending or receiving medical results or clinical data. Encryption standards need to be in place to ensure data is transmitted safely. The HealthLink messaging system is widely trusted and used in New Zealand to exchange medical information. SMS in recent years has become a widespread medium for communication. It provides a variety of m-health applications such as psychological support, booking services, safety messages, and appointment reminders [28, 57]. However, health providers need to be vigilant and ensure text messages do not include any information that could potentially expose the privacy of the patient, should the message be read by someone else.

Although not solely a privacy issue, from the healthcare context, there is a growing concern about whether an organisation should be allowed to monitor personal phone calls and emails. Clinicians' personal privacy could potentially be breached if they make personal and work calls from their work-affiliated PDA.

Health strategists believe that hospitals or practices need to be aware of laws concerning patient privacy, especially regarding wireless networks. Patient confidentiality can be maintained by using wireless protocols which meet New Zealand's encryption and authentication standards. Wireless security protocols compliance standards for both security and privacy are improving and being developed in several countries, including effective biometric and cryptographic systems [93].

RFID technology is attracting many technology and health providers as the leading auto-identification technology. The use of RFID to reduce medical errors should not be a reason to breach privacy. Of the participants, 43 per cent considered RFID tags consent as a very important challenge in m-health (see Chapter 4.1 q# 3.4). A similar number of participants, 38 percent, had a neutral opinion towards RFID tags. Technology strategists believe both patient and staff need to be informed about RFID technology capabilities and its application in context of health. RFID can possibly be introduced in New Zealand healthcare by giving the patient a choice.

5.6.2 Security issues

Security is important because it protects ones' privacy. Security awareness is increasing throughout all industries, security measures are getting complicated, and security threats are becoming more ingenious. Participants felt there was an increased awareness of the paramount need to protect peoples' sensitive information and data. Consequently, the questionnaire results demonstrate that 85.7 percent of participants chose security (physical and software) as a very important challenge in m-health (see chapter 4.1, q#3.2). Any deployment of m-health solutions should have high security standards to ensure there is no breach.

Mobile phones are widely considered to be extremely personal devices, even when owned by a hospital or healthcare facility. Among users, there is a lack of awareness of security issues. Phones can be easily misplaced, lost, or stolen. In a hospital environment, both health professionals and system administrators need to be well educated to ensure smooth operation without any security breach. Mobile phone data needs to be backed up regularly and should be password protected to ensure only authorised personnel have access.

If mobile device is lost, the data on the device can potentially be misused. Appropriate authentication mechanisms such as biometrics or complex passwords can be used to validate users. However, the more authentication barriers, the less usable the system becomes, there must be a balance.

5.6.3 Ethical issues

Mobile technologies are purported to increase access, improve quality, and decrease the costs of healthcare services. However, the characteristic of mobile technology tend to conflict with ethical principles [94]. Health strategists also highlighted that there could be ethical issues involving sensitive electronic information being recorded and transmitted to a centralised system which is accessed by several people.

A few interview participants believe that language could be a potential barrier as it could possibly confuse a patient who receives an SMS appointment reminder. While most patients appreciate being reminded of an appointment by means of an SMS, a person who is not familiar with English might get confused. Additionally, some people prefer a printout version or manual form of reply instead of an impersonal electronic confirmation (such as an email).

Health professionals indicated that training and educating staff is essential to ensure full adoption across the health sectors. It would be very challenging for a health provider if a majority of nurses adopted PDAs and only a few did not.

However, few health strategists believe that there is no direct relationship between adoption and ethics. It is about the costs related to technology, and reducing costs will speed up adoption of mobile devices.

5.6.4 Funding and payment options of service

The results disclosed various funding and payment options such as free healthcare; cost paid by patient, government, or provider; and shared cost approach which could be applied in the New Zealand healthcare industry.

There is a common understanding that citizens of New Zealand are used to receiving free healthcare. Patients are accustomed to paying taxes to receive free healthcare. Therefore, justifying to a patient the need to pay an additional amount is challenging, even though healthcare providers obtain huge efficiency gains using new technology.

A small number of those interviewed suggested that it is reasonable to expect the patient to contribute towards the cost as they are getting the convenience. For example,

the patient ideally pays for equipment such as diabetes monitors or mobile phones. The contribution should be dependent on who is getting the most benefit. Innovation and technology is increasing in the healthcare industry, and patients need to contribute towards its costs.

Moreover, the billing system would need to be changed, especially in community care organisations. Currently, Community Nurses in New Zealand are paid based on physical visits; therefore, if a physical visit was substituted for by a virtual visit using mobile technology, the nurse would not be paid.

Nevertheless, critics have also argued that the majority of contributions for new healthcare services should come from the government, as they will be able to use technology and establish consistency within different District Health Boards (DHBs). Out of the three groups, government has the capability of funding large projects through the treasury. For example, introduction of new procedures or systems, such as RFID bar coding into NZ hospitals will require hardware, software, integration, and training.

Providers

A small number of those interviewed suggested health providers should be the main contributors towards costs. For example, patients are already paying for the services when they visit a GP or dentist. If the provider sends an SMS message to remind their patient about an appointment, it will only benefit the provider, as it would help them reduce missed appointments. Hence, the practice needs to pay for the costs.

Moreover, health strategists explained that mobile applications and devices, give a high return on investment when used appropriately in business or health environment (For example RFID [12]). Hence, as patients are already taxed by the government, it can be justified that the healthcare provider should contribute the most.

Shared Cost

A majority of the interview participants analyzed the above payment options, and suggested a shared cost approach would be the best, as it would fairly divide across all stakeholders. The share of the cost should be proportional to the benefits each stakeholder receives from the adoption of technology. However, further research needs to be conducted in order to identify how the funding and payment should be divided.

5.7 Potential effectiveness of mobile technology

5.7.1 Resistance of uptake on mobile devices

The research conducted identified a whole range of areas where health planners, users, and solution providers are resistant to mobile technologies. This section summarises these issues.

Generally, people are resistant to uptake for many reasons, some of these include the elder generation (majority of population who require care) who are not technologically savvy. The questionnaire results highlighted a sense of debate among the participants — whether negative perception of patients or physicians (see chapter 4.1, q#3.5) is an important m-health challenge or not. (38% had a neutral opinion and 38% considered it a very important challenge). However, this barrier can be overcome by educating both patients and physicians about the benefits of adoption.

Moreover, statistics from the survey emphasised that personal factors such as large fingers, poor eyesight, and forgetfulness of carrying a device are considered as a significant challenge in m-health applications (see chapter 4.1, q#3.6). This could well be due to the variety of ethnicities in New Zealand. Additionally, language barrier is another problem, as the solution end users may not be English speaking. The cost of the mobile devices is very high, particularly the ones which qualify enabling healthcare applications.

The public system would resist changing, as they need to pay extra for healthcare due to new technology. The effectiveness and efficiency gains need to be communicated to everyone in order for them to accept and adopt mobile technology.

Technology is not always the problem; it is also about how it is applied, educated, and deployed effectively. It cannot be generalised whether or not to resist, it is more of a case-by-case scenario where it may or may not be beneficial to resist mobile technologies.

Patients

Often patients resist, especially when technology requires additional payments to be made, when there is no motivation whatsoever. They would create excuses which will limit the uptake. Some patients are found to be a bit reluctant to change. Hence, the change control will be a challenge to introducing new devices.

Providers

Healthcare providers tend to focus primarily on patient care, and if technology is going to obstruct or alter their routine in proving patient care, they resist the change.

Also, clinicians might feel that their decisions are being made using a machine (knowledge base) rather than their knowledge.

Providers need to be motivated, and benefits of the respective application must be clearly explained for them to make a decision on whether or not they wish to use it. Providers would also resist if it is going to affect their personal life(e.g. getting text message in regards to their budgets, while they are on a vacation).

Government

The government is resistant, as they are responsible for funding the majority of the projects throughout NZ's healthcare sectors; however, the government has future strategies which mobile technologies can complement.

5.7.2 Adoption of mobile devices in New Zealand

New Zealand is considered to be slow at adopting new applications rather than a fast implementer. A countrywide initiative needs to take place to introduce new m-health applications into New Zealand healthcare. Since NZ is a small country, it is more controllable. Initiating projects throughout a large country would be much more complex, compared to New Zealand, which is more easily controlled.

In recent times, government has displayed definite leadership in addressing problems of patient safety. Once the project of using RFID is launched, it will provide a good momentum to take New Zealand forward. There are also widespread SMS applications being used, showing signs of adoption and acceptance.

The survey results of Chapter 4.1, question 4, are valuable for addressing which critical success factors can be achieved using which mobile devices. The critical success factors which are relevant to New Zealand healthcare include reduced cost, user acceptance, increased efficiency, improved patient safety and care, quality of service, secure connectivity, remote access for clinicians, sustainability of mobile applications, and location independence for patients. The majority of CSFs could be met by a variety of mobile devices. However, the two most significant mobile devices were PDA and laptop as they were considered to be capable of facilitating most of the CSFs. Hence, New Zealand should consider adopting PDAs and laptops throughout all healthcare sectors. Nevertheless, RFID was the only mobile device which could meet the "improve patient safety" CSF, which could be argued.

How to reduce resistance and provide opportunities

Healthcare providers require sufficient service plans with an efficient quick turnaround for repairs and/or having replacement units available in case something breaks. There has to be minimal disruption to both patients and healthcare providers.

Privacy, security and budget issues, and training required to operate the system appropriately should be addressed prior to full deployment. As long as there is proven value to the healthcare sector and its users, a lot of resistance would be diminished.

No resistance

The patients would not resist adopting new applications driven by mobile devices, if they could go home early from hospital or receive appointment or medication reminders on their mobile phone. Additionally, the results highlighted that the clinicians or patients are not resistant to uptake of mobile devices, once they are informed or educated about the benefits.

Chapter 6: Conclusions

Mobile devices are widely adopted and are being used in both private and communal aspects of life. Mobile devices such as, tablet PCs, PDAs, smart phones, mobile phones, and RFID have a lot of potential in the healthcare industry. Many m-health applications emerge by utilizing these innovative devices and high-speed communication networks, which can be applied across all health sectors and enhance healthcare services for patients.

Globally, the demand for better healthcare continues to rise. New Zealand too faces several challenges and pressures to deliver improved healthcare services to its citizens. Challenges include increase of elderly population, increasing chronic diseases, re-emergence of old diseases, diversity of communities, and moreover, increasing cost of new medical technology-based treatments. The technology vendors and health strategists suggest that utilizing mobile technology could assist in meeting the high demands in the New Zealand health sector.

Mobile devices are useful as they allow health professionals to work more efficiently by providing remote access to information at point-of-care, and moving healthcare out of hospitals and closer to the patients, consequently, addressing the needs of many citizens and reducing administration costs. M-health provides a range of applications driven by devices. However, they do compromise several inherent issues which need to be analysed to ensure business requirements are met.

6.1 Potential of mobile devices

The penetration of ubiquitous mobile technology into the healthcare domain has seen the growing demand for m-health applications to address many issues facing New Zealand as well as many other developed countries. The pilot study participants responded very positively in respect of mobile devices in New Zealand healthcare; these results can be extrapolated to most developed nations who face similar challenges. The devices studied were identified with many potential applications. Overall, all participants were very confident and encouraged the use of mobile devices in New Zealand healthcare.

Mobile devices are required in all healthcare sectors. However, the community sector is considered to be one of the main areas that could benefit the most. Community care consists of a majority of mobile personnel who perform home visits or help in

community-based projects. Mobile devices facilitate real-time access to information at point-of-care. Laptops, tablet PCs, and PDAs with wireless communication allow healthcare workers to collect data at point-of-care in electronic format rather than on paper. Data can be synchronised with the healthcare provider without requiring the field personnel to return to the office for several days. The potential application is very significant because electronic format is of high value in the healthcare industry as it can be stored, analysed, and interpreted correctly to make better decisions. However, accessing data would be limited when there is no Internet available.

The patient's failure to attend appointments has a significant impact on the ability of healthcare providers to provide efficient and effective healthcare services. Health planners suggested a lot of potential for the use of simple SMS technology; this can facilitate sending appointment reminders and lab results, and facilitate preventive care and patient support applications. Moreover, SMS can be used for monitoring patients and helping to maintain contact between patient and provider while away from practice/hospital. Appointment reminders help reduce DNAs (Do Not Attend) significantly, which enables full utilisation of clinical and administrative staff and increases revenue opportunities. Moreover, it decreases the period of time that patients must wait for an appointment booking. This application implementation is very reasonable compared to its benefits. The ubiquity of mobile phones in New Zealand encourages the adoption of SMS alerts and educates citizen for healthy well-being. Preventive care methods promote healthier living, which in turn reduces health budgets and increases the quality of life for the population.

Health strategists and technologists consider RFID technology to have huge potential in the secondary healthcare sector and in the pharmaceutical industry. RFID still has not been exploited in New Zealand's healthcare industry. RFID provides many applications which would greatly assist in reducing administration costs and increasing efficiency and patient safety. It has the ability to track patients and staff, manage assets, and provide traceability across the pharmaceutical supply chain. It will help stop the counterfeit of drugs, and achieve the five rights of medication safety by using RFID tags in hospitals. New Zealand needs to conduct a pilot study to evaluate the benefits; based on the results, it should implement RFID technology throughout New Zealand's health industry.

The pilot study uncovered several applications for each of the devices examined; laptops, tablet PCs, PDAs, smart phones, mobile phones and RFIDs. PDAs and laptops were the most effective devices. Both clinical and non-clinical applications were described in the thesis. However, RFID was especially effective in non-clinical

applications. The utility of each application is directly dependent on which sector and audience is being targeted.

6.2 Challenges and Implications

The adoption of m-health applications in New Zealand healthcare is directly dependent on the challenges and implications mobile devices introduce into the healthcare environment. Challenges include addressing inherent technical constraints, privacy, security, and ethical issues surrounding mobile devices. Some of the challenges which were discovered in this pilot study are opinion-based, and should not be generalised across the whole New Zealand population. In this section, the most significant challenges and implications will be described.

One of most mentioned technical constraints across all mobile devices is their size. Both health and technology strategists argued regarding screen size and form factor of mobile devices. The small screen real state would create problems for building smart applications, and is considered to be a major constraint to adoption of mobile devices. Mobile devices are not always considered as user-friendly, hence functionality, comfort, and form factors need to be addressed to suit its application. Most of the mobile devices are fairly expensive, and very fragile. They need to be constructed to withstand accidental drops and spills. This would encourage adoption and allow health workers to perform in various conditions and environments.

Most modern devices include storage space (memory), which could be used to store various data, including personal and clinical information. However, security of mobile devices is one of the challenges yet to be addressed thoroughly; they tend to easily be lost or stolen which could breach user privacy, as there is no effective security on most devices. One possible solution would be to have the data accessed from a secure online repository.

RFID technologies tracking capability raises many questions about potential violations of personal privacy. Reading distance of RFID is considered to be a constraint when used in hospitals. Instead of scanning one patient, it might return information on multiple patients located in the same area, which could create confusion. RFID systems are different compared to other identification methods because communication is without any contact and line-of-sight. This makes it very difficult to detect when communication is taking place via the RFID tag.

New Zealand has a wide range of ethnic backgrounds and languages making it challenging to convey the benefits of mobile devices to each group in the community. For example, some groups prefer paper-based reports rather than electronic. New Zealand citizens need to be educated and well-informed about mobile technology to ensure adoption across all health sectors.

There are many political and cost-related implications which affect the expansion of m-health applications. Currently in New Zealand, there is no clear guidance of national standards (security and privacy standards) for m-health applications; this slows the development of new initiatives by health technology experts. Funding and payments of new projects will be debated among patients, providers, and government. For example, patients would not want to pay additional costs as they are used to getting free healthcare by paying their taxes.

6.3 Introducing m-health into New Zealand

The proliferation of mobile communication and computing technologies will continue. As applications develop, we will learn their capabilities and limitations.

The findings of this study recommends that before introducing mobile devices, especially RFID, in New Zealand healthcare sectors, the related security and privacy threats need to be recognised and appropriate countermeasures need to be taken by technology enablers, as well as by government. The cost of implementing technological countermeasures is very marginal compared to the applications mobile devices can offer.Countermeasures need to combine a variety of viewpoints such as legal, technological, and social to ensure privacy of personal information is not breeched. It has also become increasingly significant to understand the factors essential to technology acceptance by health care professionals and patients.

Additionally, organisational change management, and workflows need to be systematically and analytically studied, to ensure the introduction of m-health applications would be able to sustain on an ongoing basis. The convenience and ease of communication that mobile devices can offer will help empower patients to maintain their health, and when required, assist them to recover quickly, and to enjoy healthy well-being.

6.4 Future Research

Future research based on this thesis can be recommended in a variety of areas. Firstly, the development of proof of concept prototypes based on m-health applications highlighted in the current research. Once the proof of concept has visibility over technical and security issues, and overall requirements, it should be implemented and tested as a pilot study to ensure all technical and security issues are being addressed, and if the solution is sustainable.

Exploring the use of new mobile devices like Apple iPhone in the healthcare industry would address many technical constraints discussed in this thesis. Apple's recent announcement of allowing third party developers to create applications on the iPhone is perhaps an area where further study can be conducted to develop an easy to use health technology application. For example, electronic health records (EHRs) and clinical decision support (CDS) will encourage physicians to adopt a mobile device which in return translates into better healthcare for patients. Apple iPhone encompasses many features including easy to use via multi-touch screen, look and feel, phone, camera, media player, and web browser. So, if a physician would want to carry one device which does everything, then iPhone would be an ideal solution.

A case study needs to be conducted in each of health sectors: primary, secondary, and community, in order to find out the minimum acceptable security requirements for adoption of mobile devices in the healthcare domain. This will provide future initiatives with clear guidelines to develop new solutions which meet the security requirements. Additionally, further research is required to address how to provide mobile security. Lastly, this research project recommends investigating the opportunities and barriers of mobile networks such as Wi-Fi, WiMax, 3G, and mesh networks; this is due to the significant increase in ubiquity of wireless enabled devices such as laptops, tablet PCs, PDAs, and mobile phones.

Appendix A
Invitation letter for participating organizations

Massey University

PARTICIPANT INFORMATION SHEET

<Name>
Chief Executive / Director
<Organisation>
<Address>

Dear <Name>

Re: Research Project: Potential of Mobile Devices in New Zealand Health Care.

My name is Asfahaan 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.

Today mobile devices are being utilized in many aspects of private life and communal services due to their portability, convergence, storage, connectivity, communication, etc, which traditional personal computers (PCs) cannot emulate. Current and emerging developments in mobile devices have also allowed the potential of many applications that will radically impact future health care delivery systems. Many developed nations around the world have demonstrated the prospect of mobile devices in health care. The present research is directed to indentifying the potiential of mobile devices in New Zealand health care.

I am aiming to conduct interviews with health industry professionals in Primary, Secondary and Community health sectors and with technology vendors. I would like to invite staff from Healthphone Solutions Limited to participate in my research and I would appreciate any assistance you can offer me. The research will be divided into two parts:

    a) Questionnaire
    b) Interview

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 fifteen 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 2007. 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 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 (027) 2210399 or write to me at:

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Tel. 09 4140800 extn. 9319

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

Massey University

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

PARTICIPANT INFORMATION SHEET

Re: Research Project: Potential of Mobile Devices in New Zealand Health Care.

My name is Asfahaan 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.

Today mobile devices are being utilized in many aspects of private life and communal services due to their portability, convergence, storage, connectivity, communication, etc, which traditional personal computers (PCs) cannot emulate. Current and emerging developments in mobile devices have also allowed the potential of many applications that will radically impact future health care delivery systems. Many developed nations around the world have demonstrated the prospect of mobile devices in health care. The present research is directed to indentifying the potiential of mobile devices in New Zealand health care.

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. If you do consent to particpate, you may withdraw from the research project at any time without giving a reason up until 31 Dec 2007. 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) Questionnaire.

Firstly, a short questionnaire with some supplementary questions will be conducted prior the interview. It is expected that this questionnaire would take around 15 minutes to complete.

b) Interview

Your participation would involve a one-on-one interview. Interviews would take about 45 minutes, and be conducted during your own convienience. 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 2007.

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 (027) 2210399 or write to me at :

Asfahaan 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
Tel. 027 2210399
Email: asfahaan@tasmanit.com

My supervisor and the Head of Department: **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

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

Massey University

**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: Potential of Mobile Devices in New Zealand Health Care

Researcher: Asfahaan Mirza

To: <Name>

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 2007 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)

❑ Complete a questionnaire prior to the interview.

❑ Interview - I agree that the interview may be audio taped[1] (YES/NO)

❑ 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.

Appendix D

Short survey – print version

Massey University

SHORT SURVEY

Project: Potential of Mobile Devices in New Zealand Health Care

By: Asfahaan Mirza
Massey University 2007
Supervisor: Professor Tony Norris

Overview: Current and emerging developments in mobile devices have also allowed the potential of many applications that will radically impact future health care delivery systems. Many developed nations around the world have demonstrated the prospect of mobile devices in health care. The present research is directed to identifying the potential of mobile devices in New Zealand health care. 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.

This survey can be accessed and conduced online. Please visit:
http://mhealthsurvey.tasmanit.com

Many thanks for your interest and help.

Your profile:

Name: _____

What is your occupation or job title: _____

Which one of these health sectors do you work in?

☐ Primary Health Care	☐ Secondary Health Care	☐ Community Health Care	☐ Other, Please specify

Which of the following categories describes your involvement with mobile health in New Zealand? You may tick more than one.

☐ Technology vendors	☐ Health Providers	☐ Health Strategist

Comments:_____

_____

What mobile devices do you use?

_____

_____

1

Survey available online at: http://mhealthsurvey.tasmanit.com

Question One:

Please tick which of the following Mobile health applications you are aware that you are familiar with:

M-Health Applications	Aware
Web access to evidence-based databases	☐
Medication alerts using mobile phones (SMS)	☐
E-prescribing for repeat prescriptions via mobile phones	☐
Tele-monitoring to transmit patient results to clinicians	☐
On-line electronic health records via computer or phone	☐
Community nursing contact with clinical expert advice	☐
Public health and lifestyle messages over mobile phones	☐
Emergency care for accidents, natural disasters	☐
Efficient workflow via wireless communication	☐
Optimal asset utilisation, e.g. hospital bed rostering	☐
Patient or asset (e.g. clinical equipment) location using RFID	☐
Patient appointment booking and alerts via wireless e-mail	☐
Safety of staff checks with RFID or mobile phones/networks	☐

Additional M-Health applications:

_____

_____

_____

Question Two:

Select which devices in your opinion are more suitable for clinical or non-clinical mobile applications. Please indicate level of effectiveness of the device. And add any additional devices in the spaces provided below

Devices	Clinical	Non-clinical	Both	Effectiveness				
				Least		Neutral		Very
Laptop	☐	☐	☐	☐	☐	☐	☐	☐
Tablet PC	☐	☐	☐	☐	☐	☐	☐	☐
PDA	☐	☐	☐	☐	☐	☐	☐	☐
Smart Phone	☐	☐	☐	☐	☐	☐	☐	☐
Mobile Phone	☐	☐	☐	☐	☐	☐	☐	☐
RFID	☐	☐	☐	☐	☐	☐	☐	☐

Question Three:
Indicate the level of importance of the following challenges for m-health applications

Challenges	Importance				
	Least		Neutral		Very
Privacy and confidentiality	☐	☐	☐	☐	☐
Security (Physical & Software)	☐	☐	☐	☐	☐
Authenticating user without biometrics	☐	☐	☐	☐	☐
RFID tags (authentication and consent)	☐	☐	☐	☐	☐
Negative perception of patients or physicians	☐	☐	☐	☐	☐
Personal factors such as large fingers, poor eyesight, forgetfulness of carrying the device, etc	☐	☐	☐	☐	☐
Inability to learn or train using mobile devices	☐	☐	☐	☐	☐
Affordability / Costs	☐	☐	☐	☐	☐

Additional Challenges:

_____

_____

_____

_____

Question Four:
Please match which critical success factors can be achieved with the respective devices in M-Health context.
(Tick one or more boxes)

Critical Success Factors	Laptop	Tablet PC	PDA	Mobile Phone	RFID	None
Reduce Cost	☐	☐	☐	☐	☐	☐
User Acceptance	☐	☐	☐	☐	☐	☐
Increased efficiency	☐	☐	☐	☐	☐	☐
Improve patient safety	☐	☐	☐	☐	☐	☐
Improve patient care	☐	☐	☐	☐	☐	☐
Quality of Service	☐	☐	☐	☐	☐	☐
Secure Connectivity	☐	☐	☐	☐	☐	☐
Remote access for clinicians	☐	☐	☐	☐	☐	☐
Sustainability of mobile application and or device	☐	☐	☐	☐	☐	☐
Location independence for patients	☐	☐	☐	☐	☐	☐

Additional Critical Success Factors:

_____

_____

_____

Survey available online at: http://mhealthsurvey.tasmanit.com

3

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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:	_____ _____

☐   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 results 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 (027) 2210399 or email me on asfahaan@tasmanit.com or write to me at:

Asfahaan 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.

Survey available online at: http://mhealthsurvey.tasmanit.com

4

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Appendix E
Short survey – online version

URL: http://mhealthsurvey.tasmanit.com

Massey University

5%

SHORT SURVEY

Project: Potential of Mobile Devices in New Zealand Health Care

By: Asfahaan Mirza

Massey University 2007

Supervisor: Professor Tony Norris

Overview: Current and emerging developments in mobile devices have also allowed the potential of many applications that will radically impact future health care delivery systems. Many developed nations around the world have demonstrated the prospect of mobile devices in health care. The present research is directed to identifying the potential of mobile devices in New Zealand health care. This survey is expected to take 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.

Your survey responses will be stricly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. If you have questions at any time about the survey or the procedures, you may contact Asfahaan Mirza at 0272210399 or by email at asfahaan@tasmanit.com

Many thanks for your interest and help. Please start with the survey now by clicking on the **Continue** button below.

Continue

Short Survey: Potential of Mobile Devices in New Zealand Health Care
Please contact asfahaan@tasmanit.com if you have any questions regarding this survey.

Massey University

Questions marked with a * are required

35%

Your Profile:

Name *

What is your occupation or job title *

Which one of these health sectors do you work in? *
- ○ Primary Health Care
- ○ Secondary Health Care
- ○ Community Health Care
- ○ Other, Please specify

Which of the following categories describes your involvement with mobile health in New Zealand? You may tick more than one. *
- ☐ Technology vendors
- ☐ Health Providers
- ☐ Health Strategist
- ☐ Comments

What mobile devices do you use? E.g. Mobile phone, PDA, Laptop, etc.

Continue

Short Survey: Potential of Mobile Devices in New Zealand Health Care
Please contact asfahaan@tasmanit.com if you have any questions regarding this survey.

Massey University

Questions marked with a * are required

40%

Question One:

Please tick which of the following **Mobile health applications** you are **aware** of: *

☐ Web access to evidence-based databases

☐ Medication alerts using mobile phones (SMS)

☐ E-prescribing for repeat prescriptions via mobile phones

☐ Tele-monitoring to transmit patient results to clinicians

☐ On-line electronic health records via computer or phone

☐ Community nursing contact with clinical expert advice

☐ Public health and lifestyle messages over mobile phones

☐ Emergency care for accidents, natural disasters

☐ Efficient workflow via wireless communication

☐ Optimal asset utilisation, e.g. hospital bed rostering

☐ Patient or asset (e.g. clinical equipment) location using RFID

☐ Patient appointment booking and alerts via wireless e-mail

☐ Safety of staff checks with RFID or mobile phones/networks

☐ Additional M-Health applications:

[text area]

[Continue]

Short Survey: Potential of Mobile Devices in New Zealand Health Care
Please contact asfahaan@tasmanit.com if you have any questions regarding this survey.

![Massey University]

55%

Question Two:

A) Select which devices in your opinion are more suitable for **clinical or non-clinical mobile** applications.

	Clinical	Non-clinical	Both
Laptop	○	○	○
Tablet PC	○	○	○
PDA	○	○	○
Smart Phone	○	○	○
Mobile Phone	○	○	○
RFID	○	○	○

Additional Devices:

[text box]

B) Please indicate level of **Effectiveness** of the device.
Based on the previous question.

	Least Effective		Neutral		Very Effective
Laptop	○	○	○	○	○
Tablet PC	○	○	○	○	○
PDA	○	○	○	○	○
Smart Phone	○	○	○	○	○
Mobile Phone	○	○	○	○	○
RFID	○	○	○	○	○

Continue

Short Survey: Potential of Mobile Devices in New Zealand Health Care
Please contact asfahaan@tasmanit.com if you have any questions regarding this survey.

Massey University

65%

Question Three:

Indicate the level of **Importance** of the following challenges for m-health applications

	Least Important		Neutral		Very Important
Privacy and confidentiality	○	○	○	○	○
Security (Physical & Software)	○	○	○	○	○
Authenticating user without biometrics	○	○	○	○	○
RFID tags (authentication and consent)	○	○	○	○	○
Negative perception of patients or physicians	○	○	○	○	○
Personal factors such as large fingers, poor eyesight, forgetfulness of carrying the device, etc	○	○	○	○	○
Inability to learn or train using mobile devices	○	○	○	○	○
Affordability / Costs	○	○	○	○	○

Additional Challenges:

Continue

Short Survey: Potential of Mobile Devices in New Zealand Health Care
Please contact asfahaan@tasmanit.com if you have any questions regarding this survey.

Massey University

75%

Question Four

Please match which critical success factors can be achieved with the respective devices in M-Health context.

(Tick one or more boxes)

	Laptop	Tablet PC	PDA	Mobile Phone	RFID	None
Reduce Cost	☐	☐	☐	☐	☐	☐
User Acceptance	☐	☐	☐	☐	☐	☐
Increased efficiency	☐	☐	☐	☐	☐	☐
Improve patient safety	☐	☐	☐	☐	☐	☐
Improve patient care	☐	☐	☐	☐	☐	☐
Quality of Service	☐	☐	☐	☐	☐	☐
Secure Connectivity	☐	☐	☐	☐	☐	☐
Remote access for clinicians	☐	☐	☐	☐	☐	☐
Sustainability of mobile application and or device	☐	☐	☐	☐	☐	☐
Location independence for patients	☐	☐	☐	☐	☐	☐

Additional Critical Success Factors:

Continue

Short Survey: Potential of Mobile Devices in New Zealand Health Care
Please contact asfahaan@tasmanit.com if you have any questions regarding this survey.

Massey University

Questions marked with a * are required

100%

Future Contact:

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

Name: *   [   ]

Email: [   ]

Postal Address: [   ]

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

○ Yes

○ No

Would you like to participate in a interview session for this project? *

○ Yes

○ No thanks

○ I have already been interviewed for this project

Additional Comments:

[   ]

[Continue]

Short Survey: Potential of Mobile Devices in New Zealand Health Care
Please contact asfahaan@tasmanit.com if you have any questions regarding this survey.

Massey University

Thanks so much for your time, your survey results 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 (027) 2210399 or email me on asfahaan@tasmanit.com or write to me at:

Asfahaan 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.

Your response has been saved and recorded with ID **5952036**

Thank You for completing this survey

Appendix F
Interview questions

Q1) How do you think mobile device technology can enhance health services?

- *by sector*

- *by patient/provider*

Q2) What key opportunities do you see in mobile device usage in health care?

- *Rate those or what other? – Top 5?*

Q3) What Technical constraints do you see in using mobile devices?

- *Size, Shape, connectivity...*

Q4) What challenges and implications do mobile devices introduce in the healthcare environment?

- *Security, Privacy, Ethical issues, etc.*

Q5) Who pays for the service and who will get the main benefits?

- *Patient, Physicians, HC providers, MOH, CEO, etc?*

Q6) From whom do you think the resistance to uptake mobile devices would come from?

- *Patients, Providers, MoH or Infrastructure*

Q7) How will services change as a result of mobile technology?

- *Quality of service , Convenience, Low quality service (adds to existing high quality service, Thrid party services*

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